Shoalhaven Starches Gas Pipeline Project

Soil and Water Management Plan

National Australian Pipelines Pty. Ltd

24 March 2022

→ **The Power of Commitment**

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The Power of Commitment

Abbreviations

Item	Definition
AEC	Areas of Environmental Concern
ASS	Acid Sulfate Soil
CEMP	Construction Environmental Management Plan
COC	Contaminants of Concern
CWMP	Construction Waste Management Plan
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DPIE	NSW Department of Primary Industries and Environment
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environment Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESCP	Erosion and Sediment Control Plan
Ha	Hectare
HSE	Health, Safety and Environment
HDD	Horizontal Directional Drilling
JHEA	Job Hazard and Environmental Analysis
Km	Kilometre
NAP	National Australian Pipelines Pty. Ltd.
POEO Act	*Protection of the Environment Operations Act 1997*
ROW	Right of Way
SEE	Statement of Environmental Effects
SSI	State Significant Infrastructure
SWMP	Soil and Water Management Plan
WCCMS	Water Crossing Construction Method Statement
WHS	Work Health and Safety

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1. Introduction

In accordance with the Concept Plan (MP10_0144) and Project Application (MP 10_0108), Shoalhaven Starches proposes to construct and operate an approximately 5.6 km, 300 mm (12 Inch) gas Transmission Pipeline (TP). The offtake would be located at Pestells Lane, Meroo Meadow from Jemena's existing 450 mm (18 Inch) Eastern Gas Pipeline (EGP) to the Shoalhaven plant site at 36 Bolong Road, Bomaderry (see Figure 3.1).

In addition, the Gas Pressure Reduction Station (GPRS) would be installed to ensure a continuous pressure (nominally 4,800 kPa) is maintained to service both the plant as well as the proposed Gas Cogeneration Plant that has been approved as part of the separate Shoalhaven Starches Expansion Project (MP06_0228).

The Bomaderry plant is currently supplied with natural gas but the supply is insufficient for the proposed installation of a gas fired co-generation plant and planned increased production facilities.

The NSW government granted Shoalhaven Starches' Part 3A project approval under the *Environmental Planning & Assessment Act 1979* (EP&A Act) via application number (MP10_0108) on 30 October 2012. The Project has subsequently been transitioned to State Significant Infrastructure (SSI) by the NSW Government on the 30 April 2021 (Government Gazette 174 – Environment).

A modification application, including a Statement of Environmental Effects (SEE) for MP10_0108 is currently being assessed by the Department of Planning, Industry and the Environment (DPIE). This modification is being sought for approval to:

– Relocate the location of the GPRS to the approved Packing Plant site to the north of Bolong Road
– Increase the diameter of the pipe to be used in the gas pipeline from DN150 to DN300

National Australian Pipeline Pty Ltd (NAP) have been commissioned by Shoalhaven Starches to design, procure, construct and commission the pipeline and the end of line stations.

The proposed pipeline and facilities will be designed and constructed in accordance with AS2885 Series of Australian Standards for Design, Construction, Testing and Operations of gas transmission pipelines.

1.1 Purpose of this report

The primary purpose of this Construction Soil and Water Management Plan (SWMP) is to provide a project-specific soil and water management plan that describes the environmental strategy, methods, controls and legislative and approval requirements relating to soil and water management required to be implemented during the construction phase of the proposal.

The purpose of this SWMP is to:

– Identify key activities impacting upon soil and water
– Outline construction soil and water handling requirements
– Describe soil and water management measures

This plan shall read in conjunction with the Construction Environmental Management Plan (CEMP) (GHD 2021) and is provided as an appendix to the CEMP. All employees, subcontractors and visitors shall comply with this document at all times. Subcontractors will be provided a copy of the CEMP and will be required to comply and/or align with its contents.

The Watercourse Crossing Construction Method Statement required by Schedule 3, Condition 17 of MP10_0108 is provided in Appendix A.

1.2 Approval of plan

This Plan has been prepared and technically reviewed by suitably qualified and experienced GHD personnel (see Document Status page behind cover), meeting the requirements of a 'suitably qualified and experienced person' under Condition 18 of Schedule 3 of MP10_0108.

1.3 Approved erosion and sediment control plan

An Erosion and Sediment Control Plan (ESCP) was prepared for the project as part of the 2012 Gas Pipeline Environmental Assessment (EA). This ESCP was completed by Allen, Price and Associates (APA) as Annexure 13 of the EA. As a result of the project approval, the ESCP prepared by APA is considered part of the Project Approval and is therefore the approved ESCP for the project. This SWMP document provides the necessary documentation in accordance with Conditions 15, 17 and 18 of Schedule 3 of MP 10_0108, however the specifics of the erosion and sediment controls for the project (as approved) are included in the APA ESCP, attached to this SWMP as Appendix A. The ESCP (Appendix B) meets the specific ESCP requirements of Condition 18 of Schedule 3.

1.4 Consultation

In accordance with Condition 17 of Schedule 3 and Condition 18 of Schedule 3, this plan is required to be prepared in consultation with:

- NSW Office of Water (now DPIE – Water)
- Local Council, Consultation with Council on 9 November 2021 did not identify any relevant comments; however, review of this plan was requested by Council
- Natural Resources Access Regulator (NRAR):
  - Consultation with NRAR identified that Schedule 3, Condition 17 requires modelling of scour depth be included and riparian zone setbacks. Scour depth is addressed in Appendix A
  - Riparian zone setback management is considered in Appendix A. Riparian zone rehabilitation is discussed in Section 4.5
  - Groundwater interception information must include dewatering volumes and proposed treatment/disposal methods. Further information is provided in Section 4.1.1

Copies of correspondence with these agencies is included in Appendix C.

1.5 Scope and limitations

This report has been prepared by GHD for National Australian Pipelines Pty. Ltd and may only be used and relied on by National Australian Pipelines Pty. Ltd for the purpose agreed between GHD and National Australian Pipelines Pty. Ltd as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than National Australian Pipelines Pty. Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has prepared this report on the basis of information provided by National Australian Pipelines Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Policy and legislation

2.1 Relevant conditions of consent

The site is subject to MP 10_0108, which defines relevant conditions associated with preparation of a SWMP for the project and completion of relevant construction works for the project. Table 2.1 provides a summary of conditions relevant to the implementation of this SWMP and where they have been considered/addressed in this SWMP.

Table 2.1 Relevant MP 10_0108 conditions

Condition		Relevant section
Schedule 3, Condition 15	Except as may be expressly provided in the EPL for the site, the Proponent shall comply with Section 120 of the POEO Act.	Entire Plan
Schedule 3, Condition 17	The Proponent shall prepare and implement detailed watercourse crossing construction method statements for underboring to minimise impacts on watercourses as a result of the project. These statements must: a. Be prepared in consultation with NOW by suitably qualified expert/s. b. Include project specific modelling of scour depth safety margins and core riparian zone setbacks. c. Meet the relevant requirements of NOW. d. Be approved by the Director-General prior to the commencement of construction These statements must be documented in the CEMP for the project (see condition 1 in schedule 4).	Section 4.2 and Appendix A
Schedule 3, Condition 18	The Proponent shall prepare and implement a Soil and Water Management Plan for the project to the satisfaction of the Director-General. This Plan must:	
	a. Be prepared in consultation with Council and NOW by a suitably qualified and experienced expert	Section 1.4
	b. Be approved by the Director-General prior to the commencement of construction	
	c. Detail the measures that will be employed to prevent erosion and sedimentation of soil, in accordance with the relevant requirements in the latest version of the *Managing Urban Stormwater: Soils and Construction Guideline,* in particular near riparian zones and watercourses	Section 4.1 and Appendix B
	d. Detail how water and excavated soil would be tested, handled and stored/stockpiled	
	e. Detail the protocols to be put in place and followed in the event that contaminated soil or water is encountered during construction	Section 4
	f. Outline how contaminated soil and water will be disposed or off-site (e.g., at a licensed facility)	Section 4.3.2
	g. Detail the measures that would be put in place to manage and contain potential spills during cleaning and commissioning of the pipeline	Section 4.3.2
	h. Detail the on-going monitoring, maintenance and rehabilitation measures that would be implemented for land disturbed by the project (particularly bank stabilisation and bank and stream rehabilitation in riparian zones)	Section 4.3.3
	This plan must be documented in the CEMP for the project (see condition 1 in schedule 4).	Section 4.4 & 4.5

2.2 Statement of commitments

The site is subject to MP 10_0108, which defines relevant conditions associated with preparation of a CEMP for the project and completion of relevant construction works for the project. Table 2.2 provides a summary of conditions relevant to the implementation of this SWMP and where they have been considered / addressed in this SWMP.

Table 2.2 Statement of Commitment conditions

ID	Commitment	Relevant section
Soil and Water Management		
3.1	The CEMP for the project is to make provision for erosion and sediment control.	Section 4.1 and Appendix A
3.2	A comprehensive Erosion and Sediment Control Plan (ESCP) is to be prepared for the project in accordance with the recommendations of the Erosion and Sediment Control Management Plan prepared by Allen Price & Associates (refer 24710).	Appendix A
3.3	Observe strict controls over the stripping, stockpiling and protection of topsoils and trench spoil during pipeline installation.	Section 4.1.1
3.4	Replace trench spoil and topsoils as soon as practicable.	Section 4.1.1
3.5	Install silt fencing or otherwise to protect topsoil stocks where delays prevent replacement.	Section 4.1.1
3.6	Re-establish soil conservation systems (where applicable) on freehold lands to agreed condition.	Section 4.5
3.7	Prepare activity specific water crossing construction method statements. In this regard all watercourse crossings are to be directionally bored: – With entry and exit points sufficiently setback to allow for desired Category 2 riparian objectives to be met with trenching to stop at the edge of the 20 m CRZ. As a minimum, open trenching should be stopped at the 10 m boundary of this CRZ for Category 3 watercourses in order to preserve bed and bank stability. – Which calls for designed scour depth and safety margin. The water crossing construction method statements are to be submitted to the Office of Water (DP&I) for endorsement prior to any construction near the watercourse commencing.	Appendix A Water crossing methods described in Section 4.2
3.8	Temporary watercourse vehicle crossings are to be undertaken by laying temporary gabion mattresses (or similar) on the bed of the watercourse to minimise disturbance to the bed. Temporary waterway vehicle crossings are to remain in place until the length of the pipeline between Fletchers Lane, Edwards Avenue and Railway Street is tested, commissioned and backfilled.	Section 4.1
3.10	Appropriate safety procedures should be implemented for all excavations in accordance with relevant OH&S legislation and the findings and recommendations of the assessment carried out by Coffeys.	Section 4.1
3.11	The Office of Water is to be consulted if groundwater de-watering is necessary during construction to determine if an approval is required.	Section 4.1
3.12	Each watercourse is to be assessed to determine whether the soils are sodic or non-sodic within the flood liable land. The soil properties (such as sodicity) at watercourse crossings need to be assessed to determine appropriate crossing methodologies and rehabilitation measures. The investigation should be undertaken before construction commences.	Section 4.2

ID	Commitment	Relevant section
Rehabilitation		
10.1	Vegetation rehabilitation and maintenance should be addressed in the ESCP (see SOC 3.2) and as outlined in Section 3.11 of the Erosion & Sediment Control Plan prepared by Allen Price & Associates (refer 24710).	Appendix A
10.2	Ensure topsoil and trench spoil are clearly segregated within pipeline corridor.	Section 4.5
10.3	Ensure topsoil is not placed back across working area until trench is adequately compacted to avoid settling.	Section 4.5
10.4	Stabilise topsoil with retained vegetation as soon as practicable to encourage natural regeneration of disturbed corridor.	Section 4.5
10.5	Materials used for backfilling and trenches should be materials capable of providing uniform basal, wall and corner support for the service pipes. The excavated materials from the trenches are not considered suitable materials for backfilling in the immediate vicinity of the pipeline.	Section 4.5
10.6	Local native plant species must be used to rehabilitate native riparian vegetation disturbed by the project.	Section 4.5
10.7	Rehabilitation should include the rehabilitation of watercourse crossings and the rehabilitation phase should continue until all watercourse crossing sites are identified as stable by an independent suitably qualified certifier. Any trench areas should be maintained until they are certified as stable.	Section 4.5
10.7	Re-establish previous land uses as soon as practicable after trench backfilling.	Section 4.5
10.8	Ensure land profile is re-established to previous or agreed condition.	Section 4.5
10.9	Conduct ongoing monitoring and maintenance of disturbed lands. The monitoring program would need to be undertaken to assess the outcomes of the works undertaken including areas of potential erosion and ground instability associated with construction impact. The monitoring program should include monitoring and maintenance of any bank stabilisation and stream bed and bank rehabilitation. The rehabilitation will need to be monitored until all crossing sites are identified as stable by an independent suitably qualified certifier. Monitoring should also be undertaken for the rehabilitation of native riparian vegetation where native riparian vegetation has been removed as part of the project and rehabilitated following construction. The Office of Water recommends a maintenance period of 5 years after final planting. The rehabilitation of other non-native vegetation in riparian areas should be maintained until it is established and the area has been certified as stable by a suitably qualified certifier.	Section 4.5
10.10	Monitor corridor for weed species growth.	Section 4.5
10.11	Undertake weed control and eradication where needs identified.	Section 4.5

3. Site and project description

3.1 The project site

The pipeline would run east-south-east from a connection point at the existing Eastern Gas Pipeline (EGP) at Pestells Lane, Meroo Meadow to the Shoalhaven Starches site at Bolong Road, Bomaderry (refer to Figure 3.1). The new pipeline would stop just inside the boundary of the Shoalhaven Starches site and connect into the existing reticulation system.

No trenching would be required at road, rail or creek crossings as underboring would be utilised in these areas so that the pipeline passes under with minimal disturbance. There would be no change to the existing AGL pipeline which would remain in place to continue to serve domestic requirements for the area north of the Shoalhaven River as well as the Shoalhaven Paper Mill.

3.2 Construction of the project

3.2.1 Construction activities overview

Key construction aspects are provided indicatively below:

– **Gas pipeline** – For the approximately 5.6 km gas pipeline, construction would indicatively involve:
  - Works undertaken within an approximately 25 m to 30 m right of way, to allow for transportation of construction equipment during installation of the pipeline.
  - Typical trench width of 600 mm and a bellhole/tie-in width of between 1.5 to 2 m wide.
  - Typical trench depths between one metre and 3.5 m, with average depths of 1.8 m. A minimum depth of cover of 2 m would be completed at waterway crossings. For rail crossing the depth of cover is to be a minimum of 4 m.
  - Launch/receival pits would be required with sizes of 3 x 10 m and 3 x 6 m respectively where trenchless crossings of rail, roads and waterways are proposed.

– **Construction compounds** – As described in section 3 of the CEMP. These will be utilised during construction and be rehabilitated following the works.

3.2.2 Gas pipeline

Activities for construction of the gas pipeline include:

- Progressively clearing the proposal alignment and installation of required erosion and sediment, and traffic controls.
- Stringing pipes along the alignment.
- Progressively excavating trench along the pipeline route, with trench depths and widths provided in Section 3.2.1. Excavators would dig the trench, with spoil stockpiled adjacent to the trench for backfilling after the pipeline is installed. Trench boxes/shields would be utilised for deeper trenches to protect construction personnel.
- Lay the pipe within the trench and progressively install associated infrastructure. Pipes would be bedded on granular material such as sand or gravel, which would be spread along the bottom of the trench prior to pipe laying. Imported material would be Virgin Excavated Natural Material (VENM) or bedding material or crushed rock.
- Covering the trench with excavated soil (or crushed rock when laying under sealed roads), compact and stabilise disturbed areas.
- Remove fencing and erosion and sediment controls around construction works areas and complete rehabilitation and general landscaping.
- Move to next approximately 250 m section of open trench and repeat Steps 1-5.
- Complete pipeline from Pestells Lane to PRS a length nominally 5.6 km.
- Complete Fitting line from PRS to Co-gen Plant, nominally 370 m.
- Complete Fitting line from PRS to Dryer Plant, nominally 220 m.
- Complete hydrotest, dewater and dry each of the three pipelines separately.
- Tie-ins to the station pipework.
- Installation of Cathodic protection for the pipelines.
- Commission gas pipeline, stations (Pestells lane and PRS) and the fitting lines.

Where it is assessed that soil erosion post backfilling and reinstatement can become an issue, trench breakers may be installed along the pipeline and this is likely to require cement stabilised sand backfill.

Note: this map has been prepared based on sketches provided to GHD and are subject to change once detailed design drawings become available

Paper Size ISO A3
1:3,500
0 50 100
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

National Australian Pipelines Pty Ltd
Shoalhaven Starches Gas Pipeline Project (MP10_0108)
Soil and Water Management Plan

Project No. 12560160
Revision No. A
Date 14 Feb 2022

Proposal overview

FIGURE 3.1

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Data source: Aerial imagery - Metromaps 2022 ; General topo - NSW LPI DTDB 2020 & 2015; Heritage - OEH 2020 & NSW EPI 2020; Pipeline alignment & services - National Australian Pipelines Pty Ltd. Created by: eibbertson

Note: this map has been prepared based on sketches provided to GHD and are subject to change once detailed design drawings become available

Paper Size ISO A3
1:3,500

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

GHD

National Australian Pipelines Pty Ltd
Shoalhaven Starches Gas Pipeline Project (MP10_0108)
Soil and Water Management Plan

Project No. 12560160
Revision No. A
Date 14 Feb 2022

Proposal overview

FIGURE 3.2

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Data source: Aerial imagery - Metromaps 2022 ; General topo - NSW LPI DTDB 2020 & 2015; Heritage - OEH 2020 & NSW EPI 2020; Pipeline alignment & services - National Australian Pipelines Pty Ltd. Created by: eibbertson

Paper Size ISO A3
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Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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National Australian Pipelines Pty Ltd
Shoalhaven Starches Gas Pipeline Project (MP10_0108)
Soil and Water Management Plan

Project No.	12560160
Revision No.	A
Date	14 Feb 2022

Proposal overview

FIGURE 3.3

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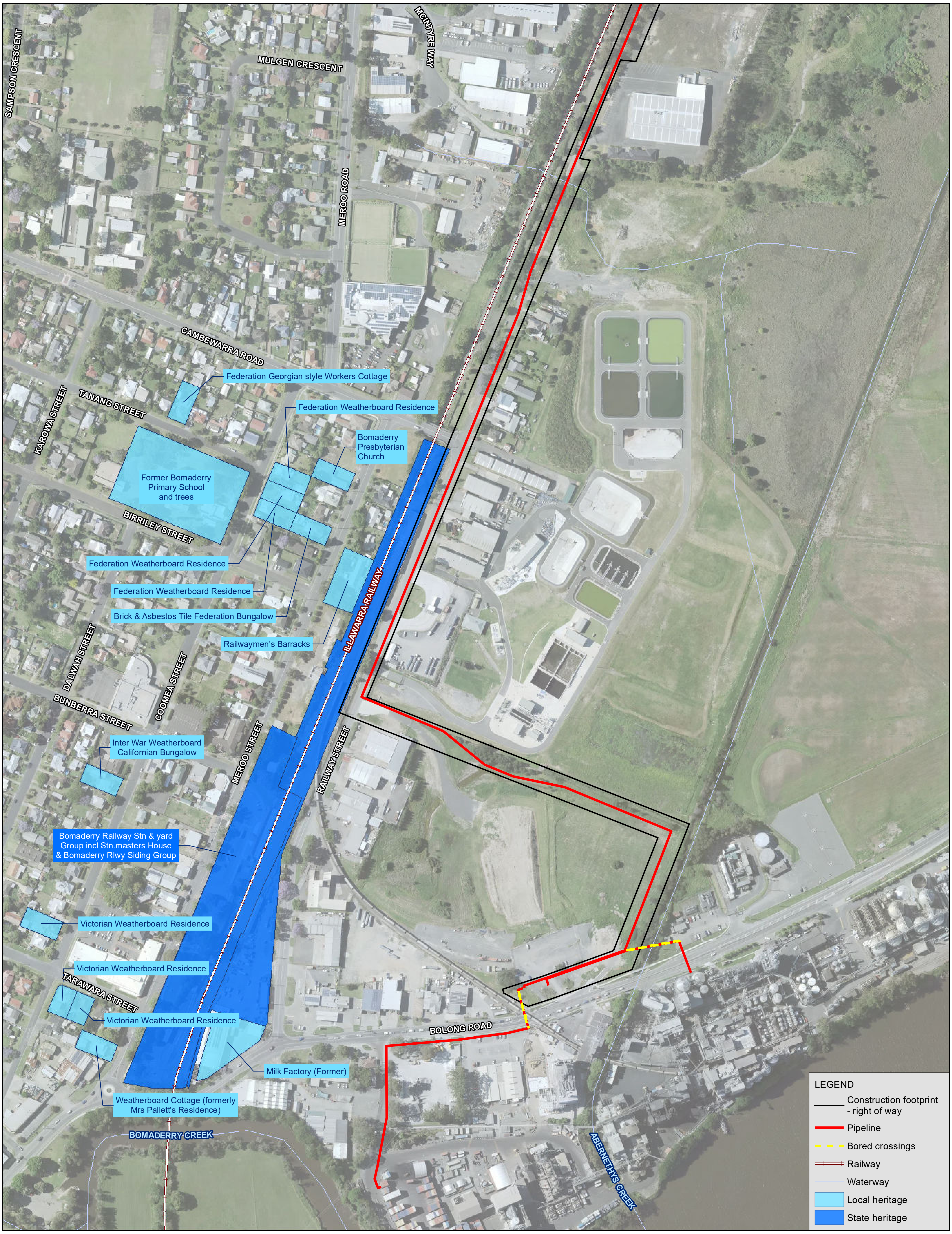
Data source: Aerial imagery - Metromaps 2022 ; General topo - NSW LPI DTDB 2020 & 2015; Heritage - OEH 2020 & NSW EPI 2020; Pipeline alignment & services - National Australian Pipelines Pty Ltd. Created by: eibbertson



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Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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National Australian Pipelines Pty Ltd
Shoalhaven Starches Gas Pipeline Project (MP10_0108)
Soil and Water Management Plan

Project No. 12560160
Revision No. A
Date 14 Feb 2022

Proposal overview

FIGURE 3.4

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Data source: Aerial imagery - Metromaps 2022 ; General topo - NSW LPI DTDB 2020 & 2015; Heritage - OEH 2020 & NSW EPI 2020; Pipeline alignment & services - National Australian Pipelines Pty Ltd. Created by: eibbertson

3.2.3 Horizontal directional drilling (HDD)

Horizonal directional drilling (HDD) involves installing the pipeline underground without trenching. A pit would be created at each end of the bore to access the required sub-surface depths. A drilling machine would then be setup next to the pit and drill rods will be steered into the launch pit to create a horizontal bore that runs below the land surface. The drilling process will be repeated from launch pit to retrieval pit until the bore hole is approx. 30% greater than the OD of the pipe.

The pipe would then be pulled through the under-bore from retrieval pit to launcher pit.

Trenchless crossings would be undertaken at:

– The Princes Highway, approximately 120 m in length
– Fletchers Lane/RailCorp intersection, approximately 60 m in length
– Unnamed waterway crossing 1, approximately 30 m in length
– Unnamed waterway crossing 2, approximately 130 m in length
– Abernathys Creek crossing, approximately 130 m in length
– Edwards Avenue, approximately 30 m in length
– Mulgen Creek crossing, approximately 150 m in length
– Manildra's private rail reserve and Bolong Road, approximately 30 m in length – for the HP fitting line
– Abernathys Creek Crossing, approx. 70 m in length – for the LP fitting line

HDD would involve:

– Establishing construction compounds approximately 20 x 40 m either side of road, rail and waterway crossings for storage of plant and equipment, and establishment of launch/receival pits, with the launch pit approximately one by six m and the receival pit approximately one by 20 m. Fencing and security measures would be installed at these sites.
– Establishing and excavating pits at the start and end of the section to be drilled, including any necessary trench support.
– Mobilising the drill equipment and installing measures to manage groundwater, if required.
– Using a bentonite-based drilling fluid to lubricate the drilling head and flush the drilled hole. Drill cuttings would be removed and contained, collected and recycled at the drill launch site. The drill fluid recycling plant would be self-contained and powered by an onsite generator. Excess spoil, cuttings and slurry that cannot be used in site restoration would be disposed at a licensed facility.
– When the required diameter of the hole is reached, the gas pipeline will be pulled through and the annulus will be grouted naturally with bentonite.
– Pulling a pipe through the HDD bore by the drill head.
– Following completion of HDD, cover the trench with excavated soil, compact and stabilize disturbed areas.
– Remove fencing and erosion and sediment controls around construction works areas and complete rehabilitation and general landscaping.

Further construction details are provided in the main CEMP document.

4. Soil and water mitigation measures

A Soil and Water Management Plan (SWMP) has been prepared for the project with detailed mitigation measures and incorporating an Erosion and Sediment Control Plan (ESCP) completed by APA as part of the Project EIS (attached as Appendix B to this plan) and Watercourse Crossing Construction Method Statements (WCCMS). NAP and their sub-consultants must comply with all the requirements of the SWMP and maintain records of compliance in accordance with section 4.9 of the CEMP.

4.1 Erosion and sediment control measures

4.1.1 General

In addition to the drilling, trenching and piping works, A number of road reserves will be impacted by construction of the proposed gas pipeline. A small portion of RailCorp's land (20-50 m) will be used for the proposed gas main. The track in the reserve is active with passenger and freight trains passing through each day to the nearby Bomaderry Railway Station and Manildra Factory. Manildra's private rail reserve will also require underboring, adjacent to Bolong Road.

The following list describes general erosion and sediment control procedures for the project for all lands:

- All works are to be carried out in accordance with Landcom's Managing Urban Stormwater; Soils and Construction Volume 1, 4th Edition, March 2004 & Volume 2A.
- The contractor shall take all reasonable measures to minimise the effects of dust emissions from the site including the spreading of mulch in areas where construction has been completed.
- All topsoil from the construction areas is to be stripped and stockpiled. Stockpiles are to be located outside areas of concentrated stormwater runoff and are required to be grass seeded or mulched if they are to remain for longer than fourteen (14) days. However, excavated topsoil should be replaced into the trench as soon as practicable.
- The movement of machinery over the site should be limited to the construction areas to avoid disturbance to existing vegetated areas. No-go areas are to be marked off prior to commencement of works. Machinery should be inspected prior to exiting construction area to ensure excess mud and debris is not tracked onto roadways. During and on completion of the workday contractors should inspect to ensure the roadways adjacent to the project site are free of excess mud/debris and clean if necessary.
- Areas of the site that are disturbed by construction works are to be topsoiled, seeded and fertilised immediately after construction works in the particular area finished and not left till the end of the overall construction.
- Construction areas shall not be left in an open and disturbed state for more than fourteen (14) days. Areas expected to be left open for periods longer than this are to be seeded.
- Filter fences are to be removed only after all disturbed areas have established a good grass covering, minimum 70%.
- Any existing bare or disturbed areas of the site not affected by the construction works are to be topsoiled, seeded and fertilised as soon as practicable after each phase of work.
- Sediment and erosion control structures are to be maintained on a daily basis during construction and on a minimum of weekly basis during the six month liability period (or as required depending upon weather conditions). All material removed from the traps is to be spread and grass seeded or disposed of, off site in an approved manner.
- All imported fill is assumed to be a material other than dispersive clay. All fill material is to be tested for dispersibility prior to placement on the site and if found to be dispersive the superintendent is to be notified prior to placement of any fill for advice on treatment of dispersive soils.

– Sediment fence/filter can be used as erosion and sediment control around stockpiles, adjacent to the main trench, around areas where underboring of watercourses will occur and be installed around the perimeter of wetlands, and should be installed at all drainage structures receiving stormwater runoff from excavated areas. Filter/sediment fences are to be constructed from an approved filter material and erected in accordance with the manufacturer's instructions.
– Swales and table drains along the route should have staked straw bale or socked mesh dams installed on road reserve shoulders that receive runoff stormwater runoff from excavated soils.
– Waste generated by the construction process should be collected and retained on site in appropriate containers and be removed offsite to a licensed landfill when appropriate.
– Washing out of concrete truck chutes should occur at specific locations predetermined prior to construction. Bermed pits with a large enough volume to take multiple pours should be excavated for this purpose. Material from the pits shall be disposed of and the pits regraded when all concrete work is complete.
– Materials that may be brought on site for construction of the proposed gas main include:
  - Aggregate of various sizes for trench backfill, bedding, and other applications.
  - Pipe and associated fittings.
  - Wood in various forms for staking, marking alignment and forming for concrete work.
  - Paint for marking alignments and the location of various utilities.
  - Where possible materials should be placed above ground on pallets or alternative.

Additional measures required by the Statement of Commitments from the EIS:

– Appropriate safety procedures should be implemented for all excavations in accordance with relevant OH&S legislation and the findings and recommendations of the assessment carried out by Coffeys.
– The DPE Water is to be consulted if groundwater de-watering is necessary during construction to determine if an approval is required.

In NSW, the taking of water and its subsequent use has historically been managed through a licensing framework under the *Water Act 1912*, which is administered by the Department of Industry – Water. This licensing framework is transitioning to a new licensing and approval framework under the *Water Management Act 2000*.

The *Water Act 1912* still applies to:

– Taking water from a water source outside water sharing plan areas
– Construction and use of water supply works outside water sharing plan areas
– Drainage works in all areas of NSW
– Aquifer interference activities in all areas of NSW

As the works would encounter groundwater, a licence under Part 5 of the *Water Act 1912* will be obtained from the Department of Industry – Water for the extraction of groundwater during the works. It is anticipated construction would dewater approximately 20,830 litres of groundwater.

Site specific measures for the project are included in Appendix B attached.

4.1.2 Watercourse crossings

The immediate area surrounding watercourses (riparian zones) are susceptible to erosion and sedimentation due to the increased possibility of flowing water in these areas. The four watercourses are minor and flow intermittently throughout the year, depending on the size of the storm event affecting the associated catchment. Erosion and sediment control management for watercourse crossings will depend on the weather preceding, during and after proposed construction period.

Mitigation measures for watercourse crossings are predominantly through design (see Appendix A) and include:

– Each watercourse is to be assessed to determine whether the soils are sodic of non-sodic within the flood liable land. The soil properties (such as sodicity) at watercourse crossings need to be assessed to determine appropriate crossing methodologies and rehabilitation measures. The investigation should be undertaken before construction commences.

- Watercourse crossings will not be made by open trenching. All watercourses will be crossed by mechanical underbore, to mitigate impacts on watercourses and surrounding riparian zones. Open trenching shall be stopped at the boundary of the core riparian zone watercourse and trench stops put in place until a suitable watercourse crossing has been made.
- Watercourses will require temporary vehicle crossings for stabilised machinery access over the 5 m – 7 m wide right-of-way to be built within un-formed road reserves. Temporary watercourse vehicle crossings are to be undertaken by laying temporary gabion mattresses (or similar) on the bed of the watercourse to minimise disturbance to the bed. Temporary waterway vehicle crossings are to remain in place until the length of the pipeline between Fletchers Lane, Edwards Avenue and Railway Street is tested, commissioned and backfilled.
- Significant erosion and sedimentation is possible at watercourse crossings and adequate control measures are needed to mitigate impacts to soils, vegetation and watercourse geomorphic condition. Stabilised work sites approximately 20 m x 40 m are to be positioned at either side of watercourse crossings for underbore machinery to be positioned to lay pipe under the bed of the watercourses. Stabilised work sites are also required at other locations along the proposed route where underboring is required and other machinery will be best positioned during non-work periods.
- Stabilised work sites are to be built only when required as staged construction of the pipeline progresses along the route. Rehabilitation is to begin immediately when trenches and watercourse crossings are backfilled and completed, respectively.

The proposed watercourse crossing drawings and details of recommended erosion and sediment controls are provided in Appendix A and Appendix B respectively.

4.1.2.1 Scour depth

There is potential for a buried pipeline to be uncovered at watercourse crossings. The minimum depth of burial, or soil cover over the pipeline is stipulated so that damage is prevented to the pipeline. Once buried, the pipeline is to remain in its covered state unless specifically removed.

According to APA, the most significant form of scour occurring at the watercourse crossings is localised scour at the outlet of bridge/culverts, due to the large catchment coupled with the size of the bridge/culverts, and constriction of the watercourses as they flow under the railway track increasing the velocity through the opening.

From the scour depth results completed by APA for the ESCP (Appendix B), the minimum pipeline depth of cover at waterway crossing 3 will need to be increased from a minimum of 2.0 m to a minimum of 5.1 m. The minimum 2 m depth of cover under the waterway beds at waterway crossings 1, 2, and 4 should be satisfactory. Refer to Appendix B for further details.

4.1.2.2 Watercourse crossing methodology

Prior to the commencement of works, a Job Safety and Environmental Analysis (JSEA) shall be developed. A risk assessment for the project has already been completed by NAP. Prestart meetings and toolbox talks will also be undertaken prior to the commencement of works.

A summary of the HDD works are provided in Table 4.1

Table 4.1 Waterway Crossing Process Summary

Input	Resources	Control	Output	Measurement
Pipes Strung	Equipment	Inspection	Site Preparation	Quality, Safety and Environment Performance Indicators
Group	Operators	Permits	HDD	No outstanding Non-conformances or client queries
Other Materials		Surveyed Alignment	Installed pipeline	
		Management Plans	Pipeline grouted	
			Entry and Exit point reinstated	
			As- built survey data compiled	

The following activities need to be completed prior to commencement of work:

- Water requirement for the boring or drilling and for wetting the surrounding area for dust control
- Check the geotechnical conditions and review any available reports
- Survey of the area
- Protection of Services; Dial Before You Dig and locate all services including:
  - Power lines
  - Water
  - Gas
  - Communication cables
  - Telephone lines
- Establish local stake holder and Landowner requirements with the Land Liaison Officer

The HDD and pipeline installation works would involve:

- Establishing construction compounds approximately 20 x 40 ms either side of road, rail and waterway crossings for storage of plant and equipment, and establishment of launch/receival pits, with the launch pit approximately one by six ms and the receival pit approximately one by 20 ms. Fencing and security measures would be installed at these sites.

  Site preparation includes:
  - Advise Traffic Controller of the activity start date (where traffic control is required).
  - Review and sign the JSEA for the work.
  - Establish the drill site including a TMP, access points of the required area. Set out the works ensure that all work activities are contained within the ROW.
  - Install temporary safety fencing and signage.
  - Install environmental control including silt fences if required.
  - Setup waste management system.
  - Excavate entrance and exit pits approximately 0.5 m below the pipe invert.
  - Entry and exit pits will be located away from the banks of the creek.
- Establishing and excavating pits at the start and end of the section to be drilled, including any necessary trench support.
- Mobilising the drill equipment and installing measures to manage groundwater, if required.
- Using a bentonite-based drilling fluid to lubricate the drilling head and flush the drilled hole. Drill cuttings would be removed and contained, collected and recycled at the drill launch site. The drill fluid recycling plant would be self-contained and powered by an onsite generator. Excess spoil, cuttings and slurry that cannot be used in site restoration would be disposed at a licensed facility.
- When the required diameter of the hole is reached, the gas pipeline will be pulled through and the annulus will be grouted naturally with bentonite.
- Pulling a pipe through the HDD bore by the drill head.
- Following completion of HDD, cover the trench with excavated soil, compact and stabilize disturbed areas.
- Remove fencing and erosion and sediment controls around construction works areas and complete rehabilitation and general landscaping.

4.2 Drilling activities management

4.2.1 Drilling fluids

A Drilling Fluid Management Plan has been developed by NAP. To reduce the risk of drilling fluid escaping to the environment, NAP has identified the following paths by which it is possible that drilling fluid could enter these sensitive areas.

– Runoff or surface water could escape the drilling compound during periods of rainfall.
– Drilling fluid could escape the drilling compound and potentially find its way into the environment.
– Drilling fluid could potentially escape the borehole during drilling through inconsistencies (cracks & fissures) in the rock. This could result in drilling fluid being deposited into underground aquifers or breaking out to the surface.
– Groundwater could seep into the borehole during the drilling operation. This ingress will result in increased drilling fluid volume and could cause drilling fluid containment facilities to become filled to capacity and possibly overloaded.

These are the only paths by which drilling fluid could be potentially lost to the environment. Therefore, it is the goal of the Drilling Fluid Management Plan to minimise the chance of drilling fluid escaping via these paths through the use of safeguards and the implementation of inspection procedures.

The key outcomes of the Drilling Fluid Management Plan as it relates to this SWMP are provided below:

– Covered earth bunds and drainage channels will be placed around the upper edges of the drill site and work area, to divert natural runoff around and away from the site so that it doesn't mix with drilling compound runoff. Necessary erosion and sedimentation control measures will be in place.
– All facilities utilised in the surface mud handling (mixing, cleaning and pumping) shall be bunded. This shall ensure natural/clean runoff contained within the compound is not mixed with drilling fluid or contaminated by oil/fuel.
– A sump pit will be constructed at the bottom of the drill site. The sump pit will be positioned (during site planning) so as all runoff from the drilling compound will flow into it. The sump pit is of such dimensions to provide a buffer for the drilling fluid returns.
– An earth bund or silt fencing will be placed on the downstream side of the bund to contain any spillage. The sump pit will be pumped out using vacuum trucks in an as required basis during the drilling operation. This will ensure that any rain event, whilst the drilling crew is not onsite, won't lead to a sump pit overflow.
– All products used to mix the drilling fluid will be covered before they are used to mix the drilling fluid. The unmixed drilling mud shall be stored on pallets keeping them off the ground and not stored within drainage lines. This will prevent the chance of any drilling fluid components escaping the drilling compound and becoming contaminants to the environment.
– All stationery plant & equipment on site is inspected on a daily basis to ensure it is in good working order to minimise the chance of fuel/oil/grease leakage.
– Adequate spill control kits containing absorbent materials, to cleanup spills from mobile equipment outside bunds shall be on site at all times.
– All excess oils and greases shall be contained within the fuel bund in order prevent any chance of leakage. The fuel bund is a fuel tank (4500 L capacity) with an inbuilt steel bundable to contain 1.5 times storage capacity of the tank.
– All used oil or grease taken from machinery during services is stored within the fuel bund. The fuel bund is regularly emptied by a licensed contractor. By designing the drill profile using the best geotechnical information available, the drilling contractor can ensure that an adequate amount of cover can be provided beneath the surface.
– The products selected to mix the drilling fluid have been carefully selected to provide the drilling fluid with sufficient Bentonite content. The Bentonite content of the drilling fluid will ensure a thin, low-permeability filter cake forms on the walls of the borehole. This will ensure no drilling fluid is lost through the walls of the borehole.

– Chances of drilling fluid seeping in the ground through storage pits (returns pits & sump pit) are minimal. Just as the drilling fluid lines the inside of the borehole it will also line the inside pits and provides an impermeable barrier hence stopping fluid from seeping into ground.

Drilling fluid loss will be tracked via volumetric tracking instrumentation. This loss tracking will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected. Nominated cored holes will also be checked to see if there are any indicators that suggest where the fluid may be lost to.

The bore path will also be visually monitored from the surface for any signs of surface frac-out. In the event of a surface frac-out occurring, all drilling operations will cease and all efforts will be made to contain the frac-out to a localised area. Sandbags will be available on site to bund the area. Excess fluids will be removed from the area using a vacuum truck. If a vacuum truck cannot access the area of frac-out, manual pumping will be used to remediate the area surrounding the frac-out.

4.2.2 Drilling compound management

Earth bunds/drainage channels or silt fencing placed on the downstream side of the drilling compound will be inspected on a daily basis and/or during and after any significant rain event to ensure their adequacy and integrity.

Earth bunding placed around the sump pit will also be inspected on a daily basis and/or after any significant rain event to ensure its adequacy and integrity.

Before the commencement of drilling and at the close down each day, all components of the mud mixing system will be visually inspected to check for signs of drilling fluid loss and to ensure its adequacy for the containment of drilling fluid.

4.3 Contamination and soil handling

A contamination assessment was undertaken by Coffey Environments as part of the Environmental Assessment (Cowman Stoddart Pty Ltd 2012) for the Project Approval. The assessment identified the following areas of environmental concern and contaminants of concern:

– Storage and use of fuels and chemicals with operations at the former rail yard depot
– Fill of unknown origin and quality
– Possible leaks from the sewer line and nearby treatment plant
– Potential application of pesticides and fertilisers

The findings of the contamination assessment indicated that areas of environmental concern have a low to moderate likelihood of contamination. The excavated material for trenching and construction of access pits for underboring are considered likely to comprise clean soil material.

Excess spoil material will be stockpiled in designated areas in accordance with the NAP Sediment Control Plan (2019). The stockpiles will be located within the construction footprint or road reserve as shown in Figure 3 of the CEMP. The excavated material will be sampled and tested in accordance with the *Waste Classification Guidelines* (NSW EPA 2014) prior to disposal at an appropriately licenced landfill facility.

Topsoil would be stripped and segregated in windrows and reused for site rehabilitation. Any vegetation that is cleared would be mulched for reuse in site rehabilitation or removed offsite for reuse in accordance with the EPA Mulch Exemption 2016.

4.3.1 Soil and stockpile management

Stockpiles will be required along the proposed route to store materials, excavated soil and topsoil. The most suitable location for theses stockpiles would most likely be over the backfilled trench of the previously completed stage or on the opposite side of the road reserve within the verge or footpath. The stockpile size and spread needs to be limited to allow machinery to pass, and also to reduce the mass sitting above the newly installed gas main and other existing services.

Erosion and sediment control will consist of:

- Sediment fence and geotextile wrapped straw bale filters on the low side of the stockpile.
- Dust emissions need to be minimised.
- Due to the relatively short construction period required during staged construction, stockpiles would not be in place for more than one week maximum, although it may be possible to utilise one stockpile location for a number of consecutive stages of construction.

Visual assessment will be undertaken to confirm that no contaminated materials are present in excavation/ stockpiling process via the Unexpected Contamination Finds procedure.

4.3.2 Unexpected contamination finds

An unexpected finds protocol has been attached to the Construction Waste Management Plan (CWMP) to provide a framework for management of unexpected finds such as asbestos containing material.

The WHS Regulation states that a person conducting a business or undertaking must not carry out or direct or allow a worker to carry out work involving asbestos if that work involves tasks including transporting, storing, removing, handling, disposing of or disturbing asbestos or ACM, except in prescribed circumstances[1].

Work involving potentially asbestos-contaminated soil is not prohibited as long as a competent person has determined the soil does not contain any visible ACM or friable asbestos; or if friable asbestos is visible, it does not contain more than trace levels of asbestos determined in accordance with AS4964:2004 *Method for the qualitative identification of asbestos in bulk samples*[2].

Indicators of contamination in soils include:

- Discolouration of the soil, including staining and horizontal layers of discolouration
- Odours from soil
- Oily sheen on water leaving soils

If potentially contaminated material is identified NAP will assess the situation and if considered necessary, commission a suitably qualified contamination specialist to undertake a contamination investigation in the area of the find. The material will be classified in accordance with the Waste Classification Guidelines (EPA, 2014).

If necessary, NAP will liaise with the relevant authorities to determine the appropriate management options. NAP (in consultation with specialists) will determine the appropriate management measures to be implemented. This may include leaving contamination undisturbed, capping of contamination, treatment or off-site disposal. Material to be disposed of off-site will be transferred to an appropriately licensed waste facility.

If the material is determined to be acid sulfate soil or potential acid sulfate soil, the management procedures outlined in the ASSMP (appended to the CEMP) will be followed.

Remedial actions will be incorporated into specific Remediation Action Plans (RAPs). RAPs will be prepared by a suitably qualified and experienced person and in accordance with all guidelines under the Contaminated Land Management Act (NSW).

RAPs will be verified by a Contaminated Land Specialist and submitted for approval prior to commencement of remediation. Relevant JSEA or SWMS will be reviewed and updated when required.

4.3.3 Spill response

Accidental spills (i.e., chemical, fuel, oils) on site have the potential result in contamination of land and water. Hydrocarbon spills will be documented as per the environmental incident process detailed in the CEMP. Environmental Incidents will be investigated and reported upon in accordance with NAP requirements.

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[1] WHS Regulation 2017, as summarised in Code of Practice – How to Manage and Control Asbestos in the Workplace, s.1.1.
[2] As noted in Section 2, ALS LOR is reported as 0.1 g/kg (0.01%). ALS notes that 'Trace' = Asbestos fibres detected by trace analysis per AS4964, and the result can be interpreted that the sample contains detectable 'respirable' asbestos fibres. The LOR for “Trace Asbestos” under ALS method EA200Q is stated to be 5 fibres. ALS advised the relationship between the LOR for fibres and for friable asbestos with regard to WHS requirements has not been clearly established.

Spill prevention to be employed on the site includes:

– Material Safety Data Sheet (MSDS)
– Appropriate Storage (self bunded storage containers within onsite facilities)
– Correct Usage

4.4 Maintenance

General maintenance of erosion and sediment controls will include:

– Any sediment fencing and water management structures will be inspected to ensure that they are functioning adequately. Where controls are observed to be not functioning correctly the control will be restored to meet the required standard. At a minimum, controls are to be inspected, maintained and cleaned fortnightly and following rain events (>20 mm in any 24-hour period).
– Where significant erosion is observed, additional controls would be implemented in general accordance with the Blue Book.

General maintenance of surface stabilisation will include:

– Checking of surface stabilisation to ensure adequate sediment/dirt binding to prevent nuisance dust generation.
– Checking of sediment tracking onto the adjoining road network.
– Where site observation indicates the potential for dust generation (i.e., evidence of sediment tracking, loose sediment material, hot dry weather conditions etc.), appropriate measures are to be implemented such as water and or soil binder application.
– Any observed sediment tracking onto the local road network is to be removed immediately by a street-sweeper or similar.

4.5 Rehabilitation

Rehabilitation measures required by the Statement of Commitments include:

– Ensure topsoil is not placed back across working area until trench is adequately compacted to avoid settling.
– Stabilise topsoil with retained vegetation as soon as practicable to encourage natural regeneration of disturbed corridor.
– Materials used for backfilling and trenches should be materials capable of providing uniform basal, wall and corner support for the service pipes. The excavated materials from the trenches are not considered suitable materials for backfilling in the immediate vicinity of the pipeline.
– Local native plant species must be used to rehabilitate native riparian vegetation disturbed by the project and in accordance with the *Controlled Activities on Waterfront Land – Guidelines for riparian corridors on waterfront land* (DPI, 2018).
– Rehabilitation should include the rehabilitation of watercourse crossings and the rehabilitation phase should continue until all watercourse crossing sites are identified as stable by an independent suitably qualified certifier. Any trench areas should be maintained until they are certified as stable.
– Re-establish previous land uses as soon as practicable after trench backfilling.
– Ensure land profile is re-established to previous or agreed condition. Re-establish soil conservation systems (where applicable) on freehold lands to agreed condition.
– Conduct ongoing monitoring and maintenance of disturbed lands. The monitoring program would need to be undertaken to assess the outcomes of the works undertaken including areas of potential erosion and ground instability associated with construction impact. The monitoring program should include monitoring and maintenance of any bank stabilisation and stream bed and bank rehabilitation. The rehabilitation will need to be monitored until all crossing sites are identified as stable by an independent suitably qualified certifier.

– Monitoring should also be undertaken for the rehabilitation of native riparian vegetation where native riparian vegetation has been removed as part of the project and rehabilitated following construction. The Office of Water recommends a maintenance period of 5 years after final planting. The rehabilitation of other non-native vegetation in riparian areas should be maintained until it is established and the area has been certified as stable by a suitably qualified certifier.
– Monitor corridor for weed species growth.
– Undertake weed control and eradication where needs identified.

4.6 Cleaning and commissioning

Once the pipeline has been fully installed in the trench and backfilling is complete, the pipeline shall be hydrostatically tested. Upon completion of the hydrotest, it is proposed that the water be discharged into the nearby creek/watercourse. Measures should be taken to prevent this discharge causing soil erosion, sedimentation, and negative impacts to aquatic fauna.

Measures to be implemented during cleaning and commissioning include:

– Discharge location to include appropriate erosion control such as discharging into a rock and/or geofabric lined sump / channel into a watercourse to minimise erosion potential.
– Cleaning waters will be appropriately chlorinated and dosed to minimise impacts to water quality in discharge.
– Water quality of discharge water will be undertaken as part of pretest and during the cleaning process (i.e., ongoing water quality monitoring) to confirm minimal impact.
– The discharge flow rate will be reduced to minimum practical during cleaning.
– Water quality should be monitored for pH, heavy metals, and total suspended solids to ensure the water meets the guidelines detailed within ANZECC 2000 and Table 4.1 below.

Sampling collection will be carried out in accordance with the RMS guideline for Construction Water Quality Monitoring and EPA publication “Approved methods for sampling and analysis of water pollutants in NSW”. This will include the following:

– Accurately labelled and recorded on chain of custody.
– Samples taken, transported and processed by a NATA accredited lab within the holding period timeframes specified for the sample preservation.
– Typical water quality parameters to be measured and associated discharge criteria are detailed in the below Table. It also details the monitoring and analytical requirements by reference to authority publications e.g., Approved Methods for Sampling and Analysis of Water Pollutants in NSW, 2004.

Table 4.2 Water Discharge Monitoring for Commissioning

Parameter	Criteria	Sampling
pH*	Preconstruction baseline (General Best Practice 6.5 – 8.5)	Probe or Grab Sample
Total Suspended Solids*	Preconstruction baseline (General Best Practice < 50 mg/L)	Probe or Grab Sample
Oil and Grease*	General Best Practice - No visible (or < 10 mg/l if visible)	Visual or Grab Sample

*ANZECC & ARMCANZ. 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

5. Management

5.1 Roles and responsibilities

The construction contractor would be responsible for implementing soil and water management measures including compound setup, drilling activities, general controls and trenching controls, maintenance, segregation, reuse and disposal. Further details on roles and responsibilities are outlined in the CEMP.

It is expected a waste contractor would be engaged to handle collection of general waste generate by the construction compounds.

5.2 Training

All employees, contractors and utility staff working on site will undergo site induction training relating to soil and water management issues. The induction training will address elements related to soil and water management including:

- Existence and requirements of this sub-plan
- Relevant legislation
- Roles and responsibilities for soil and water management
- Water quality management and protection measures
- Procedure to be implemented in the event of an unexpected discovery of contaminated land

Targeted training in the form of toolbox talks or specific training will also be provided to personnel with a key role in soil and water management. Examples of training topics include:

- ERSED control installation methodology
- Working near or in drainage lines and creeks
- Emergency response measures in high rainfall events
- Preparedness for high rainfall events
- Lessons learnt from incidents and other event e.g., high rainfall/flooding
- Spill response
- Stockpile location criteria
- Identification of potentially contaminated spoil and fill material

5.3 Monitoring and reporting

As discussed in the CEMP, a daily health safety and environmental inspection would be undertaken. The inspection would also cover visual observation that erosion and sediment controls and soils are being handled appropriately in accordance with this plan. This inspection would be reported on daily basis and assessed against the NAP project management plan, occupation health and safety plan, environmental management plan and quality assurance plan.

In addition, the following erosion and sediment control and rehabilitation monitoring in Table 5.1 is recommended as a result of the approved APA erosion and sediment control plan (Appendix B).

Table 5.1 ERSED and Vegetation Monitoring

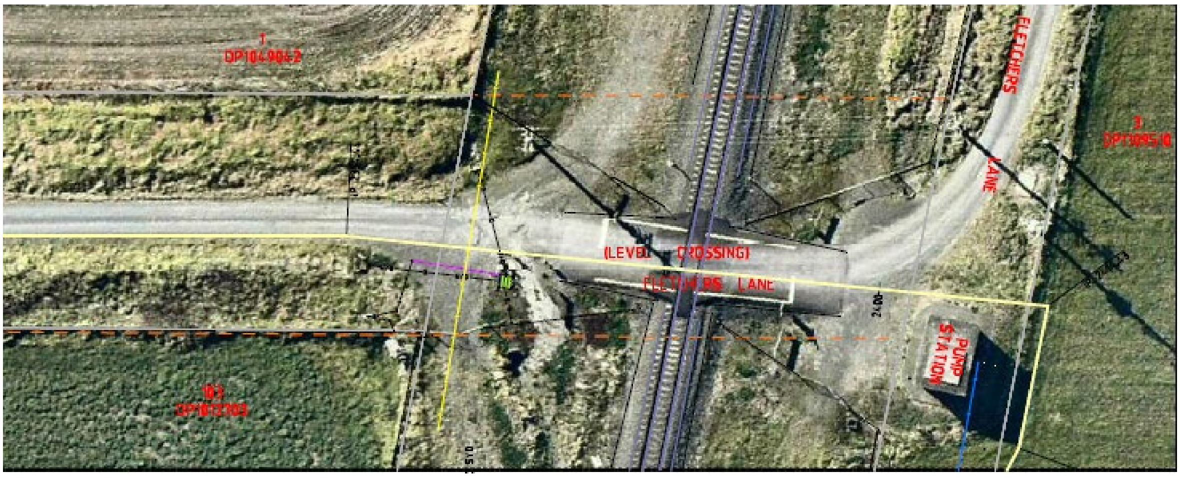
Monitoring Requirement	Frequency	Responsibility
Erosion and Sediment Control Inspections	Weekly during construction and rehabilitation periods, and Within 24 hours of any rainfall event exceeding 10 mm and periodically during periods of prolonged rainfall.	Project Environmental Officer
Inspection of Waterways	Fortnightly until completion of project	Project Environmental Officer
Inspection of Vegetation	In accordance with section 4.5 and the Flora and Fauna Plan attached to the CEMP.	Project Environmental Officer/Project Ecologist
Photographic evidence (Riparian Zones and Waterways)	Fortnightly	Project Environmental Officer

Appendix A

Watercourse Crossing Construction Method Statement

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.
ABN 88 005 339 211

SHOALHAVEN STARCHES PTY LTD
NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS –
SHOALHAVEN STARCHES BOMADERRY



Railway Crossing at Fletchers Lane Bomaderry

Work Method Statement

Document No.		NAP-SS-WMS-02		
Revision:	**Date:**	**Prepared**	**Checked**	**Approved**
Rev A	10/02/22	Mukesh Bhatia	Ajay Kesavan	Martin Moran

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1.0 INTRODUCTION

The purpose of this method statement is to provide specific instruction for the following work scope to ensure the works are adequately planned and delivered in accordance with Construction Specifications.

1.1 SCOPE

The scope of work applicable to this method statement is associated with the installation of crossings by HDD trenchless technology for Railway Crossing shown on the Shoalhaven Starches Natural Gas Pipeline IFC drawings as detailed below:

1. Drawing SS-NGP-PL-ALIGN_SHT_009 and
2. Drawing SS-NGP-XS-05

In HDD Construction, the carrier pipe string is pulled into a borehole drilled to a certain radius with minimal bending of the pipe during pull through. The pilot drill hole commences at ground level away from the entry pit with the drill rods levelling out at the required crossing depth prior to the entry pit. The drill rods are guided through the entry pit to the exit pit.

Note - The receiving pit will be pre-dug with a lead in trench/ ramp put in place to allow smooth pull back of the HDD pipe strings from the above ground position and into the reamed hole.

1.2 ABREVIATIONS AND DEFINITIONS

ALARP	As Low As Reasonable Practical
Checklist	A document that records or defines the actions that must be undertaken for a given task.
DBYD	Dial Before You Dig 1100
DPI&E	Department of Planning Industry and Environment NSW
Sydney Trains	As agent for Transport Asset Holding Entity of NSW (TAHE)
Hazard	Any operation or task that places personnel or equipment at risk to death, injury and or damage
JSEA	Job Safety Environmental Analysis
NCR	Non-Conformance Report
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
ROW	Right of Way

NAP	National Australia Pipeline Pty Ltd
Supervisor	The responsible person who oversees, or directs control of works being undertaken during the construction of the pipeline
TMP	Traffic Management Plan

1.3 REFERENCES

1. Railcorp conditions as per Section 13 (Item 31.1 to 13.7) of Appendix B Statement of Commitments of Project Approval MP10_0108-Mod1 - SHOALHAVEN STARCHES GAS PIPELINE PROJECT - INCREASE IN PIPELINE DIAMETER AND ASSOCIATED WORKS.
2. Shoalhaven Starches Natural Gas Pipeline IFC drawings
   a. SS-NGP-PL-ALIGN_SHT_009 and
   b. SS-NGP-XS-05
3. GHD Geotechnical Assessment Report | Shoalhaven Starches Gas Pipeline Project No. 12560160-REP-2 Dated 7 February 2022,
4. Shoalhaven Starches Natural Gas Pipeline Construction Environmental Management Plan (CEMP)
5. Shoalhaven Starches Natural Gas Pipeline Construction Safety Management Plan (CSMP)
6. NAP Management Plans

1.4 PERMITS

The following approvals/permits need to be in place before commencement of site works.

1. Development Application Approval-Minister for Planning and Infrastructure has approved the Development Application 10_0108-Mod-1 on 21 January 2022
2. Pipeline License
3. Consent to Construct
4. Sydney Trains (As agent for Transport Asset Holding Entity of NSW (TAHE)) Approval
5. TMP Approval
6. Council Road Opening Permits
7. Safe Work Notification

1.5 TRAFFIC MANAGEMENT PLAN (TMP)

There will be localised closure of Fletchers Lane during the HDD operation.

Speed reduction will be enforced on Fletchers Lane from the junction of Meroo Road and Fletcher Lane and Flectcher Lane railway crossing.

Specific need of the effected property owners will be addressed and resolved by appropriate TMP.

The proposed traffic management plans are attached herewith.

1.6 RESPONSIBILITIES

The Project Management Team – Project Manager, Engineer, Construction Supervisor and HSE Officer – shall ensure that all project staff are adequately skilled to perform their assigned tasks and are aware of their obligations and responsibilities with regards to OH&S, Environmental Management, Quality Assurance, Industrial Relations and Administrative Functions.

The Crew Supervisor shall be responsible for the coordination of the personnel, equipment, and materials to complete the works in accordance with the relevant specifications.

NAP will commission the services of GHD as Accredited Service Provider to prepare and monitor the Track Monitoring Plan.

1.7 JOB DESCRIPTIONS

All site personnel will have a formal job description. Detailed job descriptions for personnel have been developed and approved by the Project Manager.

To ensure that the Project is managed in accordance with the requirements of the Project and that of the contract the following key personnel have the following responsibilities.

1.7.1 Project Manager

The Project Manager is responsible for the planning, monitoring and overall execution and performance of the construction project.

The Project Manager has the authority to:

- Approve the Project Quality Management Plan and other key deliverables
- Appoint and terminate Project staff
- Delegate responsibility and authority to Project staff
- Ensuring all construction activities are performed in a safe and timely manner in accordance with the procedures, specifications, and good industry practice.
- Managing construction supervision, labour and subcontractors
- Planning construction activities
- Hold ultimate responsibility for all drilling related decisions
- Has the overall responsibility for ensuring safe work practices are followed through all aspects of the work and attends safety committee and other meetings as necessary
- Undertake Safety Audits to ensure compliance with the Safety Management Plan.
- Evaluate day to day operational safety of site with particular focus on looking for potential hazards which can be identified and remedied prior to incidents occurring.

1.7.2 GHD- Accredited Service Provider

GHD will be responsible to:

- Engineering Assessment of the ground movement and differential surface movement during construction of the crossing for the proposed construction technique being HDD.
- To carry out risk assessment of to assess the impact to the rail line from construction of the pipeline and review of the under-bore excavation.

The above two have been completed and are detailed in the GHD Geotechnical Assessment Report | Shoalhaven Starches Gas Pipeline Project No. 12560160-REP-2 Dated 7 February 2022. **The report confirms that rail settlement will not be an issue based on the proposed construction methodology.**

The following works will be completed by GHD its agent during the HDD works

- conduct track monitoring during construction and ensure trigger levels are implemented prior to works.

9.0 HAZARD IDENTIFICATION AND RISK MANAGEMENT

The NAP shall, so far as reasonably practicable, ensure that any manager or supervisor is provided with such information, instruction, and training as are necessary to ensure that each employee under their management or supervision is, while at work, so far as is reasonably practicable, safe from injury and risks to health.

All personnel must be committed to achieving a safe working environment and strive to fulfill the objectives of the Project Health, Safety and Environment policy with compliance to the Safety Management Plan and the Environmental Management Plan.

9.1 MANAGEMENT CONTROLS

9.1.1 Risk Assessment

A full project risk assessment has been undertaken and the mitigation measures identified in this have been incorporated into this Work Method Statement. A JSEA will be produced by carrying out a risk assessment on this Work Method Statement and incorporating input from work crews. Each Crew member will be required to review this JSEA.

9.1.2 JSEA

The base JSEA shall be developed with input from the Project Manager. The JSEA shall be reviewed and added to, as required by each crew, utilizing their experience in conducting the task. All crew personnel are to review and sign onto the JSEA before work begins.

Ideally, the Risk Assessment and JSEA would be added to this method statement for each task.

9.1.3 Pre-Start

Supervisors shall ensure that meetings are held prior to starting each shift, and/or whenever the work scope changes. The meetings should:

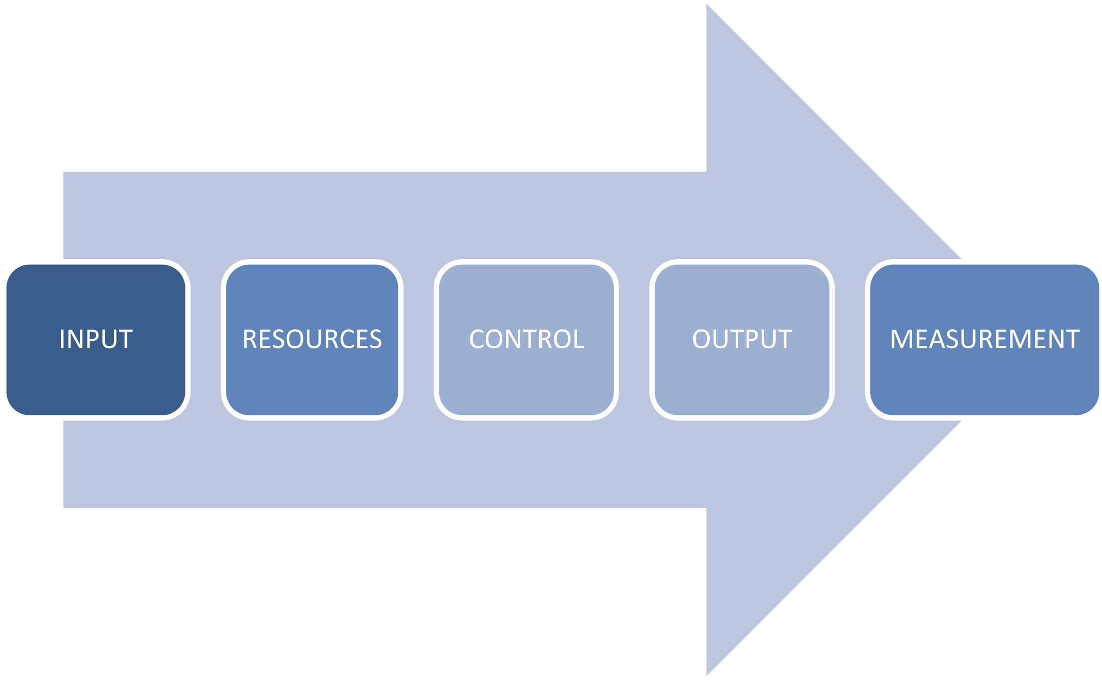
- Review the state of the works as left by the previous shift
- The target progress for the current shift
- The means of achieving the target progress
- The state of works required at the end of the shift
- Any additional safety hazards (changing conditions as work progresses)
- Any environmental hazards

9.1.4 Tool Box Meeting

Tool box meetings shall be held at regular intervals. The tool box meetings will be used to relay information such as hazard alerts between crews and make all crews aware of larger issues and general hazards.

10.0 METHOD

10.1.1 Horizontal Directional Drilling

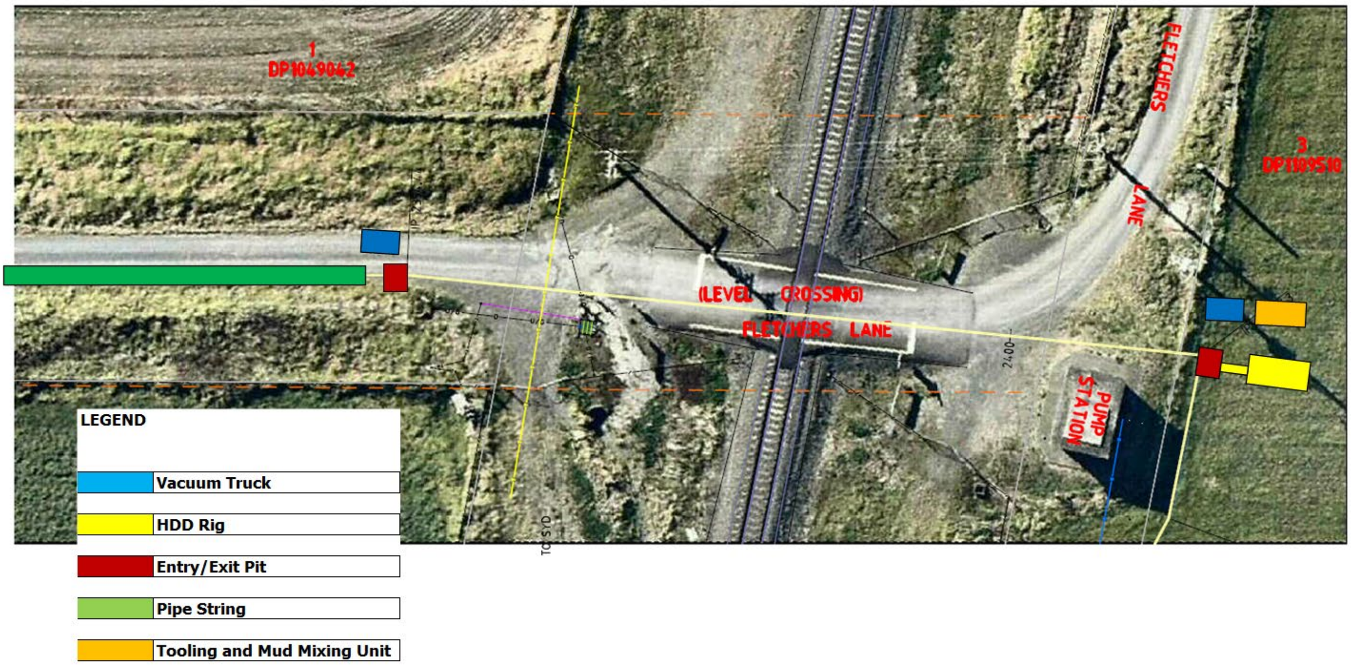


INPUT	RESOURCES	CONTROL	OUTPUT	MEASUREMENT
Pipes strung Group Other materials	Equipment Operators	Inspection Permits Surveyed Alignment Management Plans	Installed pipeline Pipeline naturally grouted Entry & Exit point reinstated As built Survey Data	QSE Key Performance Indicators No outstanding NCR's or Client queries

10.1.2 EQUIPMENT

- Vermeer D80x100 Horizontal Directional Drill
- Digitrak Falcon F5 locator
- Tooling for piloting & Reaming Process
- Vermeer MX240 Mud Mixing station
- Vacuum truck for fluid evacuation

10.1.3 PROPOSED LAYOUT



10.1.4 GEOLOGY

Sandy Clayey Gravel as per Geotechnical Investigation Report; relevant bore holes data as detailed in reference above.

10.1.5 LENGTH OF BORE AND PROFILE

Bore length – 100m Approx

Bore profile – SS-NGP-XS-05

Depth to top of pipe under rail – Ranges between 3.96m to 4.93m

Radius – 400m

10.1.6 DESIGN CONSIDERATIONS

NAP has completed the following:

- Pipeline installation stress analysis has been completed
- Frac Out Management Plan
- Overbend Stress Calculations

On a general note, based on the pipeline calculations the expected pipeline stresses are well within the Specified Minimum Yield Stress with large safety margins.

Frac out risk has been minimised by:

- Ensuring that the bore is deep under significant assets
- The drill pressures are monitored and regulated
- Appropriate mud mixes are selected
- The bore hole is reamed to at least 1.5 times the diameter of the pipeline
- Ensuring that appropriate mitigation measures are in place in the event of frac out i.e. vacuum trucks, pumps, silt fencing, traffic management etc.

10.1.7 CONSTRUCTION STEPS

1. Existing Assets located and proven prior to bore commencing
2. Reconfirm design.
3. Establish Drill unit
4. Entry & exit points pre excavated.
5. Install silt controls at bore entry and exit points in order to prevent any produced drill slurry or ground water from entry to drainage systems, these fluids will be removed via Vacuum trucks for appropriate disposal to an accredited EPA site.
6. Scan bore path for interference prior to commencement
7. Entry and exit points of bore to be excavated 500mm below invert to capture and retain produced bore slurry for removal via vac unit
8. Commence pilot to designed bore plan recording invert & alignment on route – pilot process cuts the soil and utilises drill muds to carry cuttings to entry/exit points for removal via vac unit. (approx. Diameter of Drill head Cutting edge = 125mm)
9. As the bore is being piloted our tracker monitors bore alignment and invert throughout the progression of the bore in order to construct as per design – As the tracker checks this data the drill operator can see on a screen in real time – The driller and tracker are in contact via UHF Radio – specific frequency throughout the entire process.
10. Upon pilot reaching destined exit point / pipe pullback point the drill head will be removed and a reamer (approx. 300mm, followed by 450mm) will be installed, reaming of bore continues for full length of the alignment, during which drilling muds are introduced which seal the bore walls hence permitting the naturally reamed product to blend with the drilling enhancing muds which flow to the entry exit points for removal via vac unit.

11. Throughout all piloting and reaming processes the entry and exit points are monitored for adequate mud flows at each point to ensure that a pressure point does not develop in bore.
12. Throughout all piloting and reaming processes, the bore is left flooded with drill slurry which consists of Naturally reamed and introduced bore enhancing products which fills void and supports the constructed bore.
13. Once the borehole is fully reamed, a pulling device is connected to the pipeline string via a swivel. The pullback then commences at a controlled speed.
14. The swivel between the pipe being installed and the drill string permits the pipe to rotate as friction requires between the drill slurry in bore and the 300NB pipe being installed.
15. The bore being full of drill slurry will be naturally displaced as the pipe is installed into the bore hole, the excess slurry transfers to both entry & exit points, which will be removed via vac units for disposal
16. As a result the annular space becomes fully grouted with naturally and introduced product resultant from the drilling process.
17. All surplus drilling slurry is removed from site and disposed of at an EPA registered disposal site

10.1.8 Risks regarding HDD process & Control Plan

Risk	**Controls**
Heave of Surface	All relative processes, Piloting, Reaming & pullback, The Drill tooling cuts the soils, we do not force or thrust our tooling in order to remove the natural product, The naturally cut product is encapsulated by use of the Mud Mixing enhancing products permitting the mix to flow to entry & exit points for extraction
	Throughout Piloting, Reaming and pullback the entry and exit shafts as well as bore path are monitored to ensure muds are flowing and no pressure point develops within the bore, If so work ceases and re swabbing commences to loosen up any blockage in order to recommence mud flows then re continue the relevant process
Frac Out	Can occur due to the geological conditions i.e. if not consistent. In the event this occurs,

	cease work, contain fluids, remove with vac unit, consider additional additives and action , alternatively excavate and use as a relief point for extraction of muds via a vac unit. Controls in order to eliminate this risk are by utilizing a sealing mud mix, together with at all times having a fully fluid charged bore. This risk is also mitigated due to the depth exceeding 7 metres to which the risk of Frac out or surface disruption is negligible.
Subsidence / Collapsing bore	Point 1 : the bore at all times will be fully charged with a heavy mud mix therefore a void never exists Point 2: Upon Pullback the annular space is naturally grouted with Naturally occurring spoils and Enhancing products Point 3 : at the design depths due to a fully charged bore at all times with Bore wall sealing products moisture and solids will remain in bore resulting in a supported bore at all times
Loss of Drill head (breakage)	Prior to commencing the bore the Drill head will be checked for fatigue to threads any cracking or distortion, If any of the above is evident the Drill head will be replaced by a conforming tool. The starter rod and hex collar to which the drill head connects to the drill rods will also be inspected for fatigue, distortion and cracks, if any of the above is evident this item of tooling will be replaced with a new unit. The hex collar (locking device between the starter rod and Drill head) will be checked for cracking, fatigue and distortion; if any of the above is evident a new unit will be

	supplemented. The Grub screw (hex collar retaining device) will be inspected for fatigue, thread damage, should any of the above be evident then the grub screw will be replaced by a new item. All the above ensure that the drill head and affiliated tooling are suitable to perform the required tasks. In the event that the drill head should break from the drill string sub surface within the Freeway, then the drill string will be withdrawn and the drill head will remain in soil at this location. The pilot bore will be full of Natural product from cuttings, this will be capped at surface to ensure no voids are present. Furthermore assuring that no annular space exists. New tooling will be installed and a new pilot will be performed, while abandoning the broken tooling. Should a breakage such as this occur outside the freeway then the point of breakage would be excavated to retrieve the broken tooling and backfill accordingly to standard excavation and backfilling practices. New tooling will be installed and the bore construction will continue in the exiting pilot bore and achieve the desired pilot prior to reaming

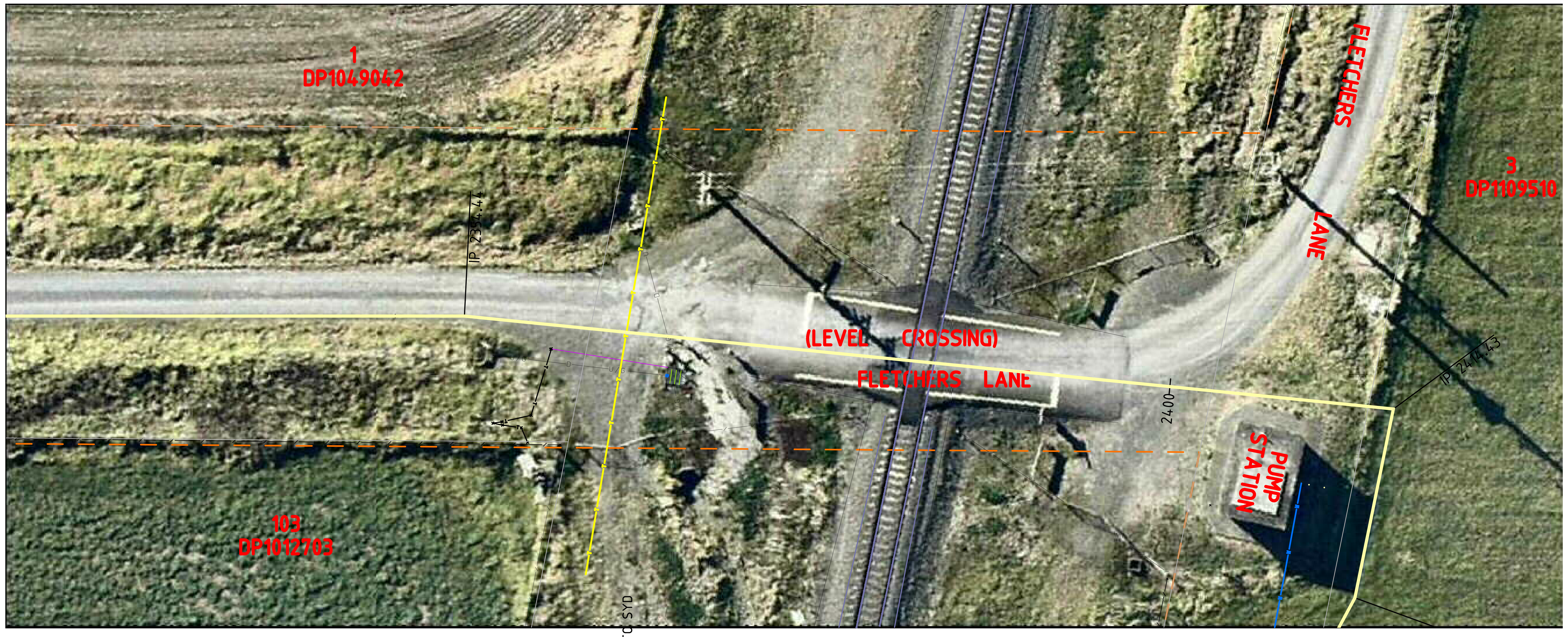
10.1.9 Mud Mix:

- A bentonite mix of 1 bag per 1000 litres is nominated to be used
- This product ensure the bore walls are sealed retaining fluids to bore, and to suspend the drill cuttings which is transferred to the eduction point, reducing friction while ensuring good flows are maintained throughout drilling and reaming processes.
- By utilizing the nominated Mud Mix this ensures a filter cake is built to seal and support the bore, the bore retains integrity due to this filter cake and the bore full of slurry prevents any collapse of the bore hole.
- Throughout the entire process drilling fluid /slurry is at all times ahead of and behind the tooling, at no time does a void exist.

APPENDIX

- Proposed Design
- Settlement Analysis GHD
- Additional Geotech Bore Logs
- Frac Out Calcs
- Pull Back Calculations
- Overbend Calculations
- Fluid Management Plan
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS
- Traffic Management Plans

PROPOSED DESIGN



Datum -2.000m

DEPTH OF COVER	1.52	1.55	1.58	1.96	2.35	2.74	3.30	3.68	4.06	4.31	4.29	3.86
NAT. SURFACE	4.01	4.01	4.00	4.00	3.99	3.99	4.16	4.38	4.70	4.93	4.91	4.52
TOP OF PIPE	2.48	2.46	2.43	2.04	1.65	1.25	0.86	0.70	0.64	0.62	0.62	0.66
Chainage	2325.00	2328.80	2330.00	2340.00	2350.00	2360.00	2370.00	2375.83	2380.00	2383.34	2384.78	2390.00

DEPTH OF COVER	3.07	3.04	1.99	1.78	1.59	1.30	1.27	1.21
NAT. SURFACE	3.96	3.98	3.44	3.40	3.37	3.37	3.37	3.37
TOP OF PIPE	0.88	0.93	1.46	1.62	1.78	2.07	2.10	2.16
Chainage	2398.63	2400.00	2410.00	2412.45	2414.30	2419.19	2420.00	2425.00

4 0 4 8 12 16 20

HORIZONTAL SCALE OF METRES 1:200

0.8 0 0.8 1.6 2.4 3.2 4.0

VERTICAL SCALE OF METRES 1:40

REV	REVISION	DATE	DRW	DES	CHK	APP
C	ROPING INFORMATION FOR DRILL STRING ADDED	18/01/22	SH	MB	AK	MM
B	ISSUED FOR REVIEW	18/11/21	SH	MB	AK	MM
A	ISSUED FOR REVIEW	11/11/21	SH	MB	AK	MM

REFERENCE DRGs	DRG No
ALIGNMENT SHEET	SS-NGP-PL-ALIGN_SHT_009

Shoalhaven Starches
MANILDRA GROUP
100% AUSTRALIAN OWNED

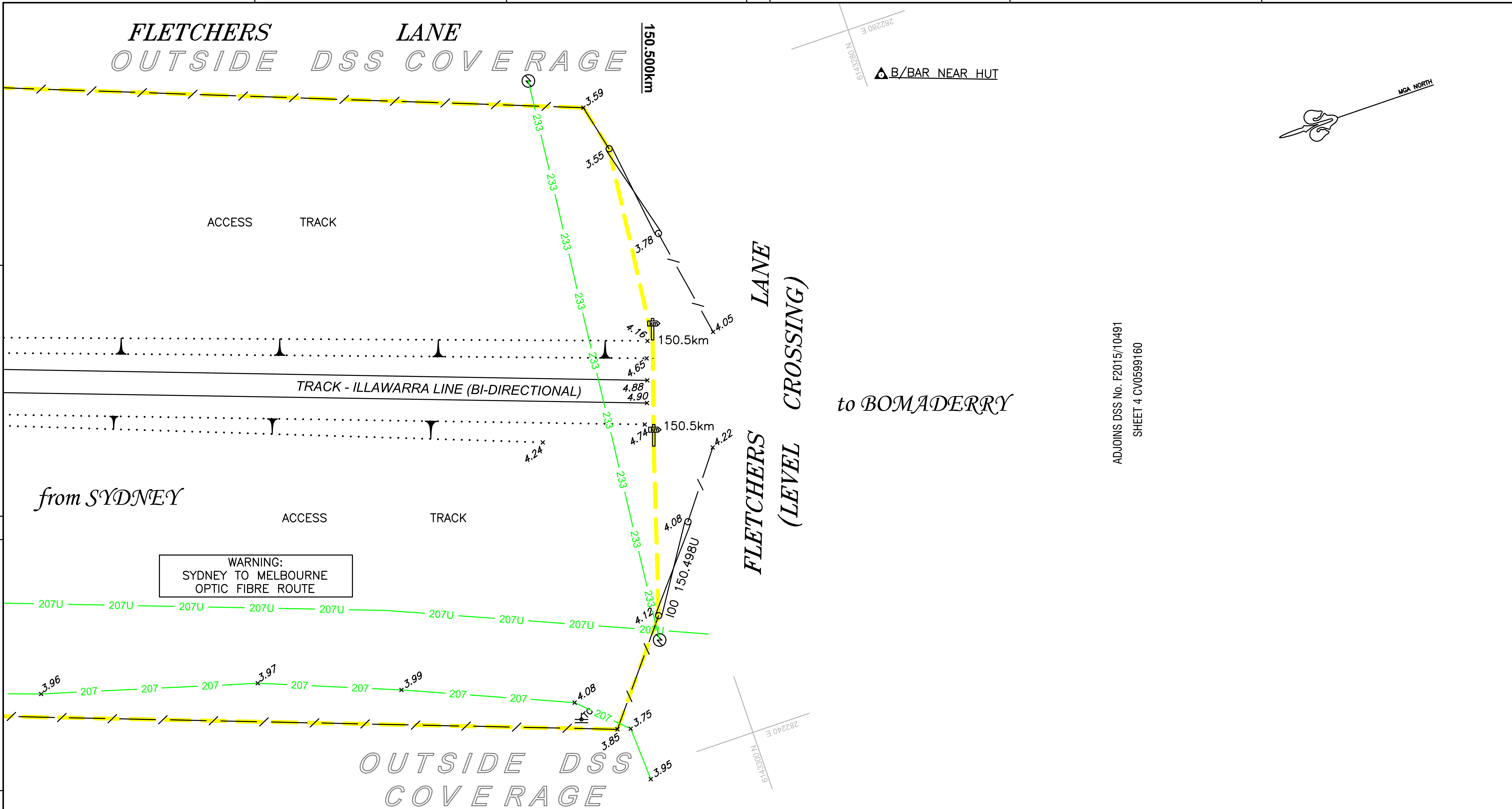
NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

	NAME	DATE
DRAWN	S.HANSON	11/11/20
DESIGNED	M. BHATIA	11/11/20
CHECKED	A. KESAVAN	11/11/20
APPROVED	M. MORAN	11/11/20

SHOALHAVEN STARCHES

NATURAL GAS PIPELINE
FLETCHER LANE RAILWAY CROSSING

DATUM	SCALE	PROJECT No	REF No	SHEET	DRG No	REV
MGA2020 Z56	1:500	2NSD170	7323		SS-NGP-PL-XS-05	C



NOTE: THIS PLAN MUST BE READ IN CONJUNCTION WITH CV 0545705 TO CV 0545706 & CV 0599126 TO CV 0599129 INCLUSIVE

CV0599155

JOINS SHEET 30

SCALE 1: 250 AT A3 — 2.5 0 2.5 5 7.5 10 — ALL DISTANCES IN METRES

AMD	REFERENCE	DESCRIPTION	VERIFIED SIGN./DATE	APPROVED SIGN./DATE

LOCATERS P/L
SURVEYOR: R. LEONARD
DRAWN: P. JAMES
SURVEY DATE: AUG. 2016
CHECKED: G. ORCHARD
REFERENCE: 160709

NSW Transport Sydney Trains
SERVICES CHKD
DRG CHKD
APPROVED

TURNERS LANE TO FLETCHERS LANE
ILLAWARRA LINE 148.150 km to 150.500 km
SERVICES SEARCH
DSS NO. F2015/10489

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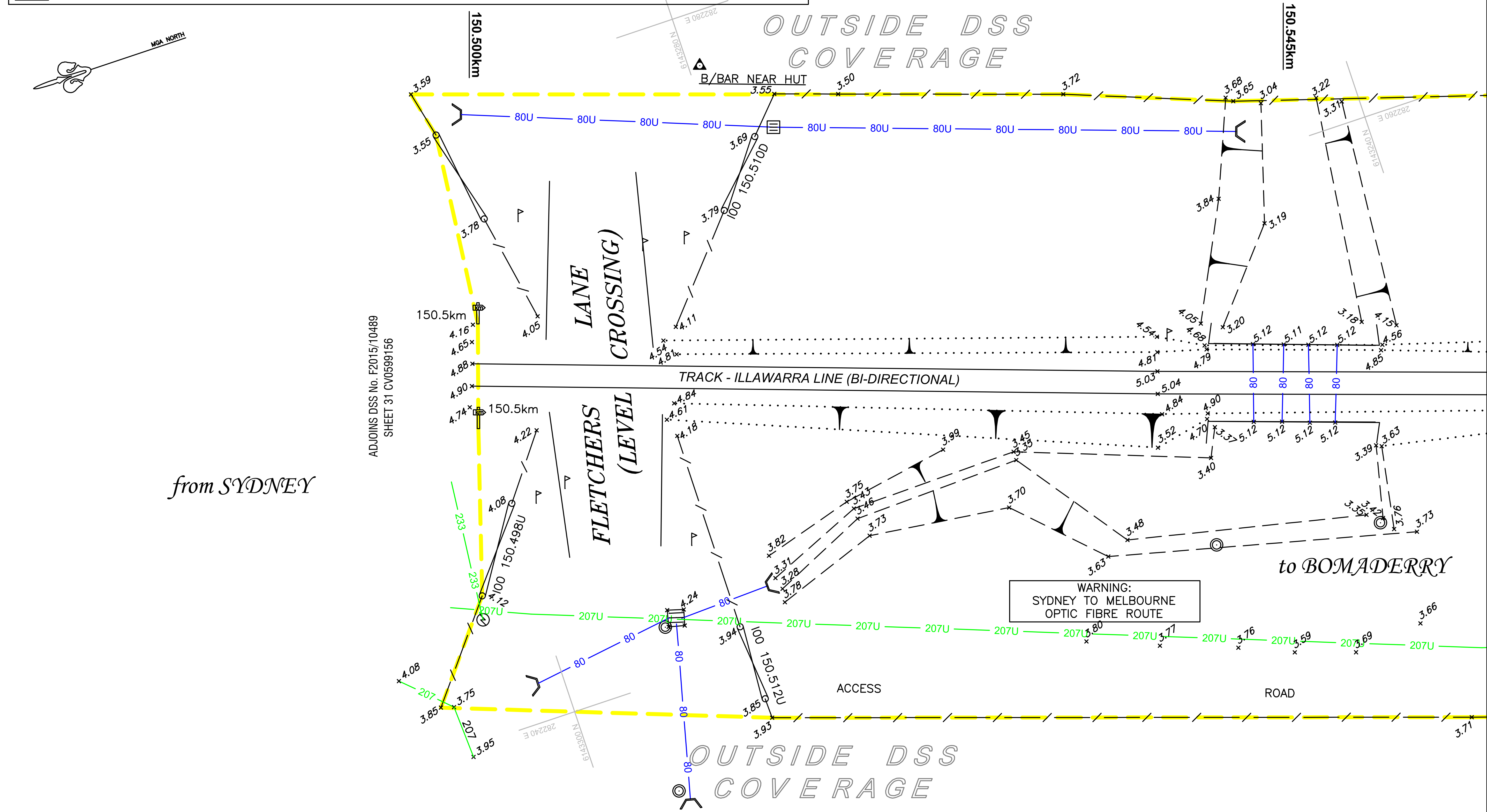
FILE NO: | SHEET 31 OF 31 | A3
STATUS: FINAL
CAD FILE NO. 148.150 F2015_10489 | CV0599156 | A

NSW Transport Sydney Trains Plan accepted for use by Sydney Trains

NOTE: THIS PLAN MUST BE READ IN CONJUNCTION WITH CV 0545705 TO CV 0545706 & CV 0599157 TO CV 0599159 INCLUSIVE



SCALE 1: 250 AT A3

2.5 0 2.5 5 7.5 10

ALL DISTANCES IN METRES

AMD	REFERENCE	DESCRIPTION	VERIFIED SIGN./DATE	APPROVED SIGN./DATE

LOCATERS P/L

SURVEYOR: R. LEONARD

DRAWN: P. JAMES

SURVEY DATE: SEPT 2016

CHECKED: G. ORCHARD

REFERENCE: 160710

Transport Sydney Trains

SERVICES CHKD

DRG CHKD

APPROVED

FLETCHERS LANE TO BOMADERRY

ILLAWARRA LINE 150.500 km to152.500 km

SERVICES SEARCH

DSS NO. F2015/10491

©

FILE NO: | SHEET 4 OF 26 | A3

STATUS: FINAL

CAD FILE NO. 150.500 F2015_10491 | CV0599160 | A

Transport Sydney Trains Plan accepted for use by Sydney Trains

GHD –

GEOTECH and SETTLEMENT ANALYSIS

Geotechnical Assessment Report

Shoalhaven Starches Gas Pipeline Project

National Australian Pipelines Pty. Ltd

07 February 2022

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Project manager	Elliot Holland
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[Status code]							
[Status code]							
[Status code]							

The Power of Commitment

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1. Introduction

1.1 Purpose of this report

As part of the Sydney Trains works approval, National Australian Pipelines Pty Ltd (NAP) requested GHD to complete a Geotechnical Assessment Report for Sydney Trains assets impacted by the Project.

1.2 Objectives and scope

Specifically, this report addresses the following requirements:

- The location of geotechnical investigations along the proposed gas alignment.
- Description of the soil/rock profile along the proposed alignment, including ground water table.
- Ground model of subsurface materials along with soil/rock parameters used for geotechnical assessment.
- Review of previous and current borehole/test pit logs, including the results of in-situ/laboratory tests.
- Geotechnical analysis of ground subsidence associated with the proposed undertrack crossing (ULX) installation at the Fletchers Lane railway crossing.
- Geotechnical assessment to consider any potential impact on rail infrastructures due to settlement/heave of construction activities.
- Risk assessment and hazard management from geotechnical perspective.

1.3 Limitations

This report has been prepared by GHD for National Australian Pipelines Pty. Ltd and may only be used and relied on by National Australian Pipelines Pty. Ltd for the purpose agreed between GHD and National Australian Pipelines Pty. Ltd as set out in section 1.1 and 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than National Australian Pipelines Pty. Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report based on information provided by National Australian Pipelines Pty. Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Assumptions

The following assumptions have been made in the assessment of potential impacts from the proposed gas pipeline.

- The proposed pipeline is DN323.9mm diameter. The under bore hole diameter is assumed to be 450 mm for purposes of the settlement analysis. It is also understood temporary support will be provided using drilling mud prior to the pipe is pulled through.
- The train surcharge assumes 300LA loading.

– The pipeline is assumed to be designed between 1 m and 2.4 m below ground level except for the rail crossing. The pipeline is assumed to be located at least 5 m from existing rail assets excluding the Fletchers Lane underbore.

2. Relevant information

2.1 Standards and specifications

The assessment was carried out in accordance with the following guidelines from Transport for New South Wales (TfNSW), Transport Asset Standards Authority (ASA):

– T HR TR 00192 ST, “Ballast”, V2.0, Issue date; 03 July 2018
– T HR CI 12120 GU, “Track reconditioning Guidelines”, V2.0, Issue date: 18 April 2019
– T HR CI 12110 ST “Earthworks and Formation”, V2.0, Issue date: 25 May 2018
– T HR CI 12111 SP “Earthwork Materials, V2.0, Issue date: 10 April 2018
– SPC207 Track monitoring requirements for undertrack excavation V1.5, 03 July 2019

Other standards and reference documents applicable to this project are summarised below:

– Standard, A. (2004). AS5100. 2-2004, Bridge design—Part 2: design loads. Standards Australia, Sydney (Australia).
– Standard, A (2017). AS1726. 4-2017, Geotechnical site investigations. Standards Australia, Sydney (Australia).

2.2 Assessment of existing geotechnical information

The existing geotechnical information for the project includes a Coffey report ‘*Acid Sulfate Soil, Contamination and Geotechnical Investigation Proposed Gas Pipeline Bomaderry NSW*’ (Reference: ENAUWOLL04006AA-R01, dated 29 July 2011). The report formed part of the Environmental Assessment for the project which had been collated by Cowman Stoddart Pty Ltd, March 2012.

The Coffey report assumes the pipeline design profile is within 1 m to 2.4 m below ground level (bgl). Therefore, the geotechnical investigations to date were scoped to define the profile up to 3 m depth.

An approximate layout plan of the alignment and previous investigations is provided as Figure 1 below.

Figure 1 ***Previous geotechnical investigations***

In summary, the ground conditions across the alignment will encounter:

– The northern half of the alignment (Coffey test pit locations CTP12 to CTP26) predominantly encountered topsoil overlying alluvial soils
– The southern half of the alignment (Coffey borehole locations CBH01 to CBH06 and test pit locations CTP06 to CTP11) predominantly encountered topsoil / fill overlying alluvium / residual soil / extremely weathered sandstone.

3. Desk study assessment

3.1 Site location and topography

The Sydney Trains rail assets that are the subject of this geotechnical assessment are located near the eastern and northern section of the proposed pipeline between the railway crossing at Fletchers Lane and Bomaderry Rail station. The terrain in these areas is noted to be level to gently undulating floodplain. The western section of the pipeline, west of Meroo Road, comprises gentle to moderately undulating rises to low hills.

The topography generally varies from less than 10 m RL and up to 30 m RL (AHD).

3.2 Regional geology

A review of the NSW Department of Resources MinView spatial viewing tool (www.minview.geoscience.gov.au) indicates the deposition sequences as shown in Figure 2 below. The northern portion of the rail line is located within Alluvial / Fluvial deposits consisting of sand, silt, gravel and clay. The central and southern portion is located within Berry Formation Sandstone. Unit descriptions for the identified geological units includes:

Q_avf	Fluvially-deposited quartz-lithic sand, silt, gravel, clay
QH_af	Alluvial floodplain, Silt, very fine- to medium-grained lithic to quartz-rich sand, clay.
Q_ab	Alluvial backswamp deposits. Organic-rich mud, peat, silt, clay.
Psbn	Fine- to very coarse-grained quartzose sandstone, with a three-fold subdivision: a very coarse-grained base with minor pebbly lenses, a central siltstone zone and a cross-bedded medium-grained quartz sandstone up-sequence.

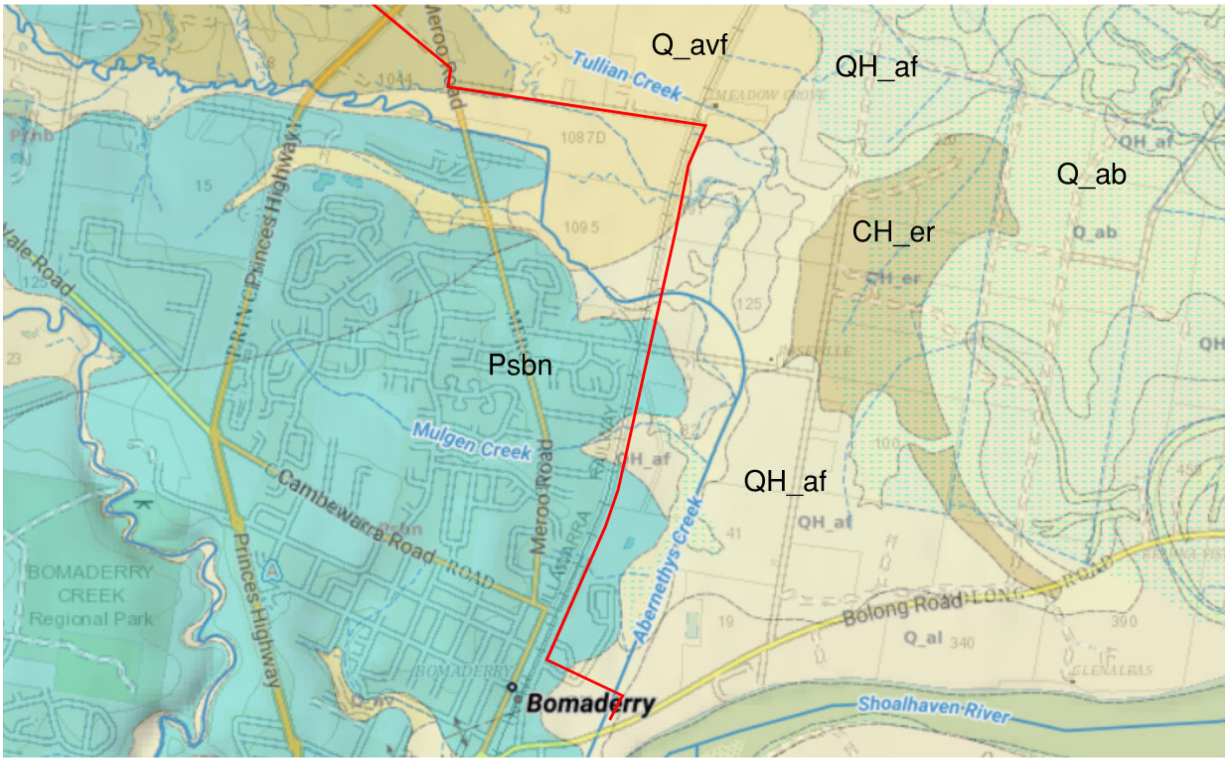

Figure 2 *Geology plan*

3.3 Acid sulfate soils

As outlined in the previous Coffey investigation report, acid sulfate soils (ASS) were identified as being low probability along and near Fletchers Lane, with increased probability at lower lying sections located in Lot 2 and Lot 5 (northern side of Bolong Road) and in the vicinity of creek crossings at CTP09 and CTP01.

Figure 3 below is an extract from the previous Coffey (2011) report.

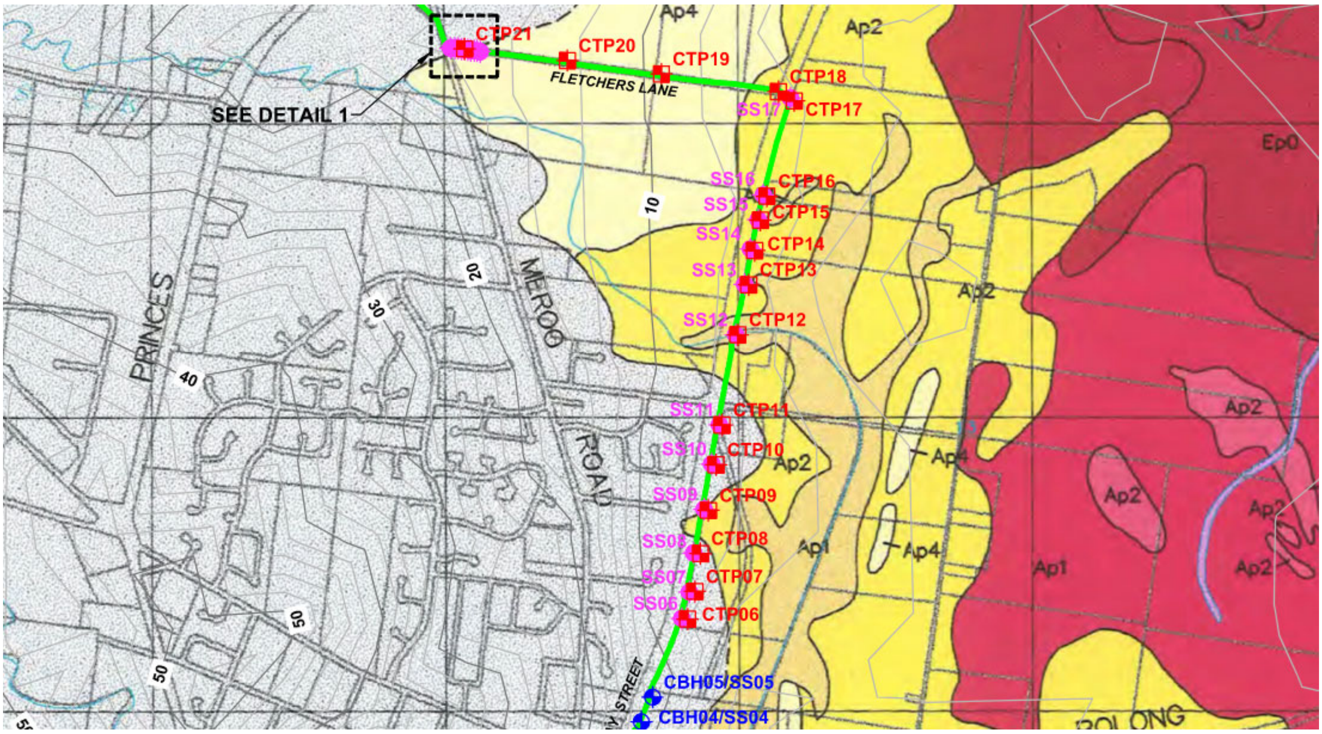

Figure 3 Acid sulfate soils map

4. Geotechnical investigation

4.1 Site walkover and inspection

A site walk over was carried out by a GHD Technical Director – Geotechnics following the completion of the additional geotechnical investigation at Fletchers Lane rail crossing (as discussed in section 4.2). The site visit involved inspection of locations accessible by public access.

The following observations were made:

– Fletchers Lane is relatively flat with pasture either side of the road (see Figure 4).
– The railway crossing is raised and appears to be constructed on fill. Ballast was observed on the fill batters (see Figure 5).
– View north at Edwards Avenue is towards the top of a hill with the ground level dropping towards Fletchers Lane (see Figure 6).
– At Edwards Ave, the railway is in cut with relatively steep batters. The material could not be inspected due to the existing vegetation, however no signs of instability were observed (see Figure 7).
– Unsealed road north of Railway Street (see Figure 8), the ground level was moderately undulating with heavy vegetation alongside the railway.
– The southern portion of Railway Street (see Figure 9), is within what appears to be an industrial area and relatively free of vegetation.

Figure 4 View along Fletchers Lane

Figure 5 ***View east at Fletchers Lane rail crossing***

Figure 6 ***View north with rail line on left (from Edwards Ave)***

Figure 7 View at bridge crossing over rail line (Edwards Ave) with existing cutting

Figure 8 View north end of Railway Street with rail line on left side behind vegetation

Figure 9 View south along Railway Street with rail line on right

4.2 Intrusive investigations

Subsequent to the review of the Coffey (2011) investigation report, GHD was informed the proposed under bore for the railway crossing at Fletchers Lane will be to a depth of 4.3 m bgl. Coffey test pit locations CTP17 and CTP18 at Fletchers Road railway crossing were noted to have terminated at 2.5 m and 2.6 m depth bgl respectively and were considered insufficient for defining the subsurface profile. An additional intrusive investigation was carried out to address the data gap. The investigations included:

- Planning, HSE documentation (JSEA, COVID approvals), subcontractor engagement, dial before you dig (DBYD) review.
- Service location of two proposed borehole locations either side of the railway crossing at Fletchers Lane with both electromagnetic and ground penetrating radar (GPR) methods.
- Assessment and detailed logging of the subsurface profiles encountered, undertaken in general accordance with AS 1726 by an experienced geotechnical engineer.

The fieldwork was carried out on Thursday 16 December 2021. Following a review of available services information (DBYD and detailed site services plans provided by NAP), local asset owners visiting site and service location scanning; a second borehole adjacent the existing pump station could not be carried out safely due to an uncertainty in the location of known assets. One borehole was completed west of the railway to a depth of 6.45 m bgl. Standard penetration testing (SPT) was carried out at 1.5 m intervals. A plan indicating the location of the GHD borehole with respect to the Fletchers Lane railway crossing is included in Appendix A. The borehole log for the GHD borehole is included in Appendix B.

5. Ground Model

As summarised in section 2.2 and 3.2, the ground conditions along the pipeline alignment were understood to vary from alluvium in the northern half and fill overlying alluvium / residual soil / extremely weathered sandstone in the southern half. Refer to the Coffey report for more detailed investigation information if required. Geotechnical units have been identified based on all available and relevant investigation information.

Table 1 Geotechnical units

Unit	Material	Sub Unit	Reference	Description
1a	FILL	Ballast	Observed at Fletchers Lane rail crossing.	
1b		Capping	Assumed to be placed below the Ballast.	
1c		Structural Fill	Assumed to be located beneath the capping layer.	No description available however assumed to be granular.
2	ALLUVIUM	NA	Identified in BH01, CTP17 and CTP 18.	CLAY: High to low plasticity, brown, dark brown, brown / grey with orange mottling and trace fine grained sand.
3	RESIDUAL SOIL	NA	Identified in BH01.	Sandy CLAY: High to low plasticity, pale yellow and grey, with fine grained sand.
4a	SANDSTONE	Extremely Weathered		Sandy Clayey GRAVEL/ Sandy Gravelly CLAY/ CLAY: Fine to coarse grained, orange brown with some pale yellow/brown pockets and some cobbles.
4b		Highly Weathered	Sandstone was encountered at locations CBH02, CBH03, CBH05 and CTP07 and CTP11.	Fine to medium grained, iron-stained orange/brown.

A profile across the rail crossing has been prepared with the relevant investigations is presented in Figure 10 below. This has been prepared to support the settlement analysis of the proposed under bore. Figure 10 indicates no rock was encountered in either of Coffey test pit CTP17 and GHD borehole BH01. Residual soil was proven from 3.8 m deep so it is anticipated weathered rock will underly at an unknown depth. The Figure 10 section has an exaggerated scale vertical to horizontal 4:1.

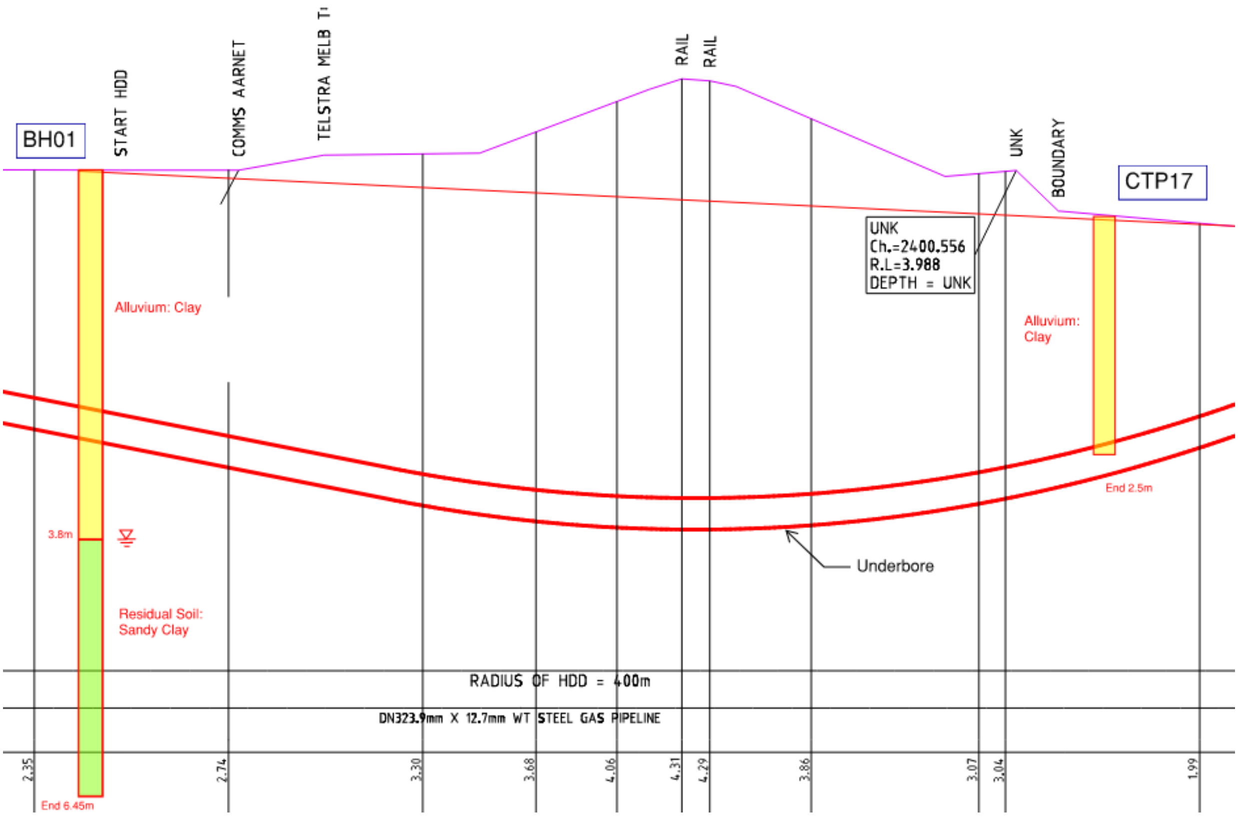

Figure 10 ***Inferred profile across Fletchers Land rail crossing***

6. Fletchers Lane Railway Crossing analysis

6.1 Methodology

The analysis of the proposed under bore beneath the existing railway has been carried out using two methods:

1. Volume loss calculation based on standard calculation spreadsheet methods
2. A 2D finite element (PLAXIS) analysis using one representative long section through the centre of the railway

The displacement profile was reviewed against ASA TfNSW specification '*SPC 207 Track Monitoring Requirements for Undertrack Excavation*'. Track details including design speed limit was assumed to enable assessment of the settlement criteria. Staged analysis during construction was not considered warranted given the size of the pipe and limited distance of the under bore. The excavation of the under bore was carried out as a single stage (post construction). The settlement analysis would not account for the stiffness of the pipe but would assess ground movement due to the excavation. The settlement profile at track level was therefore assessed against ASA specification criteria.

6.2 Sydney Trains requirements

In accordance with specification T HR RT 00192-ST the minimum and maximum ballast depths are 300 mm to 500 mm with reference to a mixed passenger and freight main line. We have adopted 300 mm thickness in the analysis.

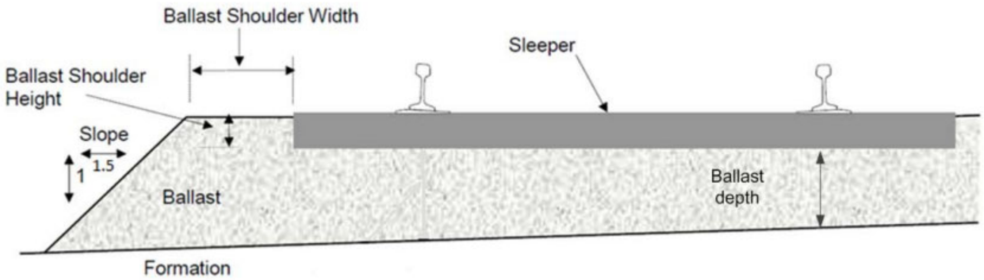

Figure 11 Typical formation diagram

With regards to the ASA Specification '*SPC 207 Track Monitoring Requirements for Undertrack Excavation*', a geotechnical assessment must establish if the soil is stiff and will be self-supporting and whether any site features or characteristics would bear on the track settlement. These items are addressed in section 6.7.

6.3 Analysis details

The following details are taken from the representative under bore cross section provided by NAP. These details have been used for the settlement modelling.

- Depth of cover under railway 4.30 m
- Diameter of under bore 0.45 m

6.4 Loading

Reference to AS5100.2-2007 Section 9 Rail Traffic, was used to calculate the applied load from rail traffic over the proposed under bore. The worst-case scenario was assumed to be when the train crosses the under bore after excavation prior to the final pipe being pulled through the under bore. In accordance with section 9.2 a simulated axel load from 300LA design traffic load was used. In accordance with AS5100.2-2007 Section 9 Rail Traffic the load factor for serviceability is 1.0.

The 300LA loading combines the two alternatives of the 300-A-12, by adding the 360 kN single axle load 2 m in front of the vehicle loading. This is to simulate six axle coupled locomotives and better represent their loading in the 15 to 22 m span range. Based on one axel group the applied uniform surcharge over a 2.5 m width is 89 kPa.

6.5 Geotechnical parameters

The geotechnical investigations conducted have been compiled and analysed to develop the geotechnical design parameters as presented in the following section.

The undrained parameters have been selected based on the insitu SPT testing and pocket penetrometer tests. No direct correlation exists with drained properties, hence these have been selected based on published correlations and on experience with similar materials.

Table 2 Geotechnical Design Parameters

Unit	Material	Strength / Consistency	γ (kN/m^3)	Cu (kPa)	φ' (deg)	c' (kPa)	υ'	E' (kPa)
1a	FILL	Very Dense	20	-	45	0	0.3	50,000
1b		Dense	19	-	36	0	0.3	40,000
1c		Dense	19	-	35	0	0.3	30,000
2	ALLUVIUM	Firm / Stiff	17	50	26	2	0.3	15,000
3	RESIDUAL SOIL	Firm / Stiff	18	50	28	3	0.3	15,000
		Very Stiff	18	110	28	5	0.3	33,000

NOTES:

γ = Unit weight, Cu = Undrained shear strength, φ' = Drained friction angle, c' = Effective cohesion, υ' = Poisson's Ratio, E' = Young's modulus

6.6 Groundwater

Groundwater strike was recorded in the GHD borehole BH01 at 3.8 m bgl. It is assumed this is close to the existing groundwater level and has been adopted in the analysis. No groundwater was noted in the previous Coffey test pits CTP17 and CTP18 near the railway crossing.

6.7 Analysis

6.7.1 Volume loss calculation

An initial volume loss calculation based on standard calculation spreadsheet methods was carried out. The calculation is based on empirical method from the paper Bracegirdle, Mair, Nyren & Taylor (1996) *'A methodology for evaluating potential damage to cast iron pipes induced by tunnelling'*. This is an estimation of ground movements using a generalised expression for settlement (Sv):

$$S_v = \frac{V_s}{\sqrt{2\pi}\ i} \cdot e^{-\frac{y^2}{2i^2}} \cdot \left[G\left(\frac{x - x_i}{i}\right) - G\left(\frac{x - x_f}{i}\right) \right]$$

The volume loss (Vs) is estimated based on the type of material with typical range of 1 to 2%. Conservatively we have adopted 3% in the analysis. The method is based on field and experimental data and assumes the pipe is in place and is used in preliminary assessments for typical settlement at ground surface. The analysis is therefore useful determining the expected movements of an in-place pipe at a representative depth and diameter.

The results of the calculation indicate movement at surface level less than 1 mm. It should be noted this does not consider surcharge loads from rail traffic.

6.7.2 2D finite element analysis

2D Finite Element (FE) PLAXIS analysis was carried out to assess the stability of an unsupported and supported excavation which includes estimated settlement at the top of ballast. A long section was generated along the centre of the rail line with the pipe crossing at 90 degrees, as shown in Figure 12. The PLAXIS analysis is considered more rigorous than the face loss method and assumes 'free field' settlement whereby no pipe is included in the analysis. This is a conservative approach but deemed adequate for small pipe diameters. It is understood drilling mud will be present during the excavation of the under bore.

A series of analysis stages were set up to represent the filling of ground over natural surface, construction of the rail line, excavation of the pipe and inclusion of the rail surcharge as the final stage. The total and differential settlements were calculated at each stage. As noted above drilling mud will temporarily support the under bore during excavation. To simulate this and prior to application of the train load, a low strength medium is added to the excavation hole in PLAXIS.

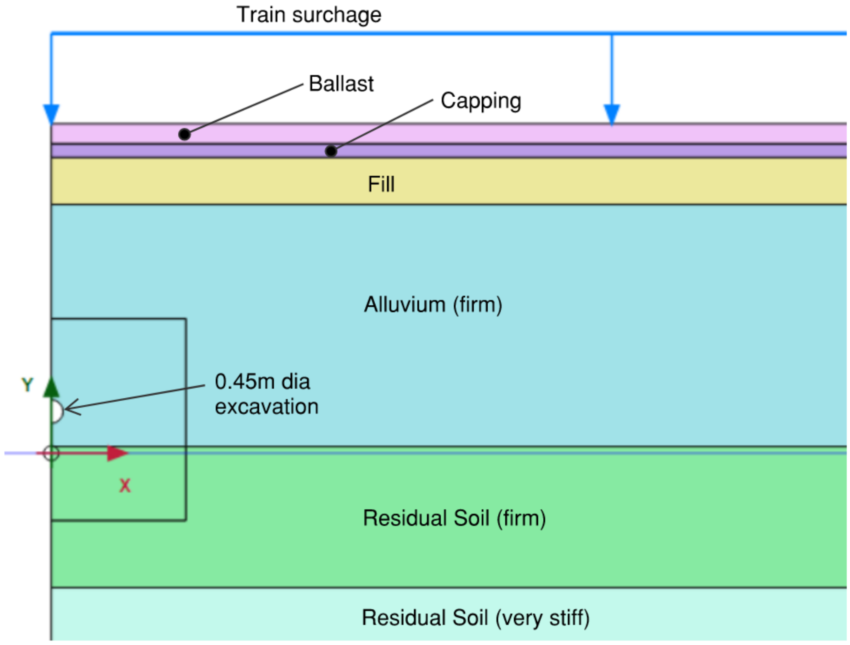

Figure 12 PLAXIS half profile (long section through rail line)

Analysis results and predicted movement

The results of the settlement analysis concluded the following:

– The under bore is assessed to be self-supporting with minimal ground movement upon excavation with no rail surcharge. This stage was assessed (conservatively) without drilling mud support. The ground movement at top of ballast is limited to less than 3 mm when assuming no rail surcharge.

  The under bore is assessed to be self-supporting with the application of the rail surcharge. The analysis shows a total of 44mm movement however negligible differential surface movement (< 1mm) due to the under bore. This stage includes the application of drilling mud to the underbore.

Assessment of ground movements

In accordance with ASA specification *'ESC 207 Track Monitoring Requirements for Undertrack Excavation'*, Section 6.1, outlines the limits of track movement.

Assuming a train speed of 100 km/hr as the maximum movement, the alarm levels of three categories have been assessed. The maximum allowable movement of the 25% normal limits is 6 mm for the short twist and 8 m line. The results of the analysis indicate the settlement at ground surface due to the excavation of the under bore is expected to be less than 3 mm. We therefore expect the movement to be less than the 25% alarm level and considered to meet acceptable requirements of the specification. Output from the above analysis is provided in Appendix C.

7. Risk Assessment

A risk assessment using GHD standard template has been prepared to assess the impact to the rail line from excavation of the pipeline and review of the under bore excavation.

As part of the risk assessment a review of the potential issues. This includes aspects related to:

– Track subsidence;
– Excavation at the base of railway embankments, that might lead to destabilisation and failure of the embankment;
– Excavation in the vicinity of overhead wiring structure footings
– Disturbance to drainage systems over railway cuttings that might lead to failure of the cutting slopes or fouling of the tracks below;
– Excavation adjacent to building, bridges or other structures that might undermine or destabilise the foundations;
– Damage to above ground railway equipment, e.g., signalling infrastructure;
– Damage to other existing underground services;
– Impact working adjacent the road and railway.

The risk assessment is included in Appendix D. It is understood no excavation should be carried out within 5 m distance of existing rail infrastructure without prior analysis and / or assessment from a qualified engineer. The risk assessment controls / actions are assuming any impact on existing infrastructure has been carried out in advance of construction.

Appendices

Appendix A

Investigation Plan

Rev	Date	Description	Des	Verf	Appvl

GHD

Drawn KP 08/01/22 Date	Client	NATIONAL AUSTRALIAN PIPELINE PTY LTD	
Designed Date	Project	SHOALHAVEN STARCHES GAS PIPELINE	Status FOR INFORMATION ONLY
Checked Date			Datum / Scale NTS / Size A3
Verified Date	Title	GEOTECHNICAL INVESTIGATION LOCATION PLAN	Drawing Number SK-001 / Revison 1
Approved			

Appendix B

Borehole Log

GENERAL NOTES

The report contains the results of a geotechnical investigation or study conducted for a specific purpose and client. The results may not be used or relied on by other parties, or used for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the report are excluded unless they are expressly stated to apply in the report.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Moreover, the location of test holes should be considered approximate, unless noted otherwise (refer report). Reference should also be made to the relevant standard sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water depths presented on the test hole logs are the depths of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater depth may differ from this recorded depth depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this depth could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities such as a change is ground surface level. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate surveys, instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data, often with only approximate locations (e.g. GPS). Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in ground conditions do occur in the natural environment, particularly between discrete test hole locations or available observation sites. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural processes.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to GHD for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system and/or to conduct monitoring as a result of this natural variability. Allowance for verification by appropriate geotechnical personnel must be recognised and programmed for construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions must include at least all of the relevant test hole and test data, together with the appropriate Standard Description sheets and remarks made in the written report of a factual or descriptive nature.

Reports are the subject of copyright and shall not be reproduced either totally or in part without the prior written consent of GHD. GHD expressly disclaims responsibility to any person other than the client arising from or in connection with this report.

Ref: DS5.5.1 Issue 0 Date: 05/10/2018

GLOSSARY OF SYMBOLS

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This standard sheet should be read in conjunction with all test hole log sheets and any idealised geological sections prepared for the investigation report.

GENERAL

Symbol	Description	Symbol	Description
D	Disturbed Sample	**R**	Rising Head Permeability Test
B	Bulk Sample	**F**	Falling Head Permeability Test
U(50)	Undisturbed Sampled (suffixed by sample size or tube diameter in mm if applicable)	**PBT**	Plate Bearing Test
CS	Core Sample (suffixed by diameter in mm)	▸—	Water Inflow (make)
ES	Soil sample for environmental sampling	—◂	Water Outflow (loss)
PID	Photoionisation Detector	▽	Temporary Water Level
SPT	Standard Penetration Test (with blows per 0.15m)	▼	Final Water Level
N	SPT Value	●	Point Load Test (axial)
HB/HW	SPT Hammer Bouncing/Hammer Weight	○	Point Load Test (diametric)
PP/HP	Pocket/Hand Penetrometer (suffixed by value kPa)	**PL**	Point Load (kPa)
PK	Packer Test (kPa)	**IMP**	Impression Device Test
PZ	Piezometer Installation	**PM**	Pressuremeter Test
SV/VS	Shear Vane Test (suffixed by value in kPa)		

SOIL SYMBOLS

Main Components		Minor Components	
SAND	FILL	sandy	vegetation, roots
GRAVEL	SILT	gravelly	silty
CLAY	TOPSOIL	clayey	*Note: Natural soils are generally a combination of constituents, e.g. sandy CLAY*

ROCK SYMBOLS

Sedimentary			Igneous	
SANDSTONE	SILTSTONE	CONGLOMERATE	GRANITIC ROCK	IGNEOUS DYKE
CLAYSTONE	SHALE	COAL	BASALTIC ROCK	

Note: Additional rock symbols may be allocated for a particular project

NATURAL DEFECTS *(Coding)*

Defect Type		Orientation					
Jt	Joint	For vertical non-oriented core ... "Dip" angle (eg. 5°) measured relative to horizontal.					
Pt	Parting	For inclined non-oriented core ... "Angle" measured relative to core axis.					
SS	Sheared Surface	For inclined oriented core ... "Dip" angle and "Dip Direction" angle (eg. 45°/225° mag.).					
WSm	Weathered Seam	**Orientation (con't)**		**Roughness**		**Coating**	
SSm	Sheared Seam	**VT**	Vertical	**Pol**	Polished	**Cn**	Clean
CSm	Crushed Seam	**HZ or 0°**	Horizontal	**So**	Smooth	**Sn**	Stained
ISm	Infilled Seam	**d / °**	Degrees	**Rf**	Rough	**Ve**	Veneer
SZ	Sheared Zone			**VR**	Very Rough	**Co**	Coating
VN	Vein			**Slk**	Slickensided		
Shape				**Infilling / Common Materials**			
Pln	Planar	**St**	Stepped	**CLAY**	Clay	**Mi**	Micaceous
Cu	Curved	**Ir**	Irregular	**Ca**	Calcite	**Mn**	Manganese
Un	Undulating	**Dis**	Discontinuous	**X**	Carbonaceous	**Py**	Pyrite
Others				**Kt**	Chlorite	**Qz**	Quartz
OP Open	**CL** Closed	**Ti**	Tight	**Fe**	Iron Oxide	**MU**	Unidentified Mineral

SOIL DESCRIPTION AND CLASSIFICATION

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Soil is described in general accordance with Australian Standard AS 1726-2017 (Geotechnical Site Investigations) in terms of visual and tactile properties, with potential refinement by laboratory testing. AS 1726 defines soil as particulate materials that occur in the ground and can be disaggregated or remoulded by hand in air or water without prior soaking. Classification of the soil is undertaken following description.

SOIL DESCRIPTION

The soil description includes a) Composition, b) Condition, c) Structure, d) Origin and e) Additional observations. 'FILL', 'TOPSOIL' or a 'MIXTURE OF SOIL AND COBBLES / BOULDERS' (with dominant fraction first) is denoted at the start of a soil description where applicable.

a) Soil Composition (soil name, colour, plasticity or particle characteristics, secondary and then minor components)

Soil Name: A soil is termed a *coarse grained soil* where the dry mass of sand and gravel particles exceeds 65% of the total. Soils with more than 35% fines (silt or clay particles) are termed *fine grained soils*. The soil name is made up of the primary soil component (in BLOCK letters), prefixed by applicable secondary component qualifiers. Minor components are applied as a qualifiers to the soil name (using the words 'with' or 'trace').

Particles are differentiated on the basis of size. 'Boulders' and 'cobbles' are outside the soil particle range, though their presence (and proportions) is noted. While individual particles may be designated as silt or clay based on grain size, fine grained soils are characterised as silt or clay based on tactile behaviour or Atterberg Limits, and not the relative composition of silt or clay sized particles.

Colour: The prominent colour is noted, followed by (spotted, mottled, streaked etc.) then secondary colours as applicable. Roughly equally proportioned colours are prefixed by (spotted, mottled, streaked etc.). Colour is described in its moist condition, though both wet and dry colours may also be provided if appropriate.

Plasticity: Fine grained soils are designated within standard ranges of plasticity based on tactile assessment or laboratory assessment of the Liquid Limit.

Particle Characteristics: The particle shape, particle distribution and particle size range within a coarse grained soil is described using standard terms. Particle composition may be described using rock or mineral names, with specific terms for carbonate soils.

Secondary and Minor Components: The primary soil is described and modified by secondary and minor components, with assessed ranges as tabulated.

Carbonate Soils: Carbonate content can be assessed by use of dilute '10%' HCl solution. Resulting clear sustained effervescence is interpreted as a *Carbonate soil* (approximately >50% carbonate), while weak or sporadic effervescence indicates *Calcareous soil* (< 50% carbonate). No effervescence is interpreted as a non-calcareous soil.

Organic and Peat Soils: Where identified, organic content is noted. *Organic soil* (2% to 25% organic matter) is usually identified by colour (usually dark grey/black) and odour (i.e. 'mouldy' or hydrogen sulphide odour). *Peat* (>25% organic matter) is identified by a spongy feel and fibrous texture. Peat soils' decomposition may be described as '*fibrous*' (little / no decomposition), '*pseudo-fibrous*' (moderate decomposition) or '*amorphous*' (full decomposition).

Fraction	Components		Particle Size (mm)
Oversize	BOULDERS		> 200
	COBBLES		63 - 200
Coarse grained soil particles	GRAVEL	Coarse	19 - 63
		Medium	6.7 -19
		Fine	2.36 - 6.7
	SAND	Coarse	0.6 - 2.36
		Medium	0.21 - 0.6
		Fine	0.075 - 0.21
Fine grained soil particles	SILT		0.002 - 0.075
	CLAY		< 0.002

Plasticity Terms (Fine Grained Soils)		Laboratory Liquid Limit Range
Silt	**Clay**	
N/A	N/A	(Non Plastic)
Low Plasticity	*Low Plasticity*	≤ 35%
	Medium Plasticity	> 35% and ≤ 50%
High Plasticity	*High Plasticity*	> 50%

Particle Distribution Terms (Coarse Grained Soils)	
Well graded	good representation of all particle sizes
Poorly graded	one or more intermediate sizes poorly represented
Gap graded	one or more intermediate sizes absent
Uniform	essentially of one size

Particle Shape Terms (Coarse Grained Soils)		
Rounded	*Sub-angular*	*Flaky or Platy*
Sub-rounded	*Angular*	*Elongated*

Secondary and Minor Components for Coarse Grained Soils			
Fines (%)	**Modifier** (as applicable)	**Accessory coarse (%)**	**Modifier** (as applicable)
≤ 5	*'trace silt / clay'*	≤ 15	*'trace sand / gravel'*
> 5, ≤ 12	*'with clay / silt'*	> 15, ≤ 30	*'with sand / gravel'*
> 12	*prefix 'silty / clayey'*	> 30	*prefix 'gravelly / sandy'*

Secondary and Minor Components for Fine Grained Soils	
% Coarse	**Modifier** (as applicable)
≤ 15	add *"trace sand / gravel"*
> 15, ≤ 30	add *"with sand / gravel"*
> 30	prefix soil *"sandy / gravelly"*

Ref: DS6.5.1.1 Rev 0 Date: 2/03/2018

SOIL DESCRIPTION AND CLASSIFICATION

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b) Soil Condition (moisture, relative density or consistency)

Moisture: Fine grained soils are described relative to plastic or liquid limits, while coarse grained soils are assessed based on appearance and feel. The observation of seepage or free water is noted on the test hole logs.

Moisture - Coarse Grained Soils		
Term		**Tactile Properties**
Dry	*('D')*	Non-cohesive, free running
Moist	*('M')*	Feels cool, darkened colour, tends to stick together
Wet	*('W')*	Feels cool, darkened colour, tends to stick together, free water forms when handling

Moisture - Fine Grained Soils		
Term		**Tactile Properties**
Moist, dry of plastic limit	*('$w < PL$')*	Hard and friable or powdery
Moist, near plastic limit	*('$w \approx PL$')*	Can be moulded
Moist, wet of plastic limit	*('$w > PL$')*	Weakened, free water forms on hands with handling
Wet, near liquid limit	*('$w \approx LL$')*	Highly weakened, tends to flow when tapped
Wet, wet of liquid limit	*('$w > LL$')*	Liquid consistency, soil flows

Relative Density (Non Cohesive Soils): The Density Index is inherently difficult to assess by visual or tactile means, and is normally assessed by penetration testing (e.g. SPT, DCP, PSP or CPT) with published correlations. Assessment may be affected by moisture and *in situ* stress conditions. Density Index assessment may be refined by combination of *in situ* density testing and laboratory reference maximum and minimum density ranges.

Consistency (Cohesive Soils): May be assessed by direct measurement (shear vane, CPT etc.), or approximate tactile correlations. Cohesive soils include fine grained soils, and coarse grained soils with sufficient fine grained components to induce cohesive behaviour. A 'design shear strength' must consider the mode of testing, the *in situ* moisture content and potential for variations of moisture which may affect the shear strength.

Relative Density (Non-Cohesive Soils)		
Term and (Symbol)		**Density Index (%)**
Very Loose	*(VL)*	≤ 15
Loose	*(L)*	> 15 and ≤ 35
Medium Dense	*(MD)*	> 35 and ≤ 65
Dense	*(D)*	> 65 and ≤ 85
Very Dense	*(VD)*	> 85

Consistency assessment can be influenced by moisture variation.

Consistency (Cohesive Soils)			
Term and (Symbol)		**Tactile Properties**	**Undrained Shear Strength**
Very Soft	*(VS)*	Extrudes between fingers when squeezed	< 12 kPa
Soft	*(S)*	Can be moulded by light finger pressure	12 - 25 kPa
Firm	*(F)*	Can be moulded by strong finger pressure	25 - 50 kPa
Stiff	*(St)*	Cannot be moulded by fingers	50 - 100 kPa
Very Stiff	*(VSt)*	Can be indented by thumb nail	100 - 200 kPa
Hard	*(H)*	Can be indented with difficulty by thumb nail	> 200 kPa
Friable	*(Fr)*	Easily crumbled or broken into small pieces by hand	-

c) Structure (zoning, defects, cementing)

Zoning: The *in situ* zoning is described using the terms below. *'Intermixed'* may be used for an irregular arrangement.

'layer' (a continuous zone across the exposed sample)

'lens' (a discontinuous layer with lenticular shape)

'pocket' (an irregular inclusion of different material).

'interbedded' or *"interlaminated'* (alternating soil types)

Defects: Described using terms below, with dimension orientation and spacing described where practical.

'parting' (an open or closed surface or crack sub parallel to layering with little / no tensile strength - open or closed)

'fissure' (as per a parting, though not parallel or sub parallel to layering – may include desiccation cracks)

'sheared seam' (zone of sub parallel near planar closely spaced intersecting smooth or slickensided fissures dividing the mass into lenticular or wedge shaped blocks)

'sheared surface' (a near planar, curved or undulating smooth, polished or slickensided surface, indicative of displacement)

'softened zone' (in clayey soils, usually adjacent to a defect with associated higher moisture content)

'tube' (tubular cavity, singly or one of a large number, often formed from root holes, animal burrows or tunnel erosion)

'tube cast' (an infilled tube – infill may vary from uncemented through to cemented or have rock properties)

'infilled seam' (sheet like soil body cutting through the soil mass, formed by infilling of open defects)

Cementation: Soils may be cemented by various substances (e.g. iron oxides and hydroxides, silica, calcium carbonate, gypsum), and the cementing agent shall be identified if practical. Cemented soils are described as:

'weakly cemented'	easily disaggregated by hand in air or water
'moderately cemented'	effort required to disaggregate the soil by hand in air or water

Materials extending beyond '*moderately cemented'* are encompassed within the rock strength range. Where consistent cementation throughout a soil mass is identified as a duricrust, it is described in accordance with duricrust rock descriptors. Where alternate descriptors of cementation development are applied for consistency with regional practices or geology, or client requirements, these are outlined separately.

Ref: DS6.5.1.1 Rev 0 Date: 2/03/2018

d) Origin

An interpretation is provided based on observations of landform, geology and fabric, and may further include assignment of a stratigraphic unit. The use of terms ‘possibly’ or ‘probably’ indicates a higher degree of uncertainty regarding the assessed origin or stratigraphic unit. Typical origin descriptors include:

Residual	Formed directly from in situ weathering with no visible structure or fabric of the parent soil or rock.
Extremely weathered	Formed directly from in situ weathering, with remnant and/or fabric from the parent rock.
Alluvial	Deposited by streams and rivers (may be applied more generically as transported by water).
Estuarine	Deposited in coastal estuaries, including sediments from inflowing rivers, streams, and tidal currents.
Marine	Deposited in a marine environment.
Lacustrine	Deposited in freshwater lakes.
Aeolian	Transported by wind.
Colluvial and Slopewash	Soil and rock debris transported down slopes by gravity (with or without assistance of water). Colluvium is typically applied to thicker / localised deposits, and slopewash for thinner / widespread deposits.
TOPSOIL	Surficial soil, typically with high levels of organic material. Topsoils buried by other transported soils are termed *‘remnant topsoil’*. Tree roots within otherwise unaltered soil does not characterise topsoil.
FILL	Any material which has been placed by anthropogenic processes (i.e. human activity).

e) Additional Observations

Additional observations may be included to supplement the soil description. Additional observations may consist of notations relating to soil characteristics (odour, contamination, colour changes with time), inferred geology (with delineation of soil horizons or geological time scale) or notes on sampling and testing application (including the reliability, recovery, representativeness, or condition of samples or test conditions and limitations). If the material is assessed to be not representative, terms such as ‘poor recovery’, ‘non-intact’, ‘recovered as’ or ‘probably’ are applied.

SOIL CLASSIFICATION

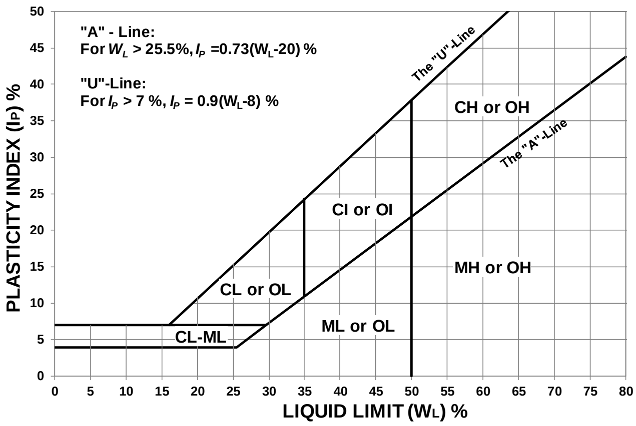
Classification allocates the material within distinct soil groups assigned a two character Group Symbol:

Coarse Grained Soils (sand and gravel: more than 65% of soil coarser than 0.075 mm)			**Fine Grained Soils** (silt and clay: more than 35% of soil finer than 0.075 mm)		
Major Division	**Group Symbol**	**Soil Group**	**Major division**	**Group Symbol**	**Soil Group**
GRAVEL (more than half of the coarse fraction is > 2.36 mm)	GW	GRAVEL, well graded	SILT and CLAY (low to medium plasticity)	ML	SILT, low plasticity
	GP	GRAVEL, poorly graded		CL	CLAY, low plasticity
	GM	Silty GRAVEL		CI	CLAY, medium plasticity
	GC	Clayey GRAVEL		OL	Organic SILT
SAND (more than half of the coarse fraction is < 2.36 mm)	SW	SAND, well graded	SILT and CLAY (high plasticity)	MH	SILT, high plasticity
	SP	SAND, poorly graded		CH	CLAY, high plasticity
	SM	Silty SAND		OH	Organic CLAY / SILT
	SC	Clayey SAND	Highly Organic	Pt	PEAT

Coarse grained soils with fines contents between 5% and 12% are provided a dual classification comprising the two group symbols separated by a dash, e.g. for a poorly graded gravel with between 5% and 12% silt fines (poorly graded ‘GRAVEL with silt’), the classification is GP-GM.

For the purpose of classification, *poorly graded, uniform,* or *gap graded* soils are all designated as poorly graded. Soils that are dominated by boulders or cobbles are described separately and are not classified.

Classification is routinely undertaken based on tactile assessment with the soil description. Refinement of soil classification may be applied using laboratory assessment, including particle size distribution and Atterberg Limits. Atterberg Limits testing is applied to the sample portion finer than 0.425 mm. Fine grained soil components are assessed on the basis of regions defined within the Modified Casagrande Chart.



BOREHOLE LOG SHEET

Client : National Australian Pipelines
Project : Shoalhaven Starches Gas Pipeline Project
Location : Fletchers Lane, Meroo Meadow, NSW

HOLE No. BH01

Position : 282231.3 E 6143297.0 N MGA94/ 56 | **Surface RL:** ~4.0 AHD | **Angle from Horiz. :** 90° | **Processed :** SBO

Rig Type : Hanjin 208 | **Mounting:** Track | **Contractor :** Total Drilling Pty Ltd | **Driller :** WG | **Checked :** DJD

Date Started : 16/12/2021 | **Date Completed :** 16/12/2021 | **Logged by :** AE/NK | **Date:** 11/01/2022

Note: * indicates signatures on original issue of log or last revision of log

DRILLING: Drilling Method: TC-bit auger (0–5 m); Hole Support \ Casing: Nil; Water: ▽ 16/12/21 at 3.80 m

MATERIAL — Description: [COBBLES/BOULDERS/FILL/TOPSOIL] then SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects

SCALE (m)	Samples & Tests	Depth metres	USC Symbol	Description	Moisture Condition	Consistency / Density Index	Comments/ Observations
0			-	[FILL]: GRAVEL: medium to coarse, angular, dark grey, with fine to coarse grained sand.	M	MD	
		0.15	CL-CI	CLAY: low to medium plasticity, dark brown, minor orange mottling (alluvium).	w < PL	F	
	SPT 3/4/7 N=11					St-VSt	0.8m, PP=250kPa
1				0.9m, becoming purple grey mottled orange.			
	SPT 3/3/5 N=8					VSt	1.3m, PP=250kPa
2				2.2m, becoming brown, traces of fine grained sand.		St	
	SPT 2/3/5 N=8						
3							
		3.80	CH	Sandy CLAY: high plasticity, pale yellow, fine grained sand (residual).	w = PL	VSt	
4							4.0m, PP=150kPa
	SPT 2/3/4 N=7			4.1m, becoming medium plasticity, grey streaked yellow.	w < PL	St	
5		5.00					

See standard sheets for details of abbreviations & basis of descriptions

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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. **12560160**

Client : National Australian Pipelines
Project : Shoalhaven Starches Gas Pipeline Project
Location : Fletchers Lane, Meroo Meadow, NSW

HOLE No. BH01

Position : 282231.3 E 6143297.0 N MGA94/ 56	**Surface RL:** ~4.0 AHD	**Angle from Horiz. :** 90°		**Processed :** SBO
Rig Type : Hanjin 208	**Mounting:** Track	**Contractor :** Total Drilling Pty Ltd	**Driller :** WG	**Checked :** DJD
Date Started : 16/12/2021	**Date Completed :** 16/12/2021	**Logged by :** AE/NK		**Date:** 11/01/2022

Note: * indicates signatures on original issue of log or last revision of log

SCALE (m)	Drilling Method	Hole Support \ Casing	Water	Samples & Tests	Depth metres	Graphic Log	USC Symbol	Description [COBBLES/BOULDERS/FILL/TOPSOIL] then SOIL NAME: plasticity / primary particle characteristics, colour, secondary and minor components, zoning (origin) and ROCK NAME: grain size, colour, fabric / texture, inclusions or minor components, durability, strength, weathering / alteration, defects	Moisture Condition	Consistency / Density Index	Comments/ Observations
	TC-bit auger	Nil					CH	Sandy CLAY: as previous.	w < PL	St	
				SPT 2/4/5 N=9							5.5m, PP=140kPa
6											
				SPT 6/8/10 N=18	6.45						
								End of borehole at 6.45 metres. Target Depth			
7											
8											
9											
10											

See standard sheets for details of abbreviations & basis of descriptions

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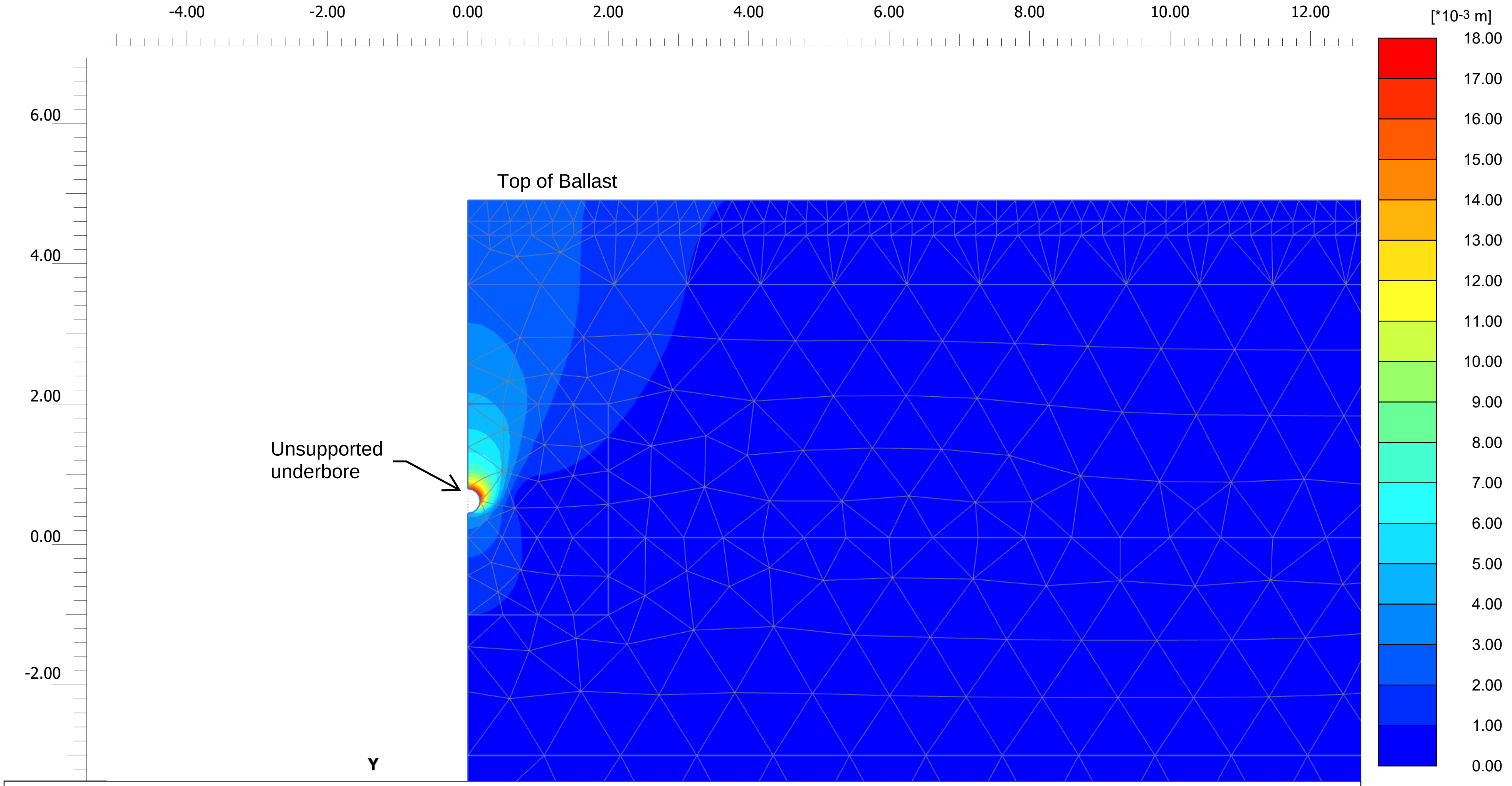
Appendix C

Settlement Analysis Outputs

Output Version 20.3.0.60



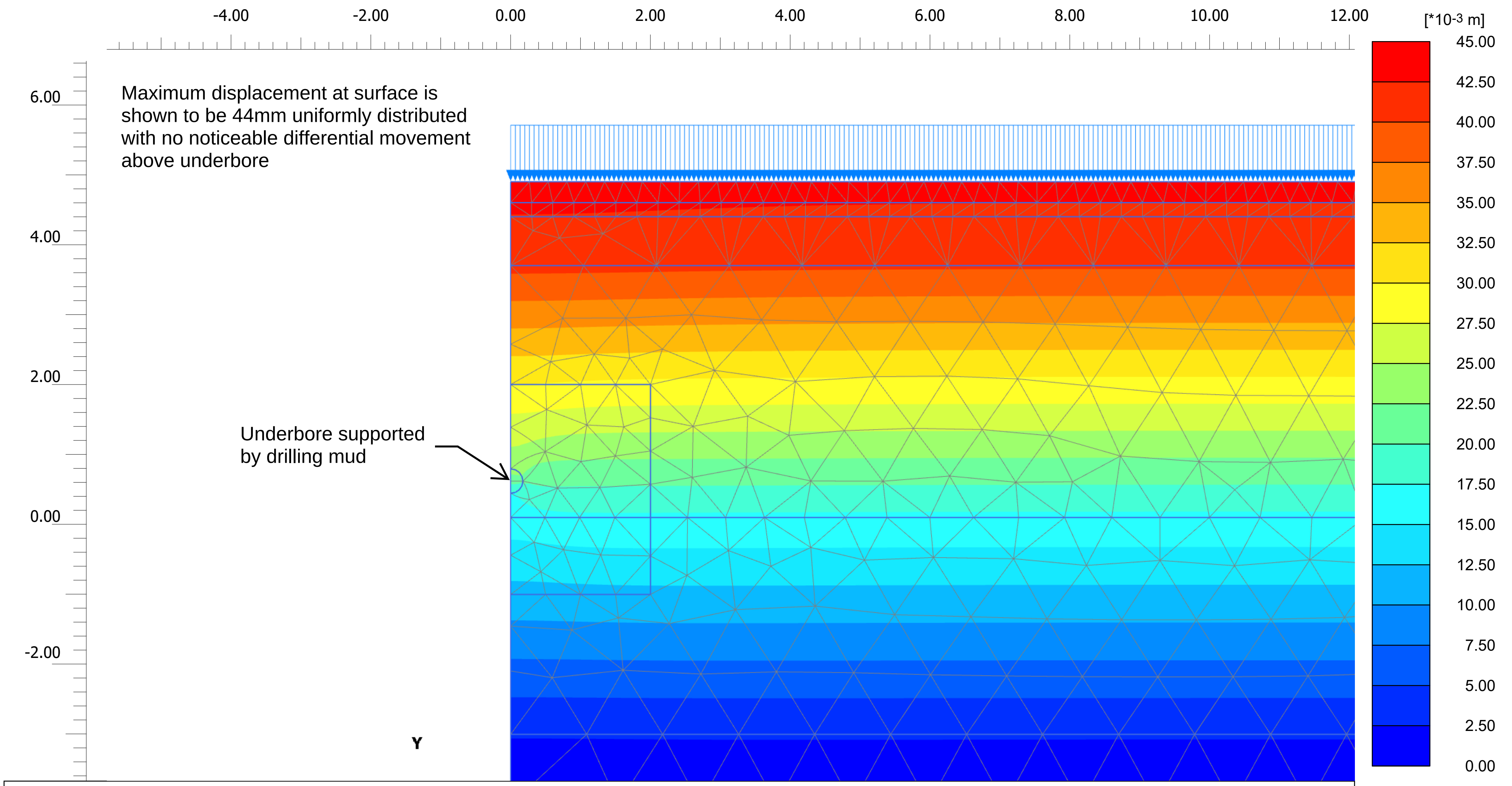
Phase displacements |Pu| (scaled up 50.0 times)

Maximum value = 0.01773 m (Element 707 at Node 438)

Project description		Date
Fletchers Lane Railway Crossing		4/02/2022

Project filename	Step	Company
Fletchers Lane Railway Ana ...	33	GHD Pty Ltd

Output Version 20.3.0.60



Phase displacements |Pu| (scaled up 20.0 times)

Maximum value = 0.04349 m (Element 84 at Node 48)

Project description		Date
Fletchers Lane Railway Crossing		4/02/2022

Project filename	Step	Company
Fletchers Lane Railway Ana ...	35	GHD Pty Ltd

Appendix D

Risk Assessment

	C	D	F	I	J	K	L	O	P	Q
2	**RISK IDENTIFICATION**			**CURRENT RISK RATING**			**RISK TREATMENT / ACTIONS**	**RESIDUAL RISK RATING Taking into account risk actions**		
3		**Risk Issue**	**Impact / Consequence**	**Consequence**	**Likelihood**	**Rating**	**Proposed treatment Strategies and Actions**	**Consequence**	**Likelihood**	**Rating**
4	1	Working alongside road and rail traffic	Striking of personnel	**Catastrophic**	Possible	Extreme	Establish perimeter fencing prior to works commencing. Brief construction personnel on safe zones.	**Catastrophic**	Very unlikely	Moderate
5	2	Unstable excavation	Damage, crushing of personnel in deep excavations	**Moderate**	Possible	Moderate	Ensure personnel do not enter unsupported excavations greater than 1.5m deep. Ensure ground support or benching is provided to excavations deeper than 1.5m or where ground conditions are unstable such as following high rainfall periods. Appropriate qualified geotetechnical engineer to review on site conditions.	**Moderate**	Very unlikely	Low
6	3	Underground services impact	Damage to assets, injury to personnel	**Catastrophic**	Possible	Extreme	Undertake dial before you dig search and brief construction personnel prior to operation of machinery. Any underground services should be identified prior to works. Establish perimeter fencing prior to works commencing. Brief construction personnel on safe zones.	**Catastrophic**	Unlikely	Significant
7	4	Overhead services impact	Damage to assets, injury to personnel	**Major**	Possible	Extreme	Assess impact of works on overhead services and ensure safe distances are adhered to between overhead services and plant	**Major**	Very unlikely	Low
8	5	Exposure to contaminated ground	Health impact to personnel	**Moderate**	Unlikely	Low	Brief construction personnel and provide appropriate training in regards to identification of contaminated ground. Review investigation outcomes. Identify procedure to manage contaminated ground prior to works. Provide appropriate PPE.	**Moderate**	Very unlikely	Low
9	6	Track subsidence	Damage to rail and subgrade	**Major**	Possible	Significant	Assess impact from underbores. If required conduct track monitoring and ensure trigger levels are implemented prior to works.	**Major**	Very unlikely	Low
10	7	Working around existing structures	Damage to rail assets	**Moderate**	Possible	Moderate	Review of existing structures by an appropriately qualified engineer to establish impact on existing structures. Brief construction personnel on construction limits.	**Moderate**	Very unlikely	Low
11	8	Working adjacent drainage infrastructure	Impact adequacy of drainage causing damage	**Moderate**	Unlikely	Low	Ensure drainage during and following construction is not impacted. Hydrology assessment required where drainage is impacted.	**Moderate**	Very unlikely	Low
12	9	Destabilisation of embankments	Failure of embankment	**Moderate**	Unlikely	Low	Geotechnical engineer to review stability where works are impacting slopes for both construction and long term conditions. Risk assessment is required where works do impact slopes to ensure stability does not impact rail infrastructure.	**Moderate**	Very unlikely	Low

Risk Outcome Matrix

Likelihood	Consequence Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	**Low**	**Moderate**	**Significant**	**Extreme**	**Extreme**
Likely	**Low**	**Low**	**Moderate**	**Significant**	**Extreme**
Possible	**Negligible**	**Low**	**Moderate**	**Significant**	**Extreme**
Unlikely	**Negligible**	**Negligible**	**Low**	**Moderate**	**Significant**
Very Unlikely	**Negligible**	**Negligible**	**Low**	**Moderate**	**Moderate**

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ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW

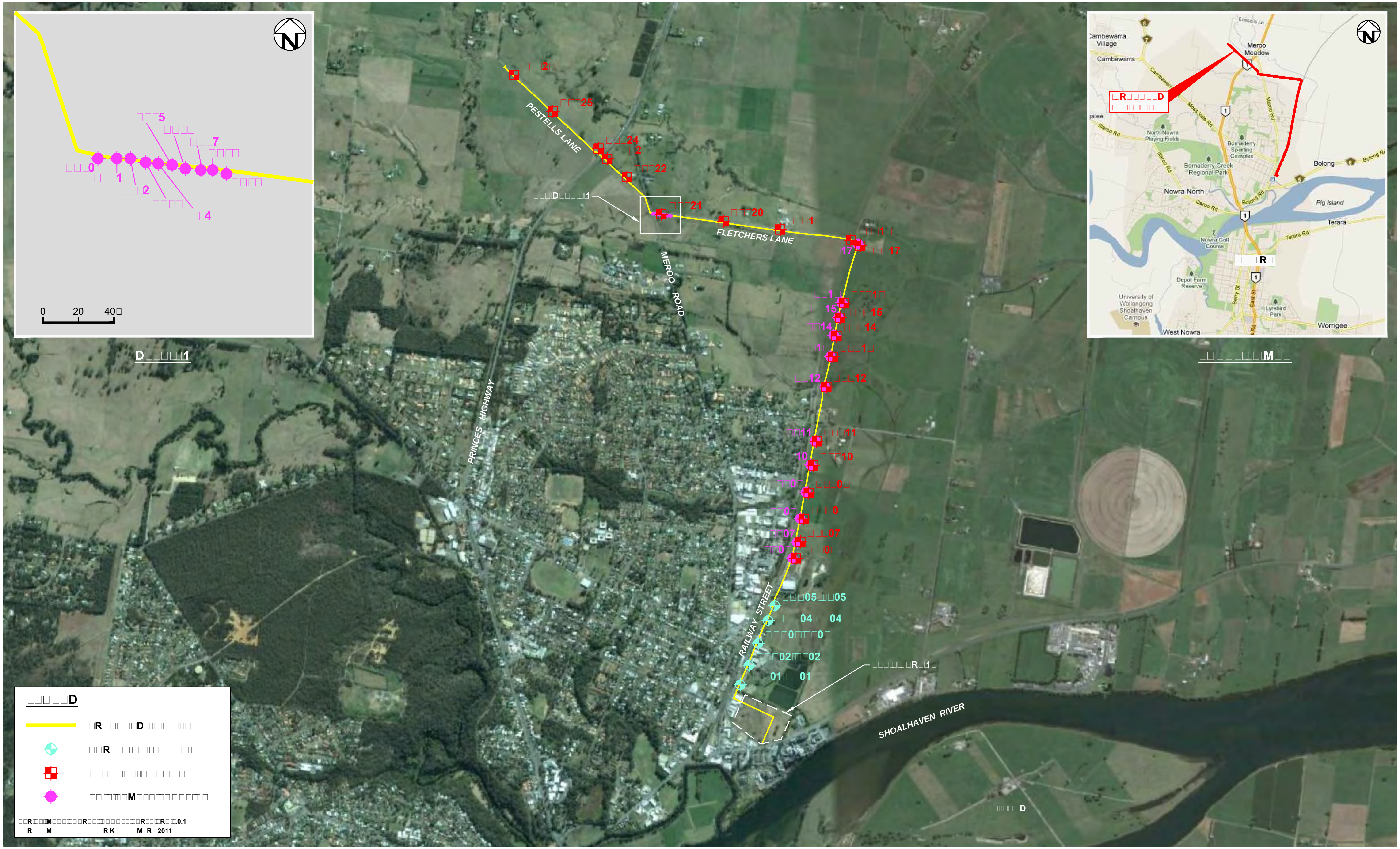
Prepared for:

MANILDRA GROUP PTY LTD
Bolong Road,
Bomaderry NSW

Report Date: 29 July 2011
Project Ref: ENAUWOLL04006AA-R01

Written/Submitted by:	Reviewed/Approved by:	Reviewed/Approved by:
Chris Appelkamp Project Engineering Geologist	Scott Morrison Associate Geotechnical Engineer	Manuel Fernandez Senior Associate Environmental Engineer

Coffey Environments Australia Pty Ltd ABN 65 140 765 902
118 Auburn Street Wollongong NSW 2500 Australia



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CA	28/07/11

100 0 100 300 500

Horizontal Scale (metres) 1:10 000

	CA/AW
	CA
	28/07/11
	AS SHOWN
	A3

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	MANILDRA GROUP PTY LTD
	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS - SHEET 1 OF 2
ENAUWOLL04006AA-R01	FIGURE 1A

revision

PLOT DATE: 28/25/2011 12:25 PM DWG FILE: F:\GEOTECHNICS\1.PROJECTS\OTHER OFFICE JOBS\WOLLONGONG\ENAUWOLL04006AA\FIGURES\ENAUWOLL04006AA_FIGURE 1A-B-C.DWG

PLOT DATE: 28/24/2011 12:24 PM DWG FILE: F:\GEOTECHNICS\1.PROJECTS\OTHER OFFICE JOBS\WOLLONGONG\ENAUWOLL04006AA\FIGURES\ENAUWOLL04006AA FIGURE 1A-B-C.DWG

revision

100 0 100 300 500

Horizontal Scale (metres) 1:10 000

dr	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

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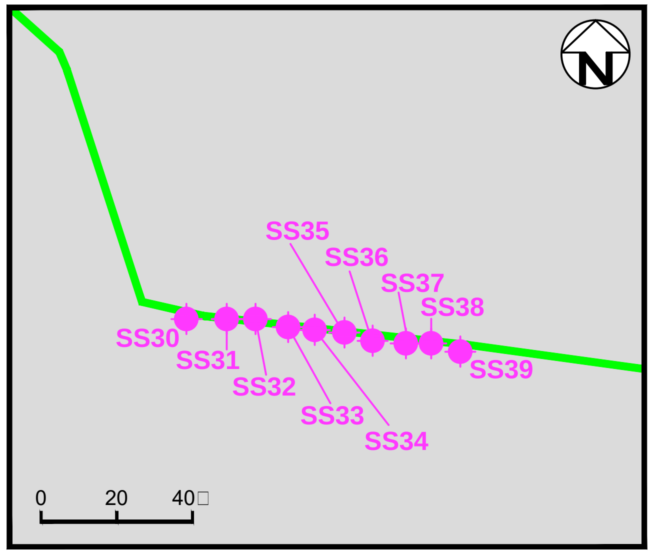
client	MANILDRA GROUP PTY LTD
project	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS - SHEET 2 OF 2
project no	ENAUWOLL04006AA-R01
figure no	FIGURE 1B

Map Class Description		Depth to Acid Sulfate Soil Materials
HIGH PROBABILITY High probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.
		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
LOW PROBABILITY Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.
		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
NO KNOWN OCCURRENCE Acid sulfate soils are not known or expected to occur in these environments.		No known occurrences of acid sulfate soil materials.

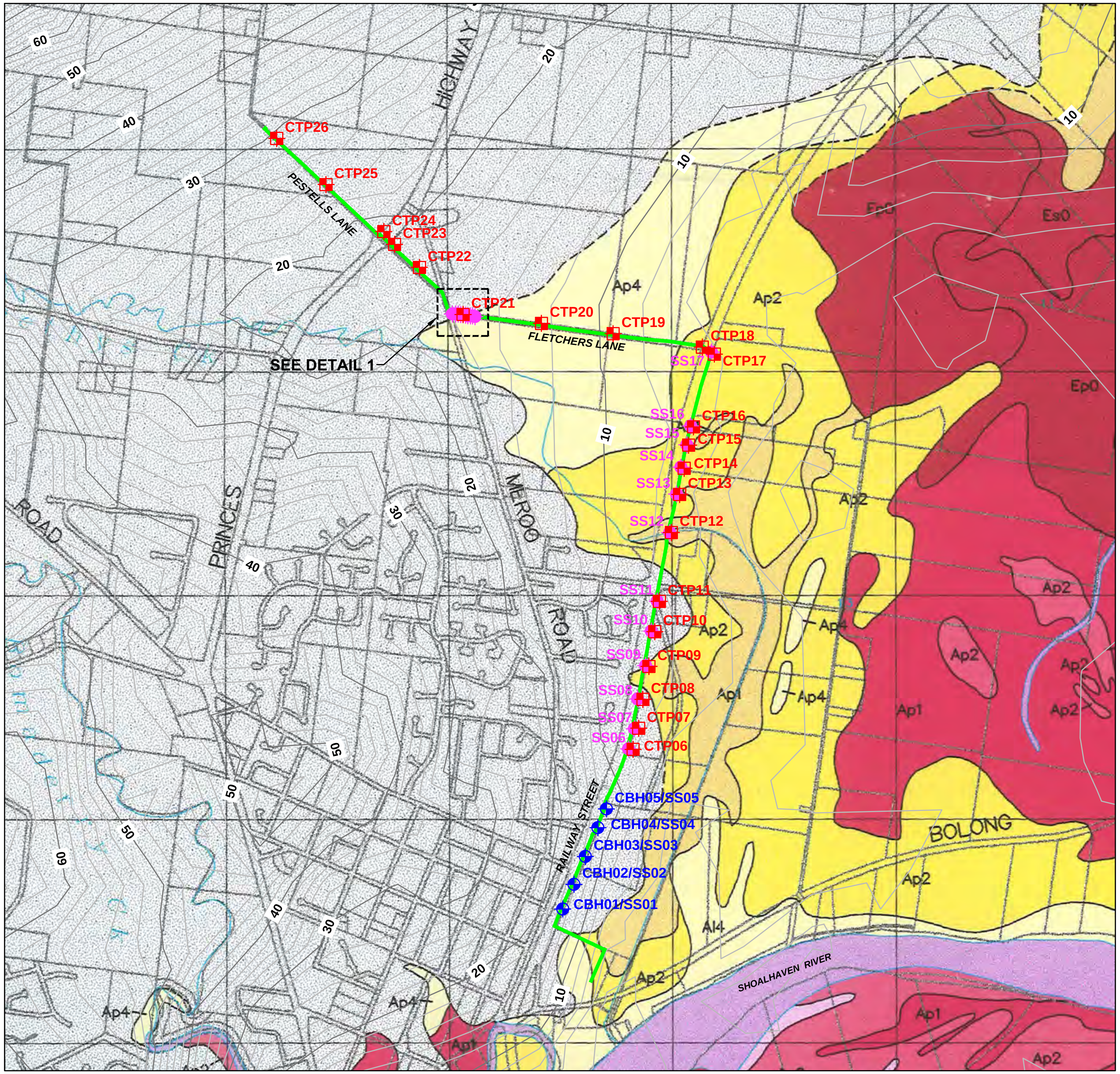


DETAIL 1

LEGEND

- PROPOSED PIPELINE
- BOREHOLE LOCATION
- TEST PIT LOCATION
- SOIL SAMPLE LOCATION

REFERNCE: BURRIER/BERRY 1:25 000 ACID SOIL RISK MAP (1997) EDITION 2, PREPARED BY THE NSW DEPARTMENT OF LAND AND WATER CONSERVATION (DLWC)



200 0 200 600 1000

Horizontal Scale (metres) 1:20 000

revision				

drawn	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

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client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH 1:25000 BURRIER/BERRY ASS RISK MAP
project no:	ENAUWOLL04006AA-R01
figure no:	FIGURE 2

PLOT DATE: 28/08/2011 12:28 PM DWG FILE: F:\GEOTECHNICS\1.PROJECTS\OTHER OFFICE JOBS\WOLLONGONG\ENAUWOLL04006AA\FIGURES\ENAUWOLL04006AA FIGURE 2.DWG

Appendix C
Engineering Logs of Boreholes and Test Pits

ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION
BOMADERRY NSW

Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
				DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
		SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
				Medium to High	None	Medium	CL	CLAY
				Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
				High	None	High	CH	CLAY
				Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS				Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.

Defect Discontinuity or break in the continuity of a substance or substances.

Mass Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbreviation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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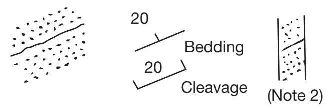
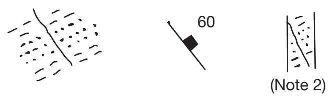
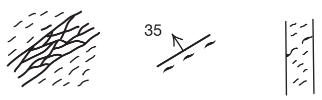
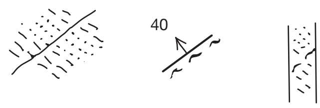
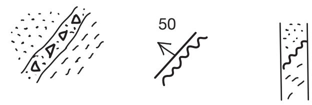
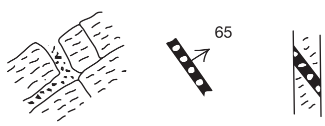
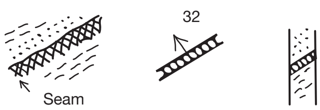
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram / Map Symbol / Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.	
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.	
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.	
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.	
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.	
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.	
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.	

DEFECT SHAPE

	TERMS
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

72710 / 07-06

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Engineering Log - Excavation

Excavation No. **CTP17**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**22.6.2011**
Principal:		Date completed:	**22.6.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model:	5T EXCAVATOR	Pit Orientation:		Easting:	282284 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6143258 m	datum:	WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED						**TOPSOL; CLAY:** Medium plasticity, brown, with some fine grained roots.	Wp	F		TOPSOIL
						0.5		CH	**CLAY:** High plasticity, brown with some orange pockets, with a trace of fine grained sand, roots and fine to coarse grained gravel.	<Wp	VSt	×	ALLUVIAL SOIL
				ASS									
				ASS		1.0						×	
				ASS		1.5							
						2.0						×	
						2.5							End on steady progress
						3.0			Test pit CTP17 terminated at 2.5m				

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	MANILDRA GROUP PTY LTD
approved	CA		project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW
date	19/07/2011			
scale	NTS		title:	PHOTO OF TEST PIT CTP17
original size	A4		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **21**

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Engineering Log - Excavation

Excavation No. **CTP18**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**4.5.2011**
Principal:		Date completed:	**4.5.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model: 7T CAT BACKHOE | Pit Orientation: E-W | Easting: 282230 m | R.L. Surface: NOT MEASURED

excavation dimensions: 2m long 0.45m wide | Northing: 6143289 m | datum: WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	NONE OBSERVED	E					**TOPSOIL; CLAY:** Medium plasticity, brown, with some roots and silt, with a trace of fine to medium grained sand and fine to coarse grained angular gravel.	<Wp	St		TOPSOIL
				ASS		0.5		CL	**CLAY:** Medium plasticity, brown/grey with some iron stained orange/brown pockets, wth some roots and fine to medium grained sand, and a trace of silt.	<Wp/Wp	VSt		ALLUVIAL SOIL
						1.0							
				ASS		1.5							
				ASS		2.0		CH	**CLAY:** High plasticity, iron stained orange/brown with grey pockets, some fine to medium grained sand, and a trace of fine to medium grained sub-angular ironstone gravel.	Wp	St/VSt		
				ASS		2.5							
						3.0			Test pit CTP18 terminated at 2.6m				CTP18 Terminated at 2.6m on steady progress

Sketch

method		support	notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation		U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4 no resistance ranging to refusal	D	disturbed sample		F	firm
B	bulldozer blade		V	vane shear (kPa)	**moisture**	St	stiff
R	ripper		Bs	bulk sample	D dry	VSt	very stiff
E	excavator	**water**	E	environmental sample	M moist	H	hard
		water level on date shown	R	refusal	W wet	Fb	friable
		water inflow			Wp plastic limit	VL	very loose
		water outflow			W_L liquid limit	L	loose
						MD	medium dense
						D	dense
						VD	very dense

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	MANILDRA GROUP PTY LTD
approved	CA		project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW
date	19/07/2011			
scale	NTS		title:	PHOTO OF TEST PIT CTP18
original size	A4		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **22**

FRAC

CALCS

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **FLETCHERS LANE RAILWAY HDD** 11/02/2022 REV 0

CAVITY EXPANSION THEORY WAS USED TO DETERMINE MAX BORE HOLE PRESSURE

The model is developed to establish the maximum allowable pressure that can be applied to a given soil without hydrofacture occuring, expressed as follows

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}} \right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G} \right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Where

pMax is the max allowable mud pressure in bore hole in kPa

Ro	Initial Bore Radius (For Pilot Hole)	4.25 inch	0.05 m			
Rpmax	Radius of Plastic Zone		0.32 m	Borehole Size	0.10795 m	
	Rmax Generally 3 times the bore hole size					

Soil Variables

$\varphi =$ Soil Friction Angle [°]		26.00 Deg		Refer 12560160-REP-2_Geotech_Rev01
$c =$ cohesion		2.00 kPa		Refer 12560160-REP-2_Geotech_Rev01
$\gamma =$ Unit weight of soil above the groundwater	17 kN	1732.93 kg/m3		Refer 12560160-REP-2_Geotech_Rev01
$\gamma' =$ Unit weight of soil below the groundwater		1732.93 kg/m3		
E = Youngs Modulus		15.00 Mpa		
v = Poissons Ratio		0.30		
G = Shear Modulus G = E / (2(1+v))		5.77 Mpa	5,769.23 kPa	

Variables Dependent on Bore Geometry at Under Rail Tracks Deepest Point - Bore Mid Point Ch 2383.34

$h_s =$ Depth of the Bore below Ground Surface	4.31 m	
$h_w =$ Height of groundwater over the bore	0.00 m	
$u =$ Groundwater Pressure	0.00 kPa	
$\sigma' =$ Effective Stress $= \gamma \cdot (h_s - h_w) + \gamma'(h_w)$	7,468.91 kg/m2	73.27 kPa

sinQ	0.438371147
cosQ	0.898794046
tanQ	0.487732589
cotQ	2.050303842

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **FLETCHERS LANE RAILWAY HDD**

11/02/2022 REV 0

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 111.2876

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.3048

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.81

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 308.76 kPa 44.77 psi

Variables Dependent on Bore Geometry at **West of Rail Track** **Ch 2360**

h_s = Depth of the Bore below Ground Surface 2.74 m

h_w = Height of groundwater over the bore 0.00 m

u = Groundwater Pressure 0.00 kPa

σ' = Effective Stress = $\gamma\cdot(h_s - h_w) + \gamma'(h_w)$ 4,748.22 kg/m2 46.58 kPa

sinQ	0.438371147
cosQ	0.898794046
tanQ	0.487732589
cotQ	2.050303842

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 72.89752

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.3048

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.87

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 204.75 kPa 29.69 psi

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **FLETCHERS LANE RAILWAY HDD** 11/02/2022 REV 0

Variables Dependent on Bore Geometry at East of Track Ch 2400

$h_s =$ Depth of the Bore below Ground Surface 3.04 m

$h_w =$ Height of groundwater over the bore 0.00 m

$u =$ Groundwater Pressure 0.00 kPa

$\sigma' =$ Effective Stress $= \gamma \cdot (h_s - h_w) + \gamma'(h_w)$ 5,268.09 kg/m2 51.68 kPa

sinQ	0.438371147
cosQ	0.898794046
tanQ	0.487732589
cotQ	2.050303842

$[\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi]$ = 80.23322

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.3048

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.85

$$p_{max} = u + [\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Borehole pressure to be less than this
224.92 kPa 32.61 psi

Check - Internal Pressure within Borehole

Annular Pressure (Pd) of Drill Fluid exerted by a mid sized HDD rig ranges from 10kPa to 52kPa for a 100 to 120m HDD

Hydrostatic pressure of the Drill Fluid is $P_{\text{drill fluid hydrostatic}} = h_{\text{drill fluid}} \times 9.81 \times \rho_{\text{drill fluid}}$

Where,

Height of drill fluid column $h_{\text{drill fluid}}$

Mud Weight $\rho_{\text{drill fluid}} = 1.20$ kg/l

(mud weight of 1.20 kg/l used due to cuttings suspended in the hole)

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **FLETCHERS LANE RAILWAY HDD** 11/02/2022 REV 0

Accordingly for various locations along the HDD path the internal pressures are as per below.

		Ph	Location of Drill Head	Expected Pd	Total Expected Internal Pressure
Pdrill fluid Hydrostatic					
	at 2.74m head (h)	32.26 kPa	1/3 into HDD	24 kPa	56.3 kPa
	at 4.31m head (h)	50.74 kPa	1/2 into HDD	31 kPa	81.7 kPa
	at 3.04m head (h)	35.79 kPa	2/3 into HDD	38 kPa	73.8 kPa

Comparing the internal pressures vs the soil bearing pressures at various points along the HDD it is clear that frac out is not probable

REFERENCES

Ariaratnam, Samuel T., Stauber, Richard M., Bell, J., Harbin, B., Cannon, F. (2003). "Predicting and Controlling Hydraulic Fracturing During Horizontal Directional Drilling" American Society of Civil Engineers Conference Proceedings Paper, New Pipeline Technologies, Security and Safety.

Bennett and Wallin, 2008. Step-By-Step Evaluation of Hydrofracture Risks for HDD Projects, Proceedings of 2008 No-Dig Conference, Dallas, Texas, April 27-May 2, 2008

Delft Geotechnics. (1997) A Report by Department of Foundations and Underground Engineering Prepared for O'Donnell Associates of Sugarland, TX.

Luger, H.J., and Hergarden, A.M. (1988) "Directional Drilling in Soft Soil: Influence of Mud Pressures", International Society of Trenchless Technology, No-Dig Conference.

Rowe, R.K. (2000). Geotechnical and Geoenvironmental Engineering Handbook. Kluwer Academic Publishing Group. The Netherlands. ISBN 0-7923-8613-2.

Staheli, K., Bennett, R.D., O'Donnell, H., Hurley, T., (1998). "Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling (HDD)", CPAR-GL-98-1, April 1998.

Terzaghi, K., and Peck, R. (1948) Soil Mechanics in Engineering Practice. John Wiley & Sons, Inc.

U.S. Army Corps of Engineers, (1990). "Engineering Manual, EM 1110-1-1904. Engineering and Design – Settlement Manual." 30 September 1990.

Xia, Hongwei (2009) Investigation of Maximum Mud Pressure Within Sand and Clay During Horizontal Directional Drilling, Ph.D. Thesis, Queen's University, Kingston, Ontario, Canada, January 2009.

Kimberlie, S, Christopher, P, Laura, W, 2010, " EFFECTIVENESS OF HYDROFACTURE PREDICTION FOR HDD DESIGN"

PULLBACK

CALCS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

ABN 88 005 339 211

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS - SHOALHAVEN STARCHES BOMADERRY

DN300 Gas Transmission Pipeline

HDD Design Calculations - Railway Crossing

Document No	NAP-SS-PL-CAL-24						
Rev	**Date**	**Purpose**	**Prepared**	**Checked**	**Approved**	**Independent Engineer**	**Date**
A	11/02/2022	For Approval	M.Bhatia	K.Moran	A.Kesavan	J.Blain	
			Project Engineer	Project Engineer	Senior Project Engineer		

1 Scope

These design calculations are for calculating pipeline stresses for road crossing

1.1 References

Referenced Document		Ref.
AZ/NZS 2885.1:2018	Pipelines – Gas and liquid petroleum,Part 1: Design and Construction Section 5.2.5	1
NAP-SS-PPR-01	Principal's Requirements	2
API SPECIFICATION 5L: May 1, 2019	Line Pipe	3
Installation of Pipelines by HDD; an Engineering Guide J D Hair Associates-1995		4
Analysis of theoritical vs actual HDD Pulling Loads J.S.Puckett J.D.Hair and Associates		5
SS-NGP-PI-XS-05 Rev C	Fletchers Lane Railway Crossing	6

1.2 Calculations

Detailed calculations have been carried out and attached herewith.

1.3 Results and Conclusions

(a) The calculations confirm that the pipeline pulllback stresses are well within the required design limits

NGP-PRS - SHOALHAVEN STARCHES BOMADERRY-DN300 Gas Transmission Pipeline
HDD Pipe Pull Back Calculations

11/02/2022
REV 0

HDD NAME **FLETCHERS LANE RAILWAY CROSSING**

Pipe Properties								
Pipe Material	Steel							
Pipe Grade	API 5L X65							
Pipe Outside Dia	Dp	323.90	mm	12.75	inches	0.3239	m
Pipe Wall Thickness	Wtp	12.70	mm	0.50	inches		
Pipe Internal Diameter	$d_p = (D_p-(2 \times w_{tp}) =$	298.50	mm	11.75	inches		
Specified Minimum Yield Stress	SMYS	65,000.00	psi	448,159,400.00	N/mm2		
Density of Pipe	ρ_p	7850.00	kg/m3				
Young's Modulus of Elasticity	$E_{steel} =$	199,948.00	N/mm2	2.04E+10	kg/m2	29,000,058.02	psi
Cross Sectional Area	$A_p = (D_p^2 - d_p^2)/4 \times \pi =$	12421.33	mm2	0.012421326	m2		
Weight of Pipe Empty in Air	$w_p = A_p \times \rho_p$	97.51	kg/m				
Mud and Soil Properties							
Mud Weight	ρ_{bent}	1.30	kg/l	10.85	ppg		
Coefficient of Friction of Soil	μ_{soil}	0.40					
Fluid Drag Co-Efficient	μ_{mud}	35.15	kg/m2	0.05	psi		
Buoyancy Control							
Pipe Material	Steel						
Pipe Grade	API 5L X65						
Pipe Outside Dia	Dbp	323.90	mm	12.75	inches		
Pipe Wall Thickness	Wtbp	12.70	mm	0.50	inches		
Pipe Internal Diameter		298.50	mm	11.75	inches		
Density of Pipe		7850.00	kg/m3				
Cross Sectional Area		12421.33	mm2	0.012421	m2		
Weight of Pipe Empty in Air		97.51	kg/m				

Type of fill substance		Water		
Density of fill material		1000.00 kg/m3		
Weight of Pipe with fill material		167.52 kg/m		

Pipeline Coatings

External Coating 1 Type/Name	3.925mm 3LPE			
Coating thicknes	tc1	4.00	mm	
Coating density	ρ_{c1}	975.00	kg/m3	
Cross Sectional Area	$A_{c1}=((D_p+2 \times t_{c1})^2-D_p^2)/4 \times \pi$	4122.17	mm2	0.004122 m2
Weight per meter	$w_{c1}= A_{c1} \times \rho_{c1}$	4.02	kg/m	
External Coating 2 Type/Name	N/A			
Coating thicknes	tc2	0.00	mm	
Coating density	ρ_{c2}	1805.00	kg/m3	
Cross Sectional Area	$A_{c2}=((D_p+2 \times t_{c1}+2 \times t_{c2})^2-(D_p+2 \times t_{c1})^2)/4 \times \pi$	0.00	mm2	0.000000 m2
Weight per meter	$w_{c2}= A_{c2} \times \rho_{c2}$	0.00	kg/m	

Weight of Pipeline in Hole

Weight of pipe empty in air	Wp	97.51	kg/m	
Weight of Bouyancy pipe filled with fluid	Wbpf	0.00		
Weight of Pipe and Coating in Air	Wptotal = (Wp +Wc1+Wc2)	101.53	kg/m	
Mud Weight	Wbent	1.30	kg/l	
Vol of fluid displaced by pipe in 1 meter	$V_{disp}= (D_p + t_{c1} + t_{c2} + w_c)^2/4 \times \pi$	84,478,750.71	mm3	84.48 Litre
Weight of fluid displaced by pipe in 1 metre	Wdisp = Vdisp x Wbent	109.82	kg	
Effective weight of pipe in hole	Wphole = Wptotal - Wdisp	-8.30	kg/m	

Pull Force Calculations

Straight Section at Point 1 - Ch 2370

Length of Straight Section	L1	85.57	m	
Radius of curvature	R	0.00	m	
Straight Section Inclination	θ_1	88.00	Deg	
Friction from soil	$\lvert frict_1 \rvert = w_{p\,hole} \times L_1 \times \sin\theta_1 \times \mu_{soil}$	-283.78	kg	
Fluid Drag	$fluid\ drag_1 = \pi \times D_p \times L_1 \times \mu_{mud}$	3061.84	kg	
Vertical Weight Component	$w_{p\,hole} \times L_1 \times \cos\theta_1$	-24.77	kg	
Length of pipe on rollers	L_{pipe}	65.66	m	
Friction factor pipe on rollers	F_{cpr}	0.30		If slings use 0.3

OVERBEND

CALCULATIONS

Natural Gas Pipeline and Pressure Reduction Station
Shoalhaven Starches
OVERBEND PIPE SUPPORT CALCS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **RAILWAY CROSSING** 11/02/2022 REV 0

SMYS	458 Mpa	
MATERIAL AND GRADE	STEEL - API 5L X65	

DISTANCE BETWEEN SUPPORTS

MAX BENDING STRESS ON PIPE TO BE LESS THAN 0.75 x 72% OF SMYS = 247.32 Mpa
This takes into account dynamic loads

Bending Moment at x $M = \frac{qx}{2}(x - L)$

q being Mass/m
x is half the distance between two pipe supports/slings/rollers
L being the total distance beween pipe supports

Bending Stress (Mx/Z)

Z being Section Modulus $I_x = \pi (d_o^4 - d_i^4) / 32do$

Do (Outside Dia)	323.90 mm	0.3239 m			
Wall Thickness	12.70 mm	0.0127 m			
Di (Inside Dia)	298.50 mm	0.2985 m			
Pipe Density	7,850.00 Kg/m3				
3LPE Density	975.00 Kg/m3	**Coating Thickness**	4 mm	0.004 m	
weight/m	105.50 Kg/m				
Mass/m (q)	1,034.96 N/m				

Distance between pipe supports (L)	42 m
x is half the distance between two pipe supports/slings/rollers	21 m
Bending Moment at x	228,207.58 Nm
Z Section Modulus	9.30E-04 m3
Bending Stress (M/Z) at x	245.36 Mpa **Check < 247.32 Mpa**

Accordingly max distance between supports is **42 m** **Our proposal is 30m to 36m**

PIPE OVERHANG DISTANCE

Max pipe over hang at free end (a) $a = \sqrt{\frac{2M_{max}}{q}}$

$$M_{max} = \frac{\sigma_{max} I}{C}$$

C being the pipe radius	0.16 m
σ_{max} being max bending stress	247.32 Mpa
I - Second Moment of Inertia $I = \pi (d_o^4 - d_i^4) / 64$	0.000150619 m4
Max Bending Moment being	230,016.04 Nm

Max pipe over hang at free end (a) **21.08 m** **Our proposal is 15m**

LONGITUDINAL BENDING STRESS DUE TO ROPING RADIUS

MAX BENDING STRESS ON PIPE TO BE LESS THAN	247.32 Mpa
Stress = E x Do/(2 x R)	
E is the Youngs Modulus	2.00E+05 Mpa

Min Roping Radius **130.93 m** **Our proposal is > 200m**

FLUID MANAGEMENT PLAN

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.
ABN 88 005 339 211

SHOALHAVEN STARCHES

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATION

FLUID MANAGEMENT PLAN & FRAC OUT MANAGEMENT

P.O. BOX 190 WHITTLESEA, VIC 3757 PH: 03 9716 3277 **FAX:** 03 9716 3244

National Australian Pipelines Pty. Ltd.

Natural Gas Pipeline and Pressure Reduction Station

Client: Shoalhaven Starches

Revision:	Issue Date:	Approved by:
Rev.0	20/01/2022	Martin J. Moran

Table of Contents

1 INTRODUCTION

It is recognised by National Australian Pipelines (NAP) that the consequences of any drilling fluid escaping the HDD drilling site compounds could be significant.

This Drilling Fluid Management Plan (FMP) addresses the following issues:

- The Purpose and Properties of Drilling Fluid;
- The Use of Drilling Fluid during a HDD operation;
- The Possible Paths by which Drilling Fluid could be lost to the environment;
- Safeguards the drilling contractor will put in place to minimise the chance of Drilling Fluid being lost to the environment;
- Inspection Procedures the drilling contractor will implement to ensure the safeguards are adequately maintained;
- Drilling Fluid Volume Tracking Procedures the drilling contractor will use to ensure that drilling fluid volumes are being checked;
- Drilling Fluid Loss Incident Management Procedure that will be used if Drilling Fluid Loss has been detected;
- Management of ground water ingress.

NAP believes the implementation of this Management Plan will:

- Ensure all practical safeguards are put in place to minimise the chance of Drilling Fluid being lost to the environment.
- Inspection Procedures will be in operation to maintain the integrity of the safeguards.
- Volumetric Drilling Fluid Tracking Procedures will be in operation to ensure that if Drilling Fluid is being lost or gained is detected and action taken.

2 CONTROL & DISTRIBUTION

The NAP Project Engineer controls this document. The Project Engineer shall ensure all persons named below are issued with a current copy.

REV NO.	CONTROLLED COPY ISSUED TO	ORGANISATION
Rev 0	Paul Whisson	Shoalhaven Starches
Rev 0	Colin Field	NAP (Site Copy)

3 GEOTECHNICAL AND HYDROLOGICAL ENVIRONMENT

The geotechnical investigation report indicates that majority of the borehole length shall be drilled through competent strata. This formation is inherently stable and is ideal for maintaining an open hole.

4 DRILLING FLUID

Drilling Fluid is a major factor in the success of any directional drilling program, and as such deserves careful consideration. The principal functions of the drilling fluid during a successful Directional Drilling operation are:

- To drive downhole motors, drill bits and reamers.
- To remove the cuttings from the bottom of the hole and carry them to the entry point.
- To cool and lubricate the drill string and drill bit.
- To line, support and protect the walls of the hole.

For a Horizontal Directional Drilling operation, the fluid demands are different from those required for drilling vertical wells. Hole cleaning ability or the ability of the drilling fluid to suspend cuttings is a much more critical factor for Horizontal Directional Drilling. Gel strength is the measure of this property.

For Horizontal Directional Drilling, low viscosity and high gel strength are required to ensure the cuttings are effectively suspended in the slurry and returned to the entry point. The drilling contractor is very experienced in Horizontal Directional Drilling operations and will be using some of the following products to mix the Drilling Fluid and guarantee these properties are met:

- BENTONITE
- KLA BORE
- POLY VIS HV

- SODA ASH
- STAR GEL

These products produce a drilling fluid with low viscosity, high gel strength and sufficient Bentonite content. The Bentonite content of the drilling fluid is critical for drilling boreholes through rock. The fine particles of Bentonite form a thin, low-permeability filter cake around the walls of the borehole. This filter cake seals the pores and other openings in rock preventing the escape of drilling fluid through the rock and the inflow of formation fluids.

The Material Safety Data Sheets (MSDS's) for these products are kept on site.

5 DRILLING FLUID CIRCULATION

It is important to gain an understanding of how drilling fluid is circulated during horizontal directional drilling, to better understand the safeguards and inspection procedures drilling contractor intends to implement to manage drilling fluid during the drilling operations.

The mud gets mixed in the mixing tank. Once the mud has been mixed adequately it is transferred to the active tank. From the active tank the drilling fluid is pumped to the drilling rig, through the drill pipe, into the borehole and onto the cutting face. The drilling fluid then suspends the cuttings and travels out of the borehole and into the borehole returns pit. The borehole returns pit is positioned directly behind the hole entry point. From returns pits the excess mud is extracted using vacuum trucks and disposed offsite.

The site set up plan shown in the work method statement should be referred to for containment facilities such as the site sedimentation fencing, sumps & bunds as this plan only refers to directional drilling fluid related controls.

6 HAZARD PATH IDENTIFICATION

NAP considers any risk to the environment of the area to be unacceptable. To reduce the risk of drilling fluid escaping to the environment NAP has identified the following paths by which it is possible that drilling fluid could enter these sensitive areas.

a) Runoff or surface water could escape the drilling compound during periods of rainfall.
b) Drilling Fluid could escape the drilling compound and potentially find its way into the environment.
c) Drilling Fluid could potentially escape the borehole during drilling through inconsistencies (cracks & fissures) in the rock. This could result in drilling fluid being deposited into underground aquifers or breaking out to the surface.
d) Groundwater could seep into the borehole during the drilling operation. This ingress will result in increased drilling fluid volume and could cause drilling fluid containment facilities to become filled to capacity and possibly overloaded.

These are the only paths by which drilling fluid could be potentially lost to the environment. Therefore it is the goal of this Management Plan to minimise the chance of drilling fluid escaping via these paths through the use of safeguards and the implementation of inspection procedures.

7 SAFEGUARDS

This section deals with the safeguards that the drilling contractor will use during the execution of this project, to control the previously identified potential drilling fluid escape paths.

The following mitigation measures will be put in place to counteract the hazards identified above:

- Earth bunds and drainage channels will be placed around the upper edges of the drill site and work area, to divert natural runoff around and away from the site so that it doesn’t mix with drilling compound runoff. Necessary erosion and sedimentation control measures will be in place.

- All facilities utilised in the surface mud handling (mixing, cleaning & pumping) shall be bunded. This shall ensure natural / clean runoff contained within the compound is not mixed with drilling fluid or contaminated by oil/fuel.

- A sump pit will be constructed at the bottom of the drill site. The sump pit will be positioned (during site planning) so as all runoff from the drilling compound will flow into it. The sump pit is of such dimensions to provide a buffer for the drilling fluid returns.

- An earth bund or silt fencing will be placed on the downstream side of the bund to contain any spillage. The sump pit will be pumped out using vacuum trucks in an as required basis during the drilling operation. This will ensure that any rain event, whilst the drilling crew is not onsite, won't lead to a sump pit overflow.

- All products used to mix the drilling fluid will be covered before they are used to mix the drilling fluid. The unmixed drilling mud shall be stored on pallets keeping them off the ground and not stored within drainage lines. This will prevent the chance of any drilling fluid components escaping the drilling compound and becoming contaminants to the environment.

- All stationery plant & equipment on site is inspected on a daily basis to ensure it is in good working order to minimise the chance of fuel/oil/grease leakage.

- Adequate spill control kits containing absorbent materials, to cleanup spills from mobile equipment outside bunds shall be on site at all times.

- All excess oils and greases shall be contained within the fuel bund in order prevent any chance of leakage. The fuel bund is a fuel tank (4500L capacity) with an inbuilt steel bund able to contain 1.5 times storage capacity of the tank.

- All used oil or grease taken from machinery during services is stored within the fuel bund. The fuel bund is regularly emptied by a licensed contractor

- By designing the drill profile using the best geotechnical information available, the drilling contractor can ensure that an adequate amount of cover can be provided beneath the surface.

- The products selected to mix the drilling fluid have been carefully selected to provide the drilling fluid with sufficient Bentonite content. The Bentonite content of the drilling fluid will ensure a thin, low-permeability filter cake forms on the walls of the borehole. This will ensure no drilling fluid is lost through the walls of the borehole.

- Chances of drilling fluid seeping in the ground through storage pits (returns pits & sump pit) are minimal. Just as the drilling fluid lines the inside of the borehole it will also line the inside pits and provides an impermeable barrier hence stopping fluid from seeping into ground.

8 INSPECTION PLAN

This section deals with the inspection procedures by which NAP intends to ensure the adequacy and integrity of the safeguard measures.

8.1 DRILLING COMPOUND RUNOFF

Earth bunds/drainage channels or silt fencing placed on the downstream side of the drilling compound will be inspected on a daily basis and/or during & after any significant rain event to ensure their adequacy and integrity.

Earth bunding placed around the sump pit will also be inspected on a daily basis and/or after any significant rain event to ensure its adequacy and integrity.

Before the commencement of drilling and at the close down each day, all components of the mud mixing system will be visually inspected to check for signs of drilling fluid loss and to ensure its adequacy for the containment of drilling fluid.

8.2 INGRESS OF GROUND WATER

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected.

8.3 DOWNHOLE FLUID LOSS TO GROUND

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected. Nominated cored holes will also be checked to see if there are any indicators that suggest where the fluid may be lost to.

The bore path will also be visually monitored from the surface for any signs of surface frac-out. In the event of a surface frac-out occurring, all drilling operations will cease and all efforts will be made to contain the frac-out to a localised area. Sand bags will be available on site to bund the area. Excess fluids will be removed from the area using a vacuum truck. If a vacuum truck cannot access the area of frac-out, manual pumping will be used to remediate the area surrounding the frac-out.

9 DRILLING FLUID VOLUME TRACKING PROCEDURE

The drilling fluid volume tracking procedure for the drilling operations is quick and easy. It has been designed this way so that regular and accurate checks can be made throughout each day to ensure that any groundwater ingress or downhole drilling fluid loss is detected quickly. This will minimise the volume of any drilling fluid loss from the compound due to overload of containment facilities (i.e. groundwater ingress) or drilling fluid loss to the ground through the borehole (i.e. downhole drilling fluid loss) and allow remediation activities to start promptly.

The drilling fluid tracking procedure involves a simple volumetric balance between measuring the volume of drilling fluid mixed and comparing it to the volume that the drilling fluid is occupying in the borehole and entry pit (this is dependent of the length of hole drilled and the volume in surface containment facilities). These two values can readily be measured onsite and comparison

of the values will quickly determine the volume of drilling fluid gained due to groundwater ingress or lost due to downhole fluid loss.

It is true that if groundwater ingress were to equal the downhole drilling fluid loss then the drilling fluid volume tracking procedure would not detect any loss. However this situation is extremely unlikely. During normal drilling operations we expect to be pumping 19L/s to 25L/s of drilling fluid up the borehole whilst groundwater water ingress, if any, is expected to be less than 1 L/s.

The measurement of the drilling fluid volume mixed can easily be measured by making the assumption that the volume of drilling fluid produced is equal to the amount of water added to the drilling fluid tank.

The theoretical volume that the drilling fluid is occupying is also a value that can be easily calculated. Two components contribute to this value. The first is the volume of drilling fluid occupying the drilled hole and the second is the volume of drilling fluid contained within the sump pits.

The volume of drilling fluid downhole is a simple calculation knowing the diameter and the length of hole drilled. The volume of drilling fluid contained within the sump pit can also be measured easily onsite. A measurement needs to be taken of the level of drilling fluid within the drilling fluid tank. Knowing this value and knowing the dimension of the containment vessel (vacuum truck) the volume can again be calculated easily.

The drilling contractor will be making this volumetric comparison regularly each day and a minimum of three checks shall be made each shift for the duration of drilling the pilot hole.

Should inconsistent ground material be found during drilling operations (this is unlikely due to the depth of profile beneath the ground and the geotechnical information supplied) the monitoring frequency will be increased to one reading for every 10m drilled.

10 DRILLING FLUID LOSS REPORTING SYSTEM

At this stage it is important to understand that it is normal to expect some drilling fluid loss during a horizontal directional drilling operation. Some losses are expected because the fluid is filling the borehole annulus (between the pipe and the bore walls), because the fluid is lining the edges of the borehole and sump pits. Therefore, it is important that normal drilling fluid losses are taken into account in the reporting system. The reporting system proposed for this project is summarised in the following table:

Drilling Fluid Loss	Situation	Action
0-15%	Normal	Continue Drilling One Reading in 30m Drilled
15-25%	Alarm	Continue Drilling Increase Monitoring Frequency One Reading in 10m Drilled
>25%	Emergency	Cease Drilling Follow Emergency Response Plan Notify Shoalhaven Starches and DPIE before recommencing HDD

10.1 DRILLING FLUID LOSS 0-15%

The volumetric drilling fluid balance has shown 0-15% drilling fluid loss. It is normal to expect some drilling fluid loss during a horizontal directional drilling operation. The situation within this zone is quite acceptable and work should continue on as normal.

10.2 DRILLING FLUID LOSS 15-25%

The volumetric drilling fluid balance has shown 15-25% drilling fluid loss. The loss of drilling fluid has now become a concern. The volumetric balance is immediately recalculated and the drilling compound is checked to ensure there is no other reason for drilling fluid loss besides downhole loss. The drilling fluid volume tracking procedure is increased from normal (three times a day) to hourly checks until the level of drilling fluid loss exceeds 25% or decreases below 10%.

10.3 DRILLING FLUID LOSS > 25%

The drilling fluid tracking procedure has shown that drilling fluid loss has exceeded 25%. It has been checked that the only reason for this drilling fluid loss is downhole drilling fluid losses. The drilling of the borehole is immediately ceased. An incident is declared and incident response procedures implemented as described in the following section 11 . The incident response plan identifies the procedure to be used when Loss of Drilling Fluid (>25%) is experienced.

11 INCIDENT RESPONSE PLAN

Refer to the Incident Management Plan for complete details on incident response procedures. The response to loss downhole drilling fluid loss in general terms will be:

1: Cease Drilling: When downhole loss exceeds 25%

2: Notify Shoalhaven Starches immediately

3: Drilling contractor to co-ordinate sealing of the borehole.

4: Notify DPIE of issue.

5: Notify DPIE prior to recommencing HDD operations.

Possible solutions are as follows:

- Pump Extremely High Viscosity Drilling Fluid in to borehole in order to attempt to gel up the leakage.
- Utilise leak sealing mud additives into the drilling fluid in order to attempt to seal the leakage.
- Addition of loss circulation products such as rice husks, cotton or shredded paper into the drilling fluid in order to attempt to seal the leakage.
- Grouting the borehole at the leakage location and drilling through the grout and continue the hole.
- Using bentonite forms filter around the borehole walls which stops water coming in the hole due to higher annular pressure as compared to the pore pressure.

The response to containment facilities failure in general terms will be:

1: Cease Drilling: When containment failure is detected

2: Notify Shoalhaven Starches immediately

3: NAP and the drilling contractor to co-ordinate containment and cleanup of the drilling fluid leakage.

Possible solutions are as follows:

- Mobilise transportable pumps on the worksite to the location of the spill and transfer the mud to a contained area.
- Utilise the excavator on site to form windrows in order to divert the flow back into contained areas.
- Utilise the excavator on site to dig a temporary hole in order for escaping drilling fluid to gather in and mobilise transportable pumps to transfer mud to a contained area.
- Mobilise additional vacuum trucks to the worksite in case there are no more effective contained areas on the site for the mud to be stored within i.e. cannot utilise transportable pumps to transfer the mud.

HEAD

TRACKING

TOOL

DigiTrak Falcon F5®
Directional Drilling Guidance System

- Wideband technology evaluates hundreds of frequencies for the best possible performance around active interference
- Ultra-low frequency options for battling passive interference on the jobsite
- Scan for interference, select optimum frequencies, and pair transmitter at the jobsite
- Switch between paired bands mid-bore
- Full Scale Sensitive Pitch provides 0.1% resolution through ±99.9% slope for precision grade work
- Max Mode filters noise to boost weak data signals and stabilize depth readings
- Standard warranty for 19- and 15-inch transmitters is 3 years/500 hours

Falcon F5 Is Now *Passive Aggressive*

The ability to choose the right transmitter frequency is more important than power in overcoming the effect of active interference. In October of 2015, DCI introduced Falcon technology, a significant new approach to overcoming active interference on HDD jobsites. DCI now introduces a new approach to addressing the problem of passive interference: sub-kilohertz frequencies. Falcon F5 with Sub-k Rebar capability allows a locating specialist to scan the jobsite and select the best frequency in the ultra-low frequency range of 0.33–0.75 kHz to combat passive interference.

Falcon Innovation Continues

Falcon is the HDD industry's only walkover guidance system able to specifically address both active and passive interference. Transmitter frequencies below 1 kHz are proven most effective for jobsites where passive interference is a problem. In addition, the new Falcon F5 receiver supports Full Scale Sensitive Pitch (FSSP) for 0.1% resolution through ±99.9% slope for precision grade work.

The Falcon F5 receiver offers the industry's first fully integrated GPS capability using the DigiTrak iGPS module. Snap on the iGPS module and it automatically powers on to receive and record satellite GPS data.

Use the free LWD Mobile app to view the progress of the bore and overlay the iGPS locate points on your smart device.

The Falcon F5 Wideband Transmitter

A Falcon F5 transmitter provides versatility in all types of active interference at frequencies of 4.5–45 kHz. The Falcon F5 wideband design vastly outperforms single-frequency transmitters of past generations. It also comes standard with fluid pressure measurement. No other guidance system allows an operator to scan for active interference and then pair optimized frequencies to a transmitter at every jobsite. This provides substantial cost savings and increases pilot bore productivity.

The Falcon F5 Sub-k Rebar Transmitter

The newest entrant into the Falcon F5 wideband transmitter lineup is the Sub-k Rebar transmitter. It uses frequencies below 1 kHz and provides frequency selection options from 0.33–0.75 kHz. This frequency range is ideal for addressing project scenarios that exhibit passive interference. Whether sidewalk, roadway, or runway, the Sub-k outperforms other options above 1 kHz. These transmitters include fluid pressure measurement as a standard feature.

Wideband Sub-k Rebar

Falcon Frequency Optimizer

DIGITAL CONTROL INCORPORATED
dci@digital-control.com ■ www.DigiTrak.com ■ 1.425.251.0559, 1.800.288.3610 (US/CAN)

Jul 402-1025-21-C metric

DigiTrak Falcon F5® Guidance System

	DigiTrak Sub-kHz			The other guys	DigiTrak Wideband								
Band Number	0.3	0.5	0.7		7	11	16	20	25	29	34	38	43
Range in kHz	.33 – .40	.40 – .58	.58 – .75	1.5 – 4.0	4.5 – 9.0	9.0 – 13.5	13.5 – 18	18 – 22.5	22.5 – 27	27 – 31.5	31.5 – 36	36 – 40.5	40.5 – 45

Ease of Use

Falcon F5 raises the bar on walkover locating system capability and ease of use. Our customers have always relied on the Falcon F5's color, icon-driven screen for easy menu navigation. *Ball-in-the-Box* has never been more powerful and still provides a real-time status of the bore in progress. Minimize downtime caused by alternative products that claim to get the job done but often fall short. Keep your project on DigiTrak and maximize your productivity.

3 Year/500 Hour Warranty

Register your new Falcon 19- or 15-inch transmitter within 90 days for an enhanced warranty of 3 years or 500 hours, whichever occurs first. Ask your dealer about an extended warranty option that provides 5 year/750 hour coverage.

Transmitter Specifications

See the separate Falcon F5 Transmitter Specification Sheet for details on the six different 19-, 15-, and 8-inch wideband options for active interference and Sub-k Rebar options for combating passive interference. Falcon F5 also supports our popular DucTrak transmitters.

Receiver Specifications

Product ID	FF5
Model number	FAR5
Receiving frequencies	0.33–45.0 kHz
Telemetry channels[1]	4
Telemetry range[2]	defined by remote display
Power source	Lithium-ion battery pack
Battery life	8–12 hrs
Functions	Menu-driven
Controls	Trigger and toggle switches
Graphic display	Full-color LCD
Audio output	Beeper
Accuracy	±5%
Voltage, current	14.4 VDC nominal, 390 mA max
Operating temperature	-20–60° C
Dimensions	27.94 x 13.97 x 38.1 cm
Weight (with battery)	3.9 kg

Aurora Touchscreen Display Specifications

Product ID and model number	AF8, AF10
Power source - cabled	10–28 VDC
Current	1.75, 2.1 A maximum
Controls	21.3, 26.4 cm touchscreen
Graphic display	LCD
Audio output	Speaker
Telemetry channels[1]	4
Telemetry range[2]	500 m
Operating temperature	-20–60° C
Dimensions[3]	24.9 x 16.8 x 8.1, 29.2 x 23.7 x 5.8 cm
Weight	1.9, 2.9 kg

[1] Local telemetry frequencies and power levels available at www.DigiTrak.com.
[2] Telemetry range can be increased with an optional external receiving antenna.
[3] Dimensions do not include external mounting hardware.

PRE-COM

RISK

ASSESSMENT

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
		ENTER ASSESSMENT DATA				**Procedural Mitigation, Codes of Practice, Australian Standards, Training and Induction Programmes, Physical Mitigation**	ENTER ASSESSMENT DATA				
Horizontal Directional Drilling	Stakeholder impact - injuries and supply/service disruption	3	4	12	High	• Establish Exclusion zone and signage to isolate drill area • Fencing HDD excavation to ensure restricted access • Warning signage • Hazard lights • SWMS for HDD • Entry and exit pits safe distance from access • Traffic Management, if required • Review Drilling and HDD management plan in conjunction with Shoalhaven Starches	2	3	6	Low	Y
	Handling/Bulk Storage/transporting hazardous or dangerous goods - spills, contamination, skin irritation and burns	3	4	12	High	• Ensuring containers labelled and sealed • Register of Dangerous Goods, MSDS in Site Office • Appropriate lift location • Appropriate equipment for handling/transfer • Correct PPE to be worn in accordance with Shoalhaven Starches and NAP induction as well as MSDS requirements • Spill kits in site yard and on refuelling vehicle • MSDS on file and upto date • Employee trained and competent. • Induction. • Shoalhaven Starches Audits • Licensed operator to carry bulk dangerous goods. • All transport done In accordance with EPA guidelines	2	3	6	Low	Y
	Entanglement occurs during drilling - Unauthorised personnel to work area Automated Actions, Pinch points from rod loading and jaw clamps - Soft tissue injuries	3	4	12	High	• Exclusion zone around drill identified • Authorised Persons Only Signage. • Visitor sign on Log. • Obtain Work permit • SWMS for HDD • Machinery guarding • Trained competent operators verified for employees / subcontractors • No loose clothing allowed • Isolation & tag out protocols for maintenance	2	4	8	Moderate	Y
	Noise emitted from drilling plant - OH&S issues	5	3	15	High	• All plant to be risk assessed and have scheduled maintenance / servicing • Selection of equipment to provide noise attenuation • Appropriate PPE • Job rotation to reduce exposure limit (Where required)	2	2	4	Negligible	Y
	Impact with an existing services - injuries	3	4	12	High	• Approved Boring Procedure and HDD Management Plan in conjunction with NAP and Shoalhaven Starches requirements • Tracking of the bore during drilling • Exposure of services where possible, with spotter when borer is in proximity. • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipelines • DBYD and service register to be developed to ascertain risk of impact to services	2	4	8	Moderate	Y
	Drilling Failure - major supply/service issues	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan.	2	4	8	Moderate	Y

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
						• Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline • Emergency response plan (Frac out management plan)					
	Frac out occurring impacting roadways / environment	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan • Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline / impact to road • Emergency response plan (Frac out management plan)	2	4	8	Moderate	Y

SWMS

Jelmac Industries Pty Ltd
2 Jeanette Maree Court
Kilsyth VIC 3137
Phone: 0417 351 908
ABN: 60 165 118 972

Jelmac Industries Pty Ltd
SWMS
Safe Work Method Statement

THIS FORM IS TO IDENTIFY TASK / SITE HAZARDS AND TO MINIMISE THE RISKS TO PERSONS AND/OR DAMAGE TO PROPERTY.					
Project:	National Australia Pipelines				
Site Address:	Railway Bore				
Site Muster Point:		**Start Date:**		**Supervisor**	Brad Boote
Specific Task:	Directional Drilling & Vacuum Truck	**Finish Date:**		**Phone:**	0417351908
Plant & Equipment:	Directional Drill, Vacuum Truck, Support Vehicle. Hand tools.				
Hazardous Materials:					
Personal Protective Equipment Required:	Uniform; Footwear ☑; Hi Visibility ☑; Hard Hat ☑; Eyewear ☑; Fall Arrest ☐; Gloves ☑; Hearing ☑; Dust Mask ☑; First Aid ☑				
Managers Approval:	Brad Boote	**Signed:**		**Date:**	20-01-2022

CONSEQUENCES	POSSIBLE COURSES OF ACTION	LIKELIHOOD	MINOR (1)	SERIOUS (2)	SEVERE (3)	MAJOR (4)	CATASTROPHIC (5)
MINOR	First Aid, No Medical Treatment required. Spillages, leaks or other escapes, which occur and are contained. Supervisor to report and monitor.	(A)...ALMOST CERTAIN Will likely occur once or more every couple of years. Expected to or occurs regularly.	Medium	High	High	Extreme	Extreme
SERIOUS	Lost time injury/medical treatment required. Spillages or leakages, which have migrated offsite. Supervisor to report and manage by routine procedures. Immediate reparative/first aid action required.	(B)...LIKELY Will likely occur once or more in 10 years.	Low	Medium	High	High	Extreme
SEVERE	Single permanent or partial disability. Discharge of any substance from site, which has the potential to harm the environment. Supervisor to report and manage by specific monitoring plan or procedures. Stop work, immediate reparative/first aid action required.	(C)...POSSIBLE Could occur but not probable. Has not occurred at Jelmac.	Low	Low	Medium	High	High
MAJOR	Total permanent disability. Actual material harm to the environment on or off site with short-term effects and reparable by remedial action. Supervisor to report and allocate responsibility to appropriate senior manager. Stop work, immediate attention needed urgently.	(D)...UNLIKELY Not expected to occur. Has not occurred at Jelmac but has occurred within the industry in Australia.	Negligible	Low	Low	Medium	High
CATASTROPHIC	Multiple fatalities or total permanent disability. Actual material harm to the environment on or offsite with long term or irreparable effects. Supervisor to report and notify appropriate senior manager to manage via detailed control plan. Stop work, quarantine site, supervisor to contact relevant emergency services.	(E)...RARE May occur in exceptional circumstances. Has occurred in known history in the industry.	Negligible	Negligible	Low	Low	Medium

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Standards & Requirements	Occupation Health & Safety (OHS) Act 2004, Occupation Health & Safety (OHS) Regulations 2007,	FSR1: Temporary works, excavations and underground and overhead services FSR 02: Plant Equipment NAP Ground Penetration Permit	NAE PTW Certificates of Competency TM Plan

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Safety Management	Lack of safe work practices places workers, public and wildlife at risk.	A	5	E	All Jelmac Directional Drilling staff members are issued upon acceptance of employment a Safety Folder containing all occupational health and safety procedures. Staff members are expected to refer to and follow these procedures to ensure safe work practices. Staff and emergency contact details are provided at the rear of the folder. Site-specific forms SWMS and JSA are available.	E	3	L	Management/ Supervisors/ All Personnel
	First Aid	Lack of sufficient first aid can significantly increase injury.	C	3	M	All vehicles are equipped with a Standard Workplace First Aid Kit. Injury is to be assessed and medical assistance sought if required. Follow Emergency Procedures if required and consult Emergency Contact Details if necessary.	C	2	L	Management/ Supervisors/ All Personnel
	Environmental Management	Wildlife, significant vegetation, noxious weeds, waste, hazardous chemicals and materials.	C	3	M	Identify Environmental Management procedure. Inspect, identify and assess risks. Ensure compliance with local, state or EPA guidelines. Ensure safe removal or avoidance of any wildlife and or vegetation. Ensure wash down of plant and machinery to avoid transfer of any noxious weeds. If asbestos is encountered, stop works immediately and contact engineer or supervisor. Control of Drill slurry , erect silt controls at Bore entry & exit, Remove excess via Vac unit for disposal to EPA accredited site	E	1	N	Management/ Supervisors/ All Personnel

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	Emergency Preparedness	Fire, explosion, flood, bush fire, bomb threats.	E	5	M	Plant and LV Inductions need to be completed. Identify Emergency Procedures procedure. Assess location and impending weather conditions and forecast. All trucks and plant are equipped with fire extinguishers, which are all current with tags as per legislative requirements. Ensure any hoses are clearly labelled and accessible, ensure work areas suitable, secure and clear, avoid creating fire hazards and consider evacuation plans. Identify Emergency Contact Details form. Ensure all staff are identified and accounted for in the event of an emergency.	E	3	L	Management/ Supervisors/ All Personnel
	Weather	Exposure to UV radiation, extreme weather conditions (Extreme heat, Rain, Storms), Visibility.	C	2	L	Identify and assess impending weather conditions and forecast. Use sunscreen, hats/protective brims, long sleeve shirts, and neck flaps. Reassess site and work conditions in extreme weather conditions or poor visibility. Source extra equipment; modify safe work practices or hours of work as necessary.	E	2	N	Management/ Supervisors/ All Personnel
	PPE (Personal Protective Equipment)	Inappropriate or inadequate personal protective equipment can result in injury, overexposure to elements and lack of identification to the public or co-workers.	C	2	L	Issue of appropriate personal protective equipment prior to works or as required per task – long sleeves and trousers to be worn at all times. All staff must wear high visibility clothing and/or vests and approved safety boots wherever applicable. Hard hats and safety glasses are issued at employment and are to be worn at all times. Sunscreen is available to all staff at all times. Staff members are expected to return worn/damaged items to management for replacement.	E	2	N	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Drive to or from site and site access	Vehicular and Pedestrian Traffic. Collisions with other vehicles. Collisions with static structures. Collisions with pedestrians.	**A**	**5**	**E**	Driver must be appropriately licenced for the class of vehicle being driven/operated. Driver must abide all road rules. Driver must ensure vehicle is fit for task, road worthy, registered and must complete a Daily Plant Checklist prior to use. All personnel are to be made aware of the "Safe Entry and Exit of Worksite" procedure and be pre-started prior to entering site.	**B**	**5**	**E**	Driver
	Establish correct location	Time Wastage / economic loss.	**B**	**1**	**L**	Correct documentation and plans, effective communication. Refer to engineers construction pack,	**E**	**1**	**N**	Site Supervisor
	Traffic Management	Struck By Traffic Pedestrian Interface Non Compliance	**B**	**3**	**H**	No works within 7 metres of road without Traffic Management in place. Must have a spotter/observer to monitor pedestrian traffic and any site movement. Pedestrians to be escorted around works where required. Ensure a No Go Zone around Directional Drill and points of drill head entry and exit by placement of Temporary fencing for full perimeter of work zones to ensure public and personnel safety. Works in shared user path, access to be maintained at all times. Beware of pedestrians and implement exclusion zone. Refer to vehicle access plan	**E**	**2**	**N**	Site Supervisor / All Personnel
	Manual Handling	Physical Injury	**C**	**2**	**L**	Determine position, size and weight of object. Consider use of mechanical aids or extra personnel for task. Ensure appropriate personal protective equipment is worn. Adopt good posture and movement technique. Two persons required to reposition temporary timber stairs for batter access. Report any injuries or near miss and always consider any relevant improvements.	**D**	**1**	**N**	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Using hand tools	Manual Handling, condition and maintenance, incorrect usage, risk of injury, use as a weapon.	C	2	L	Ensure manual handling advice and techniques are employed. Consider and ensure you are using the appropriate tool for the task. Ensure tools are inspected and maintained, replace if damaged. Ensure all tools are accounted for and secure.	E	2	N	Site Supervisor / All Personnel
	Working with chemicals	Spillage, Explosion, Inhalation, Absorption & Ingestion	D	3	L	All chemicals to be used in conjunction with appropriate SDS, which are attached to the back of the SWMS. Ensure compliance with EPA guidelines. Ensure suitable storage and transport. SDS available at hand. Ensure user competency, adequate signage, and chemical spill / clean-up kits available, personal protective equipment available. Identify Emergency Contact Details.	E	3	L	Site Supervisor / All Personnel
	Presence of existing services	Striking of services	B	4	H	Identify and assess location. NAP Ground Penetration Permit Action Dial Before You Dig information. Identify asset owners. Pothole, hand expose and sight all high-risk services outside of rail corridor on each side of the proposed alignment in order to ascertain inverts and alignments of assets in the design vicinity so the bore design can be considered in relation to existing assets. Modify route and or employ safe work practices to avoid disturbance or damages to at risk services.	E	3	L	Management/ Site Supervisor

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Plant, machinery and equipment	Compliance/ Failure	D	2	L	All plant and equipment to be site inspected. Ensure all plant and equipment is inspected and cleared for use. Pre-start equipment checks, Regular service and maintenance checks and records.	E	1	N	All Personnel
		Movement of vehicles and machinery	B	4	H	Ensure machinery is equipped with suitable warning and hazard identifying devices (e.g. signs, lights, and alarms) and appropriately maintained. All operators hold appropriate license/s, to be VOC'd and comply with plant manufacturers operating guidelines. Ensure site awareness and security is maintained prior to operation. Exclusion zone of 5m to be maintained from drill head when operational.	D	4	M	All Personnel
		Spillage of diesel fuel and/or oil and lubricants	D	2	L	Refuelling to occur at properly designated area e.g. service station or depot refuelling area. Vehicle to carry Spills Kit to absorb any accidental leakage.	D	1	N	All Personnel
		Presence of existing overhead services	C	3	M	Identify any overhead services and ensure safe working distance from service is maintained.	E	3	L	All Personnel
	Unloading and Set Up Of Machinery.	Unloading plant from truck	C	3	M	Assess area for potential hazards i.e. uneven ground, overhead obstacles, safe deployment of ramps. No standing or climbing on the back of trucks without handrails.	E	1	N	All Personnel
		Overhead obstacles	C	3	M	Move to safer location.	E	1	N	All Personnel
		Ramps	C	2	L	Ensure appropriate ramps are installed and maintained.	E	2	N	All Personnel

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	Boring.	Machine Failure	C	1	L	Pre-start equipment checks, regular service and maintenance checks and records.	E	1	N	All Personnel
		Slipping from batter	C	5	H	No walking on batter. Access only using the stairs provided.	E	2	N	All Personnel
		Excess Drill Mud	C	1	L	Use vacuum truck to remove sludge during the drilling process. Dispose of excess Drilling slurry to an EPA accredited facility	D	1	N	All Personnel
		Frac out	C	1	L	Stop and assess immediate risk and secure if necessary. Use Vac Truck to remove sludge. Erect Silt Controls Prevent any flows to Drainage system, inclusive of Ground water. All clean up via vac unit	D	1	N	All Personnel
		Pipe pull back	C	3	M	Ensure effective communication with drill rig operator. Monitor Mud flows as annular space is filled, Removing excess via vac unit for disposal to an EPA facility.	E	3	L	All Personnel
	Site Reinstatement	Open excavations / Open pits	C	3	M	Backfill or secure. Ensure all lids are replaced or open pits secured.	E	2	N	All Personnel
		Trip Hazards	C	2	L	Remove.	E	1	N	All Personnel
		Heavy equipment, tools, products	C	2	L	Correct manual handling techniques.	D	1	N	All Personnel

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EMPLOYEE SIGN OFF

I have read and understood all tasks, hazards and control measures described within this document and agree to comply with the controls prescribed herein.

No.	Name of Employee	Date	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

TRAFFIC MANAGEMENT PLANS

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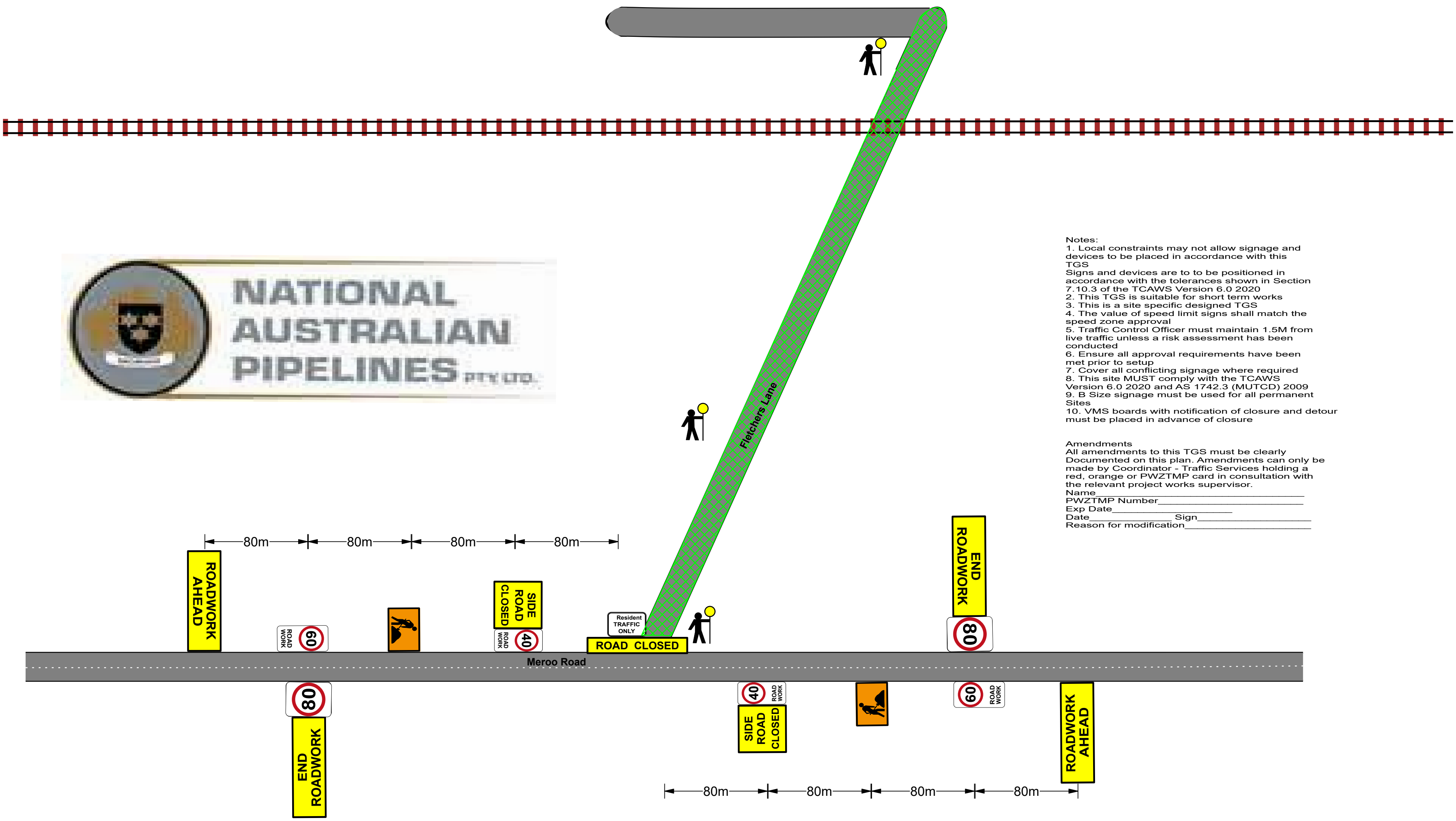
NATIONAL AUSTRALIAN PIPELINES PTY LTD



Notes:
1. Local constraints may not allow signage and devices to be placed in accordance with this TGS
Signs and devices are to to be positioned in accordance with the tolerances shown in Section 7.10.3 of the TCAWS Version 6.0 2020
2. This TGS is suitable for short term works
3. This is a site specific designed TGS
4. The value of speed limit signs shall match the speed zone approval
5. Traffic Control Officer must maintain 1.5M from live traffic unless a risk assessment has been conducted
6. Ensure all approval requirements have been met prior to setup
7. Cover all conflicting signage where required
8. This site MUST comply with the TCAWS Version 6.0 2020 and AS 1742.3 (MUTCD) 2009
9. B Size signage must be used for all permanent Sites
10. VMS boards with notification of closure and detour must be placed in advance of closure

Amendments
All amendments to this TGS must be clearly Documented on this plan. Amendments can only be made by Coordinator - Traffic Services holding a red, orange or PWZTMP card in consultation with the relevant project works supervisor.
Name________________________________
PWZTMP Number_______________________
Exp Date____________________
Date_______________ Sign____________________
Reason for modification______________________

Traffic PROFESSIONALS

Implemented By

Name -

Signed -

Cert No -

Fletchers Lane Closure

WORKERS ON FOOT
NO GO ZONE =
RESTRICTED ZONE =
SHARED ZONE =
SITE EXIT = X
SITE ENTRY = E
EVACUATION POINT = EP

D = THE SPEED OF TRAFFIC MEASURED IN KM/H

EG: 80KM = 80M
70KM = 70M
60KM = 60M
50KM = 50M

SEE SECTION 4.2
TRAFFIC CONTROL AT WORK SITES MANUAL

WORK AREA =

TGS USED AS A GUIDE

PREPARED BY Maryann Spresser
PWZT TCT004609 : Expiry: 13/07/2022

TMP No:
TMPACs-NAP-02
TGS Designed Date: 25/11/2021
TGS Expire Date: 25/11/2022

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

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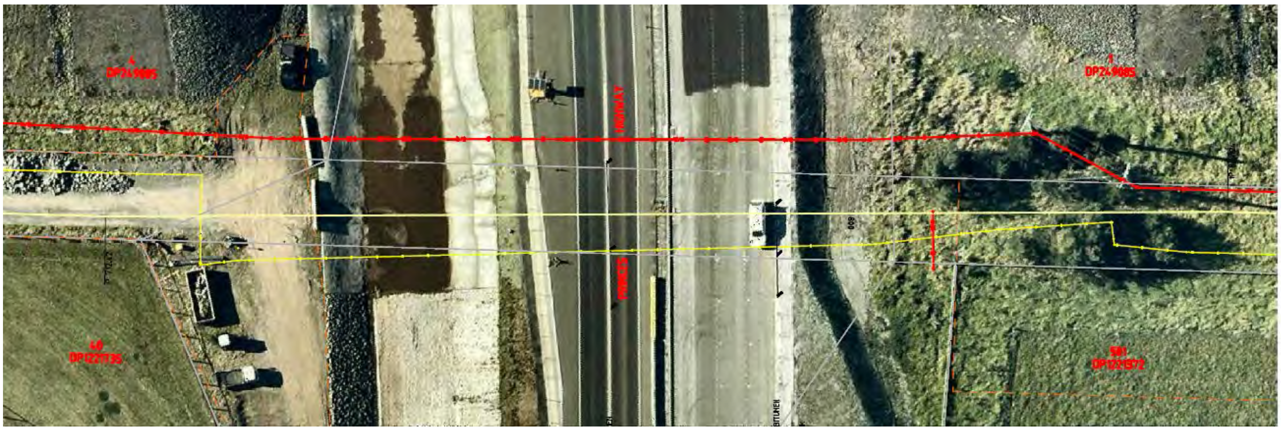
SHOALHAVEN STARCHES PTY LTD

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS – SHOALHAVEN STARCHES BOMADERRY



Princes Highway Crossing HDD

Work Method Statement

Document No.		NAP-SS-WMS-01		
Revision:	**Date:**	**Prepared**	**Checked**	**Approved**
Rev A	18/01/21	Mukesh Bhatia	Ajay Kesavan	Martin Moran

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APPENDIX

- Fluid Management Plan
- Proposed Design
- Pull Back Calculations
- Overbend Calculations
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS
- Geotech
- Plant Risk Assessment
- Traffic Management Plans

1.0 INTRODUCTION

The purpose of this method statement is to provide specific instruction for the following work scope to ensure the works are adequately planned and delivered in accordance with Construction Specifications.

1.1 SCOPE

The scope of work applicable to this method statement is associated with the installation of crossings by HDD trenchless technology for Princes Highway crossings shown on the Shoalhaven Starches Natural Gas Pipeline IFC drawings as detailed below:

1. Drawing SS-NGP-PL-ALIGN_SHT_003 and
2. Drawing SS-NGP-XS-03

In HDD Construction, the carrier pipe string is pulled into a borehole drilled to a certain radius with minimal bending of the pipe during pull through. The pilot drill hole commences at ground level away from the entry pit with the drill rods levelling out at the required crossing depth prior to the entry pit. The drill rods are guided through the entry pit to the exit pit.

Note - The receiving pit will be pre-dug with a lead in trench/ ramp put in place to allow smooth pull back of the HDD pipe strings from the above ground position and into the reamed hole.

1.2 ABREVIATIONS AND DEFINITIONS

ALARP	As Low As Reasonable Practical
Checklist	A document that records or defines the actions that must be undertaken for a given task.
DBYD	Dial Before You Dig 1100
DPI&E	Department of Planning Industry and Environment NSW
TfNSW	Transport for NSW
Hazard	Any operation or task that places personnel or equipment at risk to death, injury and or damage
JSEA	Job Safety Environmental Analysis
NCR	Non-Conformance Report
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
ROW	Right of Way
NAP	National Australia Pipeline Pty Ltd

Supervisor	The responsible person who oversees, or directs control of works being undertaken during the construction of the pipeline
TMP	Traffic Management Plan

1.3 REFERENCES

1. TfNSW Ref. STH11/00145/05 and STH11/00145/06 Dated 28 October 2021 Attachment 1 detailing conditions for Road related matters in response to consultation for application to modify concept plan (MP10_0144 MOD1) and Project Approval (MP10_018 MOD1) SHOALHAVEN STARCHES GAS PIPELINE PROJECT - INCREASE IN PIPELINE DIAMETER AND ASSOCIATED WORKS.
2. Shoalhaven Starches Natural Gas Pipeline IFC drawings
    a. SS-NGP-PL-ALIGN_SHT_003 and
    b. SS-NGP-XS-03
3. Golder Associates' Geotechnical Investigation Factual Report No. 1414569-049-r-Rev2 Dated 21 July 2017, Borehole Data for Bore Hole ID's BH1031, BH-PLB-01 and BHP-PLB-07.
4. Shoalhaven Starches Natural Gas Pipeline Construction Environmental Management Plan (CEMP)
5. Shoalhaven Starches Natural Gas Pipeline Construction Safety Management Plan (CSMP)
6. NAP Management Plans

1.4 PERMITS

The following approvals/permits need to be in place before commencement of site works.

1. Development Application Approval
2. Pipeline License
3. Consent to Construct
4. TfNSW Approval
5. TMP Approval
6. Council Road Opening Permits
7. Worksafe Notification

1.5 TRAFFIC MANAGEMENT PLAN (TMP)

There will be localised closure of Pestells Lane during the HDD operation.

Speed reduction will be enforced on Meroo Rd

Speed reduction may also be required on Princess Highway during the pilot drilling phase to assist with head tracking.

The proposed traffic management plans are attached herewith.

1.6 RESPONSIBILITIES

The Project Management Team – Project Manager, Engineer, Construction Supervisor and HSE Officer – shall ensure that all project staff are adequately skilled to perform their assigned tasks and are aware of their obligations and responsibilities with regards to OH&S, Environmental Management, Quality Assurance, Industrial Relations and Administrative Functions.

The Crew Supervisor shall be responsible for the coordination of the personnel, equipment, and materials to complete the works in accordance with the relevant specifications.

1.7 JOB DESCRIPTIONS

All site personnel will have a formal job description. Detailed job descriptions for personnel have been developed and approved by the Project Manager.

To ensure that the Project is managed in accordance with the requirements of the Project and that of the contract the following key personnel have the following responsibilities.

1.7.1 Project Manager

The Project Manager is responsible for the planning, monitoring and overall execution and performance of the construction project.

The Project Manager has the authority to:

- Approve the Project Quality Management Plan and other key deliverables
- Appoint and terminate Project staff
- Delegate responsibility and authority to Project staff
- Ensuring all construction activities are performed in a safe and timely manner in accordance with the procedures, specifications, and good industry practice.
- Managing construction supervision, labour and subcontractors
- Planning construction activities
- Hold ultimate responsibility for all drilling related decisions
- Has the overall responsibility for ensuring safe work practices are followed through all aspects of the work and attends safety committee and other meetings as necessary
- Undertake Safety Audits to ensure compliance with the Safety Management Plan.
- Evaluate day to day operational safety of site with particular focus on looking for potential hazards which can be identified and remedied prior to incidents occurring.

9.0 HAZARD IDENTIFICATION AND RISK MANAGEMENT

The NAP shall, so far as reasonably practicable, ensure that any manager or supervisor is provided with such information, instruction, and training as are necessary to ensure that each employee under their management or supervision is, while at work, so far as is reasonably practicable, safe from injury and risks to health.

All personnel must be committed to achieving a safe working environment and strive to fulfill the objectives of the Project Health, Safety and Environment policy with compliance to the Safety Management Plan and the Environmental Management Plan.

9.1 MANAGEMENT CONTROLS

9.1.1 Risk Assessment

A full project risk assessment has been undertaken and the mitigation measures identified in this have been incorporated into this Work Method Statement. A JSEA will be produced by carrying out a risk assessment on this Work Method Statement and incorporating input from work crews. Each Crew member will be required to review this JSEA.

9.1.2 JSEA

The base JSEA shall be developed with input from the Project Manager. The JSEA shall be reviewed and added to, as required by each crew, utilizing their experience in conducting the task. All crew personnel are to review and sign onto the JSEA before work begins.

Ideally, the Risk Assessment and JSEA would be added to this method statement for each task.

9.1.3 Pre-Start

Supervisors shall ensure that meetings are held prior to starting each shift, and/or whenever the work scope changes. The meetings should:

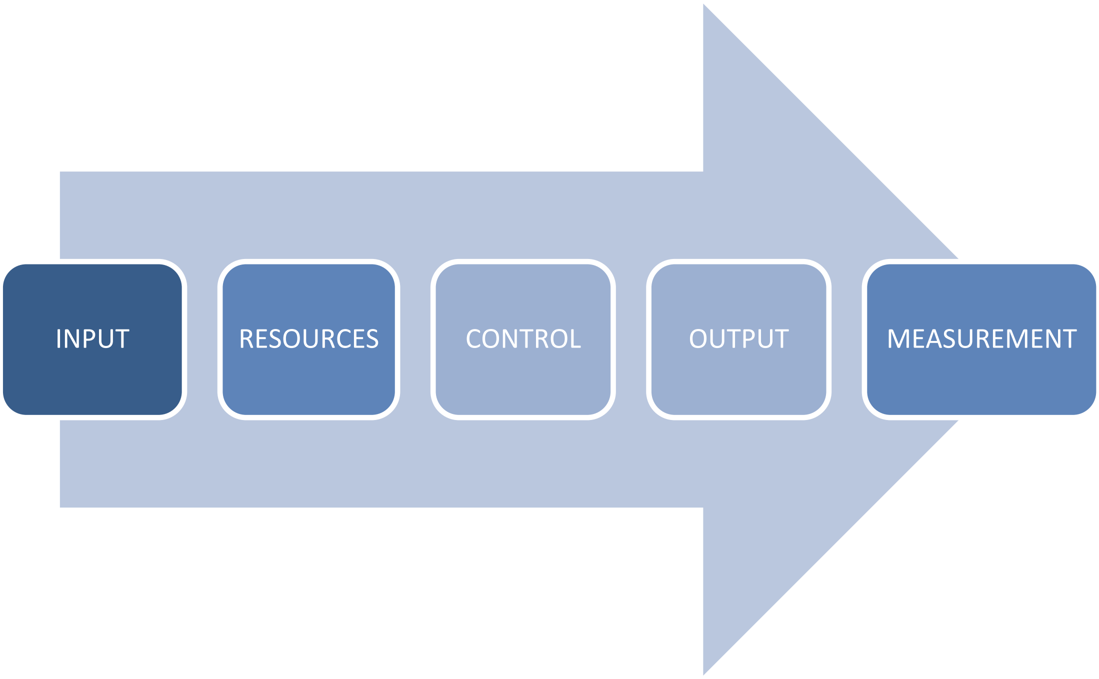
- Review the state of the works as left by the previous shift
- The target progress for the current shift
- The means of achieving the target progress
- The state of works required at the end of the shift
- Any additional safety hazards (changing conditions as work progresses)
- Any environmental hazards

9.1.4 Tool Box Meeting

Tool box meetings shall be held at regular intervals. The tool box meetings will be used to relay information such as hazard alerts between crews and make all crews aware of larger issues and general hazards.

10.0 METHOD

10.1.1 Horizontal Directional Drilling

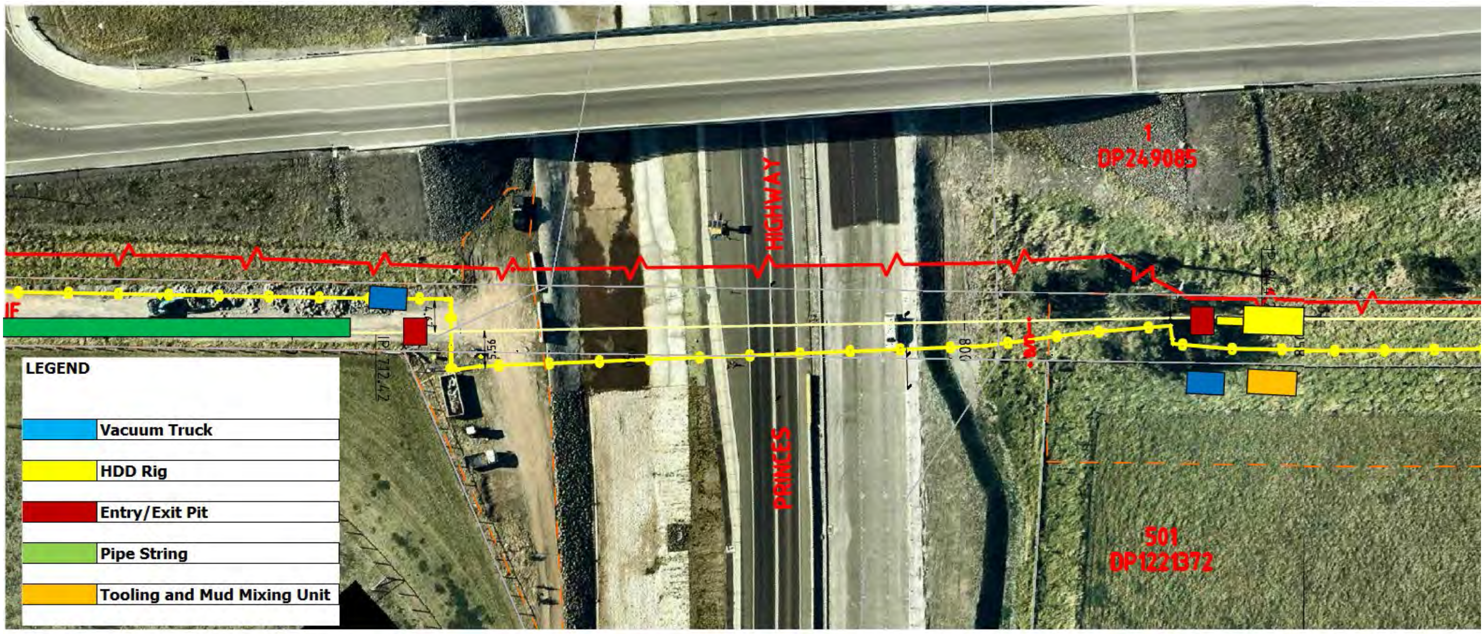


INPUT	RESOURCES	CONTROL	OUTPUT	MEASUREMENT
Pipes strung	Equipment	Inspection	Installed pipeline	QSE Key Performance Indicators
Group	Operators	Permits	Pipeline naturally grouted	No outstanding NCR's or Client queries
Other materials		Surveyed Alignment	Entry & Exit point reinstated	
		Management Plans	As built Survey Data	

10.1.2 EQUIPMENT

- Vermeer D80x100 Horizontal Directional Drill
- Digitrak Falcon F5 locator
- Tooling for piloting & Reaming Process
- Vermeer MX240 Mud Mixing station
- Vacuum truck for fluid evacuation

10.1.3 PROPOSED LAYOUT



10.1.4 GEOLOGY

Sandy Clayey Gravel as per Geotechnical Investigation Report; relevant bore holes data as detailed in reference above.

10.1.5 LENGTH OF BORE AND PROFILE

Bore length – 120m Approx

Bore profile – SS-NGP-XS-03

Depth to top of pipe under road – Ranges between 3.5m to 7.5m

Radius – 400m

10.1.6 DESIGN CONSIDERATIONS

NAP has completed the following:

- Pipeline installation stress analysis has been completed
- Frac Out Management Plan
- Overbend Stress Calculations

On a general note, based on the pipeline calculations the expected pipeline stresses are well within the Specified Minimum Yield Stress with large safety margins.

Frac out risk has been minimised by:

- Ensuring that the bore is deep under significant assets
- The drill pressures are monitored and regulated
- Appropriate mud mixes are selected
- The bore hole is reamed to at least 1.5 times the diameter of the pipeline
- Ensuring that appropriate mitigation measures are in place in the event of frac out i.e. vacuum trucks, pumps, silt fencing, traffic management etc.

10.1.7 CONSTRUCTION STEPS

1. Establish Drill unit
2. Existing Assets located and proved prior to bore commencing
3. Entry & exit points pre excavated.
4. Install silt controls at bore entry and exit points in order to prevent any produced drill slurry or ground water from entry to drainage systems, these fluids will be removed via Vacuum trucks for appropriate disposal to an accredited EPA site.
5. Recheck detail of all existing assets to ensure they have been proven and located prior to commencement
6. Scan bore path for interference prior to commencement
7. Entry and exit points of bore to be excavated 500mm below invert to capture and retain produced bore slurry for removal via vac unit
8. Commence pilot to designed bore plan recording invert & alignment on route – pilot process cuts the soil and utilises drill muds to carry cuttings to entry/exit points for removal via vac unit. (approx. Diameter of Drill head Cutting edge = 125mm)
9. As the bore is being piloted our tracker monitors bore alignment and invert throughout the progression of the bore in order to construct as per design – As the tracker checks this data the drill operator can see on a screen in real time – The driller and tracker are in contact via UHF Radio – specific frequency throughout the entire process.
10. Upon pilot reaching destined exit point / pipe pullback point the drill head will be removed and a reamer (approx. 300mm, followed by 450mm) will be installed, reaming of bore continues for full length of the alignment, during which drilling muds are introduced which seal the bore walls hence permitting the naturally reamed product to blend with the drilling enhancing muds which flow to the entry exit points for removal via vac unit.

11. Throughout all piloting and reaming processes the entry and exit points are monitored for adequate mud flows at each point to ensure that a pressure point does not develop in bore.
12. Throughout all piloting and reaming processes, the bore is left flooded with drill slurry which consists of Naturally reamed and introduced bore enhancing products which fills void and supports the constructed bore.
13. Once the borehole is fully reamed, a pulling device is connected to the pipeline string via a swivel. The pullback then commences at a controlled speed.
14. The swivel between the pipe being installed and the drill string permits the pipe to rotate as friction requires between the drill slurry in bore and the 300NB pipe being installed.
15. The bore being full of drill slurry will be naturally displaced as the pipe is installed into the bore hole, the excess slurry transfers to both entry & exit points, which will be removed via vac units for disposal
16. As a result the annular space becomes fully grouted with naturally and introduced product resultant from the drilling process.
17. All surplus drilling slurry is removed from site and disposed of at an EPA registered disposal site

10.1.8 Risks regarding HDD process & Control Plan

Risk	**Controls**
Heave of Surface	All relative processes, Piloting, Reaming & pullback, The Drill tooling cuts the soils, we do not force or thrust our tooling in order to remove the natural product, The naturally cut product is encapsulated by use of the Mud Mixing enhancing products permitting the mix to flow to entry & exit points for extraction
	Throughout Piloting, Reaming and pullback the entry and exit shafts as well as bore path are monitored to ensure muds are flowing and no pressure point develops within the bore, If so work ceases and re swabbing commences to loosen up any blockage in order to recommence mud flows then re continue the relevant process
Frac Out	Can occur due to the geological conditions i.e. if not consistent. In the event this occurs,

	cease work, contain fluids, remove with vac unit, consider additional additives and action , alternatively excavate and use as a relief point for extraction of muds via a vac unit. Controls in order to eliminate this risk are by utilizing a sealing mud mix, together with at all times having a fully fluid charged bore. This risk is also mitigated due to the depth exceeding 7 metres to which the risk of Frac out or surface disruption is negligible.
Subsidence / Collapsing bore	Point 1 : the bore at all times will be fully charged with a heavy mud mix therefore a void never exists Point 2: Upon Pullback the annular space is naturally grouted with Naturally occurring spoils and Enhancing products Point 3 : at the design depths due to a fully charged bore at all times with Bore wall sealing products moisture and solids will remain in bore resulting in a supported bore at all times
Loss of Drill head (breakage)	Prior to commencing the bore the Drill head will be checked for fatigue to threads any cracking or distortion, If any of the above is evident the Drill head will be replaced by a conforming tool. The starter rod and hex collar to which the drill head connects to the drill rods will also be inspected for fatigue, distortion and cracks, if any of the above is evident this item of tooling will be replaced with a new unit. The hex collar (locking device between the starter rod and Drill head) will be checked for cracking, fatigue and distortion; if any of the above is evident a new unit will be

	supplemented. The Grub screw (hex collar retaining device) will be inspected for fatigue, thread damage, should any of the above be evident then the grub screw will be replaced by a new item. All the above ensure that the drill head and affiliated tooling are suitable to perform the required tasks. In the event that the drill head should break from the drill string sub surface within the Freeway, then the drill string will be withdrawn and the drill head will remain in soil at this location. The pilot bore will be full of Natural product from cuttings, this will be capped at surface to ensure no voids are present. Furthermore assuring that no annular space exists. New tooling will be installed and a new pilot will be performed, while abandoning the broken tooling. Should a breakage such as this occur outside the freeway then the point of breakage would be excavated to retrieve the broken tooling and backfill accordingly to standard excavation and backfilling practices. New tooling will be installed and the bore construction will continue in the exiting pilot bore and achieve the desired pilot prior to reaming

10.1.9 Mud Mix:

- A bentonite mix of 1 bag per 1000 litres is nominated to be used
- This product ensure the bore walls are sealed retaining fluids to bore, and to suspend the drill cuttings which is transferred to the eduction point, reducing friction while ensuring good flows are maintained throughout drilling and reaming processes.
- By utilizing the nominated Mud Mix this ensures a filter cake is built to seal and support the bore, the bore retains integrity due to this filter cake and the bore full of slurry prevents any collapse of the bore hole.
- Throughout the entire process drilling fluid /slurry is at all times ahead of and behind the tooling, at no time does a void exist.

APPENDIX

- Fluid Management Plan
- Proposed Design
- Pull Back Calculations
- Overbend Calculations
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS
- Geotech
- Plant Risk Assessment
- Traffic Management Plans

FLUID MANAGEMENT PLAN

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.
ABN 88 005 339 211

SHOALHAVEN STARCHES

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATION

FLUID MANAGEMENT PLAN & FRAC OUT MANAGEMENT

P.O. BOX 190 WHITTLESEA, VIC 3757 PH: 03 9716 3277 FAX: 03 9716 3244

National Australian Pipelines Pty. Ltd.

Natural Gas Pipeline and Pressure Reduction Station

Client: Shoalhaven Starches

Revision:	Issue Date:	Approved by:
Rev.0	20/01/2022	Martin J. Moran

Table of Contents

1 INTRODUCTION

It is recognised by National Australian Pipelines (NAP) that the consequences of any drilling fluid escaping the HDD drilling site compounds could be significant.

This Drilling Fluid Management Plan (FMP) addresses the following issues:

- The Purpose and Properties of Drilling Fluid;
- The Use of Drilling Fluid during a HDD operation;
- The Possible Paths by which Drilling Fluid could be lost to the environment;
- Safeguards the drilling contractor will put in place to minimise the chance of Drilling Fluid being lost to the environment;
- Inspection Procedures the drilling contractor will implement to ensure the safeguards are adequately maintained;
- Drilling Fluid Volume Tracking Procedures the drilling contractor will use to ensure that drilling fluid volumes are being checked;
- Drilling Fluid Loss Incident Management Procedure that will be used if Drilling Fluid Loss has been detected;
- Management of ground water ingress.

NAP believes the implementation of this Management Plan will:

- Ensure all practical safeguards are put in place to minimise the chance of Drilling Fluid being lost to the environment.
- Inspection Procedures will be in operation to maintain the integrity of the safeguards.
- Volumetric Drilling Fluid Tracking Procedures will be in operation to ensure that if Drilling Fluid is being lost or gained is detected and action taken.

2 CONTROL & DISTRIBUTION

The NAP Project Engineer controls this document. The Project Engineer shall ensure all persons named below are issued with a current copy.

REV NO.	CONTROLLED COPY ISSUED TO	ORGANISATION
Rev 0	Paul Whisson	Shoalhaven Starches
Rev 0	Colin Field	NAP (Site Copy)

3 GEOTECHNICAL AND HYDROLOGICAL ENVIRONMENT

The geotechnical investigation report indicates that majority of the borehole length shall be drilled through competent strata. This formation is inherently stable and is ideal for maintaining an open hole.

4 DRILLING FLUID

Drilling Fluid is a major factor in the success of any directional drilling program, and as such deserves careful consideration. The principal functions of the drilling fluid during a successful Directional Drilling operation are:

- To drive downhole motors, drill bits and reamers.
- To remove the cuttings from the bottom of the hole and carry them to the entry point.
- To cool and lubricate the drill string and drill bit.
- To line, support and protect the walls of the hole.

For a Horizontal Directional Drilling operation, the fluid demands are different from those required for drilling vertical wells. Hole cleaning ability or the ability of the drilling fluid to suspend cuttings is a much more critical factor for Horizontal Directional Drilling. Gel strength is the measure of this property.

For Horizontal Directional Drilling, low viscosity and high gel strength are required to ensure the cuttings are effectively suspended in the slurry and returned to the entry point. The drilling contractor is very experienced in Horizontal Directional Drilling operations and will be using some of the following products to mix the Drilling Fluid and guarantee these properties are met:

- BENTONITE
- KLA BORE
- POLY VIS HV

- SODA ASH
- STAR GEL

These products produce a drilling fluid with low viscosity, high gel strength and sufficient Bentonite content. The Bentonite content of the drilling fluid is critical for drilling boreholes through rock. The fine particles of Bentonite form a thin, low-permeability filter cake around the walls of the borehole. This filter cake seals the pores and other openings in rock preventing the escape of drilling fluid through the rock and the inflow of formation fluids.

The Material Safety Data Sheets (MSDS's) for these products are kept on site.

5 DRILLING FLUID CIRCULATION

It is important to gain an understanding of how drilling fluid is circulated during horizontal directional drilling, to better understand the safeguards and inspection procedures drilling contractor intends to implement to manage drilling fluid during the drilling operations.

The mud gets mixed in the mixing tank. Once the mud has been mixed adequately it is transferred to the active tank. From the active tank the drilling fluid is pumped to the drilling rig, through the drill pipe, into the borehole and onto the cutting face. The drilling fluid then suspends the cuttings and travels out of the borehole and into the borehole returns pit. The borehole returns pit is positioned directly behind the hole entry point. From returns pits the excess mud is extracted using vacuum trucks and disposed offsite.

The site set up plan shown in the work method statement should be referred to for containment facilities such as the site sedimentation fencing, sumps & bunds as this plan only refers to directional drilling fluid related controls.

6 HAZARD PATH IDENTIFICATION

NAP considers any risk to the environment of the area to be unacceptable. To reduce the risk of drilling fluid escaping to the environment NAP has identified the following paths by which it is possible that drilling fluid could enter these sensitive areas.

a) Runoff or surface water could escape the drilling compound during periods of rainfall.

b) Drilling Fluid could escape the drilling compound and potentially find its way into the environment.

c) Drilling Fluid could potentially escape the borehole during drilling through inconsistencies (cracks & fissures) in the rock. This could result in drilling fluid being deposited into underground aquifers or breaking out to the surface.

d) Groundwater could seep into the borehole during the drilling operation. This ingress will result in increased drilling fluid volume and could cause drilling fluid containment facilities to become filled to capacity and possibly overloaded.

These are the only paths by which drilling fluid could be potentially lost to the environment. Therefore it is the goal of this Management Plan to minimise the chance of drilling fluid escaping via these paths through the use of safeguards and the implementation of inspection procedures.

7 SAFEGUARDS

This section deals with the safeguards that the drilling contractor will use during the execution of this project, to control the previously identified potential drilling fluid escape paths.

The following mitigation measures will be put in place to counteract the hazards identified above:

- Earth bunds and drainage channels will be placed around the upper edges of the drill site and work area, to divert natural runoff around and away from the site so that it doesn’t mix with drilling compound runoff. Necessary erosion and sedimentation control measures will be in place.

- All facilities utilised in the surface mud handling (mixing, cleaning & pumping) shall be bunded. This shall ensure natural / clean runoff contained within the compound is not mixed with drilling fluid or contaminated by oil/fuel.

- A sump pit will be constructed at the bottom of the drill site. The sump pit will be positioned (during site planning) so as all runoff from the drilling compound will flow into it. The sump pit is of such dimensions to provide a buffer for the drilling fluid returns.

- An earth bund or silt fencing will be placed on the downstream side of the bund to contain any spillage. The sump pit will be pumped out using vacuum trucks in an as required basis during the drilling operation. This will ensure that any rain event, whilst the drilling crew is not onsite, won't lead to a sump pit overflow.

- All products used to mix the drilling fluid will be covered before they are used to mix the drilling fluid. The unmixed drilling mud shall be stored on pallets keeping them off the ground and not stored within drainage lines. This will prevent the chance of any drilling fluid components escaping the drilling compound and becoming contaminants to the environment.

- All stationery plant & equipment on site is inspected on a daily basis to ensure it is in good working order to minimise the chance of fuel/oil/grease leakage.

- Adequate spill control kits containing absorbent materials, to cleanup spills from mobile equipment outside bunds shall be on site at all times.

- All excess oils and greases shall be contained within the fuel bund in order prevent any chance of leakage. The fuel bund is a fuel tank (4500L capacity) with an inbuilt steel bund able to contain 1.5 times storage capacity of the tank.

- All used oil or grease taken from machinery during services is stored within the fuel bund. The fuel bund is regularly emptied by a licensed contractor

- By designing the drill profile using the best geotechnical information available, the drilling contractor can ensure that an adequate amount of cover can be provided beneath the surface.

- The products selected to mix the drilling fluid have been carefully selected to provide the drilling fluid with sufficient Bentonite content. The Bentonite content of the drilling fluid will ensure a thin, low-permeability filter cake forms on the walls of the borehole. This will ensure no drilling fluid is lost through the walls of the borehole.

- Chances of drilling fluid seeping in the ground through storage pits (returns pits & sump pit) are minimal. Just as the drilling fluid lines the inside of the borehole it will also line the inside pits and provides an impermeable barrier hence stopping fluid from seeping into ground.

8 INSPECTION PLAN

This section deals with the inspection procedures by which NAP intends to ensure the adequacy and integrity of the safeguard measures.

8.1 DRILLING COMPOUND RUNOFF

Earth bunds/drainage channels or silt fencing placed on the downstream side of the drilling compound will be inspected on a daily basis and/or during & after any significant rain event to ensure their adequacy and integrity.

Earth bunding placed around the sump pit will also be inspected on a daily basis and/or after any significant rain event to ensure its adequacy and integrity.

Before the commencement of drilling and at the close down each day, all components of the mud mixing system will be visually inspected to check for signs of drilling fluid loss and to ensure its adequacy for the containment of drilling fluid.

8.2 INGRESS OF GROUND WATER

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected.

8.3 DOWNHOLE FLUID LOSS TO GROUND

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected. Nominated cored holes will also be checked to see if there are any indicators that suggest where the fluid may be lost to.

The bore path will also be visually monitored from the surface for any signs of surface frac-out. In the event of a surface frac-out occurring, all drilling operations will cease and all efforts will be made to contain the frac-out to a localised area. Sand bags will be available on site to bund the area. Excess fluids will be removed from the area using a vacuum truck. If a vacuum truck cannot access the area of frac-out, manual pumping will be used to remediate the area surrounding the frac-out.

9 DRILLING FLUID VOLUME TRACKING PROCEDURE

The drilling fluid volume tracking procedure for the drilling operations is quick and easy. It has been designed this way so that regular and accurate checks can be made throughout each day to ensure that any groundwater ingress or downhole drilling fluid loss is detected quickly. This will minimise the volume of any drilling fluid loss from the compound due to overload of containment facilities (i.e. groundwater ingress) or drilling fluid loss to the ground through the borehole (i.e. downhole drilling fluid loss) and allow remediation activities to start promptly.

The drilling fluid tracking procedure involves a simple volumetric balance between measuring the volume of drilling fluid mixed and comparing it to the volume that the drilling fluid is occupying in the borehole and entry pit (this is dependent of the length of hole drilled and the volume in surface containment facilities). These two values can readily be measured onsite and comparison

of the values will quickly determine the volume of drilling fluid gained due to groundwater ingress or lost due to downhole fluid loss.

It is true that if groundwater ingress were to equal the downhole drilling fluid loss then the drilling fluid volume tracking procedure would not detect any loss. However this situation is extremely unlikely. During normal drilling operations we expect to be pumping 19L/s to 25L/s of drilling fluid up the borehole whilst groundwater water ingress, if any, is expected to be less than 1 L/s.

The measurement of the drilling fluid volume mixed can easily be measured by making the assumption that the volume of drilling fluid produced is equal to the amount of water added to the drilling fluid tank.

The theoretical volume that the drilling fluid is occupying is also a value that can be easily calculated. Two components contribute to this value. The first is the volume of drilling fluid occupying the drilled hole and the second is the volume of drilling fluid contained within the sump pits.

The volume of drilling fluid downhole is a simple calculation knowing the diameter and the length of hole drilled. The volume of drilling fluid contained within the sump pit can also be measured easily onsite. A measurement needs to be taken of the level of drilling fluid within the drilling fluid tank. Knowing this value and knowing the dimension of the containment vessel (vacuum truck) the volume can again be calculated easily.

The drilling contractor will be making this volumetric comparison regularly each day and a minimum of three checks shall be made each shift for the duration of drilling the pilot hole.

Should inconsistent ground material be found during drilling operations (this is unlikely due to the depth of profile beneath the ground and the geotechnical information supplied) the monitoring frequency will be increased to one reading for every 10m drilled.

10 DRILLING FLUID LOSS REPORTING SYSTEM

At this stage it is important to understand that it is normal to expect some drilling fluid loss during a horizontal directional drilling operation. Some losses are expected because the fluid is filling the borehole annulus (between the pipe and the bore walls), because the fluid is lining the edges of the borehole and sump pits. Therefore, it is important that normal drilling fluid losses are taken into account in the reporting system. The reporting system proposed for this project is summarised in the following table:

Drilling Fluid Loss	Situation	Action
0-15%	Normal	Continue Drilling One Reading in 30m Drilled
15-25%	Alarm	Continue Drilling Increase Monitoring Frequency One Reading in 10m Drilled
>25%	Emergency	Cease Drilling Follow Emergency Response Plan Notify Shoalhaven Starches and DPIE before recommencing HDD

10.1 DRILLING FLUID LOSS 0-15%

The volumetric drilling fluid balance has shown 0-15% drilling fluid loss. It is normal to expect some drilling fluid loss during a horizontal directional drilling operation. The situation within this zone is quite acceptable and work should continue on as normal.

10.2 DRILLING FLUID LOSS 15-25%

The volumetric drilling fluid balance has shown 15-25% drilling fluid loss. The loss of drilling fluid has now become a concern. The volumetric balance is immediately recalculated and the drilling compound is checked to ensure there is no other reason for drilling fluid loss besides downhole loss. The drilling fluid volume tracking procedure is increased from normal (three times a day) to hourly checks until the level of drilling fluid loss exceeds 25% or decreases below 10%.

10.3 DRILLING FLUID LOSS > 25%

The drilling fluid tracking procedure has shown that drilling fluid loss has exceeded 25%. It has been checked that the only reason for this drilling fluid loss is downhole drilling fluid losses. The drilling of the borehole is immediately ceased. An incident is declared and incident response procedures implemented as described in the following section 11 . The incident response plan identifies the procedure to be used when Loss of Drilling Fluid (>25%) is experienced.

11 INCIDENT RESPONSE PLAN

Refer to the Incident Management Plan for complete details on incident response procedures. The response to loss downhole drilling fluid loss in general terms will be:

1: Cease Drilling: When downhole loss exceeds 25%

2: Notify Shoalhaven Starches immediately

3: Drilling contractor to co-ordinate sealing of the borehole.

4: Notify DPIE of issue.

5: Notify DPIE prior to recommencing HDD operations.

Possible solutions are as follows:

- Pump Extremely High Viscosity Drilling Fluid in to borehole in order to attempt to gel up the leakage.
- Utilise leak sealing mud additives into the drilling fluid in order to attempt to seal the leakage.
- Addition of loss circulation products such as rice husks, cotton or shredded paper into the drilling fluid in order to attempt to seal the leakage.
- Grouting the borehole at the leakage location and drilling through the grout and continue the hole.
- Using bentonite forms filter around the borehole walls which stops water coming in the hole due to higher annular pressure as compared to the pore pressure.

The response to containment facilities failure in general terms will be:

1: Cease Drilling: When containment failure is detected

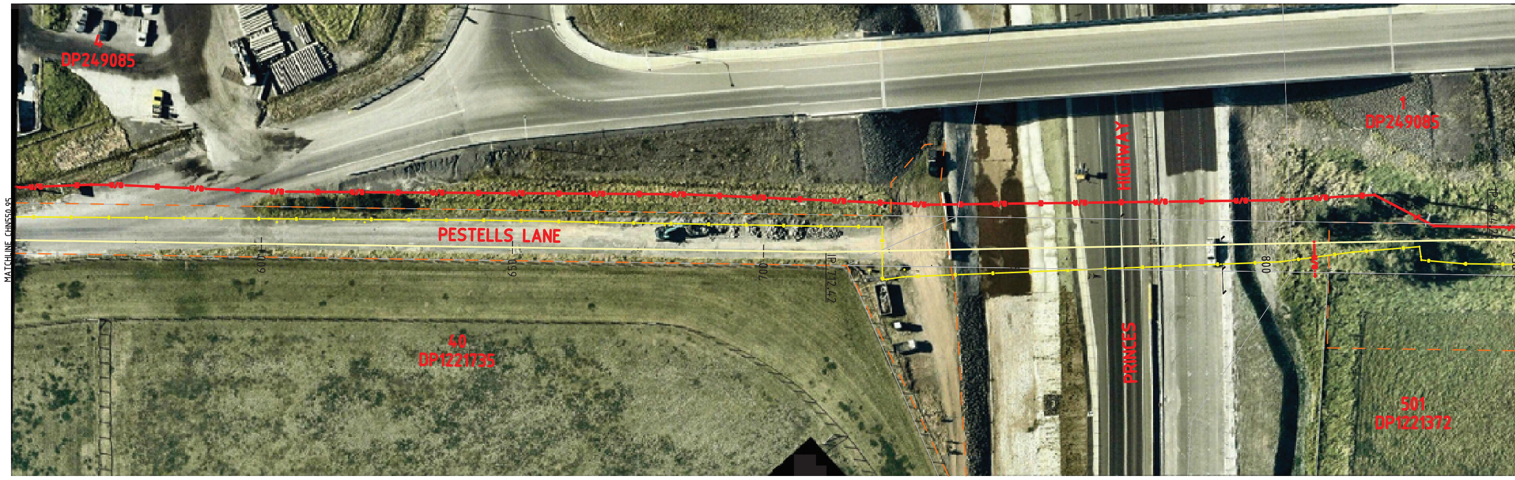
2: Notify Shoalhaven Starches immediately

3: NAP and the drilling contractor to co-ordinate containment and cleanup of the drilling fluid leakage.

Possible solutions are as follows:

- Mobilise transportable pumps on the worksite to the location of the spill and transfer the mud to a contained area.
- Utilise the excavator on site to form windrows in order to divert the flow back into contained areas.
- Utilise the excavator on site to dig a temporary hole in order for escaping drilling fluid to gather in and mobilise transportable pumps to transfer mud to a contained area.
- Mobilise additional vacuum trucks to the worksite in case there are no more effective contained areas on the site for the mud to be stored within i.e. cannot utilise transportable pumps to transfer the mud.

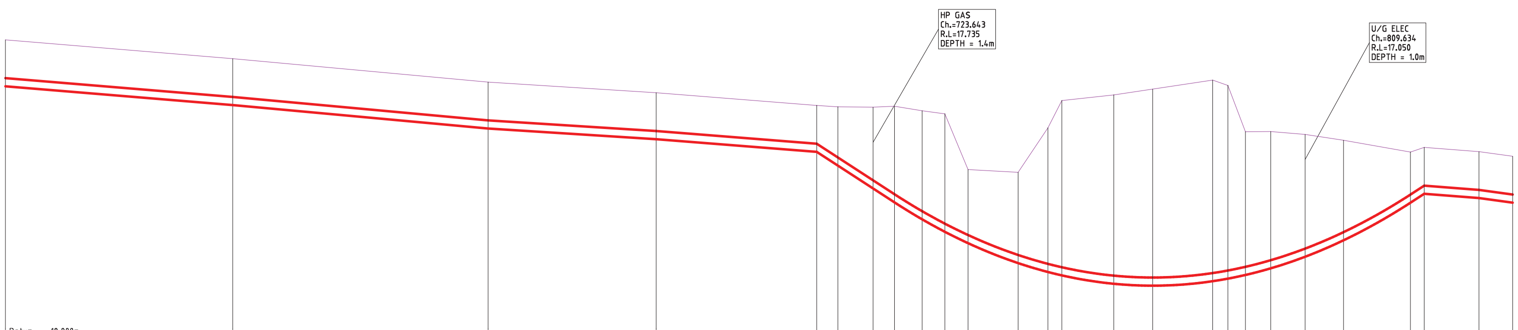
PROPOSED DESIGN



NOTE
1. IMAGE SOURCED FROM NEARMAP (17/08/2021)

LEGEND

- PROPOSED ALIGNMENT
- EXISTING GAS PIPELINE
- UNDERGROUND ELECTRIC CABLES
- UNDERGOUND COMMS CABLES
- UNDERGOUND WATER PIPE
- TRENCH BREAKER
- CADASTRAL BOUNDARY
- FENCE LINE
- EDGE OF BITUMEN
- EDGE OF FORMED GRAVEL ROAD
- TELSTRA PIT
- SEWERAGE PIT
- OVERHEAD ELEC WIRES
- POWER POLE
- EXTENTS OF RIGHT OF WAY
- MARKER POST
- ELECTROLYSIS TEST POINT
- RAILWAY TRACK



PROGRESSIVE HOIZONTAL DISTANCE	NAT SURFACE LEVEL	TOP OF PIPE LEVEL	HORIZONTAL BENDS
550.95	21.81	20.29	
596.19	21.07	19.54	
647.01	20.13	18.61	
680.47	19.71	18.18	
712.42	19.20	17.68	13° V.O.B.
716.64	19.15	17.13	COLD BEND1°/m
723.64	19.14	16.22	
727.91	19.17	15.67	
733.41	18.99	14.99	
737.92	18.87	14.50	
742.55	16.65	14.04	
752.52	16.54	13.25	
758.44	18.31	12.90	
761.21	19.40	12.76	
771.55	19.62	12.43	
779.30	19.85	12.35	
791.24	20.21	12.53	
794.26	20.00	12.63	
797.76	18.16	12.78	
802.79	18.16	13.04	
809.63	18.05	13.50	
817.29	17.82	14.16	
830.59	17.35	15.65	13° V.O.B.
833.34	17.53	16.01	COLD BEND1°/m
844.24	17.36	15.84	1.9° RHB
850.95	17.18	15.66	ROPED 120m RAD

MINIMUM COVER	1.20m
LANDHOLDER	
MARKER TAPE	
MARKER POSTS	
SOIL TYPE	
PIPELINE LOCATION CLASS	

10 0 10 20 30 40 50
HORIZONTAL SCALE OF METRES 1:500

2 0 2 4 6 8 10
VERTICAL SCALE OF METRES 1:100

SPECIFICATION FOR DN300 GAS PIPELINE

PIPE: 323.9mm X 12.7mm WT
MANUFACTURED TO API STD. 5L X65M. PSL2 ERW

COATING: THREE LAYER PE 300/125/2500-3500 Um
TO CAN/CSA - Z245.20 AND Z245.21 SERIES 18

JOINT COATING: BUTYLEN. 2TAPE (AS40/R20) SYSTEM WITH PRIMER
HOT FORMED BENDS COATED WITH 2000 MICRONS OF HBE95

FIELD WELDING: AS2885.2-2020 NDT 100% TIER 1 WORKMANSHIP
HOT FORMED BENDS COATED WITH 2000 MICRONS OF HBE95

BENDS: 5D HOT FORMED BENDS TO 1S015590:2018
COLD FORMED BENDS: AS2885.1-2018

HYDROTEST: AS2885.5 - 2020
MAXIMUM STRENGTH TEST PRESSURE : 31,760 kPa
MINIMUM STRENGTH TEST PRESSURE : 19,125 kPa
MINIMUM LEAK TEST PRESSURE : 17,215 kPa

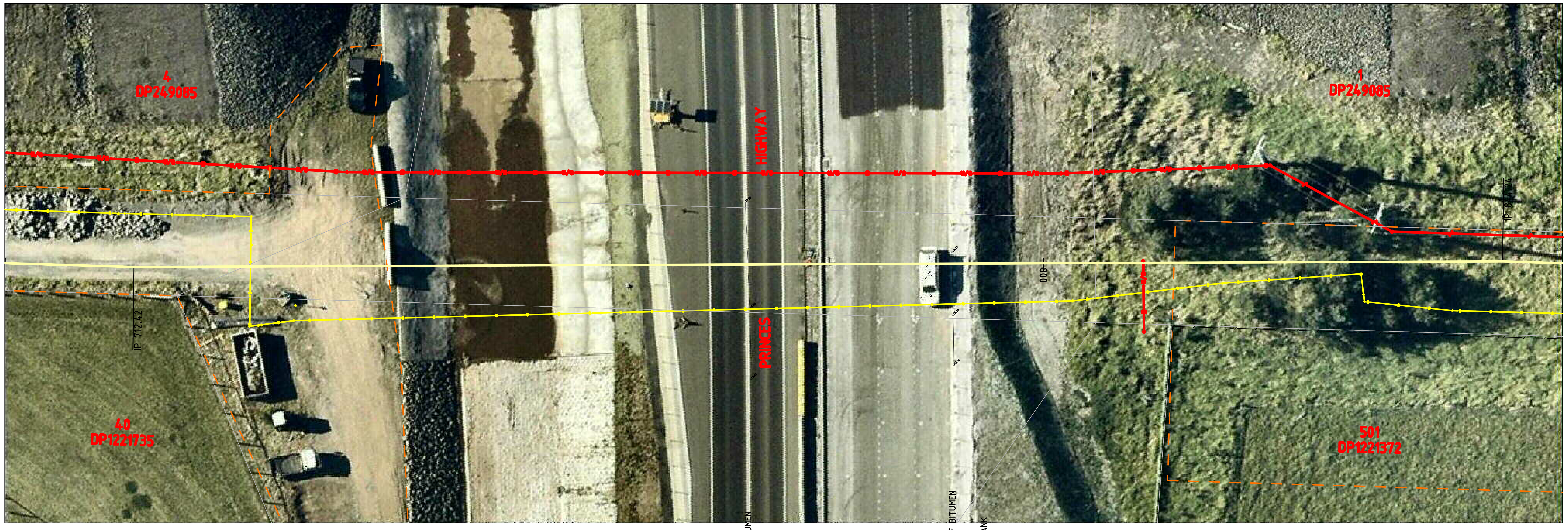
REV	REVISION	DATE	DRW	DES	CHK	APP	REFERENCE DRGs	DRG No
							PRINCES HIGHWAY CROSSING DRAWING	SS-NGP-PL-XS-03
A	ISSUED FOR REVIEW	27/09/21	SH	MB	AK	MM	LOCALITY PLAN AND DRAWING LIST	SS-NGP-PL-OVERVIEW

Shoalhaven Starches
MANILDRA GROUP
100% AUSTRALIAN OWNED
NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

	NAME	DATE
DRAWN	S.HANSON	01/11/20
DESIGNED	M. BHATIA	01/11/20
CHECKED	A. KESAVAN	01/11/20
APPROVED	M. MORAN	01/11/20

SHOALHAVEN STARCHES
NATURAL GAS PIPELINE
ALIGNMENT SHEET SHEET 3 OF 20

DATUM	SCALE	PROJECT No	REF No	SHEET	DRG No	REV
MGA2020 Z56	1:500	2NSD170	7323		SS-NGP-PL-ALIGN_SHT_003	A



Datum 11.000m

DEPTH OF COVER	1.52	1.52	1.52	2.45	3.70	3.59	3.14	6.11	7.13	7.50
NAT. SURFACE	19.40	19.24	19.20	19.14	19.10	17.87	16.57	18.92	19.59	19.85
TOP OF PIPE	17.88	17.72	17.68	16.69	15.40	14.29	13.43	12.82	12.46	12.35
Chainage	700.00	710.00	712.42	720.00	730.00	740.00	750.00	760.00	770.00	779.30

DEPTH OF COVER	7.52	7.68	5.27	4.51	3.29	1.79	1.52	1.52	1.52	1.52
NAT. SURFACE	19.88	20.18	18.16	18.04	17.72	17.37	17.53	17.43	17.36	17.21
TOP OF PIPE	12.35	12.49	12.89	13.53	14.43	15.58	16.01	15.91	15.84	15.68
Chainage	780.00	790.00	800.00	810.00	820.00	830.00	833.34	840.00	844.24	850.00

5 0 5 10 15 20 25
HORIZONTAL SCALE OF METRES 1:250

1 0 1 2 3 4 5
VERTICAL SCALE OF METRES 1:50

REV	REVISION	DATE	DRW	DES	CHK	APP	REFERENCE DRGs	DRG No
B	ROPING INFORMATION FOR DRILL STRING ADDED	19/01/22	SH	MB	AK	MM	HDD INSTALLATION - STANDARD DRAWING	NAP-DWG-SD-0013
A	ISSUED FOR REVIEW	11/11/21	SH	MB	AK	MM	ALIGNMENT SHEET	SS-NGP-PL-ALIGN_SHT_003

Shoalhaven Starches
MANILDRA GROUP
100% AUSTRALIAN OWNED

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

	NAME	DATE
DRAWN	S.HANSON	11/11/21
DESIGNED	M. BHATIA	11/11/21
CHECKED	A. KESAVAN	11/11/21
APPROVED	M. MORAN	11/11/21

SHOALHAVEN STARCHES

NATURAL GAS PIPELINE
PRINCES HIGHWAY CROSSING DRAWING

DATUM	SCALE	PROJECT No	REF No	SHEET	DRG No	REV
MGA2020 Z56	1:500	2NSD170	7323		SS-NGP-PL-XS-03	B

HDD

CALCULATIONS

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS
- SHOALHAVEN STARCHES BOMADERRY

DN300 Gas Transmission Pipeline

HDD Design Calculations-Princes Highway Crossing

Document No	NAP-SS-PL-CAL-23						
Rev	**Date**	**Purpose**	**Prepared**	**Checked**	**Approved**	**Independent Engineer**	**Date**
A	20/01/2022	Preliminary Issue	M.Bhatia	K.Moran	A.Kesavan	J.Blain	
			Project Engineer	Project Engineer	Senior Project Engineer		

1 Scope

These design calculations are for calculating pipeline stresses for road crossing

1.1 References

Referenced Document		Ref.
AZ/NZS 2885.1:2018	Pipelines – Gas and liquid petroleum,Part 1: Design and Construction Section 5.2.5	1
NAP-SS-PPR-01	Principal's Requirements	2
API SPECIFICATION 5L: May 1, 2019	Line Pipe	3
Installation of Pipelines by HDD; an Engineering Guide J D Hair Associates-1995		4
Analysis of theoritical vs actual HDD Pulling Loads J.S.Puckett J.D.Hair and Associates		5
SS-NGP-PI-XS-03 Rev B	Princes Highway Crossing Drawing	6

1.2 Calculations

Detailed calculations have been carried out and attached herewith.

1.3 Results and Conclusions

(a) The calculations confirm that the pipeline pulllback stresses are well within the required design limits

NGP-PRS - SHOALHAVEN STARCHES BOMADERRY-DN300 Gas Transmission Pipeline
HDD Pipe Pull Back Calculations

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

20/01/2022

REV 0

HDD NAME <u>PRINCESS HIGHWAY CROSSING</u>

Pipe Properties

Pipe Material	Steel			
Pipe Grade	API 5L X65			
Pipe Outside Dia	Dp	323.90 mm	12.75 inches	0.3239 m
Pipe Wall Thickness	Wtp	12.70 mm	0.50 inches	
Pipe Internal Diameter	$d_p = (D_p - (2 \times w_{tp}) =$	298.50 mm	11.75 inches	
Specified Minimum Yield Stress	SMYS	65,000.00 psi	448,159,400.00 N/mm2	
Density of Pipe	ρ_p	7850.00 kg/m3		
Young's Modulus of Elasticity	$E_{steel} =$	199,948.00 N/mm2	2.04E+10 kg/m2	29,000,058.02 psi
Cross Sectional Area	$A_p = (D_p^2 - d_p^2)/4 \times \pi =$	12421.33 mm2	0.012421326 m2	
Weight of Pipe Empty in Air	$w_p = A_p \times \rho_p$	97.51 kg/m		

Mud and Soil Properties

Mud Weight	ρ_{bent}	1.30 kg/l	10.85 ppg
Coefficient of Friction of Soil	μ_{soil}	0.40	
Fluid Drag Co-Efficient	μ_{mud}	35.15 kg/m2	0.05 psi

Buoyancy Control

Pipe Material	Steel		
Pipe Grade	API 5L X65		
Pipe Outside Dia	Dbp	323.90 mm	12.75 inches
Pipe Wall Thickness	Wtbp	12.70 mm	0.50 inches
Pipe Internal Diameter		298.50 mm	11.75 inches
Density of Pipe		7850.00 kg/m3	
Cross Sectional Area		12421.33 mm2	0.012421 m2
Weight of Pipe Empty in Air		97.51 kg/m	
Type of fill substance		Water	
Density of fill material		1000.00 kg/m3	
Weight of Pipe with fill material		167.52 kg/m	

Pipeline Coatings

External Coating 1 Type/Name	3.925mm 3LPE		
Coating thicknes	tc1	4.00 mm	
Coating density	ρ_{c1}	975.00 kg/m3	
Cross Sectional Area	$A_{c1} = ((D_p + 2 \times t_{c1})^2 - D_p^2)/4 \times \pi$	4122.17 mm2	0.004122 m2
Weight per meter	$w_{c1} = A_{c1} \times \rho_{c1}$	4.02 kg/m	
External Coating 2 Type/Name	N/A		
Coating thicknes	tc2	0.00 mm	
Coating density	ρ_{c2}	1805.00 kg/m3	
Cross Sectional Area	$A_{c2} = ((D_p + 2 \times t_{c1} + 2 \times t_{c2})^2 - (D_p + 2 \times t_{c1})^2)/4 \times \pi$	0.00 mm2	0.000000 m2
Weight per meter	$w_{c2} = A_{c2} \times \rho_{c2}$	0.00 kg/m	

Weight of Pipeline in Hole

Weight of pipe empty in air	Wp	97.51 kg/m	
Weight of Bouyancy pipe filled with fluid	Wbpf	0.00	
Weight of Pipe and Coating in Air	Wptotal = (Wp +Wc1+Wc2)	101.53 kg/m	
Mud Weight	Wbent	1.30 kg/l	
Vol of fluid displaced by pipe in 1 meter	$V_{disp} = (D_p + t_{c1} + t_{c2} + w_c)^2/4 \times \pi$	84,478,750.71 mm3	84.48 Litre
Weight of fluid displaced by pipe in 1 metre	Wdisp = Vdisp x Wbent	109.82 kg	
Effective weight of pipe in hole	Wphole = Wptotal - Wdisp	-8.30 kg/m	

Pull Force Calculations

Straight Section at Point 1 - Ch 730

Length of Straight Section	L1	30.61 m	
Radius of curvature	R	0.00 m	
Straight Section Inclination	θ_1	83.50 Deg	
Friction from soil	$\lvert frict_1 \rvert = w_{p\ hole} \times L_1 \times \sin\theta_1 \times \mu_{soil}$	-100.92 kg	
Fluid Drag	$fluid\ drag_1 = \pi \times D_p \times L_1 \times \mu_{mud}$	1095.28 kg	
Vertical Weight Component	$w_{p\ hole} \times L_1 \times \cos\theta_1$	-28.75 kg	
Length of pipe on rollers	L_{pipe}	114.00 m	
Friction factor pipe on rollers	F_{cpr}	0.30	If slings use 0.3
Pullforce pipe on rollers	$T_{rollers} = L_{pipe} \times w_p \times F_{cpr}$	3334.75 kg	
Pullforce from section 1 component	$\Delta T_{BA} = \lvert frict_1 \rvert + fluid\ drag_1 - (w_{p\ hole} \times L_1 \times \cos\theta_1)$	1224.95 kg	
Pull force at end of section 1	$T_B = \Delta T_{BA} + T_{rollers}$	**4,559.70 kg**	

Curved Section at Point 2 - Ch 779.3

Radius of curvature	R2	400.00 m	
Inclination at start of curve	θ_{2a}	83.50 Deg	
Inclination at end of curve	θ_{2b}	90.00 Deg	
Included angle of arc	α_2	6.50 Deg	
Inclination average	$\alpha_{2avg} = (\theta_{2a} + \theta_{2b})/2$	86.75 Deg	
Arc deflection	$h_2 = R_2 \times (1 - \cos(\alpha_2/2))$	0.64 m	
Length of arc	$L_{arc2} = \alpha_2/360 \times 2 \times \pi \times R_2$	45.40 m	
Bending moment of inertia	$I = \pi \times (D_p^4 - d_p^4)/64$	150,619,023.73 mm4	1.51E-04 m4
Initial value of Tave2	T_{ave2i}	6044.98 kg	
Factor j	$j_2 = (E \times I/T_{ave2})^{0.5}$	22.54 m	
Factor U	$U_2 = L_{arc2}/j_2$	2.01 m	
Factor Y	$Y_2 = 1/8 \times L_{arc2}^2 - j_2^2 \times (1 - 1/\cosh[U_2/2])$	77.06 m2	
Factor X	$X_2 = 0.25 \times L_{arc2} - j_2/2 \times \tanh(U_2/2)$	2.73 m	
Contact Force N	$N_2 = [T_{ave2} \times h_2 - (w_{p\ hole} \times \sin(\alpha_{2avg}) \times Y_2)]/X_2$	1656.05 kg	
Friction force from soil	$\lvert frict_2 \rvert = N_2 \times \mu_{soil}$	662.42 kg	
Fluid Drag	$fluid\ drag_2 = \pi \times D_p \times L_{arc2} \times \mu_{mud}$	1624.38 kg	
	$W_{phole} \times L_{arc2} \times \cos(\alpha_{2avg}) =$	-21.35 kg	
Pull Force from Section 2 component	$\Delta T_{CB} = 2 \times \lvert frict_2 \rvert + fluid\ drag_2 - (W_{phole} \times L_{arc2} \times \cos(\alpha_{2avg}))$	2970.57 kg	
Pull Force at end of curved section 2	$T_C = \Delta T_{CB} + T_B$	**7,530.26 kg**	
Check Tave2 final value	$T_{ave2f} = (T_C + T_B)/2$	6044.98 kg	
% difference quality check	$(T_{ave2f} - T_{ave2i})/T_{ave2i} \times 100\%$	0.0%	

Straight Section at Point 3 - Ch779.3

Length of Straight Section	L3	0.00 m	
Straight Section Inclination	θ_3	90.00 Deg	
Friction from soil	$\lvert frict_3 \rvert = w_{p\ hole} \times L_3 \times \sin\theta_3 \times \mu_{soil}$	0.00 kg	
Fluid Drag	$fluid\ drag_3 = \pi \times D_p \times L_3 \times \mu_{mud}$	0.00 kg	
Vertical Weight Component	$w_{p\ hole} \times L_3 \times \cos\theta_3$	0.00 kg	
Pullforce from section 3 component	$\Delta T_{DC} = \lvert frict_3 \rvert + fluid\ drag_3 - (w_{p\ hole} \times L_3 \times \cos\theta_3)$	0.00 kg	
Pull force at end of section 3	$T_D = \Delta T_{DC} + T_C$	**7,530.26 kg**	

Curved Section at Point 4 - Ch 830

Radius of curvature	R4	400.00 m	
Inclination at start of curve	θ_{4a}	90.00 Deg	
Inclination at end of curve	θ_{4b}	81.00 Deg	
Included angle of arc	α_4	9.00 Deg	
Inclination average	$\alpha_{4avg} = (\theta_{4a} + \theta_{4b})/2$	85.50 Deg	
Arc deflection	$h_4 = R_4 \times (1 - \cos(\alpha_4/2))$	1.23 m	
Length of arc	$L_{arc4} = \alpha_4/360 \times 2 \times \pi \times R_4$	62.86 m	
Bending moment of inertia	$I = \pi \times (D_p^4 - d_p^4)/64$	150,619,023.73 mm4	1.51E-04 m4
Initial value of Tave4	T_{ave4i}	9404.40 kg	
Factor j	$j_4 = (E \times I/T_{ave4})^{0.5}$	18.07 m	
Factor U	$U_4 = L_{arc4}/j_4$	3.48 m	

Factor Y	$Y_4 = 1/8 \times L_{arc4}^2 - j_4^2 \times (1 - 1/\cosh[U_4/2])$	278.66	m2
Factor X	$X_4 = 0.25 \times L_{arc4} - j_4/2 \times \tanh(U_4/2)$	7.22	m
Contact Force N	$N_4 = [T_{ave4} \times h_4 - (w_{p\ hole} \times \sin(\alpha_{4avg}) \times Y_4)]/X_4$	1925.05	kg
Friction force from soil	$\lvert frict_4 \rvert = N_4 \times \mu_{soil}$	770.02	kg
Fluid Drag	$fluid\ drag_4 = \pi \times D_p \times L_{arc4} \times \mu_{mud}$	2249.14	kg
	$W_{phole} \times L_{arc4} \times \cos(\alpha_{4avg}) =$	-40.91	kg
Pull Force from Section 4 component	$\Delta T_{ED} = 2 \times \lvert frict_4 \rvert + fluid\ drag_4 - (W_{phole} \times L_{arc4} \times \cos(\alpha_{4avg}))$	3830.09	kg
Pull Force at end of curved section 4	$T_E = \Delta T_{ED} + T_D$	**11,360.36**	**kg**
Check Tave4 final value	$T_{ave4f} = (T_D + T_E)/2$	9,445.31	kg
% difference quality check	$(T_{ave4f} - T_{ave4i})/T_{ave4i} \times 100\%$	0.4%	

Straight Section at Point 5 - Ch 844.24

Length of Straight Section	L5	14.12	m
Straight Section Inclination	θ_5	81.00	Deg
Friction from soil	$\lvert frict_5 \rvert = w_{p\ hole} \times L_5 \times \sin\theta_5 \times \mu_{soil}$	46.28	kg
Fluid Drag	$fluid\ drag_5 = \pi \times D_p \times L_5 \times \mu_{mud}$	505.24	kg
Vertical Weight Component	$w_{p\ hole} \times L_5 \times \cos\theta_5$	-18.32	kg
Pullforce from section 5 component	$\Delta T_{FE} = \lvert frict_5 \rvert + fluid\ drag_5 - (w_{p\ hole} \times L_5 \times \cos\theta_5)$	569.84	kg
Pull force at end of section 5	$T_F = \Delta T_{FE} + T_E$	**11,930.20**	**kg**

STRESS ANALYSIS

SMYS		for API 5L X65 PIPE	65,000.00	psi	448.16	Mpa
Allowable Tensile Stress	**ftp**	0.9 x SMYS	58,500.00	psi	**403.34**	**Mpa**
Allowable Bending Stress	**fbp**	$[0.84 - \{1.74 \times SMYS \times D_p/(E \times w_{tp})\}] \times SMYS$	331.88	Mpa		
Allowable Hoop Stress	**fhp**	$0.88 \times E \times (w_{tp}/D_p)^2$	270.51	Mpa		

END OF STRAIGHT SECTION 1 — **Ch 730**

	Pull force at end of section 1		4,559.70	kg
Tensile Stress	ft1 = Tb/Ap		**3.60**	**Mpa**
	Allowable Tensile Stress ftp		403.34	Mpa
	Check	**ft1 <ftp**	**TRUE**	
Longitudinal Bending Stress	fb1 = E x Dp/(2 x R)		-	
	Allowable Bending Stress fbp		331.88	Mpa
	Check	**fb1<fbp**	**TRUE**	
Hoop Stress	$f_{h1} = (\Delta p_1 \times D_p)/(2 \times w_{tp})$			
Wtp	Pipe wall thickness in inches			
External hydrostatic pressure p1 =	mud wt (ppg) x depth1 (ft)/19.25			
		depth1	3.70	m
		depth1	12.21	ft
		p1	6.88	psi
		fh1	87.76	psi
		fh1	**0.61**	**Mpa**
	Allowable Hoop Sress fhp		270.51	Mpa
	Check	**fh1<fhp**	**TRUE**	
Combined Stresses, Tensile and Bending				
unity check	$f_{t1}/(0.9 \times SMYS) + f_{b1}/F_b$		0.01	
	Check	**<1.00**	**TRUE**	
Combined Stresses, Tensile, Bending and Hoop Stress				
unity check	$A^2 + B^2 + 2v \times \lvert A \rvert \times \lvert B \rvert$			
	$A = (f_{t1}+f_{b1}-0.5 \times f_{h1}) \times 1.25/ SMYS$		0.01	
	v = poissons ratio (steel)		0.30	
	$B = 1.5 \times f_{h1}/F_{hc}$		0.00	
Therefore	$A^2 + B^2 + 2v \times \lvert A \rvert \times \lvert B \rvert$		0.00	
	Check	**<1.00**	**TRUE**	

END OF CURVED SECTION 2 — **Ch 779.3**

	Pull Force at end of curved section 2		7,530.26	kg
Tensile Stress	ft2 = TC/Ap		**5.95**	**Mpa**
	Allowable Tensile Stress ftp		403.34	Mpa
	Check	**ft2 <ftp**	**TRUE**	
Longitudinal Bending Stress	fb2 = E x Dp/(2 x R)		11,741.40	psi
			80.95	**Mpa**
	Allowable Bending Stress fbp		331.88	Mpa
	Check	**fb2<fbp**	**TRUE**	

Hoop Stress $f_{h2} = (\Delta p_2 \times D_p)/(2 \text{ X } w_{tp})$

Wtp — Pipe wall thickness in inches

External hydrostatic pressure p2 = mud wt (ppg) x depth2 (ft)/19.25

depth2	7.50	m
depth2	24.75	ft
p2	13.95	psi
fh2	177.89	psi
fh2	**1.23**	**Mpa**

Allowable Hoop Sress fhp — 270.51 Mpa

Check — **fh2<fhp** — **TRUE**

Combined Stresses, Tensile and Bending

unity check $f_{t2}/(0.9 \times SMYS) + f_{b2}/F_b$ — 0.26

Check — **<1.00** — **TRUE**

Combined Stresses, Tensile, Bending and Hoop Stress

unity check $A^2 + B^2 + 2v \times |A| \times |B|$

A = (ft2+fb2-0.5*fh2)*1.25/SMYS — 0.24

v = poissons ratio (steel) — 0.30

B = 1.5 * fh2/Fhc — 0.01

Therefore $A^2 + B^2 + 2v \times |A| \times |B|$ — 0.06

Check — **<1.00** — **TRUE**

END OF STRAIGHT SECTION 3 — **Ch 779.3**

Pull force at end of section 3 — 7,530.26 kg

Tensile Stress ft3 = Td/Ap — **5.95 Mpa**

Allowable Tensile Stress ftp — 403.34 Mpa

Check — **ft3 <ftp** — **TRUE**

Longitudinal Bending Stress fb3 = E x Dp/(2 x R) — -

Allowable Bending Stress fbp — 331.88 Mpa

Check — **fb3<fbp** — **TRUE**

Hoop Stress fh3 = (p3 x Dp)/(2 x Wtp)

Wtp — Pipe wall thickness in inches

External hydrostatic pressure p3 = mud wt (ppg) x depth3(ft)/19.25

depth 3	7.50	m
depth 3	24.75	ft
p3	13.95	psi
fh3	177.89	psi
fh3	**1.23**	**Mpa**

Allowable Hoop Sress fhp — 270.51 Mpa

Check — **fh3<fhp** — **TRUE**

Combined Stresses, Tensile and Bending

unity check $f_{t3}/(0.9 \times SMYS) + f_{b3}/F_b$ — 0.01

Check — **<1.00** — **TRUE**

Combined Stresses, Tensile, Bending and Hoop Stress

unity check $A^2 + B^2 + 2v \times |A| \times |B|$

$A = (f_{t3}+f_{b3}-0.5 \times f_{h3}) \times 1.25/ SMYS$ — 0.01

v = poissons ratio (steel) — 0.30

$B = 1.5 \times f_{h3}/F_{hc}$ — 0.01

Therefore $A^2 + B^2 + 2v \times |A| \times |B|$ — 0.00

Check — **<1.00** — **TRUE**

END OF CURVED SECTION 4 — **Ch 830**

Pull Force at end of curved section 4 — 11,360.36 kg

Tensile Stress ft4 = TE/Ap — **8.97 Mpa**

Allowable Tensile Stress ftp — 403.34 Mpa

Check — **ft4 <ftp** — **TRUE**

Longitudinal Bending Stress fb2 = E x Dp/(2 x R) — 11,741.40 psi

80.95 Mpa

Allowable Bending Stress fbp — 331.88 Mpa

Check — **fb4<fbp** — **TRUE**

Hoop Stress $f_{h4} = (\Delta p_4 \times D_p)/(2 \text{ X } w_{tp})$

Wtp — Pipe wall thickness in inches

External hydrostatic pressure p4 = mud wt (ppg) x depth4 (ft)/19.25

depth4	1.79	m
depth4	5.91	ft
p4	3.33	psi
fh4	42.46	psi
fh4	**0.29**	**Mpa**

Allowable Hoop Sress fhp — 270.51 Mpa

Check — **fh4<fhp** — **TRUE**

Combined Stresses, Tensile and Bending

unity check	$f_{t4}/(0.9 \times SMYS) + f_{b4}/F_b$		0.27	
	Check	**<1.00**		**TRUE**

Combined Stresses, Tensile, Bending and Hoop Stress

unity check	$A^2 + B^2 + 2v \times \lvert A \rvert \times \lvert B \rvert$			
	$A = (f_{t4}+f_{b4}-0.5 \times f_{h4}) \times 1.25/ SMYS$		0.25	
	v = poissons ratio (steel)		0.30	
	$B = 1.5 \times f_{h4}/F_{hc}$		0.00	
Therefore	$A^2 + B^2 + 2v \times \lvert A \rvert \times \lvert B \rvert$		0.06	
	Check	**<1.00**		**TRUE**

END OF STRAIGHT SECTION 5 **Ch 844.24**

Pull force at end of section 5 11,930.20 kg

Tensile Stress	ft5 = TF/Ap		**9.42 Mpa**	
	Allowable Tensile Stress ftp		403.34 Mpa	
	Check	**ft5 <ftp**		**TRUE**
Longitudinal Bending Stress	fb5 = E x Dp/(2 x R)		-	
	Allowable Bending Stress fbp		331.88 Mpa	
	Check	**fb5<fbp**		**TRUE**
Hoop Stress	fh5 = (p5 x Dp)/(2 x Wtp)			
Wtp	Pipe wall thickness in inches			
External hydrostatic pressure p5 =	mud wt (ppg) x depth5(ft)/19.25			
		depth5	0.00 m	
		depth5	0.00 ft	
		p5	0.00 psi	
		fh5	0.00 psi	
		fh5	**- Mpa**	
	Allowable Hoop Sress fhp		270.51 Mpa	
	Check	**fh5<fhp**		**TRUE**

Combined Stresses, Tensile and Bending

unity check	$f_{t5}/(0.9 \times SMYS) + f_{b5}/F_b$		0.02	
	Check	**<1.00**		**TRUE**

Combined Stresses, Tensile, Bending and Hoop Stress

unity check	$A^2 + B^2 + 2v \times \lvert A \rvert \times \lvert B \rvert$			
	$A = (f_{t5}+f_{b5}-0.5 \times f_{h5}) \times 1.25/ SMYS$		0.03	
	v = poissons ratio (steel)		0.30	
	$B = 1.5 \times f_{h5}/F_{hc}$		0.00	
Therefore	$A^2 + B^2 + 2v \times \lvert A \rvert \times \lvert B \rvert$		0.00	
	Check	**<1.00**		**TRUE**

References

1. " Installation of Pipelines by HDD an Engineering Guide " J.D Hair and Associates 1995
2. "Analysis of theoretical vs actual HDD Pulling loads " J.S.Puckett J.D Hair and Associates 2003

OVERBEND

CALCULATIONS

Natural Gas Pipeline and Pressure Reduction Station
Shoalhaven Starches
OVERBEND PIPE SUPPORT CALCS

HDD NAME **PRINCESS HIGHWAY HDD** 20/01/2022 REV 0

SMYS	458	Mpa				
MATERIAL AND GRADE	STEEL - API 5L X65					

DISTANCE BETWEEN SUPPORTS

MAX BENDING STRESS ON PIPE TO BE LESS THAN 0.75 x 72% OF SMYS = 247.32 Mpa
This takes into account dynamic loads

Bending Moment at x $M = \frac{qx}{2}(x - L)$

q being Mass/m
x is half the distance between two pipe supports/slings/rollers
L being the total distance beween pipe supports

Bending Stress (Mx/Z)

Z being Section Modulus $I_x = \pi (d_o^4 - d_i^4) / 32do$

Do (Outside Dia)	323.90	mm	0.3239	m				
Wall Thickness	12.70	mm	0.0127	m				
Di (Inside Dia)	298.50	mm	0.2985	m				
Pipe Density	7,850.00	Kg/m3						
3LPE Density	975.00	Kg/m3	**Coating Thickness**		4	mm	0.004	m
weight/m	105.50	Kg/m						
Mass/m (q)	1,034.96	N/m						
Distance between pipe supports (L)	42	m						
x is half the distance between two pipe supports/slings/rollers	21	m						
Bending Moment at x	228,207.58	Nm						
Z Section Modulus	9.30E-04	m3						
Bending Stress (M/Z) at x	245.36	Mpa	**Check**	**<**	**247.32**	**Mpa**		

Accordingly max distance between supports is **42 m** **Our proposal is 30m to 36m**

PIPE OVERHANG DISTANCE

Max pipe over hang at free end (a) $a = \sqrt{\frac{2M_{max}}{q}}$

$M_{max} = \frac{\sigma_{max} I}{C}$

C being the pipe radius	0.16	m
σ_{max} being max bending stress	247.32	Mpa
I - Second Moment of Inertia		
$I = \pi (d_o^4 - d_i^4) / 64$	0.000150619	m4
Max Bending Moment being	230,016.04	Nm
Max pipe over hang at free end (a)	**21.08**	**m**

Our proposal is 15m

LONGITUDINAL BENDING STRESS DUE TO ROPING RADIUS

MAX BENDING STRESS ON PIPE TO BE LESS THAN	247.32	Mpa
Stress = E x Do/(2 x R)		
E is the Youngs Modulus	2.00E+05	Mpa
Min Roping Radius	**130.93**	**m**

Our proposal is > 200m

HEAD TRACKING TOOL

DigiTrak
FALCON F5®

Directional Drilling Guidance System

- Wideband technology evaluates hundreds of frequencies for the best possible performance around active interference
- Ultra-low frequency options for battling passive interference on the jobsite
- Scan for interference, select optimum frequencies, and pair transmitter at the jobsite
- Switch between paired bands mid-bore
- Full Scale Sensitive Pitch provides 0.1% resolution through ±99.9% slope for precision grade work
- Max Mode filters noise to boost weak data signals and stabilize depth readings
- Standard warranty for 19- and 15-inch transmitters is 3 years/500 hours

Falcon F5 Is Now *Passive Aggressive*

The ability to choose the right transmitter frequency is more important than power in overcoming the effect of active interference. In October of 2015, DCI introduced Falcon technology, a significant new approach to overcoming active interference on HDD jobsites. DCI now introduces a new approach to addressing the problem of passive interference: sub-kilohertz frequencies. Falcon F5 with Sub-k Rebar capability allows a locating specialist to scan the jobsite and select the best frequency in the ultra-low frequency range of 0.33–0.75 kHz to combat passive interference.

Falcon Innovation Continues

Falcon is the HDD industry's only walkover guidance system able to specifically address both active and passive interference. Transmitter frequencies below 1 kHz are proven most effective for jobsites where passive interference is a problem. In addition, the new Falcon F5 receiver supports Full Scale Sensitive Pitch (FSSP) for 0.1% resolution through ±99.9% slope for precision grade work.

The Falcon F5 receiver offers the industry's first fully integrated GPS capability using the DigiTrak iGPS module. Snap on the iGPS module and it automatically powers on to receive and record satellite GPS data.

Use the free LWD Mobile app to view the progress of the bore and overlay the iGPS locate points on your smart device.

The Falcon F5 Wideband Transmitter

A Falcon F5 transmitter provides versatility in all types of active interference at frequencies of 4.5–45 kHz. The Falcon F5 wideband design vastly outperforms single-frequency transmitters of past generations. It also comes standard with fluid pressure measurement. No other guidance system allows an operator to scan for active interference and then pair optimized frequencies to a transmitter at every jobsite. This provides substantial cost savings and increases pilot bore productivity.

The Falcon F5 Sub-k Rebar Transmitter

The newest entrant into the Falcon F5 wideband transmitter lineup is the Sub-k Rebar transmitter. It uses frequencies below 1 kHz and provides frequency selection options from 0.33–0.75 kHz. This frequency range is ideal for addressing project scenarios that exhibit passive interference. Whether sidewalk, roadway, or runway, the Sub-k outperforms other options above 1 kHz. These transmitters include fluid pressure measurement as a standard feature.

Wideband Sub-k Rebar

Falcon Frequency Optimizer

DIGITAL CONTROL INCORPORATED
dci@digital-control.com ■ www.DigiTrak.com ■ 1.425.251.0559, 1.800.288.3610 (US/CAN)

Jul 402-1025-21-C metric

DigiTrak FALCON F5® Guidance System

	DigiTrak Sub-kHz			The other guys	DigiTrak Wideband								
Band Number	0.3	0.5	0.7		7	11	16	20	25	29	34	38	43
Range in kHz	.33 – .40	.40 – .58	.58 – .75	1.5 – 4.0	4.5 – 9.0	9.0 – 13.5	13.5 – 18	18 – 22.5	22.5 – 27	27 – 31.5	31.5 – 36	36 – 40.5	40.5 – 45

Ease of Use

Falcon F5 raises the bar on walkover locating system capability and ease of use. Our customers have always relied on the Falcon F5's color, icon-driven screen for easy menu navigation. *Ball-in-the-Box* has never been more powerful and still provides a real-time status of the bore in progress. Minimize downtime caused by alternative products that claim to get the job done but often fall short. Keep your project on DigiTrak and maximize your productivity.

3 Year/500 Hour Warranty

Register your new Falcon 19- or 15-inch transmitter within 90 days for an enhanced warranty of 3 years or 500 hours, whichever occurs first. Ask your dealer about an extended warranty option that provides 5 year/750 hour coverage.

Transmitter Specifications

See the separate Falcon F5 Transmitter Specification Sheet for details on the six different 19-, 15-, and 8-inch wideband options for active interference and Sub-k Rebar options for combating passive interference. Falcon F5 also supports our popular DucTrak transmitters.

Receiver Specifications

Product ID	FF5
Model number	FAR5
Receiving frequencies	0.33–45.0 kHz
Telemetry channels[1]	4
Telemetry range[2]	defined by remote display
Power source	Lithium-ion battery pack
Battery life	8–12 hrs
Functions	Menu-driven
Controls	Trigger and toggle switches
Graphic display	Full-color LCD
Audio output	Beeper
Accuracy	±5%
Voltage, current	14.4 VDC nominal, 390 mA max
Operating temperature	-20–60° C
Dimensions	27.94 x 13.97 x 38.1 cm
Weight (with battery)	3.9 kg

Aurora Touchscreen Display Specifications

Product ID and model number	AF8, AF10
Power source - cabled	10–28 VDC
Current	1.75, 2.1 A maximum
Controls	21.3, 26.4 cm touchscreen
Graphic display	LCD
Audio output	Speaker
Telemetry channels[1]	4
Telemetry range[2]	500 m
Operating temperature	-20–60° C
Dimensions[3]	24.9 x 16.8 x 8.1, 29.2 x 23.7 x 5.8 cm
Weight	1.9, 2.9 kg

[1] Local telemetry frequencies and power levels available at www.DigiTrak.com.
[2] Telemetry range can be increased with an optional external receiving antenna.
[3] Dimensions do not include external mounting hardware.

PRE-COM

RISK

ASSESSMENT

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
		ENTER ASSESSMENT DATA				**Procedural Mitigation, Codes of Practice, Australian Standards, Training and Induction Programmes, Physical Mitigation**	ENTER ASSESSMENT DATA				
Horizontal Directional Drilling	Stakeholder impact - injuries and supply/service disruption	3	4	12	High	• Establish Exclusion zone and signage to isolate drill area • Fencing HDD excavation to ensure restricted access • Warning signage • Hazard lights • SWMS for HDD • Entry and exit pits safe distance from access • Traffic Management, if required • Review Drilling and HDD management plan in conjunction with Shoalhaven Starches	2	3	6	Low	Y
	Handling/Bulk Storage/transporting hazardous or dangerous goods - spills, contamination, skin irritation and burns	3	4	12	High	• Ensuring containers labelled and sealed • Register of Dangerous Goods, MSDS in Site Office • Appropriate lift location • Appropriate equipment for handling/transfer • Correct PPE to be worn in accordance with Shoalhaven Starches and NAP induction as well as MSDS requirements • Spill kits in site yard and on refuelling vehicle • MSDS on file and upto date • Employee trained and competent. • Induction. • Shoalhaven Starches Audits • Licensed operator to carry bulk dangerous goods. • All transport done In accordance with EPA guidelines	2	3	6	Low	Y
	Entanglement occurs during drilling - Unauthorised personnel to work area Automated Actions, Pinch points from rod loading and jaw clamps - Soft tissue injuries	3	4	12	High	• Exclusion zone around drill identified • Authorised Persons Only Signage. • Visitor sign on Log. • Obtain Work permit • SWMS for HDD • Machinery guarding • Trained competent operators verified for employees / subcontractors • No loose clothing allowed • Isolation & tag out protocols for maintenance	2	4	8	Moderate	Y
	Noise emitted from drilling plant - OH&S issues	5	3	15	High	• All plant to be risk assessed and have scheduled maintenance / servicing • Selection of equipment to provide noise attenuation • Appropriate PPE • Job rotation to reduce exposure limit (Where required)	2	2	4	Negligible	Y
	Impact with an existing services - injuries	3	4	12	High	• Approved Boring Procedure and HDD Management Plan in conjunction with NAP and Shoalhaven Starches requirements • Tracking of the bore during drilling • Exposure of services where possible, with spotter when borer is in proximity. • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipelines • DBYD and service register to be developed to ascertain risk of impact to services	2	4	8	Moderate	Y
	Drilling Failure - major supply/service issues	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan.	2	4	8	Moderate	Y

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
						• Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline • Emergency response plan (Frac out management plan)					
	Frac out occurring impacting roadways / environment	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan • Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline / impact to road • Emergency response plan (Frac out management plan)	2	4	8	Moderate	Y

SWMS

Jelmac Industries Pty Ltd
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Kilsyth VIC 3137
Phone: 0417 351 908
ABN: 60 165 118 972

THIS FORM IS TO IDENTIFY TASK / SITE HAZARDS AND TO MINIMISE THE RISKS TO PERSONS AND/OR DAMAGE TO PROPERTY.					
Project:	National Australia Pipelines				
Site Address:	Princess Highway				
Site Muster Point:		**Start Date:**		**Supervisor**	Brad Boote
Specific Task:	Directional Drilling & Vacuum Truck	**Finish Date:**		**Phone:**	0417351908
Plant & Equipment:	Directional Drill, Vacuum Truck, Support Vehicle. Hand tools.				
Hazardous Materials:					
Personal Protective Equipment Required:	Uniform; Footwear ☑; Hi Visibility ☑; Hard Hat ☑; Eyewear ☑; Fall Arrest ☐; Gloves ☑; Hearing ☑; Dust Mask ☑; First Aid ☑				
Managers Approval:	Brad Boote	**Signed:**		**Date:**	20-01-2022

CONSEQUENCES	POSSIBLE COURSES OF ACTION	LIKELIHOOD	MINOR (1)	SERIOUS (2)	SEVERE (3)	MAJOR (4)	CATASTROPHIC (5)
MINOR	First Aid, No Medical Treatment required. Spillages, leaks or other escapes, which occur and are contained. Supervisor to report and monitor.	(A)...ALMOST CERTAIN Will likely occur once or more every couple of years. Expected to or occurs regularly.	Medium	High	High	Extreme	Extreme
SERIOUS	Lost time injury/medical treatment required. Spillages or leakages, which have migrated offsite. Supervisor to report and manage by routine procedures. Immediate reparative/first aid action required.	(B)...LIKELY Will likely occur once or more in 10 years.	Low	Medium	High	High	Extreme
SEVERE	Single permanent or partial disability. Discharge of any substance from site, which has the potential to harm the environment. Supervisor to report and manage by specific monitoring plan or procedures. Stop work, immediate reparative/first aid action required.	(C)...POSSIBLE Could occur but not probable. Has not occurred at Jelmac.	Low	Low	Medium	High	High
MAJOR	Total permanent disability. Actual material harm to the environment on or off site with short-term effects and reparable by remedial action. Supervisor to report and allocate responsibility to appropriate senior manager. Stop work, immediate attention needed urgently.	(D)...UNLIKELY Not expected to occur. Has not occurred at Jelmac but has occurred within the industry in Australia.	Negligible	Low	Low	Medium	High
CATASTROPHIC	Multiple fatalities or total permanent disability. Actual material harm to the environment on or offsite with long term or irreparable effects. Supervisor to report and notify appropriate senior manager to manage via detailed control plan. Stop work, quarantine site, supervisor to contact relevant emergency services.	(E)...RARE May occur in exceptional circumstances. Has occurred in known history in the industry.	Negligible	Negligible	Low	Low	Medium

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Standards & Requirements	Occupation Health & Safety (OHS) Act 2004, Occupation Health & Safety (OHS) Regulations 2007,	FSR1: Temporary works, excavations and underground and overhead services FSR 02: Plant Equipment NAP Ground Penetration Permit	NAE PTW Certificates of Competency TM Plan

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Safety Management	Lack of safe work practices places workers, public and wildlife at risk.	**A**	**5**	**E**	All Jelmac Directional Drilling staff members are issued upon acceptance of employment a Safety Folder containing all occupational health and safety procedures. Staff members are expected to refer to and follow these procedures to ensure safe work practices. Staff and emergency contact details are provided at the rear of the folder. Site-specific forms SWMS and JSA are available.	**E**	**3**	**L**	Management/ Supervisors/ All Personnel
	First Aid	Lack of sufficient first aid can significantly increase injury.	**C**	**3**	**M**	All vehicles are equipped with a Standard Workplace First Aid Kit. Injury is to be assessed and medical assistance sought if required. Follow Emergency Procedures if required and consult Emergency Contact Details if necessary.	**C**	**2**	**L**	Management/ Supervisors/ All Personnel
	Environmental Management	Wildlife, significant vegetation, noxious weeds, waste, hazardous chemicals and materials.	**C**	**3**	**M**	Identify Environmental Management procedure. Inspect, identify and assess risks. Ensure compliance with local, state or EPA guidelines. Ensure safe removal or avoidance of any wildlife and or vegetation. Ensure wash down of plant and machinery to avoid transfer of any noxious weeds. If asbestos is encountered, stop works immediately and contact engineer or supervisor. Control of Drill slurry , erect silt controls at Bore entry & exit, Remove excess via Vac unit for disposal to EPA accredited site	**E**	**1**	**N**	Management/ Supervisors/ All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Emergency Preparedness	Fire, explosion, flood, bush fire, bomb threats.	E	5	M	Plant and LV Inductions need to be completed. Identify Emergency Procedures procedure. Assess location and impending weather conditions and forecast. All trucks and plant are equipped with fire extinguishers, which are all current with tags as per legislative requirements. Ensure any hoses are clearly labelled and accessible, ensure work areas suitable, secure and clear, avoid creating fire hazards and consider evacuation plans. Identify Emergency Contact Details form. Ensure all staff are identified and accounted for in the event of an emergency.	E	3	L	Management/ Supervisors/ All Personnel
	Weather	Exposure to UV radiation, extreme weather conditions (Extreme heat, Rain, Storms), Visibility.	C	2	L	Identify and assess impending weather conditions and forecast. Use sunscreen, hats/protective brims, long sleeve shirts, and neck flaps. Reassess site and work conditions in extreme weather conditions or poor visibility. Source extra equipment; modify safe work practices or hours of work as necessary.	E	2	N	Management/ Supervisors/ All Personnel
	PPE (Personal Protective Equipment)	Inappropriate or inadequate personal protective equipment can result in injury, overexposure to elements and lack of identification to the public or co-workers.	C	2	L	Issue of appropriate personal protective equipment prior to works or as required per task – long sleeves and trousers to be worn at all times. All staff must wear high visibility clothing and/or vests and approved safety boots wherever applicable. Hard hats and safety glasses are issued at employment and are to be worn at all times. Sunscreen is available to all staff at all times. Staff members are expected to return worn/damaged items to management for replacement.	E	2	N	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Drive to or from site and site access	Vehicular and Pedestrian Traffic. Collisions with other vehicles. Collisions with static structures. Collisions with pedestrians.	A	5	E	Driver must be appropriately licenced for the class of vehicle being driven/operated. Driver must abide all road rules. Driver must ensure vehicle is fit for task, road worthy, registered and must complete a Daily Plant Checklist prior to use. All personnel are to be made aware of the “Safe Entry and Exit of Worksite” procedure and be pre-started prior to entering site.	B	5	E	Driver
	Establish correct location	Time Wastage / economic loss.	B	1	L	Correct documentation and plans, effective communication. Refer to engineers construction pack,	E	1	N	Site Supervisor
	Traffic Management	Struck By Traffic Pedestrian Interface Non Compliance	B	3	H	No works within 7 metres of road without Traffic Management in place. Must have a spotter/observer to monitor pedestrian traffic and any site movement. Pedestrians to be escorted around works where required. Ensure a No Go Zone around Directional Drill and points of drill head entry and exit by placement of Temporary fencing for full perimeter of work zones to ensure public and personnel safety. Works in shared user path, access to be maintained at all times. Beware of pedestrians and implement exclusion zone. Refer to vehicle access plan	E	2	N	Site Supervisor / All Personnel
	Manual Handling	Physical Injury	C	2	L	Determine position, size and weight of object. Consider use of mechanical aids or extra personnel for task. Ensure appropriate personal protective equipment is worn. Adopt good posture and movement technique. Two persons required to reposition temporary timber stairs for batter access. Report any injuries or near miss and always consider any relevant improvements.	D	1	N	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Using hand tools	Manual Handling, condition and maintenance, incorrect usage, risk of injury, use as a weapon.	C	2	L	Ensure manual handling advice and techniques are employed. Consider and ensure you are using the appropriate tool for the task. Ensure tools are inspected and maintained, replace if damaged. Ensure all tools are accounted for and secure.	E	2	N	Site Supervisor / All Personnel
	Working with chemicals	Spillage, Explosion, Inhalation, Absorption & Ingestion	D	3	L	All chemicals to be used in conjunction with appropriate SDS, which are attached to the back of the SWMS. Ensure compliance with EPA guidelines. Ensure suitable storage and transport. SDS available at hand. Ensure user competency, adequate signage, and chemical spill / clean-up kits available, personal protective equipment available. Identify Emergency Contact Details.	E	3	L	Site Supervisor / All Personnel
	Presence of existing services	Striking of services	B	4	H	Identify and assess location. NAP Ground Penetration Permit Action Dial Before You Dig information. Identify asset owners. Pothole, hand expose and sight all high-risk services outside of rail corridor on each side of the proposed alignment in order to ascertain inverts and alignments of assets in the design vicinity so the bore design can be considered in relation to existing assets. Modify route and or employ safe work practices to avoid disturbance or damages to at risk services.	E	3	L	Management/ Site Supervisor

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Plant, machinery and equipment	Compliance/ Failure	**D**	**2**	**L**	All plant and equipment to be site inspected. Ensure all plant and equipment is inspected and cleared for use. Pre-start equipment checks, Regular service and maintenance checks and records.	**E**	**1**	**N**	All Personnel
		Movement of vehicles and machinery	**B**	**4**	**H**	Ensure machinery is equipped with suitable warning and hazard identifying devices (e.g. signs, lights, and alarms) and appropriately maintained. All operators hold appropriate license/s, to be VOC'd and comply with plant manufacturers operating guidelines. Ensure site awareness and security is maintained prior to operation. Exclusion zone of 5m to be maintained from drill head when operational.	**D**	**4**	**M**	All Personnel
		Spillage of diesel fuel and/or oil and lubricants	**D**	**2**	**L**	Refuelling to occur at properly designated area e.g. service station or depot refuelling area. Vehicle to carry Spills Kit to absorb any accidental leakage.	**D**	**1**	**N**	All Personnel
		Presence of existing overhead services	**C**	**3**	**M**	Identify any overhead services and ensure safe working distance from service is maintained.	**E**	**3**	**L**	All Personnel
	Unloading and Set Up Of Machinery.	Unloading plant from truck	**C**	**3**	**M**	Assess area for potential hazards i.e. uneven ground, overhead obstacles, safe deployment of ramps. No standing or climbing on the back of trucks without handrails.	**E**	**1**	**N**	All Personnel
		Overhead obstacles	**C**	**3**	**M**	Move to safer location.	**E**	**1**	**N**	All Personnel
		Ramps	**C**	**2**	**L**	Ensure appropriate ramps are installed and maintained.	**E**	**2**	**N**	All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Boring.	Machine Failure	C	1	L	Pre-start equipment checks, regular service and maintenance checks and records.	E	1	N	All Personnel
		Slipping from batter	C	5	H	No walking on batter. Access only using the stairs provided.	E	2	N	All Personnel
		Excess Drill Mud	C	1	L	Use vacuum truck to remove sludge during the drilling process. Dispose of excess Drilling slurry to an EPA accredited facility	D	1	N	All Personnel
		Frac out	C	1	L	Stop and assess immediate risk and secure if necessary. Use Vac Truck to remove sludge. Erect Silt Controls Prevent any flows to Drainage system, inclusive of Ground water. All clean up via vac unit	D	1	N	All Personnel
		Pipe pull back	C	3	M	Ensure effective communication with drill rig operator. Monitor Mud flows as annular space is filled, Removing excess via vac unit for disposal to an EPA facility.	E	3	L	All Personnel
	Site Reinstatement	Open excavations / Open pits	C	3	M	Backfill or secure. Ensure all lids are replaced or open pits secured.	E	2	N	All Personnel
		Trip Hazards	C	2	L	Remove.	E	1	N	All Personnel
		Heavy equipment, tools, products	C	2	L	Correct manual handling techniques.	D	1	N	All Personnel

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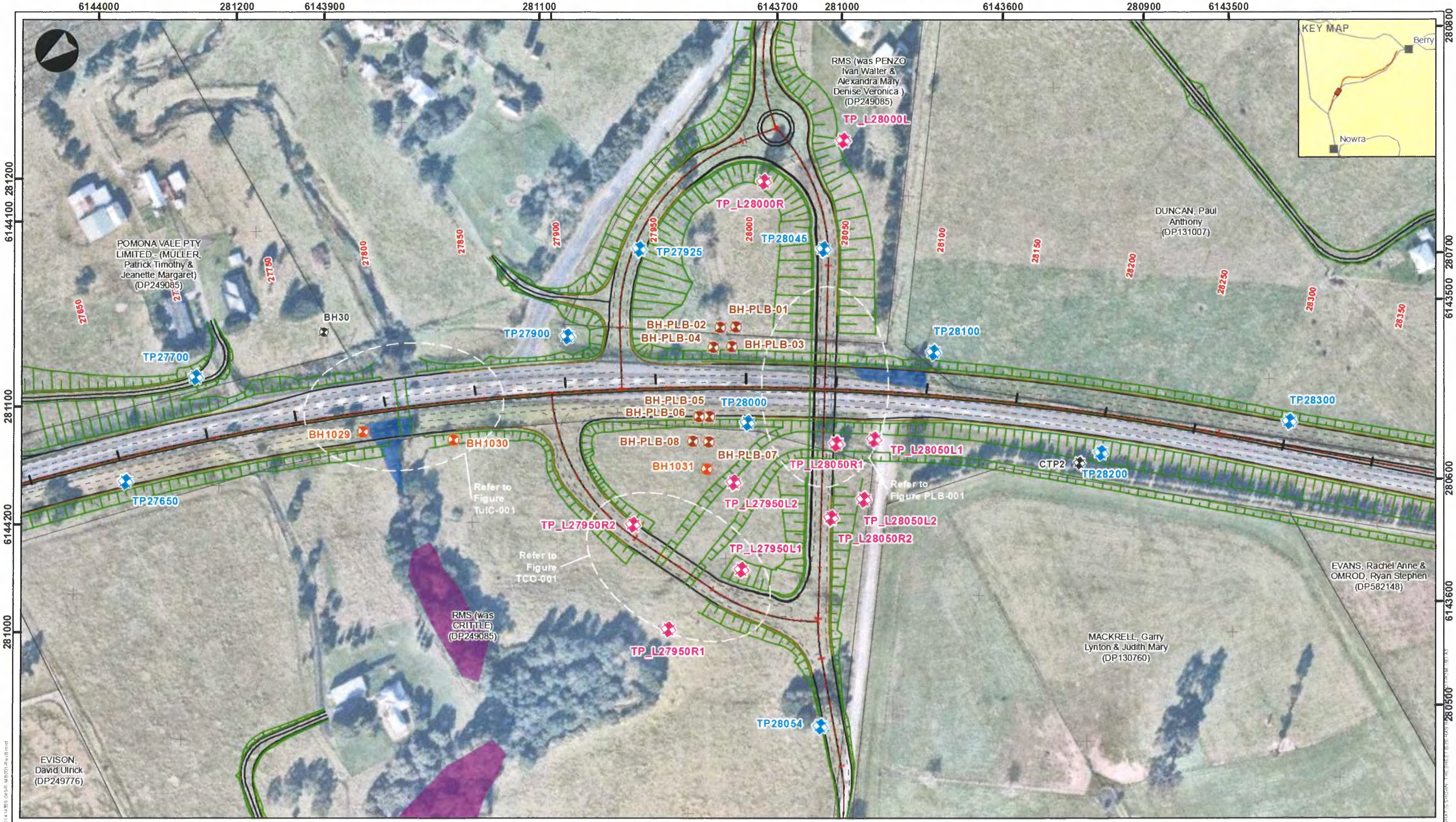
EMPLOYEE SIGN OFF

I have read and understood all tasks, hazards and control measures described within this document and agree to comply with the controls prescribed herein.

No.	Name of Employee	Date	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

GEOTECH



LEGEND

- Highway and Local Road TPs
- Main Line Culvert TPs
- Minor Line Culvert TPs
- Bulk TPs
- 2000 - Stage 2 Cut BHs
- 2000 - Stage 2 Bridge BHs
- 1000 - Stage 1 BHs
- 500 - Stage 1 TPs
- CPTs
- Previous Investigation BHs
- Previous Investigation TPs
- Previous Investigation CPTs

Threatened Ecological Communities

- Acacia scrub
- Currambene Batemans lowland forest
- Illawarra gully wet forest
- Reedland
- Riverbank forest
- Shoalhaven sandstone forest
- South Coast gully woodland

REFERENCE(S)
ALIGNMENT: XCCL-AA007343-NSX-00-RD01-CONTROL-ALIGN-SC1000_3D.DWG (2015-10-26)
IMAGERY: NEARMAP WMS
COORDINATE SYSTEM: GDA 1994 MGA ZONE 56

0 50 100
1:2,000 METERS

CLIENT
HYDER CONSULTING

PROJECT
BERRY TO BOMBADERRY PRINCES HIGHWAY UPGRADE

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-12-18
DESIGNED	ICD
PREPARED	TCH
REVIEWED	BC
APPROVED	JND

TITLE
GEOTECHNICAL INVESTIGATION PLAN
SHEET 13 OF 16

PROJECT NO	REPORT	REV	FIGURE
1414569	049-R	A	13

REPORT OF BOREHOLE: BH1031

Golder Associates

CLIENT: Hyder
PROJECT: Berry to Bomaderry Upgrade
LOCATION: Princes Highway
JOB NO: 1414569

COORDS: 280846.22 m E 6143878.34 m N MGA94 56
SURFACE RL: 19.96 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 24.49 m

DRILL RIG: Edson 3000
CONTRACTOR: BHC Drilling
LOGGED: FDS DATE: 1/4/15
CHECKED: BJF DATE: 16/12/15

Drilling					Sampling	Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AST	L	GWNO	0	19.96		ML	Clayey SILT medium liquid limit, brown	M	S	
			0.30	19.66		CH	Silty CLAY high plasticity, dark brown, trace gravel			
	M		1.00	18.96	1.00 m BH1031-001 U50 1.00-1.40 m pp 400-500kpa	CI	Gravelly CLAY high plasticity, dark brown grey, trace sand		St - VSt	
			2.00	17.96	BH1031-002 U50 2.50-2.90 m pp 600+kpa	CH	Silty CLAY high plasticity, grey red-brown			
			3.50	16.46	BH1031-003 pp 600+ kpa SPT 4.00-4.45 m 7, 12, 17 N=29	CH	Sandy CLAY high plasticity, grey red-brown, trace sub-rounded to sub-angular, up to 10mm gravel		VSt - H	
			5.00	14.96		CH	Sandy Gravelly CLAY high plasticity, dark brown, sub-rounded to sub-angular, up to 10mm gravel, medium sand			
	H		5.60	14.36	5.50 m BH1031-004 SPT 5.50-5.78 m 24, 25/125mm N>25	GC	Sandy Clayey GRAVEL medium coarse grained, to 20 mm, sub-rounded to sub-angular, red-brown black, high plasticity clay, medium to coarse sand, inferred EW siltstone with limonite staining		D - VD	
RT	M	03/12/15	6.00	13.96		GC	Sandy Clayey GRAVEL medium coarse grained, to 2 mm, grey, medium to coarse sand, inferred medium dense	M - W	MD	
							For Continuation Refer to Sheet 2			

For Continuation Refer to Sheet 2

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a
RL3

Golder Associates

REPORT OF BOREHOLE: BH1031

SHEET: 2 OF 4

CLIENT: Hyder	COORDS: 280846.22 m E 6143878.34 m N MGA94 56	DRILL RIG: Edson 3000	
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.96 m DATUM: AHD	CONTRACTOR: BHC Drilling	
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: FDS	DATE: 1/4/15
JOB NO: 1414569	HOLE DEPTH: 24.49 m	CHECKED: BJF	DATE: 16/12/15

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
				0–9							
					9.49		Continuation of Sheet 1				
HQ3	GWNO	100	90 (95)		10.43		CORE LOSS SILTSTONE SANDY grey and orange brown, indistinct bedding	DW		9.56 m: B, 0°, Pl, Sm, limonite Sn 9.66-9.72 m: Bx2, 15°, sp ≈ 40-60 mm, Pl, silty clay, Ct 2mm Vr-Ct 9.75 m: J, 5-10°, Pl, Sm, limonite Sn	
				10							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F02a RL3

REPORT OF BOREHOLE: BH1031

Golder Associates

SHEET: 3 OF 4

CLIENT: Hyder	COORDS: 280846.22 m E 6143878.34 m N MGA94 56	DRILL RIG: Edson 3000
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.96 m DATUM: AHD	CONTRACTOR: BHC Drilling
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: FDS DATE: 1/4/15
JOB NO: 1414569	HOLE DEPTH: 24.49 m	CHECKED: BJF DATE: 16/12/15

METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	DEFECT DESCRIPTION & Additional Observations
HQ3	GWNO			10		SILTSTONE SANDY grey and orange brown, indistinct bedding	DW	9.83 m: B, 30°, Un, Sm, limonite Sn 9.86 m: B, 5-30°, Un, Sm, limonite Sn 9.91 m: B, 30-40°, St, Sm, silty clay Ct 10.07 m: DB 10.22 m: B, 0-5°, Pl, Sm, limonite Sn 10.24 m: B, 5-10°, Pl, silty clay, grey Cn 10.30 m: B, 30°, Pl, silty clay, grey Cn 10.35 m: B, 0-5°, Pl, silty clay, grey Cn 10.45-10.90 m: B, 5-10°, Pl, silty clay, grey Cn 10.47 m: J, 20°, St, Sm, limonite Sn 10.79 m: J, 20°, St, Sm, limonite Sn
		100	90 (95)	11	10.90 9.06	sand fine to coarse grained		11.26 m: J, 30°, Pl, Sm, limonite Sn 11.67-11.79 m: B, 5-10°, Pl, silty clay, grey Cn, 10 mm 11.80-11.83 m: J, 35°, Un, Sm, limonite Sn 11.93-12.05 m: DS, 90-80°, Pl, Sm, silty clay, grey Ct, 30 mm 11.98 m: B, 5°, Un, Sm, limonite Sn 12.06 m: B, 10-15°, Pl 12.30 m: J, 45°, St, Sm, clayey gravel Ct, 5 mm 12.47 m: DB
		100	85 (100)	13, 14	12.70 7.26	grey		12.67 m: B, 0-5°, Un, Ro, limonite Sn 12.73 m: B, 5-10°, Pl, Sm, limonite Sn 12.84 m: DB 12.89 m: B, 5°, Un, Ro, silty clay, grey Ct, 1 mm 13.01 m: B, 5°, Un, Sm, limonite Sn 13.04 m: B, 5°, Un, Sm, limonite Sn 13.05-13.22 m: B, 0-5°, Un, Sm, silty clay, grey Ct, 2 mm 13.26 m: J, 60°, Pl, Sm, limonite Vr, truncated by 4x intact B, 0-5, Un 13.49 m: B, 5°, Un, Sm, limonite Sn 13.58 m: J, 30°, Pl, Sm, gravelly silt Ct, 4 mm 13.69 m: B, 10°, Pl, Sm, limonite Sn 13.70 m: J, 80-85°, Un, Sm, silty clay, grey Ct, 1 mm 13.78 m: J, 30°, Pl, Sm, silty clay, grey Ct, 1 mm 13.87 m: B, 5°, Un, Sm, limonite Sn 13.94 m: DB 14.03 m: B, 0-5°, Pl, Sm, limonite Sn
				15, 16	14.47 5.49	SANDSTONE fine to coarse grained, massive, orange brown and grey, with fine to course gravel of siltstone and quartz		14.20 m: DB 14.25 m: B, 30°, Pl, Cn 14.34 m: B, 30°, Pl, silty clay Ct, 4 mm 14.40 m: J, 30°, Pl, silty clay Ct, 2 mm 14.44 m: B, 0-5°, Pl, silty clay Ct, 1 mm 14.45 m: B, 0-5°, Pl, silty clay Ct, 1 mm 14.48 m: C, 0-5°, Un, Ro, siltstone/sandstone 15.43 m: B, 0-5°, Pl, Ro, Cn
		100	95 (100)	17, 18	17.20 2.76	with siltstone clasts up to 30mm, grey		17.17 m: B, 5-10°, Un, Sm, limonite Sn 18.04 m: B, 5-10°, Un, Ro, clayey sand Vr 18.31 m: DB 18.49 m: DB
		100	30 (100)	19, 20	18.80 1.16	decrease in angular clasts		19.05 m: J, 10°, Pl, Ro, Cn 19.13-21.08 m: J, 85-90°, Un, Sm-Ro, clayey gravel Ct, 5 mm 19.50 m: J, 5-10°, Pl, Ro, gravelly clay Ct, 15 mm 19.83 m: J, 0-5°, Pl, Ro, Cn

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REPORT OF BOREHOLE: BH1031

Golder Associates

		SHEET: 4 OF 4	
CLIENT: Hyder	COORDS: 280846.22 m E 6143878.34 m N MGA94 56	DRILL RIG: Edson 3000	
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.96 m DATUM: AHD	CONTRACTOR: BHC Drilling	
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: FDS	DATE: 1/4/15
JOB NO: 1414569	HOLE DEPTH: 24.49 m	CHECKED: BJF	DATE: 16/12/15

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)
HQ3	GWNO	100	30 (100)	20			SANDSTONE fine to coarse grained, massive, orange brown and grey, with fine to course gravel of siltstone and quartz	SW		20.00 m: J, 0-5°, Pl, Ro, Sn 20.19 m: B, 5°, Pl, Ro, silty clay Vr 20.59 m: J, 5°, Un, Sm, clayey gravel Ct, 4 mm 20.90 m: DB	
				21						21.60-21.90 m: J, 70-80°, Un, Ro, limonite Sn	
		100	100 (100)	22	21.93 -1.97		becomes grey, no staining	SW - FR		21.92 m: B, 15°, Un, Sm, Cn 22.57 m: B, 15°, Pl, Sm, silty clay Vr 22.71 m: B, 0°, Pl, Sm, silty clay Vr 22.88 m: B, 0-5°, Un, Ro, Cn	
				23							
				24	24.49 -4.53		END OF BOREHOLE @ 24.49 m TARGET DEPTH PIEZOMETER INSTALLED			24.00 m	
				25							
				26							
				27							
				28							
				29							
				30							

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REPORT OF BOREHOLE: BH-PLB-01

CLIENT: Hyder	COORDS: 280899.25 m E 6143818.95 m N MGA94 56	DRILL RIG: Ute mounted
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 18.05 m DATUM: AHD	CONTRACTOR: Tightsite
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: AM DATE: 7/8/15
JOB NO: 1414569	HOLE DEPTH: 25.00 m	CHECKED: BJF DATE: 16/12/15

Drilling					Sampling	Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	GWNE	0	18.05		CL	Silty CLAY low plasticity, brown, with some roots	D - M	F - St	TOPSOIL
				0.45 17.60	BH-PLB-01-001 SPT 1.00-1.45 m 3, 5, 8 N=13	CI-CH	Silty CLAY medium to high plasticity, brown and pale grey		St - VSt	ALLUVIUM
	H		2	2.00 16.05	BH-PLB-01-002 SPT 2.50-2.95 m 8, 11, 18 N=29 BH-PLB-01-003 SPT 4.00-4.45 m 7, 14, 18 N=32	CH	Silty CLAY high plasticity, orange brown and grey brown		H	
ADT				5.50 12.55	5.50 m BH-PLB-01-004 SPT 5.50-5.95 m 12, 12, 13 N=25 PP 6.70 m =450 kPa	CH	Gravelly CLAY medium to high plasticity, orange brown and grey, fine to coarse grained, rounded to sub-angular siltstone gravel, trace rounded to sub-rounded, inferred high to very high strength, igneous cobbles	M	VSt - H	
NMLC	M	95-100% Water RETURN	7	7.10			CORE LOSS			
				7.20 10.85	PP 7.70 m =500 kPa	CH	Gravelly CLAY medium to high plasticity, orange brown, fine to coarse grained, rounded to sub-angular siltstone gravel, trace rounded to sub-rounded, inferred high to very high strength, igneous cobbles			
			8	7.95 10.10			CORE LOSS			
				8.23 9.82	PP 8.70 m =320 kPa	CH	Gravelly CLAY medium to high plasticity, orange brown with some pale grey, fine grained, rounded to sub-angular siltstone gravel, trace rounded to sub-rounded, inferred high to very high strength, igneous cobbles, trace fine to coarse grained sand			
				9.47			CORE LOSS			
				8.48	PP 9.70 m =420 kPa	CI-CH				
			10							

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REPORT OF BOREHOLE: BH-PLB-01

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SHEET: 2 OF 4

CLIENT: Hyder	COORDS: 280899.25 m E 6143818.95 m N MGA94 56	DRILL RIG: Ute mounted
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 18.05 m DATUM: AHD	CONTRACTOR: Tightsite
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: AM DATE: 7/8/15
JOB NO: 1414569	HOLE DEPTH: 25.00 m	CHECKED: BJF DATE: 16/12/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
NMLC	M	95-100% Water RETURN	10					CI-CH	Gravelly CLAY medium to high plasticity, orange brown with some pale grey, fine grained, rounded to sub-angular siltstone gravel, with some rounded to sub-rounded, inferred high to very high strength, igneous cobbles, trace fine to coarse grained sand	M	VSt - H	ALLUVIUM
			11		PP 10.90 m =400 kPa							
					PP 11.40 m =440 kPa							
			12									
					PP 12.60 m =300 kPa							
			13		PP 13.30 m =320 kPa							
			14		PP 14.20 m =480 kPa							
			15		PP 15.50 m =240 kPa							
			16		PP 16.20 m =220 kPa							
				16.54 / 1.51					CORE LOSS			
			17	17.00 / 1.05				GP	Gravelly COBBLES to 200 mm, rounded to sub-angular, sedimentary and igneous cobbles, inferred medium to very high strength, orange brown and grey to pale grey, fine grained, rounded to sub-angular siltstone gravel		D - VD	
			18									
									For Continuation Refer to Sheet 3			
			19									
			20									

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GAP 8_09.0 UB.GLB Log GAP NON-CORED FULL PAGE 1414569 STAGE TWO LOGS.GPJ <<DrawingFile>> 18/12/2015 14:54 8.30.004 Datgel Tools

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REPORT OF BOREHOLE: BH-PLB-01

CLIENT: Hyder	COORDS: 280899.25 m E 6143818.95 m N MGA94 56	DRILL RIG: Ute mounted
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 18.05 m DATUM: AHD	CONTRACTOR: Tightsite
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: AM DATE: 7/8/15
JOB NO: 1414569	HOLE DEPTH: 25.00 m	CHECKED: BJF DATE: 16/12/15

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
				10–18							
					18.30		Continuation of Sheet 2				
NMLC	95-100% Water RETURN	100	90 (100)	18.30–20	-0.25		SANDSTONE fine to medium grained, grey, indistinct bedding	SW - MW		18.37-18.37 m: B, 0-5°, Pl-Un, Ro, clay Cn-Vr 18.37-18.50 m: J, 60°, Pl, Ro, clay Cn-Vr 18.37-18.37 m: B, 0-5°, Pl-Un, Ro, clay Cn-Vr 18.37-18.50 m: J, 60°, Pl, Ro, clay Cn-Vr 18.55-18.57 m: B, 10°, Pl, Ro, Cn, possible handling break 18.96-18.96 m: B, 5°, Pl, Ro, clay Cn-Vr 19.21-19.21 m: B, 0°, Pl, Ro, clay Cn-Vr 19.50-19.51 m: J, 10°, Pl, Ro, clay Cn-Vr 19.53-19.53 m: J, 10°, Pl, Ro, clay Cn-Vr 19.71-19.80 m: J, 50°, Pl, Ro, clay Cn-Vr	

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REPORT OF BOREHOLE: BH-PLB-01

CLIENT: Hyder	COORDS: 280899.25 m E 6143818.95 m N MGA94 56	SHEET: 4 OF 4
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 18.05 m DATUM: AHD	DRILL RIG: Ute mounted
LOCATION: Princes Highway	INCLINATION: -90°	CONTRACTOR: Tightsite
JOB NO: 1414569	HOLE DEPTH: 25.00 m	LOGGED: AM DATE: 7/8/15
		CHECKED: BJF DATE: 16/12/15

Drilling: METHOD: NMLC; WATER: 95-100% Water RETURN

TCR	RQD (SCR)	DEPTH (metres)	DEPTH / RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	DEFECT DESCRIPTION & Additional Observations
100	90 (100)	20		SANDSTONE fine to medium grained, grey, indistinct bedding	SW - MW	19.93-20.00 m: J, 50°, Pl, Ro, clay Cn-Vr 20.04-20.05 m: J, 20°, Pl, Ro, clay Cn-Vr 20.18-20.29 m: J, 60°, Pl-Un, Ro, clay Vr 20.29-20.36 m: J, 60°, Pl-Un, Ro, clay Cn-Vr
100	85 (95)	21				20.58-20.68 m: J, 50°, Pl-Un, Ro, clay Cn-Vr
100	60 (100)		21.30 / -3.25	SANDSTONE fine to medium grained, orange brown with some pale grey, indistinct bedding		21.16-21.16 m: B, 0-5°, Pl-Un, Ro, Cn 21.22-21.22 m: B, 0°, Pl-Un, Ro, Cn 21.28-21.30 m: B, 10°, Pl-Un, Ro, Cn 21.35-21.35 m: B, 5°, Pl-Un, Ro, Cn 21.44-21.51 m: J, 40°, Pl, Ro, Cn 21.71-21.77 m: J, 35°, Pl, Ro, Cn 21.80-21.82 m: J, 20°, Pl, Ro, Cn 21.90-21.96 m: J, 30°, Pl, Ro, Cn
100	75 (100)	22	21.95 / -3.90	becoming grey	FR - SW	22.20-22.30 m: J, 60°, Pl, Ro, Cn
		23	22.35 / -4.30	becoming orange brown with some pale grey		22.60-22.60 m: B, 5-10°, Pl-Un, Ro, Cn 22.73-22.78 m: J, 30°, Pl, Ro, Cn 22.91-22.91 m: B, 5°, Pl, Ro, Cn 23.12-23.20 m: J, 50°, Pl, Ro, Cn 23.27-23.27 m: B, 0°, Pl, Ro, Cn 23.44-23.51 m: J, 50°, Pl, Ro, Cn 23.51-23.64 m: J, 50°, sp = 10-20 mm, Pl, Ro, Cn 23.76-23.81 m: J, 20-70°, Pl, Ro, Cn 23.86-23.86 m: B, 0-5°, Pl, Ro, clay Vr
100	90 (100)	24	23.90 / -5.85	becoming grey		23.91-23.91 m: B, 5-20°, Pl, Ro, Cn 24.50-24.91 m: J, 85-90°, Pl-Un, Ro, Cn
		25	25.00 / -6.95	END OF BOREHOLE @ 25.00 m TARGET DEPTH GROUTED		
		26				
		27				
		28				
		29				
		30				

Column headings: GRAPHIC LOG; INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH); AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)

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REPORT OF BOREHOLE: BH-PLB-07

SHEET: 1 OF 4

CLIENT: Hyder	COORDS: 280857.68 m E 6143868.76 m N MGA94 56	DRILL RIG: Mobile B80
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.59 m DATUM: AHD	CONTRACTOR: Nealings Drilling
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: JN DATE: 15/7/15
JOB NO: 1414569	HOLE DEPTH: 23.17 m	CHECKED: JDM DATE: 27/7/15

Drilling					Sampling	Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH / RL	SAMPLE OR FIELD TEST	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	GWNE	0	19.59			Sandy CLAY high plasticity, dark brown, fine grained sand, with trace rootlets	M		FILL
ADV	L / M	GWNE	0.40	0.40 19.19	BH-Bridge10-07-001 SPT 1.00-1.45 m 2, 3, 5 N=8 BH-Bridge10-07-002 U 1.50-1.90 m		CLAY high plasticity, brown, with some silt and trace rootlets	M		
ADV	M	GWNE	2.20	2.20 17.39	BH-Bridge10-07-003 SPT 2.50-2.95 m 6, 8, 12 N=20	CH	Silty CLAY high plasticity, brown	M	St - VSt	ALLUVIUM
ADV	H	GWNE	2.80	2.80 16.79		CI-CH	Gravelly CLAY medium to high plasticity, pale grey and dark brown, fine grained, sub-rounded gravel, with trace organic matter	M	St - VSt	
ADV	H	GWNE	3.00	3.00 16.59	BH-Bridge10-07-004 SPT 4.00-4.45 m 8, 12, 13 N=25	CH	Sandy CLAY high plasticity, pale grey and dark brown, fine to medium grained sand, with trace rootlets	M	St - VSt	
NMLC	H	GWNO	4.91	4.91 14.68		GC	Gravelly CLAY with cobbles high plasticity, pale grey and brown, fine to coarse grained, sub-rounded gravel, fine to coarse grained, rounded to sub-rounded, very high strength cobbles, medium to coarse grained sand	M	VSt - H	
NMLC	H	GWNO	7.12	7.12 12.47		CH	Gravelly Sandy CLAY high plasticity, pale grey to orange brown, fine to coarse grained sand, fine to coarse grained, sub-rounded to sub-angular gravel	M	St	
NMLC	H	GWNO	7.54	7.54 12.05		GC	Gravelly CLAY with cobbles high plasticity, pale grey and brown, fine to coarse grained, sub-rounded gravel, fine to coarse grained, rounded to sub-rounded, very high strength cobbles, medium to coarse grained sand	M	VSt - H	
NMLC	L	GWNO	8.64	8.64 10.95			CORE LOSS			
NMLC	H	GWNO	9.13	9.13 10.46		GC	Gravelly CLAY with cobbles high plasticity, pale grey and brown, fine to coarse grained, sub-rounded gravel, fine to coarse grained, rounded to sub-rounded, very high strength cobbles, medium to coarse grained sand	M	VSt - H	
NMLC	H	GWNO	9.56	9.56 10.03		CH	Sandy CLAY grey to orange brown, fine to medium grained sand	M	St	

Depth scale: 0 – 10 m

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REPORT OF BOREHOLE: BH-PLB-07

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SHEET: 2 OF 4

CLIENT: Hyder	COORDS: 280857.68 m E 6143868.76 m N MGA94 56	DRILL RIG: Mobile B80
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.59 m DATUM: AHD	CONTRACTOR: Nealings Drilling
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: JN DATE: 15/7/15
JOB NO: 1414569	HOLE DEPTH: 23.17 m	CHECKED: JDM DATE: 27/7/15

Drilling					Sampling	Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
NMLC	H	GWNO	10				CH	Sandy CLAY grey to orange brown, fine to medium grained sand	M	St	ALLUVIUM
			11	11.05 8.54			CH	Sandy Gravelly CLAY high plasticity, grey and orange brown, fine grained, rounded to sub-rounded gravel, fine to coarse grained sand	M	VSt - H	
				11.50 8.09			GC	Gravelly CLAY with cobbles high plasticity, pale grey and orange brown, fine to coarse grained, sub-rounded gravel, fine to coarse grained, rounded to sub-rounded, very high strength cobbles, medium to coarse grained sand		VSt - H	
				11.73 7.86				CORE LOSS			
			12	11.96 7.63			GC	Gravelly CLAY with cobbles high plasticity, pale grey and orange brown, fine to coarse grained, sub-rounded gravel, fine to coarse grained, rounded to sub-rounded, very high strength cobbles, medium to coarse grained sand	M	VSt - H	
				12.74				CORE LOSS			
			13	12.89 6.70			GC	Gravelly CLAY with cobbles high plasticity, pale grey and orange brown, fine to coarse grained, sub-rounded gravel, fine to coarse grained, rounded to sub-rounded, very high strength cobbles, medium to coarse grained sand	M	St VSt - H	
			14					For Continuation Refer to Sheet 3			
			15								
			16								
			17								
			18								
			19								
			20								

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REPORT OF BOREHOLE: BH-PLB-07

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CLIENT: Hyder	COORDS: 280857.68 m E 6143868.76 m N MGA94 56	SHEET: 3 OF 4	
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.59 m DATUM: AHD	DRILL RIG: Mobile B80	
LOCATION: Princes Highway	INCLINATION: -90°	CONTRACTOR: Nealings Drilling	
JOB NO: 1414569	HOLE DEPTH: 23.17 m	LOGGED: JN	DATE: 15/7/15
		CHECKED: JDM	DATE: 27/7/15

Drilling						Field Material Description		Defect Information
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH / RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	DEFECT DESCRIPTION & Additional Observations
				10 – 13	13.89	Continuation of Sheet 2		
NMLC	GWNO	100	100 (100)	14	5.70	SANDSTONE medium to coarse grained, orange brown, indistinct laminations, trace fine to coarse grained, rounded to sub rounded gravel	HW - MW	
		100	90 (100)	15				15.06 m: B, 0-5°, Un, Ro, Cn 15.13-15.20 m: DS, sand
								15.78-15.81 m: DS, sand 15.88-16.00 m: DS, sand
				16	16.22 / 3.37	fine grained, rounded to sub rounded gravel		
					16.43 / 3.16	fine to medium grained, rounded to sub rounded gravel from 16.43 to 17.94m		
				17	17.22 / 2.37	fine grained, rounded to sub rounded gravel		
					17.43 / 2.16	fine to medium grained, rounded to sub rounded gravel from 17.43 to 17.49m		17.72 m: B, 13°, Pl-St, Ro, Cn 17.87-18.07 m: J, 75-85°, Un, Ro, Sn
				18	17.94 / 1.65	fine to medium grained, rounded to sub rounded gravel from 17.94 to 17.98m		
					1.55			18.27 m: B, 16°, Pl, Ro, Cn
		100	100 (100)		18.34	siltstone laminations from 0 - 10 degrees	FR	
					18.48	becoming grey	EW	18.44-18.48 m: DS, 15°, sandy clay
					1.11	fine to medium grained, rounded to sub rounded gravel from 18.48 to 18.72m	FR	
				19 – 20	20.00			

INFERRED STRENGTH $Is_{(50)}$ MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH) — AVERAGE DEFECT SPACING (mm) (10, 30, 100, 300, 1000, 3000)

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GAP gINT FN. F02a RL3

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REPORT OF BOREHOLE: BH-PLB-07

SHEET: 4 OF 4

CLIENT: Hyder	COORDS: 280857.68 m E 6143868.76 m N MGA94 56	DRILL RIG: Mobile B80
PROJECT: Berry to Bomaderry Upgrade	SURFACE RL: 19.59 m DATUM: AHD	CONTRACTOR: Nealings Drilling
LOCATION: Princes Highway	INCLINATION: -90°	LOGGED: JN DATE: 15/7/15
JOB NO: 1414569	HOLE DEPTH: 23.17 m	CHECKED: JDM DATE: 27/7/15

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
NMLC	GWNO	100	100 (100)	20	-0.41		SANDSTONE medium to coarse grained, grey, with trace fine grained rounded to sub rounded gravel	FR		19.95 m: B, 0-10°, Un, Ro, sandy clay Vr	
					20.27 / -0.68		trace medium to coarse grained gravel			20.23 m: B, 11°, Pl, Ro, sandy clay Vr	
										20.53 m: B, 8°, Pl-Un, Ro, sandy clay Vr	
				21							
										21.57 m: B, 10°, Pl-Un, Ro, sandy clay Vr	
										21.77 m: DS, 0-20°, sandy clay, 3 mm	
				22						22.00 m: J, 33°, Un-St, Ro, Cn	
				23	23.17						
					-3.58		END OF BOREHOLE @ 23.17 m TARGET DEPTH GROUTED AND MARKER STAKE PLACED				
				24							
				25							
				26							
				27							
				28							
				29							
				30							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F02a RL3

GAP 8_09.0 LIB.GLB Log GAP CORED BOREHOLE 1414569 STAGE TWO LOGS.GPJ <<DrawingFile>> 18/12/2015 14:59 8.30.004 Datgel Tools

RISK

ASSESSMENTS

Vermeer®

Horizontal Directional Drill

D80x100 Series II

NAVIGATOR®

Efficiency at its Best.

The Vermeer® D80x100 Series II Navigator® horizontal directional drill (HDD) was designed with the operator in mind. A climate-controlled cab with 360-degree visibility, a state-of-the-art operator's station and dual joystick controls all help to increase operator efficiency in the field.

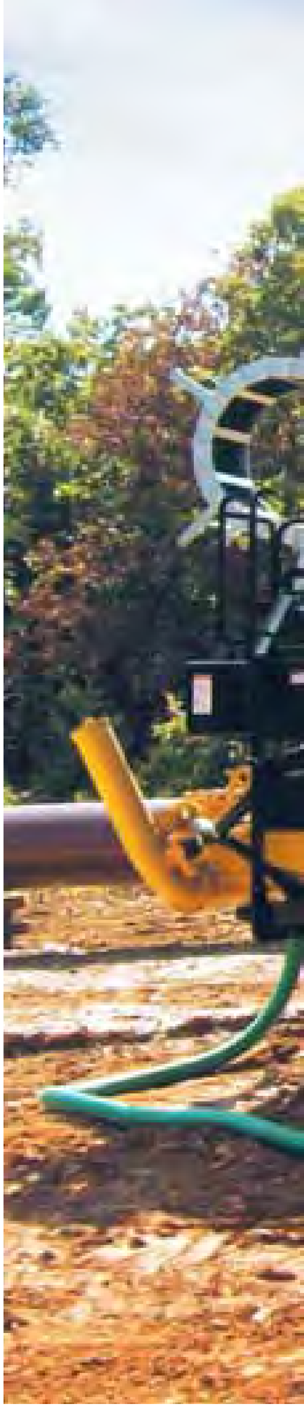
The D80x100 Series II delivers 10,000 ft-lb (13,558.2 Nm) of rotational torque and 80,000 lb (36,287.4 kg) of thrust/pullback force to perform a wide range of bores in difficult ground conditions. Equipped with a 200 hp (149.1 kW) John Deere diesel engine, the D80x100 Series II offers a 150 gpm (567.8 L/min) or 200 gpm (757.1 L/min) onboard pump for increased back-reaming efficiency and power to downhole mud motors.

For increased strength, the D80x100 Series II is equipped with a pre- heat-treated alloy steel rack-and-pinion carriage drive. Bolt-on gear rack sections make replacement easy when compared to welded gear rack sections.

An optional telescopic crane allows the drill operator to change out rod boxes without the use of an excavator or backhoe. The remote-controlled crane gives the operator freedom to move around the drill for improved visibility when replacing rod boxes. The crane has a lift capacity of 7530 lb (3415.6 kg) and a maximum reach of over 20' (6.1 m).

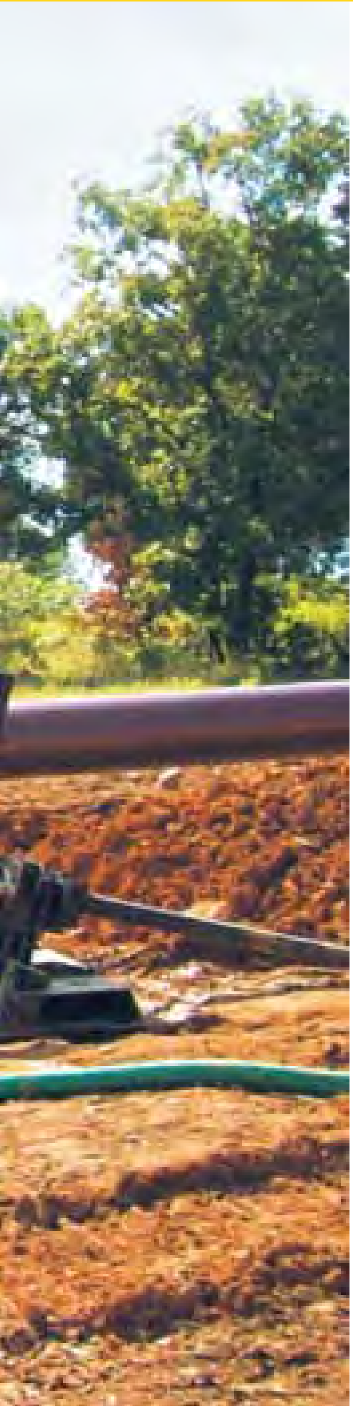
Climate-controlled cab. The standard cab provides 360-degree visibility for easy monitoring of all machine operations. Independent heating and air-conditioning controls allow the operator to control the cab climate and enhance comfort in all weather conditions, including snow, rain and summer heat. A full-size hinged door provides easy access to the operator's station, while tinted glass windows help reduce glare and heat from the sun.

State-of-the-art operator's station. Dual joysticks control functions for drilling fluid flow, breakout vise and throttle, and are integrated into the thrust and rotation controls. This feature provides the operator fingertip control over repetitive drill functions.



Rack-and-pinion drive. This system provides for smooth operation. The rack is sectionalized and bolts on for easy repair or replacement.

The floating vise feature allows the breakout system to clamp the full rod upsets during breakout of the lower and upper joints. The D80x100 Series II uses replaceable breakout dies.



Protect your investment. *In addition to the Vermeer Equipment Limited Warranty, Vermeer offers you peace of mind by providing additional lifetime limited warranty protection on all rack gears and pinion gears.**

* Covered components: all rack gears and pinion gears. Excludes carriage, carriage rollers and guide rollers. See policy for details.

Measured to exact tolerances. Firestick® drill stem from Vermeer is designed to handle high-torque drilling situations while retaining a large inside diameter for superior drilling fluid flow. Constructed of Vermeer-specified high-carbon alloy steel, Firestick drill stem features one-piece forged rods that have been heat-treated for uniform strength and consistent quality.

D80x100 Series II Specifications

General
Length (transport): 29.8' (9.1 m)
Width (transport): 93" (236.2 cm)
Height: 118" (299.7 cm)
Height (with crane option): 11' (3.4 m)
Weight (24-rod box): 42,500 lb (19,277.7 kg)
Weight (12-rod box, crane): 43,000 lb (19,504.5 kg)

Power
Engine: John Deere 6068 Tier 3
Gross power rating: 200 hp (149.1 kW)
Rated rpm: 2400

Fluid Capacities
Engine oil (including filter): 5 gal (18.9 L)
Fuel tank: 75 gal (283.9 L)
Hydraulic tank: 85 gal (321.8 L)

Operational
Max spindle torque:
- Low: 10,000 ft-lb (13,558.2 Nm)
- Medium: 6700 ft-lb (9084 Nm)
- High: 5000 ft-lb (6779.1 Nm)

Max spindle speed: 180 rpm
Thrust: 80,000 lb (36,287.4 kg)
Pullback: 80,000 lb (36,287.4 kg)
Min bore diameter: 5" (12.7 cm)
Max ground drive speed: 3.2 mph (5.1 km/h)
Max carriage speed: 175 fpm (53.3 m/min)
Drill rack angle: 33°
Remote lockout: Yes
Electrical strike alert: Yes

Drilling Fluid System
Max flow: 150 or 200 gpm (567.8 or 757.1 L/min)
Max pressure: 1100 psi (75.8 bar)

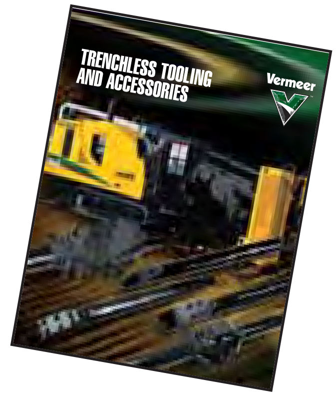
Features
Breakout system: Power vise
Drilling lights
Flow indicator

Crane
Weight: 2500 lb (1134 kg)
Max lifting capacity: 7530 lb (3415.6 kg)
Max lifting capacity (at full reach): 2350 lb (1065.9 kg)
Rotation: 200°
Max reach: 20.6' (6.3 m)

Drill Rod
Type: Firestick
Length: 15' (4.6 m)
Joint diameter: 3.625" (9.2 cm)
Pipe diameter: 3.5" (8.9 cm)
Weight: 250 lb (113.4 kg)
Clip weight (12-rod box): 3550 lb (1610.3 kg);
(24-rod box): 6550 lb (2971 kg)
Min bend radius: 197.4' (60.2 m)
Rod carrying capacity (24-rod box): 360' (109.7 m)

Vermeer offers everything from specialty tooling to training and technology.

At any given time, more than half of all horizontal directional drilling units in the world are Vermeer Navigator machines. To help ensure smooth-running operations, Vermeer offers everything you need – from one-day training seminars to computer software – for more efficient bore planning and performance.



The Vermeer Cutting Edge Group produces some of the world's most popular HDD, specialty and custom-made tooling. Call for a FREE HDD accessories catalog! ***Call 1-866-VERMEER***

Vermeer drilling fluid management systems, including the MX240 (shown), provide the horizontal directional drill with quality mud mixing in a minimum amount of time.

Wetting agents, polymers and bentonites — you need the right mix to get through the tough bores. Vermeer offers specially formulated nontoxic polymer and bentonite drilling fluids to get the job done.

Locating systems are developed by working closely with the world's premier locating companies. Vermeer helps keep you on the leading edge of technology by offering a variety of options designed to meet the needs of varying applications.

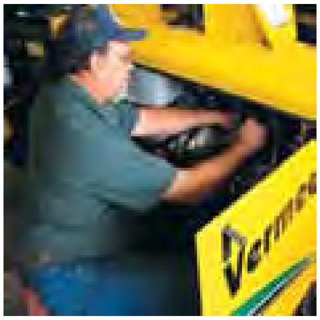
Vermeer features a global team of Navigator HDD solutions specialists that provide localized training and operation expertise designed for the conditions in your area.

Position HDD as green with e-CALC by Vermeer, a software tool developed to help estimate and compare the carbon emissions of various underground installation methods, including horizontal directional drilling and open-cut with excavators.

The efficient, economical way to plan a bore. Vermeer software heightens professionalism by aiding the operator in preplanning the bore and comparing the planned bore path with the actual bore path.

The Vermeer dealer network: Reliable support, all over the world.

With nearly 200 locations across the globe - you're never far from an independent, authorized Vermeer dealer. Our dealers are in place to support your success with product expertise that's second to none.



When you need service, you can count on your local Vermeer dealer. With multiple locations, remote service trucks, and factory-offered technician training, your local Vermeer dealer offers reliable service that keeps your equipment running.

Vermeer parts are designed and manufactured to original specifications, so whether they're new parts or replacement parts, they'll live up to the Vermeer name.

Vermeer®

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Fax: (641) 621-7773
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Call toll-free 1-888-VERMEER
1-888-837-6337 (U.S.A. only)

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PN 296287192

ALL ABOUT
TRAINING
& SAFETY

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
0447 243 040

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Baxter Vic 3911

Assessment Number: 0704	**Assessment Date:** 07-04-2020
Plant Type: Track Mounted Drilling Rig : ***Plant Make:*** Vermeer ***Plant Model:*** D80x10011 ***Reg,d :*** ***Plant Serial No:*** *IVRZ2707491000436* ***D Asset No:*** ***KM/ Hour Meter: 3913***	**Assessment Facilitated by:** Paul Berrill **Assessment Participants:** (Name & Title)
Plant Owner Name: Jelmac Directional Drilling	**Initial Assessment** ☒ **Follow up Assessment** (See below) ☐

Follow up based on change to:

Use of plant ☐ **System of work** ☐ **Plant Environment** ☐ **New or additional information** ☐ **Plant through modification** ☐

Is the plant designed to perform the task? Yes ☒ No ☐

Has the plant been modified from the original condition? Yes ☐ No ☒

Is the plant in good working condition and free of weeds & mud? Yes ☒ No ☐

All identified action items closed out/addressed (plant checks)? Yes ☒ No ☐

Is the plant safe to operate? Yes ☒ No ☐

Date: 07-04-2020 **Signature:** PBerrill

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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Risk / Opportunity Rating Table (see description of Risk Consequence, Opportunity Consequence and Likelihood Ratings)

Likelihood rating					
Almost Certain	D	C	B	A	A
Likely	D	D	C	B	A
Possible	E	D	C	C	B
Unlikely	E	E	D	C	B
Rare	E	E	D	D	C
Consequence rating	1	2	3	4	5

Action Table

Residual risk / opp level	Suggested action	Timing of status report and management plans	Authority for continued toleration or improvement of residual rating.
A	Take action to eliminate or implement additional controls to reduce it to acceptable level "Onsite activities" must not commence	Report as soon as practicable. .	Project Leadership Supervisor/ team leader
B	Implement additional controls reduce it to "Onsite activities" – must not commence without Corporate Management review	Manage and re-evaluate risk / opportunity to allow reporting days.. Manage and re-evaluate risk / opportunity to allow reporting every two weeks	Manager and / or Supervisor /Team leader OH&S site safety officer
C	Implement additional controls reduce it to "Onsite activities" – must not commence without Site Management review	Manage and re-evaluate risk / opportunity to allow reporting monthly	Project Manager/ Site Supervisor/ Team Leader/ Site Safety Officer
D	Will still require attention within existing operations to reduce to "Onsite Activities" – Site Management must determine appropriate level of management and supervision prior to commencement of activity	Manage and re-evaluate risk / opportunity to allow reporting every quarter	Team Leader / Site Safety Officer
E	Lower priority. May be tolerable. .	Monitor, manage and carryout activity in accordance with identified controls	Supervisor / Safety Officer

Action and Approval Scheme

These suggested timings and tolerance levels in the Action Table will be overridden by specific policies of the company that either dictate shorter timeframes for corrective action or zero tolerance. For example, the company has a zero tolerance policy for Safety and Environmental risks.

The decision to tolerate a risk or capture a opportunity should be based on a consideration of:

Whether the risk / opportunity is being controlled to a level that is reasonably achievable;

Whether it would be cost-effective to further control risk or capture the opportun

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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+Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
1. ENTANGLEMENT: Can anyone's hair clothing, gloves, necktie, jewellery, cleaning brushes, rags and other materials become entangled with moving parts of plant or materials in motion?							
a) Can anybody become entangled with moving parts of plant or materials in motion?	Y		Keep clear warning decals	Y			
			Keep clear slew area decal	N/A			
			Engine covers fitted	Y			
			Rotating parts warning decals	Y			
			Has operator been inducted?	Y			
a) Material falling off plant	Y		Attachments (eg: Forks)	N/A			
			Moving bucket/hammer	N/A			
b) Unexpected movement of the plant	Y		Neutral start switch	No			
			Crush zone warning decal	Y			
			Reversing Light	N/A			
			Rear vision Mirror	N/A			
			Look Behind Before Reversing Decal	No			
			Pedals non slip surface	Y			
			Controls have appropriate knobs	Y			
			Amber flashing beacon	Y			
			Reversing alarm	Y			
c) lack of capacity for plant to be slowed, stopped or immobilised	Y		Service brake operational	Y			
			Parking brake operational	N/A			
			Hydrastatic drive forward/reverse leavers	Y			
d) The plant tipping or rolling over	Y		ROPS cabin	Y			
			FOPS cabin	N/A	SWMS		
			If cabin non ROPS, SWMS must be conducted for each job site	Y	A SWMS should be conducted for each job site		
e) Parts of plant collapsing	Y		Safety bars or props fitted	Y			
			Use safety bar when working under raised attachments decal	Y			

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
f) Coming into contact with moving parts of the plant during testing, inspection, operation, maintenance, cleaning or repair	Y		Do not stand under raised attachments decal	Y	On tilt cabin		
			Battery isolation switch fitted	Y	Remove Battery Before commencing any work		
g) Being thrown off or under the plant	Y		Seatbelt fitted	Y			
			Wear Seatbelt decal	Y			
			ROPS fitted seat belt must be worn decal	Y			
			No passengers decal	Y			
			Operator cabin fully enclosed	Y			
h) Being trapped between the plant and fixed structures during maintenance	Y		Training – signs, decals, barricades	Y			
a) Coming into contact with sharp or flying objects	Y		Any visible signs of sharp edges	No			
			Guards, Warning Signs, Hard Hat, Safety Boots, Face and Eyes	Y			
b) Coming into contact with moving parts of the plant during testing or repair of the plant	Y		Machine to be maintained to a safe standard by company	Y			
c) The plant, parts for the plant or work pieces disintegrating	Y		Protection of personnel	Y			
d) The mobility of the plant	Y		Danger machine may reverse without warning decal	Y			
e) Uncontrolled or unexpected movement of the plant	Y		Crush zone warning decal	Y			
				Y			

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
4. SHEARING: Can anybody's body parts be sheared between two parts of the plant or between a part of the plant and work structure?							
a) Body parts being sheared between plant or structures	Y		Do not start decal	Y			
			Attach safety bar before entering decal	Y	On Cabin Tilt		
a) Coming into contact with hot parts	Y		High mounted exhaust	Y			
			Hot Part decal	Y			
			Exhaust guarding	Y			
			Fire extinguisher supplied	Y	As per jobsite requirements		
a) Uncontrolled or unexpected movement of the plant or the material handled by the plant	Y		Foot brake	Y			
			Park brake	Y			
			Hydrastatic drive	Y			
			Forward/reverse controls	Y			
b) Changing cutting edges and attachments	Y		Quick hitch independent latching device supplied	No			
			Safety pin fitted	No			
			Safe operation of quick hitch is operators responsibility decal in operators line of sight	N/A			
c) The plant, part of the plant or work pieces disintegrating	Y		Machine guarding	Y			
			Keep clear decal	Y			
			Pre-start inspection	Y	Addressed by daily inspection booklet		
d) work pieces being ejected	Y		Machine guarding	Y			
			Keep clear decal	Y			
e) Mobility of the plant	Y		Glass – safe operation conditions	Y			
			Reversing alarm	Y			
			Amber flashing beacon	Y			
			Brake lights and turn signals	Y			
			Warning horn	Y			
			Controls instructions are identified and in English	Y			
f) Other factors not mentioned	Y			Y			

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
7. HIGH PRESSURE FLUID: Can anyone come into contact with fluids under high pressure?							
a) Leaking hydraulic hoses	Y		Hoses have been checked	Y	No Leaks at time of Assessment		
	Y		Warning decals	Y			
	Y		Diesel Decal	Y			
	Y		Cooling system decal	Y			
	Y		Hydraulic oil decal	Y			
a) coming into contact with live overhead conductors	Y		Has a SWMS been conducted?	Y			
			Underground services – Dial Before You Dig	Y			
			Certificate for No Go Zone	Y			
			Look up and Live decal in operators sight	Y			
			Electrical wire warning decal	Y			
b) Damaged Leads	Y		Battery cover fitted	Y			
			Battery decal	Y			
c) Lack of isolation procedures	Y		Isolation switch on battery	Y			
			Isolation decal	Y			
d) Damaged Switches	Y		Only qualified and trained people must complete task and SWMS must be completed	Y			
a) Lack of proper work platform	Y		Prevention of falls – *hand rails*	Y			
			Falling Hazard Decal	Y			
			Non Slip Surface	Y			
b) Poor floor or walking surface	Y		Non Slip tape	Y			
c) Lack of proper stairs or steps	Y		Steps and footings in place	Y			
			Use three points of contact decal	Y			
d) lack of guardrail/ handrail/grabs	Y		Guardrails – hand rails in place	Y			
e) Can someone fall from over 2M?	Y		Guardrails/Harness/Platform Ladder	Y			
f) Poor housekeeping	Y		No visible signs of excessive lubricant leakage during prestart checks	No			
			Operators station clear of debris, tools, bottles, chains, grease gun	N/A			

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Potential Hazard	Identified		Control Methods in Place	YesNo N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
10. ERGONOMIC: Can anyone be injured due to:							
a) Poor seating	Y		Seat adjustment controls operating	Y			
			Seat in usable condition	Y			
b) Constrained body effort	Y		Operating levers and pedals in operators reach	Y			
			Remove rear vandal cover each day decal	Y			
11. SUFFOCATION: Can anyone be suffocated due to lack of oxygen or atmospheric contamination?							
a) Heat Stress	Y		Ventilation	Y			
			Air Conditioning	Y	Carry water and wear correct PPE		
12. OTHER HAZARDS: Can anyone be injured or suffer ill-health from exposure to chemicals, toxic gases, or vapours, fumes, dust, noise, vibration, radiation or other factors not mentioned?							
a) Hazardous substances, noise, dangerous goods, plant, manual handling, trenching, prevention of falls	Y		Addressed by compliance codes and training	Y			
b) Fumes	Y		Engine fumes not excessive at high idle	Y			
			Door/window seals serviceable	Y			
c) Noise	Y		In limit of 85 DBA	Y	High Revs: 83.4 DBA		
			Hearing protection supplied	Y			
			Hearing protection decal	Y			
d) Other items	Y		Load capacity chart fitted	N/A			
			Lifting points – closed eye	No			
			SWL – WWL decal on dipper	N/A			
			Lift over 1 tonnes – Lock out fitted	N/A			
			Operator issued with PPE	Y			
e) Chemicals	Y		MSDS (Material Safety Data Sheets)	Y			
			Do not drink Decal	Y			

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
13. OPERATOR							
a) Does the operator hold a certificate of safety qualification to operate this plant	Y		Holds relevant qualifications	Y	To be assessed by company		
			Certificate No	Y			
			Types of plant	Y			
			Issue date	Y			
b) Operators manual issued	Y		In the machine/office	Y			
			Operators manual in English	Y			
			Manual in readable condition	Y			
			Instructions for attachments	Y			
14. DOCUMENTATION: Can documentation be provided for:							
a) daily plant inspection record book	Y		Plant inspection book/sheets	Y			
			Date of last entry	Y			
b) Servicing and maintenance of records (Crack testing report – cranes, concrete booms)	Y		Records held by company and available upon request	Y	If not on site, addressed by company		

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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GENERAL NOTES

The Owner/Operator of the above Mobile Plant should conduct an inspection at least once a year. All procedures and control methods are maintained to requirements of the National WHS Regulations, National Standards (Safe Work Australia), OH&S Safety Regulations Victoria 2017, Division 5 & the National Standards For Plant (NOHSC:1010 (1994))
In particular, when any alteration or change is made to the Mobile Plant, a review of both Control Methods and Documentation should be made.
A Mobile Plant Risk Assessment should be conducted at change of location. Refer to Plant Regs.

DISCLAIMER

This Mobile Plant Hazard & Risk Assessment Report (referred to hereafter as 'Assessment') contains information that is privileged and confidential and produced only for use by the Entity of person named on the front cover sheet of this Assessment.

This Mobile Plant Hazard & Risk Assessment does not eliminate the Owner/Operator responsibility to maintain the Mobile Plant as per National WHS Regulations & the OH&S Safety Regulations Victoria 20017, Division 5.

This Assessment provides information that is based on an inspection that was made on the date noted on the Assessment cover sheet. If any addition, alteration or modification has been made to this Mobile item Plant subsequent to that date, it may not conform to a satisfactory level of acceptance - therefore the Mobile Plant Hazard & Risk Assessment is null and void.

I acknowledge receipt of the complete Assessment for the Mobile Plant item detailed above.

Supervisor/Operator (Please Print):		Signature:	
Name of Assessor:	Paul Berrill	Signature:	PBerrill
Date:	07-04-2020		

Paul Berrill
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NOISE REPORT

This Noise Report is a Guide ONLY

Sound Level Meter Used:	Digital Sound Lever Meter N19 Q1362		
Background Noise Level	Below 50 DBA	**Risk Assessment Number:**	0704
Results – Operator Station Stationary			
Low Idle DBA:	DBA 75.9	**High Idle DBA:**	DBA 83.4
Operators Station (Operational) DBA:	DBA		
Cabin Type:		Overhead Frame (Fully enclosed, overhead frame only, frame & side windows, open, other)	

85 DBA @ ___m
(Front Left)

85 DBA @ ___m
(Front Right)

Front

Plant

Rear

85 DBA @ ___m
(Rear Left)

85 DBA @ m
(Rear Right)

Additional Comments:

Please note: Diagram (on left) can only be completed if noise exceeds 85DBA at operator station and owner/operator is in attendance at time of risk assessment, this is a noise GUIDE only. If the operator is not in attendance, then this diagram may become invalid and will not be completed.

Hearing Protection Zone Recommended around the equipment	Radius __7____m
Note:	Hearing protection is required for bystanders if they enter the hearing protection zone measured as a radius from the equipment. Without hearing protection, bystanders may be exposed to noise at or above 85DBA within this zone.

ALL ABOUT TRAINING & SAFETY

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
0447 243 040

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Assessment Number: 0510			**Assessment Date:** 09-07-2020
Plant Type: Mud Mixing Truck	***Plant Make:*** Mercedes Benz	***Plant Model:*** Actros	**Assessment Facilitated by:** Paul Berrill
Reg,d : XNV-620 ***D Asset No:***	***Plant Serial No:*** *WDB9342412K900598* ***KM/ Hour Meter: 840728***		**Assessment Participants:** (Name & Title)
Plant Owner Name: Jelmac Directional Drilling			**Initial Assessment** ☒ **Follow up Assessment** (See below) ☐

Follow up based on change to:

Use of plant ☐ **System of work** ☐ **Plant Environment** ☐ **New or additional information** ☐ **Plant through modification** ☐

Is the plant designed to perform the task?	Yes ☒	No ☐
Has the plant been modified from the original condition?	Yes ☐	No ☒
Is the plant in good working condition and free of weeds & mud?	Yes ☒	No ☐
All identified action items closed out/addressed (plant checks)?	Yes ☒	No ☐
Is the plant safe to operate?	Yes ☒	No ☐

Date: 09-07-20 **Signature:** [signature]

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Risk / Opportunity Rating Table (see description of Risk Consequence, Opportunity Consequence and Likelihood Ratings)

Likelihood rating	1	2	3	4	5
Almost Certain	D	C	B	A	A
Likely	D	D	C	B	A
Possible	E	D	C	C	B
Unlikely	E	E	D	C	B
Rare	E	E	D	D	C
	Consequence rating				

Action Table

Residual risk / opp level	Suggested action	Timing of status report and management plans	Authority for continued toleration or improvement of residual rating.
A	Take action to eliminate or implement additional controls to reduce it to acceptable level "Onsite activities" must not commence	Report as soon as practicable. .	Project Leadership Supervisor/ team leader
B	Implement additional controls reduce it to "Onsite activities" – must not commence without Corporate Management review	Manage and re-evaluate risk / opportunity to allow reporting days.. Manage and re-evaluate risk / opportunity to allow reporting every two weeks	Manager and / or Supervisor /Team leader OH&S site safety officer
C	Implement additional controls reduce it to "Onsite activities" – must not commence without Site Management review	Manage and re-evaluate risk / opportunity to allow reporting monthly	Project Manager/ Site Supervisor/ Team Leader/ Site Safety Officer
D	Will still require attention within existing operations to reduce to "Onsite Activities" – Site Management must determine appropriate level of management and supervision prior to commencement of activity	Manage and re-evaluate risk / opportunity to allow reporting every quarter	Team Leader / Site Safety Officer
E	Lower priority. May be tolerable. .	Monitor, manage and carryout activity in accordance with identified controls	Supervisor / Safety Officer

Action and Approval Scheme

These suggested timings and tolerance levels in the Action Table will be overridden by specific policies of the company that either dictate shorter timeframes for corrective action or zero tolerance. For example, the company has a zero tolerance policy for Safety and Environmental risks.

The decision to tolerate a risk or capture a opportunity should be based on a consideration of:

Whether the risk / opportunity is being controlled to a level that is reasonably achievable;

Whether it would be cost-effective to further control risk or capture the opportun

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
0447 243 040

PO Box 193
Baxter Vic 3911

+Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
1. ENTANGLEMENT: Can anyone's hair clothing, gloves, necktie, jewellery, cleaning brushes, rags and other materials become entangled with moving parts of plant or materials in motion?							
a) Can anybody become entangled with moving parts of plant or materials in motion?	Y		Keep clear warning decals	Y			
			Keep clear slew area decal	Y			
			Engine covers fitted	Y			
			Rotating parts warning decals	Y			
			Has operator been inducted?	Y			
a) Material falling off plant	Y		Attachments (eg: Forks)	Y			
			Moving bucket/hammer	Y			
b) Unexpected movement of the plant	Y		Neutral start switch	No			
			Crush zone warning decal	Y			
			Reversing Light	Y			
			Rear vision Mirror	Y			
			Look Behind Before Reversing Decal	Y			
			Pedals non slip surface	Y			
			Controls have appropriate knobs	Y			
			Amber flashing beacon	Y			
			Reversing alarm	Y			
c) lack of capacity for plant to be slowed, stopped or immobilised	Y		Service brake operational	Y			
			Parking brake operational	Y			
			Hydrastatic drive forward/reverse leavers	Y			
d) The plant tipping or rolling over	Y		ROPS cabin	Y			
			FOPS cabin	Y	SWMS		
			If cabin non ROPS, SWMS must be conducted for each job site	Y	A SWMS should be conducted for each job site		
e) Parts of plant collapsing	Y		Safety bars or props fitted	Y			
			Use safety bar when working under raised attachments decal	Y			

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
f) Coming into contact with moving parts of the plant during testing, inspection, operation, maintenance, cleaning or repair	Y		Do not stand under raised attachments decal	Y	On tilt cabin		
			Battery isolation switch fitted	Y	Remove Battery Before commencing any work		
g) Being thrown off or under the plant	Y		Seatbelt fitted	Y			
			Wear Seatbelt decal	Y			
			ROPS fitted seat belt must be worn decal	Y			
			No passengers decal	Y			
			Operator cabin fully enclosed	Y			
h) Being trapped between the plant and fixed structures during maintenance	Y		Training – signs, decals, barricades	Y			
a) Coming into contact with sharp or flying objects	Y		Any visible signs of sharp edges	No			
			Guards, Warning Signs, Hard Hat, Safety Boots, Face and Eyes	Y			
b) Coming into contact with moving parts of the plant during testing or repair of the plant	Y		Machine to be maintained to a safe standard by company	Y			
c) The plant, parts for the plant or work pieces disintegrating	Y		Protection of personnel	Y			
d) The mobility of the plant	Y		Danger machine may reverse without warning decal	Y			
e) Uncontrolled or unexpected movement of the plant	Y		Crush zone warning decal	Y			
				Y			

Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
4. SHEARING: Can anybody's body parts be sheared between two parts of the plant or between a part of the plant and work structure?							
a) Body parts being sheared between plant or structures	Y		Do not start decal	Y			
			Attach safety bar before entering decal	Y	On Cabin Tilt		
a) Coming into contact with hot parts	Y		High mounted exhaust	Y			
			Hot Part decal	Y			
			Exhaust guarding	Y			
			Fire extinguisher supplied	Y	As per jobsite requirements		
a) Uncontrolled or unexpected movement of the plant or the material handled by the plant	Y		Foot brake	Y			
			Park brake	Y			
			Hydrastatic drive	Y			
			Forward/reverse controls	Y			
b) Changing cutting edges and attachments	Y		Quick hitch independent latching device supplied	Y			
			Safety pin fitted	Y			
			Safe operation of quick hitch is operators responsibility decal in operators line of sight	Y			
c) The plant, part of the plant or work pieces disintegrating	Y		Machine guarding	Y			
			Keep clear decal	Y			
			Pre-start inspection	Y	Addressed by daily inspection booklet		
d) work pieces being ejected	Y		Machine guarding	Y			
			Keep clear decal	Y			
e) Mobility of the plant	Y		Glass – safe operation conditions	Y			
			Reversing alarm	Y			
			Amber flashing beacon	Y			
			Brake lights and turn signals	Y			
			Warning horn	Y			
			Controls instructions are identified and in English	Y			
f) Other factors not mentioned	Y			Y			

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
7. HIGH PRESSURE FLUID: Can anyone come into contact with fluids under high pressure?							
a) Leaking hydraulic hoses	Y		Hoses have been checked	Y	No Leaks at time of Assessment		
	Y		Warning decals	Y			
	Y		Diesel Decal	Y			
	Y		Cooling system decal	Y			
	Y		Hydraulic oil decal	Y			
a) coming into contact with live overhead conductors	Y		Has a SWMS been conducted?	Y			
			Underground services – Dial Before You Dig	Y			
			Certificate for No Go Zone	Y			
			Look up and Live decal in operators sight	Y			
			Electrical wire warning decal	Y			
b) Damaged Leads	Y		Battery cover fitted	Y			
			Battery decal	Y			
c) Lack of isolation procedures	Y		Isolation switch on battery	Y			
			Isolation decal	Y			
d) Damaged Switches	Y		Only qualified and trained people must complete task and SWMS must be completed	Y			
a) Lack of proper work platform	Y		Prevention of falls – *hand rails*	Y			
			Falling Hazard Decal	Y			
			Non Slip Surface	Y			
b) Poor floor or walking surface	Y		Non Slip tape	Y			
c) Lack of proper stairs or steps	Y		Steps and footings in place	Y			
			Use three points of contact decal	Y			
d) lack of guardrail/ handrail/grabs	Y		Guardrails – hand rails in place	Y			
e) Can someone fall from over 2M?	Y		Guardrails/Harness/Platform Ladder	Y			
f) Poor housekeeping	Y		No visible signs of excessive lubricant leakage during prestart checks	No			
			Operators station clear of debris, tools, bottles, chains, grease gun	N/A			

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	YesNo N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
10. ERGONOMIC: Can anyone be injured due to:							
a) Poor seating	Y		Seat adjustment controls operating	Y			
			Seat in usable condition	Y			
b) Constrained body effort	Y		Operating levers and pedals in operators reach	Y			
			Remove rear vandal cover each day decal	Y			
11. SUFFOCATION: Can anyone be suffocated due to lack of oxygen or atmospheric contamination?							
a) Heat Stress	Y		Ventilation	Y			
			Air Conditioning		Carry water and wear correct PPE		
12. OTHER HAZARDS: Can anyone be injured or suffer ill-health from exposure to chemicals, toxic gases, or vapours, fumes, dust, noise, vibration, radiation or other factors not mentioned?							
a) Hazardous substances, noise, dangerous goods, plant, manual handling, trenching, prevention of falls	Y		Addressed by compliance codes and training	Y			
b) Fumes	Y		Engine fumes not excessive at high idle	Y			
			Door/window seals serviceable	Y			
c) Noise	Y		In limit of 85 DBA	Y	High Revs: 70 DBA		
			Hearing protection supplied	Y			
			Hearing protection decal	Y			
d) Other items	Y		Load capacity chart fitted	Y			
			Lifting points – closed eye	Y			
			SWL – WWL decal on dipper	Y			
			Lift over 1 tonnes – Lock out fitted	N/A			
			Operator issued with PPE	Y			
e) Chemicals	Y		MSDS (Material Safety Data Sheets)	Y			
			Do not drink Decal	Y			

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
13. OPERATOR							
a) Does the operator hold a certificate of safety qualification to operate this plant	Y		Holds relevant qualifications	Y	To be assessed by company		
			Certificate No	Y			
			Types of plant	Y			
			Issue date	Y			
b) Operators manual issued	Y		In the machine/office	Y			
			Operators manual in English	Y			
			Manual in readable condition	Y			
			Instructions for attachments	Y			
14. DOCUMENTATION: Can documentation be provided for:							
a) daily plant inspection record book	Y		Plant inspection book/sheets	Y			
			Date of last entry	Y			
b) Servicing and maintenance of records (Crack testing report – cranes, concrete booms)	Y		Records held by company and available upon request	Y	If not on site, addressed by company		

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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GENERAL NOTES

The Owner/Operator of the above Mobile Plant should conduct an inspection at least once a year. All procedures and control methods are maintained to requirements of the National WHS Regulations, National Standards (Safe Work Australia), OH&S Safety Regulations Victoria 2017, Division 5 & the National Standards For Plant (NOHSC:1010 (1994))
In particular, when any alteration or change is made to the Mobile Plant, a review of both Control Methods and Documentation should be made.
A Mobile Plant Risk Assessment should be conducted at change of location. Refer to Plant Regs.

DISCLAIMER

This Mobile Plant Hazard & Risk Assessment Report (referred to hereafter as 'Assessment') contains information that is privileged and confidential and produced only for use by the Entity of person named on the front cover sheet of this Assessment.

This Mobile Plant Hazard & Risk Assessment does not eliminate the Owner/Operator responsibility to maintain the Mobile Plant as per National WHS Regulations & the OH&S Safety Regulations Victoria 20017, Division 5.

This Assessment provides information that is based on an inspection that was made on the date noted on the Assessment cover sheet. If any addition, alteration or modification has been made to this Mobile item Plant subsequent to that date, it may not conform to a satisfactory level of acceptance - therefore the Mobile Plant Hazard & Risk Assessment is null and void.

I acknowledge receipt of the complete Assessment for the Mobile Plant item detailed above.

Supervisor/Operator (Please Print):		Signature:	
Name of Assessor:	Paul Berrill	Signature:	PBerrill
Date:	09-07-2020		

Paul Berrill
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NOISE REPORT

This Noise Report is a Guide ONLY

Sound Level Meter Used:	Digital Sound Lever Meter N19 Q1362		
Background Noise Level	Below 50 DBA	**Risk Assessment Number:**	0510
Results – Operator Station Stationary			
Low Idle DBA:	DBA 60.0	**High Idle DBA:**	DBA 70.4
Operators Station (Operational) DBA:	DBA		
Cabin Type:	Overhead Frame (Fully enclosed, overhead frame only, frame & side windows, open, other)		

Additional Comments:

85 DBA @ ___m (Front Left)

85 DBA @ ___m (Front Right)

Front
Plant
Rear

85 DBA @ ___m (Rear Left)

85 DBA @ m (Rear Right)

Please note: Diagram (on left) can only be completed if noise exceeds 85DBA at operator station and owner/operator is in attendance at time of risk assessment, this is a noise GUIDE only. If the operator is not in attendance, then this diagram may become invalid and will not be completed.

Hearing Protection Zone Recommended around the equipment	Radius __7____m
Note:	Hearing protection is required for bystanders if they enter the hearing protection zone measured as a radius from the equipment. Without hearing protection, bystanders may be exposed to noise at or above 85DBA within this zone.

ALL ABOUT
TRAINING
& SAFETY

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill PO Box 193

Assessment Number: 22305	**Assessment Date:** 9 -07 -20
Plant Type: Vacuum ***Plant Make:*** Vac Dig ***Plant Model:*** VP1800-10000 ***Reg,d : XV73IH*** ***Asset No:*** ***Plant Serial No VTD1800-T10000-260520*** ***KM/ Hour Meter: 121***	**Assessment Facilitated by:** Paul Berrill **Assessment Participants:** (Name & Title)
Plant Owner Name: Jelmac Directional Drilling	**Initial Assessment** ☒ **Follow up Assessment** (See below) ☐

Follow up based on change to:

Use of plant ☐ **System of work** ☐ **Plant Environment** ☐ **New or additional information** ☐ **Plant through modification** ☐

Is the plant designed to perform the task?	Yes ☒	No ☐
Has the plant been modified from the original condition?	Yes ☐	No ☒
Is the plant in good working condition and free of weeds &	Yes ☒	No ☐
All identified action items closed out/addressed (plant checks)?	Yes ☒	No ☐
Is the plant safe to operate?	Yes ☒	No ☐

Date: 19- - 21 **Signature:** PB

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Risk / Opportunity Rating Table (see description of Risk Consequence, Opportunity Consequence and Likelihood Ratings)

Likelihood rating	1	2	3	4	5
Almost Certain	D	C	B	A	A
Likely	D	D	C	B	A
Possible	E	D	C	C	B
Unlikely	E	E	D	C	B
Rare	E	E	D	D	C

Consequence rating

Action and Approval Scheme

These suggested timings and tolerance levels in the Action Table will be overridden by specific policies of the company that either dictate shorter timeframes for corrective action or zero tolerance. For example, the company has a zero tolerance policy for Safety and Environmental risks.

The decision to tolerate a risk or capture a opportunity should be based on a consideration of:

Whether the risk / opportunity is being controlled to a level that is reasonably achievable;

Whether it would be cost-effective to further control risk or capture the opportun

Action Table

Residual risk / opp level	Suggested action	Timing of status report and management plans	Authority for continued toleration or improvement of residual rating.
A	Take action to eliminate or implement additional controls to reduce it to acceptable level "Onsite activities" must not commence	Report as soon as practicable. .	Project Leadership Supervisor/ team leader
B	Implement additional controls reduce it to "Onsite activities" – must not commence without Corporate Management review	Manage and re-evaluate risk / opportunity to allow reporting days.. Manage and re-evaluate risk / opportunity to allow reporting every two weeks	Manager and / or Supervisor /Team leader OH&S site safety officer
C	Implement additional controls reduce it to "Onsite activities" – must not commence without Site Management review	Manage and re-evaluate risk / opportunity to allow reporting monthly	Project Manager/ Site Supervisor/ Team Leader/ Site Safety Officer
D	Will still require attention within existing operations to reduce to "Onsite Activities" – Site Management must determine appropriate level of management and supervision prior to commencement of activity	Manage and re-evaluate risk / opportunity to allow reporting every quarter	Team Leader / Site Safety Officer
E	Lower priority. May be tolerable. .	Monitor, manage and carryout activity in accordance with identified controls	Supervisor / Safety Officer

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
0447 243 040

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Baxter Vic 3911

Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
1. ENTANGLEMENT: Can anyone's hair clothing, gloves, necktie, jewellery, cleaning brushes, rags and other materials become entangled with moving parts of plant or materials in motion?							
a) Can anybody become entangled with moving parts of plant or materials in motion?	Y		Keep clear warning decals	Y			
			Keep Clear Slew Area decals	No			
			Engine covers fitted	Y			
			Rotating parts warning decals	Y			
			Has operator been inducted?	Y			
2. CRUSHING: Can anyone be crushed due to:							
a) Material falling off plant	Y		Neutral start switch	Y			
b) Unexpected movement of the plant	Y		Crush zone warning decal	Y			
			Look Behind Before Reversing Decal	Y			
			Pedals non slip surface	N/A			
			Controls have appropriate knobs	Y			
			Amber flashing beacon	Y			
			Reversing alarm	N/A			
c) lack of capacity for plant to be slowed, stopped or immobilised	Y		Hydrastatic drive forward/reverse leavers	Y			
d) The plant tipping or rolling over	Y		If cabin non ROPS, SWMS must be conducted for each job site	Y	A SWMS should be conducted for each job site		
e) Parts of plant collapsing	Y		Safety Bar fitted	Y			

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
f) Coming into contact with moving parts of the plant during testing, inspection, operation, maintenance, cleaning or repair	Y		Do not stand under raised attachments decal	Y			
			Battery isolation switch fitted	Y			
g) Being thrown off or under the plant	Y						
			SAFETY HARNESS	N/A			
h) Being trapped between the plant and fixed structures during maintenance	Y		Training – signs, decals, barricades	N/A			
3. CUTTING: Can anyone be cut, stabbed or punctured due to:							
a) Coming into contact with sharp or flying objects	Y		Any visible signs of sharp edges	No			
			Guards, Warning Signs, Hard Hat, Safety Boots, Face and Eyes	Y			
b) Coming into contact with moving parts of the plant during testing or repair of the plant	Y		Machine to be maintained to a safe standard by company	Y			
c) The plant, parts for the plant or work pieces disintegrating	Y		Protection of personnel	Y			
d) The mobility of the plant	Y		Danger machine may reverse without warning decal	Y			
e) Uncontrolled or unexpected movement of the plant	Y		Crush zone warning decal	Y			
f) Other factors not mentioned							

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
4. SHEARING: Can anybody's body parts be sheared between two parts of the plant or between a part of the plant and work structure?							
a) Body parts being sheared between plant or structures	Y		Do not start decal	Y			
5. HIGH TEMPRETURES: Can anyone be burnt due to contact with moving parts or surfaces of the plant or materials handled by the plant?							
a) Coming into contact with hot parts	Y		High mounted exhaust	Y			
			Hot Part decal	Y			
			Exhaust guarding	Y			
			Fire extinguisher supplied	Y	As per jobsite requirements		
6. STRIKING: Can anyone be struck by moving objects due to:							
a) Uncontrolled or unexpected movement of the plant or the material handled by the plant	Y		Hydrastatic drive	Y			
			Forward/reverse controls	Y			
b) Changing cutting edges and attachments		No					
c) The plant, part of the plant or work pieces disintegrating	Y		Machine guarding	Y			
			Keep clear decal	Y			
			Pre-start inspection	Y	To be addressed by daily inspection booklet		
d) work pieces being ejected	Y		Machine guarding	Y			
			Keep clear decal	Y			
			Reversing alarm	Y			
			Amber flashing beacon	Y			
			Warning horn	Y			
			Controls instructions are identified and in English	Y			
f) Other factors not mentioned							

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
7. HIGH PRESSURE FLUID: Can anyone come into contact with fluids under high pressure?							
a) Leaking hydraulic hoses	Y		Hoses have been checked	Y	There are no leaking hoses		
			Warning decals	Y			
			Diesel Decal	Y			
			Cooling system decal	Y			
			Hydraulic oil decal	Y			
8. ELECTRICAL: Can anyone be injured by electrical shock or burnt due to:							
a) coming into contact with live overhead conductors	Y		Has a JSA been conducted?	Y			
			Certificate for No Go Zone	Y			
			Look up and Live decal in operators sight	Y			
			Electrical wire warning decal	No			
b) Damaged Leads	Y		Battery cover fitted	Y			
			Battery decal	Y			
c) Lack of isolation procedures	Y		Isolation switch on battery	Y			
			Isolation decal	Y			
d) Damaged Switches	Y		Only qualified and trained people must complete task and SWMS must be completed	Y			
9. FALLING – SLIPPING: Can anyone using the plant or in the vicinity of the plant, slip, trip or fall from heights over 2 meters?							
a) Lack of proper work platform	Y		Prevention of falls – *hand rails*	N/A	To be addressed by hand rails, guard rails or SWMS		
			Falling Hazard Decal	Y			
			Non Slip Surface	Y			
b) Poor floor or walking surface	Y		Non Slip tape	Y			
c) Lack of proper stairs or steps	Y		Steps and footings in place	Y			
			Use three points of contact decal	Y			
d) lack of guardrail/ handrail/grabs	Y		Guardrails – hand rails in place	Y			
e) Can someone fall from over 2M?	Y		Guardrails/Harness/Platform Ladder	Y			
f) Poor housekeeping	Y		No visible signs of excessive lubricant leakage during prestart checks	Y			
			Operators station clear of debris, tools, bottles, chains, grease gun	Y			

Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
10. ERGONOMIC: Can anyone be injured due to:							
a) Poor seating		No					
b) Constrained body effort	Y		Operating levers and pedals in operators reach	Y			
11. SUFFOCATION: Can anyone be suffocated due to lack of oxygen or atmospheric contamination?							
a) Heat Stress	Y		Ventilation	N/A			
			Air Conditioning	N/A	Carry water and wear correct PPE		
12. OTHER HAZARDS: Can anyone be injured or suffer ill-health from exposure to chemicals, toxic gases, or vapours, fumes, dust, noise, vibration, radiation or other factors not mentioned?							
a) Hazardous substances, noise, dangerous goods, plant, manual handling, trenching, prevention of falls	Y		Addressed by compliance codes and training	Y			
b) Fumes	Y		Engine fumes not excessive at high idle	No			
c) Noise	Y		In limit of 85 DBA	Y	High Revs: DBA		
			Hearing protection supplied	Y			
			Hearing protection decal	Y			
d) Other items	Y		Load capacity chart fitted	N/A			
			SWL – WWL decal on basket	N/A			
			Operator issued with PPE	Y			
e) Chemicals	Y		MSDS (Material Safety Data Sheets)	No			
			Do not drink Decal	Y			
13. OPERATOR							
a) Does the operator hold a certificate of safety qualification to operate this plant	Y		Holds relevant qualifications	Y	To be assessed by company		
			Certificate No	No			
			Types of plant	Y			
			Issue date	Y			
b) Operators manual issued	Y		In the machine/office	Y			
			Operators manual in English	Y			
			Manual in readable condition	Y			
			Instructions for attachments	Y			

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
14. DOCUMENTATION: Can documentation be provided for:							
a) daily plant inspection record book	Y		Plant inspection book/sheets	Y			
			Date of last entry	Y			
b) Servicing and maintenance of records (Crack testing report – cranes, concrete booms)	Y		Records held by company and available upon request	Y	If not on site, addressed by company		

GENERAL NOTES

The Owner/Operator of the above Mobile Plant should conduct an inspection at least once a year. All procedures and control methods are maintained to requirements of the National WHS Regulations, National Standards (Safe Work Australia), OH&S Safety Regulations Victoria 2017, Division 5 & the National Standards For Plant (NOHSC:1010 (1994))
In particular, when any alteration or change is made to the Mobile Plant, a review of both Control Methods and Documentation should be made.
A Mobile Plant Risk Assessment should be conducted at change of location. Refer to Plant Regs.

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PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
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I acknowledge receipt of the complete Assessment for the Mobile Plant item detailed above.

Supervisor/Operator (Please Print):		Signature:	
Name of Assessor:	Paul Berrill	Signature:	PBerrill
Date:	19-02-2021		

Paul Berrill
0447 243 040

PO Box 193
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NOISE REPORT

This Noise Report is a Guide ONLY

Sound Level Meter Used:	Digital Sound Lever Meter N19 Q1362		
Background Noise Level	Below 50 DBA	**Risk Assessment Number:**	22305
Results – Operator Station Stationary			
Low Idle DBA:	DBA	**High Idle DBA:**	DBA
Operators Station (Operational) DBA:	DBA		
Cabin Type:		Overhead Frame (Fully enclosed, overhead frame only, frame & side windows, open, other)	

Additional Comments:

85 DBA @ ___m
(Front Left)

85 DBA @ ___m
(Front Right)

Front
Plant
Rear

85 DBA @ ___m
(Rear Left)

85 DBA @ m
(Rear Right)

Please note: Diagram (on left) can only be completed if noise exceeds 85DBA at operator station and owner/operator is in attendance at time of risk assessment, this is a noise GUIDE only. If the operator is not in attendance, then this diagram may become invalid and will not be completed.

Hearing Protection Zone Recommended around the equipment	Radius __7____m
Note:	Hearing protection is required for bystanders if they enter the hearing protection zone measured as a radius from the equipment. Without hearing protection, bystanders may be exposed to noise at or above 85DBA within this zone.

ALL ABOUT
TRAINING
& SAFETY

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
0447 243 040

PO Box 193
Baxter Vic 3911

Assessment Number: 1049	**Assessment Date:** 09 -07-2020
Plant Type: Vacum Truck ***Plant Make:*** Isuzu ***Plant Model:*** FHFYH -500 ***Reg,d : XV73IH*** ***Plant Serial No JALFHY77TH7000433*** ***D Asset No:*** ***KM/ Hour Meter: 391***	**Assessment Facilitated by:** Paul Berrill **Assessment Participants:** (Name & Title)
Plant Owner Name: **Jelmac Directional Drilling**	**Initial Assessment** ☒ **Follow up Assessment** (See below) ☐
Follow up based on change to: **Use of plant** ☐ **System of work** ☐ **Plant Environment** ☐ **New or additional information** ☐ **Plant through modification** ☐	

Is the plant designed to perform the task? Yes ☒ No ☐

Has the plant been modified from the original condition? Yes ☐ No ☒

Is the plant in good working condition and free of weeds & mud? Yes ☒ No ☐

All identified action items closed out/addressed (plant checks)? Yes ☒ No ☐

Is the plant safe to operate? Yes ☒ No ☐

Date: 09-07-2020 **Signature:** PB

Risk / Opportunity Rating Table (see description of Risk Consequence, Opportunity Consequence and Likelihood Ratings)

Likelihood rating		1	2	3	4	5
	Almost Certain	D	C	B	A	A
	Likely	D	D	C	B	A
	Possible	E	D	C	C	B
	Unlikely	E	E	D	C	B
	Rare	E	E	D	D	C
		Consequence rating				

Action Table

Residual risk / opp level	Suggested action	Timing of status report and management plans	Authority for continued toleration or improvement of residual rating.
A	Take action to eliminate or implement additional controls to reduce it to acceptable level "Onsite activities" must not commence	Report as soon as practicable. .	Project Leadership Supervisor/ team leader
B	Implement additional controls reduce it to "Onsite activities" – must not commence without Corporate Management review	Manage and re-evaluate risk / opportunity to allow reporting days.. Manage and re-evaluate risk / opportunity to allow reporting every two weeks	Manager and / or Supervisor /Team leader OH&S site safety officer
C	Implement additional controls reduce it to "Onsite activities" – must not commence without Site Management review	Manage and re-evaluate risk / opportunity to allow reporting monthly	Project Manager/ Site Supervisor/ Team Leader/ Site Safety Officer
D	Will still require attention within existing operations to reduce to "Onsite Activities" – Site Management must determine appropriate level of management and supervision prior to commencement of activity	Manage and re-evaluate risk / opportunity to allow reporting every quarter	Team Leader / Site Safety Officer
E	Lower priority. May be tolerable. .	Monitor, manage and carryout activity in accordance with identified controls	Supervisor / Safety Officer

Action and Approval Scheme

These suggested timings and tolerance levels in the Action Table will be overridden by specific policies of the company that either dictate shorter timeframes for corrective action or zero tolerance. For example, the company has a zero tolerance policy for Safety and Environmental risks.

The decision to tolerate a risk or capture a opportunity should be based on a consideration of:

Whether the risk / opportunity is being controlled to a level that is reasonably achievable;

Whether it would be cost-effective to further control risk or capture the opportun

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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0447 243 040

PO Box 193
Baxter Vic 3911

Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
1. ENTANGLEMENT: Can anyone's hair clothing, gloves, necktie, jewellery, cleaning brushes, rags and other materials become entangled with moving parts of plant or materials in motion?							
a) Can anybody become entangled with moving parts of plant or materials in motion?	Y		Keep clear warning decals	Y			
			Keep Clear Slew Area decals	Y			
			Engine covers fitted	Y			
			Rotating parts warning decals	Y			
			Has operator been inducted?	Y			
2. CRUSHING: Can anyone be crushed due to:							
a) Material falling off plant	Y		Neutral start switch	Y			
b) Unexpected movement of the plant	Y		Crush zone warning decal	Y			
			Look Behind Before Reversing Decal	Y			
			Pedals non slip surface	Y			
			Controls have appropriate knobs	Y			
			Amber flashing beacon	Y			
			Reversing alarm	Y			
c) lack of capacity for plant to be slowed, stopped or immobilised	Y		Hydrastatic drive forward/reverse leavers	Y			
d) The plant tipping or rolling over	Y		If cabin non ROPS, SWMS must be conducted for each job site	Y	A SWMS should be conducted for each job site		
e) Parts of plant collapsing	Y		Safety Bar fitted	Y			

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Baxter Vic 3911

Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
f) Coming into contact with moving parts of the plant during testing, inspection, operation, maintenance, cleaning or repair	Y		Do not stand under raised attachments decal	Y			
			Battery isolation switch fitted	Y			
g) Being thrown off or under the plant	Y			Y			
			SAFETY HARNESS	Y			
h) Being trapped between the plant and fixed structures during maintenance	Y		Training – signs, decals, barricades	Y			
3. CUTTING: Can anyone be cut, stabbed or punctured due to:							
a) Coming into contact with sharp or flying objects	Y		Any visible signs of sharp edges	Y			
			Guards, Warning Signs, Hard Hat, Safety Boots, Face and Eyes	Y			
b) Coming into contact with moving parts of the plant during testing or repair of the plant	Y		Machine to be maintained to a safe standard by company	Y			
c) The plant, parts for the plant or work pieces disintegrating	Y		Protection of personnel	Y			
d) The mobility of the plant	Y		Danger machine may reverse without warning decal	Y			
e) Uncontrolled or unexpected movement of the plant	Y		Crush zone warning decal	Y			
f) Other factors not mentioned							

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
4. SHEARING: Can anybody's body parts be sheared between two parts of the plant or between a part of the plant and work structure?							
a) Body parts being sheared between plant or structures	Y		Do not start decal	Y			
5. HIGH TEMPRETURES: Can anyone be burnt due to contact with moving parts or surfaces of the plant or materials handled by the plant?							
a) Coming into contact with hot parts	Y		High mounted exhaust	Y			
			Hot Part decal	Y			
			Exhaust guarding	Y			
			Fire extinguisher supplied	Y	As per jobsite requirements		
6. STRIKING: Can anyone be struck by moving objects due to:							
a) Uncontrolled or unexpected movement of the plant or the material handled by the plant	Y		Hydrastatic drive	Y			
			Forward/reverse controls	Y			
b) Changing cutting edges and attachments		No					
c) The plant, part of the plant or work pieces disintegrating	Y		Machine guarding	Y			
			Keep clear decal	Y			
			Pre-start inspection	Y	To be addressed by daily inspection booklet		
d) work pieces being ejected	Y		Machine guarding	Y			
			Keep clear decal	Y			
			Reversing alarm	Y			
			Amber flashing beacon	Y			
			Warning horn	Y			
			Controls instructions are identified and in English	Y			
f) Other factors not mentioned							

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
7. HIGH PRESSURE FLUID: Can anyone come into contact with fluids under high pressure?							
a) Leaking hydraulic hoses	Y		Hoses have been checked	Y	There are no leaking hoses		
			Warning decals	Y			
			Diesel Decal	Y			
			Cooling system decal	Y			
			Hydraulic oil decal	Y			
8. ELECTRICAL: Can anyone be injured by electrical shock or burnt due to:							
a) coming into contact with live overhead conductors	Y		Has a JSA been conducted?	Y			
			Certificate for No Go Zone	Y			
			Look up and Live decal in operators sight	Y			
			Electrical wire warning decal	Y			
b) Damaged Leads	Y		Battery cover fitted	Y			
			Battery decal	Y			
c) Lack of isolation procedures	Y		Isolation switch on battery	Y			
			Isolation decal	Y			
d) Damaged Switches	Y		Only qualified and trained people must complete task and SWMS must be completed	Y			
9. FALLING – SLIPPING: Can anyone using the plant or in the vicinity of the plant, slip, trip or fall from heights over 2 meters?							
a) Lack of proper work platform	Y		Prevention of falls – *hand rails*	Y	To be addressed by hand rails, guard rails or SWMS		
			Falling Hazard Decal	Y			
			Non Slip Surface	Y			
b) Poor floor or walking surface	Y		Non Slip tape	Y			
c) Lack of proper stairs or steps	Y		Steps and footings in place	Y			
			Use three points of contact decal	Y			
d) lack of guardrail/ handrail/grabs	Y		Guardrails – hand rails in place	Y			
e) Can someone fall from over 2M?	Y		Guardrails/Harness/Platform Ladder	Y			
f) Poor housekeeping	Y		No visible signs of excessive lubricant leakage during prestart checks	Y			
			Operators station clear of debris, tools, bottles, chains, grease gun	Y			

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Potential Hazard	Identified YES	Identified NO	Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
10. ERGONOMIC: Can anyone be injured due to:							
a) Poor seating		No					
b) Constrained body effort	Y		Operating levers and pedals in operators reach	Y			
11. SUFFOCATION: Can anyone be suffocated due to lack of oxygen or atmospheric contamination?							
a) Heat Stress	Y		Ventilation	Y			
			Air Conditioning	N/A	Carry water and wear correct PPE		
12. OTHER HAZARDS: Can anyone be injured or suffer ill-health from exposure to chemicals, toxic gases, or vapours, fumes, dust, noise, vibration, radiation or other factors not mentioned?							
a) Hazardous substances, noise, dangerous goods, plant, manual handling, trenching, prevention of falls	Y		Addressed by compliance codes and training	Y			
b) Fumes	Y		Engine fumes not excessive at high idle	Y			
c) Noise	Y		In limit of 85 DBA	Y	High Revs: 76 DBA		
			Hearing protection supplied	Y			
			Hearing protection decal	Y			
d) Other items	Y		Load capacity chart fitted	Y			
			SWL – WWL decal on basket	Y			
			Operator issued with PPE	Y			
e) Chemicals	Y		MSDS (Material Safety Data Sheets)	Y			
			Do not drink Decal	Y			
13. OPERATOR							
a) Does the operator hold a certificate of safety qualification to operate this plant	Y		Holds relevant qualifications	Y	To be assessed by company		
			Certificate No	Y			
			Types of plant	Y			
			Issue date	Y			
b) Operators manual issued	Y		In the machine/office	Y			
			Operators manual in English	Y			
			Manual in readable condition	Y			
			Instructions for attachments	Y			

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Potential Hazard	Identified		Control Methods in Place	Yes No N/A	Additional Control Methods Required / Comments	Action Date	Date Completed
	YES	NO					
14. DOCUMENTATION: Can documentation be provided for:							
a) daily plant inspection record book	Y		Plant inspection book/sheets	Y			
			Date of last entry	Y			
b) Servicing and maintenance of records (Crack testing report – cranes, concrete booms)	Y		Records held by company and available upon request	Y	If not on site, addressed by company		

GENERAL NOTES

The Owner/Operator of the above Mobile Plant should conduct an inspection at least once a year. All procedures and control methods are maintained to requirements of the National WHS Regulations, National Standards (Safe Work Australia), OH&S Safety Regulations Victoria 2017, Division 5 & the National Standards For Plant (NOHSC:1010 (1994))
In particular, when any alteration or change is made to the Mobile Plant, a review of both Control Methods and Documentation should be made.
A Mobile Plant Risk Assessment should be conducted at change of location. Refer to Plant Regs.

DISCLAIMER

This Mobile Plant Hazard & Risk Assessment Report (referred to hereafter as 'Assessment') contains information that is privileged and confidential and produced only for use by the Entity of person named on the front cover sheet of this Assessment.

This Mobile Plant Hazard & Risk Assessment does not eliminate the Owner/Operator responsibility to maintain the Mobile Plant as per National WHS Regulations & the OH&S Safety Regulations Victoria 20017, Division 5.

PLANT HAZARD & RISK ASSESSMENT OF MOBILE PLANT

Paul Berrill
0447 243 040

PO Box 193
Baxter Vic 3911

This Assessment provides information that is based on an inspection that was made on the date noted on the Assessment cover sheet. If any addition, alteration or modification has been made to this Mobile item Plant subsequent to that date, it may not conform to a satisfactory level of acceptance - therefore the Mobile Plant Hazard & Risk Assessment is null and void.

I acknowledge receipt of the complete Assessment for the Mobile Plant item detailed above.

Supervisor/Operator (Please Print):		Signature:	
Name of Assessor:	Paul Berrill	Signature:	PBerrill
Date:	09-07-2020		

Paul Berrill
0447 243 040

PO Box 193
Baxter Vic 3911

NOISE REPORT

This Noise Report is a Guide ONLY

Sound Level Meter Used:	Digital Sound Lever Meter N19 Q1362		
Background Noise Level	Below 50 DBA	**Risk Assessment Number:**	1049
Results – Operator Station Stationary			
Low Idle DBA:	DBA 66.6	**High Idle DBA:**	DBA 76.3
Operators Station (Operational) DBA:	DBA		
Cabin Type:	Overhead Frame (Fully enclosed, overhead frame only, frame & side windows, open, other)		

Additional Comments:

85 DBA @ ___m
(Front Left)

85 DBA @ ___m
(Front Right)

Front
Plant
Rear

85 DBA @ ___m
(Rear Left)

85 DBA @ m
(Rear Right)

Please note: Diagram (on left) can only be completed if noise exceeds 85DBA at operator station and owner/operator is in attendance at time of risk assessment, this is a noise GUIDE only. If the operator is not in attendance, then this diagram may become invalid and will not be completed.

Hearing Protection Zone Recommended around the equipment	Radius __7____m
Note:	Hearing protection is required for bystanders if they enter the hearing protection zone measured as a radius from the equipment. Without hearing protection, bystanders may be exposed to noise at or above 85DBA within this zone.

TRAFFIC MANAGEMENT PLANS

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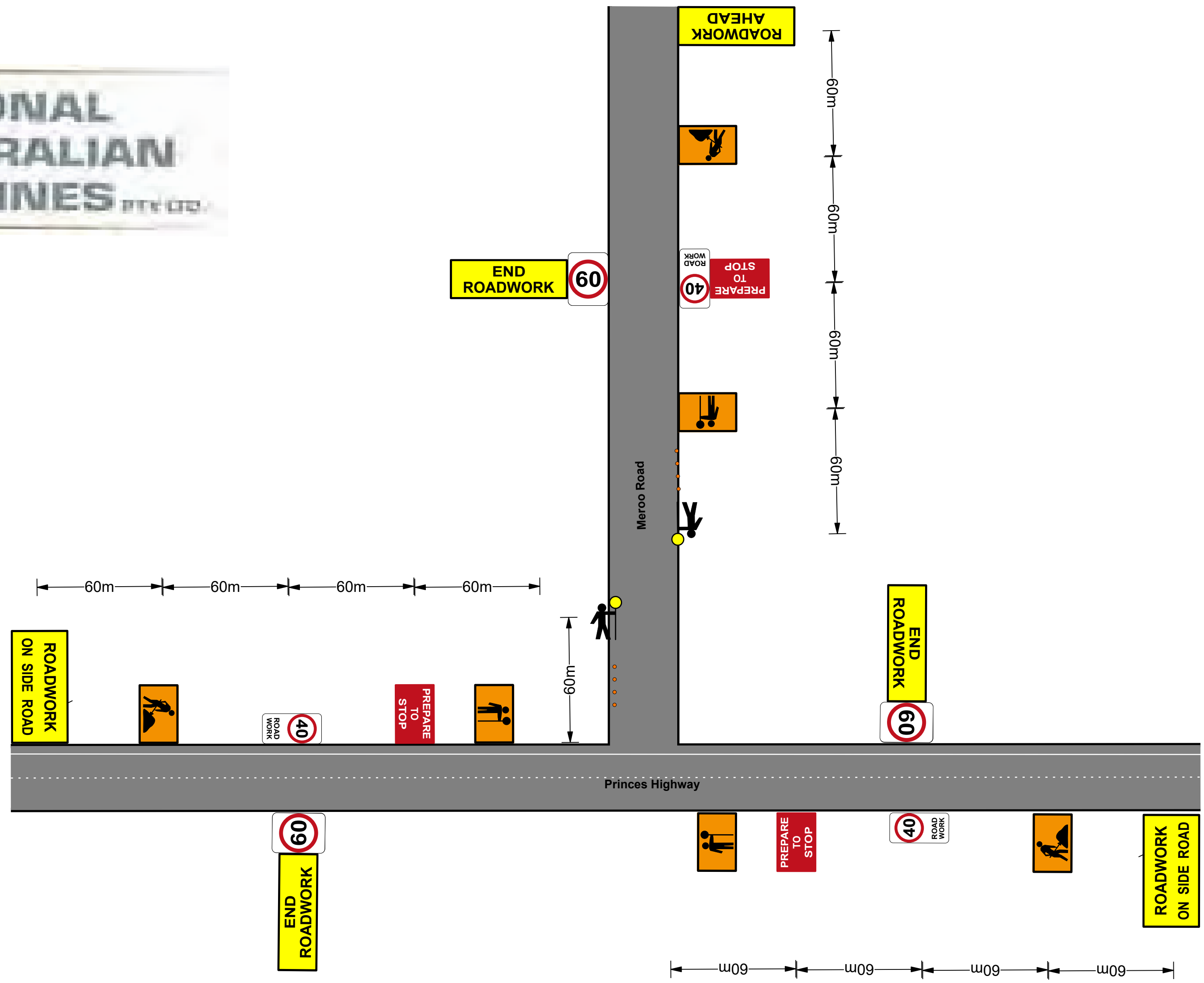

Notes:
1. Local constraints may not allow signage and devices to be placed in accordance with this TGS
Signs and devices are to to be positioned in accordance with the tolerances shown in Section 7.10.3 of the TCAWS Version 6.0 2020
2. This TGS is suitable for short term works
3. This is a site specific designed TGS
4. The value of speed limit signs shall match the speed zone approval
5. Traffic Control Officer must maintain 1.5M from live traffic unless a risk assessment has been conducted
6. Ensure all approval requirements have been met prior to setup
7. Cover all conflicting signage where required
8. This site MUST comply with the TCAWS Version 6.0 2020 and AS 1742.3 (MUTCD) 2009
9. B Size signage must be used for all permanent Sites

Amendments
All amendments to this TGS must be clearly Documented on this plan. Amendments can only be made by Coordinator - Traffic Services holding a red, orange or PWZTMP card in consultation with the relevant project works supervisor.
Name______________________________
PWZTMP Number______________________
Exp Date____________________
Date____________ Sign__________________
Reason for modification_____________________

Traffic PROFESSIONALS

Name -

Cert No -

Implemented By

Signed -

Princes Hwy TMA WORKS

WORKERS ON FOOT
NO GO ZONE =
RESTRICTED ZONE =
SHARED ZONE =
SITE EXIT = X
SITE ENTRY = E
EVACUATION POINT = EP

D = THE SPEED OF TRAFFIC MEASURED IN KM/H
EG: 80KM = 80M
70KM = 70M
60KM = 60M
50KM = 50M
SEE SECTION 4.2 TRAFFIC CONTROL AT WORK SITES MANUAL

WORK AREA =

TGS USED AS A GUIDE

PREPARED BY Maryann Spresser
PWZT TCT004609 : Expiry: 13/07/2022

TMP No:
TMPACs-NAP-08
TGS Designed Date: 25/11/2021
TGS Expire Date: 25/11/2022

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Impact Protection Vehicles shall be situated behind the work vehicles to provide cover in the trafficable lane and to give advance warning of the works to oncoming vehicles. The IPVs and Traffic Control Truck shall display a speed reduction based on the permanent speed of the road and reduce the speed to 40 past the work area.
Where dynamic works cannot be safely completed, The works shall revert back to a static worksite.

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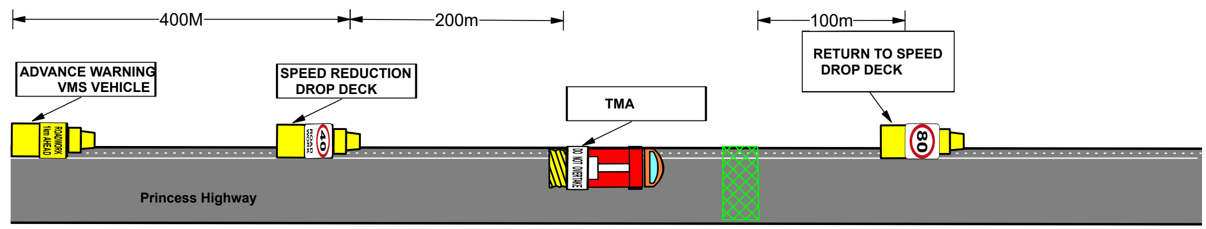

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PWZTMP Number________________
Exp Date________________
Date____________ Sign________________
Reason for modification________________

Traffic PROFESSIONALS

Implemented By

Name - Signed -

Cert No -

Princes Hwy TMA WORKS

WORKERS ON FOOT
NO GO ZONE =
RESTRICTED ZONE =
SHARED ZONE =
SITE EXIT =
SITE ENTRY =
EVACUATION POINT =

D = THE SPEED OF TRAFFIC MEASURED IN KM/H
SEE SECTION 4.2 TRAFFIC CONTROL AT WORK SITES MANUAL

EG: 80KM = 80M
70KM = 70M
60KM = 60M
50KM = 50M

WORK AREA =

TGS USED AS A GUIDE

PREPARED BY Maryann Spresser
PWZT TCT004609 : Expiry: 13/07/2022

TMP No:
TMPACs-NAP-09
TGS Designed Date: 26/11/2021
TGS Expire Date: 26/11/2022

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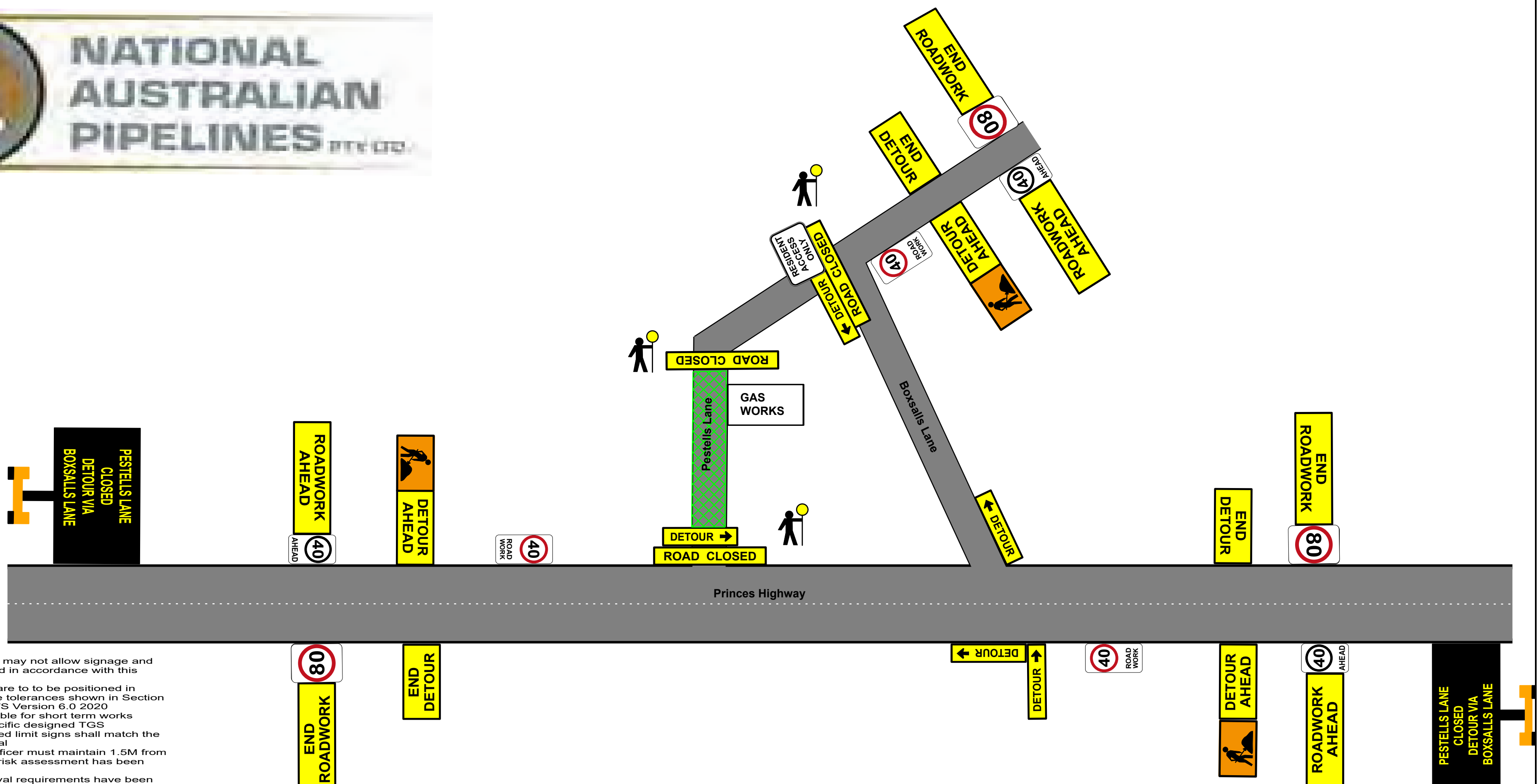

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7. Cover all conflicting signage where required
8. This site MUST comply with the TCAWS Version 6.0 2020 and AS 1742.3 (MUTCD) 2009
9. B Size signage must be used for all permanent Sites
10. VMS boards with notification of closure and detour must be placed in advance of closure

Amendments
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Name________________________
PWZTMP Number____________________
Exp Date________________
Date_________ Sign_____________
Reason for modification____________________

D = RECOMMENDED TAPER LENGTHS
SEE SECTION 5.2 TRAFFIC CONTROL AT WORK SITES MANUAL

< 45 km/H = 15M	76-85 km/H = 130M
46-55 km/H = 30M	86-95 km/H = 145M
56-65 km/H = 60M	96-105 km/H = 160M
66-75 km/H = 115M	105 km/H+ = 180M

D = THE SPEED OF TRAFFIC MEASURED IN KM/H
SEE SECTION 4.2 TRAFFIC CONTROL AT WORK SITES MANUAL

EG: 80KM = 80M, 70KM = 70M, 60KM = 60M, 50KM = 50M

PEDESTRIANS / PEDESTRIANS
PEDESTRIAN SIGNS TO BE INSTALLED WHERE APPLICABLE IF REQUIRED

TCP 41 USED AS A GUIDE

Author : *M Spresser*

PREPARED BY Mary-Ann Spresser
CERT NO: TCT004609 Expiry: 13/07/2022

PLAN NOT TO SCALE

Implemented By

Name:…………………………..........
Date:...
Signed:……………………..............
Cert No:……………………..............

WORKERS ON FOOT

SITE EXIT = X
SITE ENTRY = E
EVACUATION POINT = EP
NO GO ZONE =
RESTRICTED ZONE =
SHARED ZONE =

This plan is in accordance with AS 1742.3 Traffic Control Devices at worksites and The RTA "Traffic Control at worksites" 2020 manual. 6.0

Pestells Lane Closure

WORK AREA =

TRAFFIC PROFESSIONALS DOES NOT ACCEPT LIABILITY FOR IMPLEMENTATION OF THIS TCP IF NOT DIRECTLY INVOLVED IN ITS IMPLEMENTATION

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Notes:
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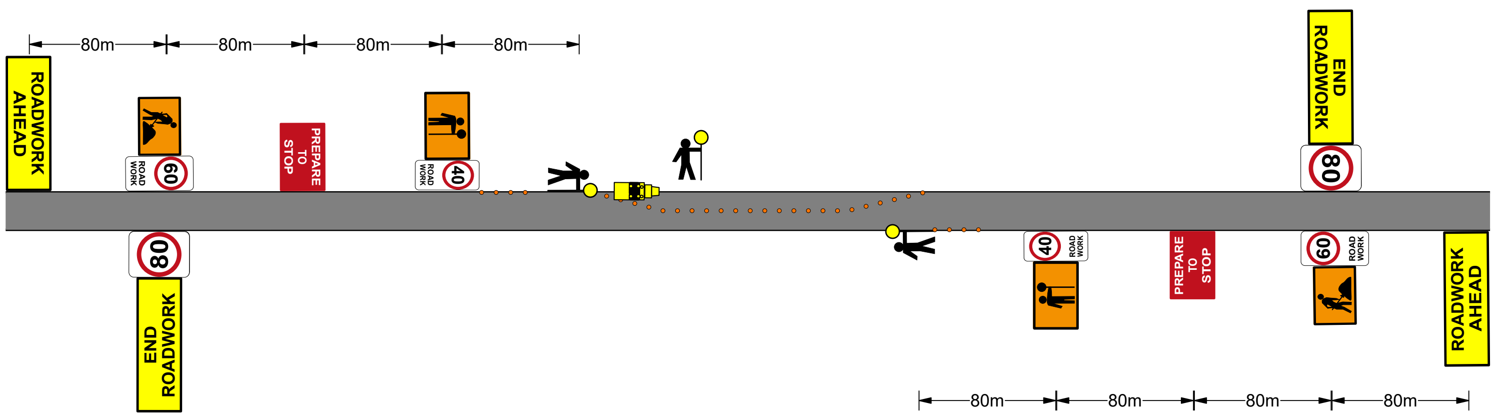
Reason for modification___________________



Traffic PROFESSIONALS

Implemented By

Name -

Signed -

Cert No -

Meroo Road
Bomaderry
Stop/Slow

WORKERS ON FOOT
NO GO ZONE =
RESTRICTED ZONE =
SHARED ZONE =
SITE EXIT = X
SITE ENTRY = E
EVACUATION POINT = EP

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SEE SECTION 4.2
TRAFFIC CONTROL AT WORK SITES MANUAL

WORK AREA =

TGS USED AS A GUIDE

PREPARED BY Maryann Spresser
PWZT TCT004609 : Expiry: 13/07/2022

TMP No:

TMPACs-NAP-03

TGS Designed Date: 25/11/2021
TGS Expire Date: 25/11/2022

SHOALHAVEN STARCHES PTY LTD
NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS – SHOALHAVEN STARCHES BOMADERRY

JEMENA PIPELINE CROSSINGIPELINE CROSSING – TP GAS PIPELINE – MOD 1

Work Method Statement

Document No.		NAP-SS-WMS-05		
Revision:	**Date:**	**Prepared**	**Checked**	**Approved**
Rev A	11/02/22	Mukesh Bhatia	Ajay Kesavan	Martin Moran

TABLE OF CONTENTS

APPENDIX

- Fluid Management Plan
- Geotech Report
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS

1.1 INTRODUCTION

Shoalhaven Starches is currently in the process of constructing a gas fired co-generation plant for planned increase in production facilities. This has necessitated the need to construct the following assets which National Australian Pipelines has been contracted to deliver:

A 300mm (12 Inch) Transmission Pipeline (TP) with the offtake at Pestells Lane, Meroo Meadow from the existing Jemena's 450 mm (18 Inch) Eastern Gas Pipeline (EGP) to the plant at 36 Bolong Road, Bomaderry, a length of approximately 5.6 Km.

Approximately 5.6 km, DN 300 Class 900 Licensed Gas Transmission Pipeline from Pestells Lane to the Pressure Reduction Station (PRS) at 36 Bolong Road.

Pressure Reduction Station (PRS) at 36 Bolong Road, Bomaderry including Pig Receiver for the pipeline.

Two fitting Lines from the proposed PRS

- A DN300 Class300, nominally 360m pipeline to the proposed cogeneration plant.
- A DN450 High pressure (210 kPa), nominally 182m pipeline tie-in to the plant

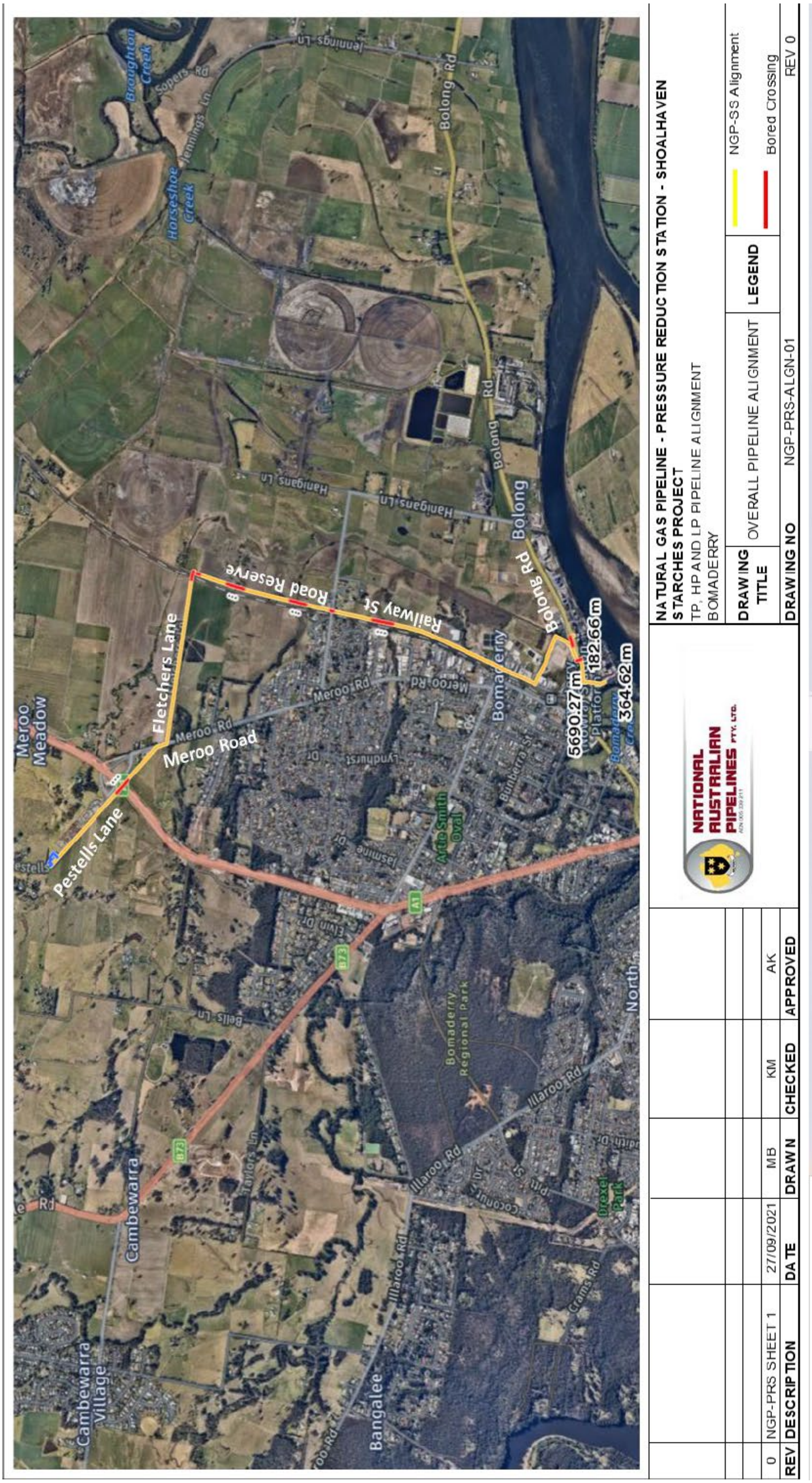
1.2 SCOPE

This method statement details out construction methodology for construction of the DN300 TP Gas Main under Jemena's EGP Pipeline at Pestels Lane, Meroo Meadow.

This document will provide governance for following processes:

- Survey
- Service location
- Underground Services Locating Procedure
- HDD string fabrication
- Trenching near existing Jemena Assets
- Mini HDD under Jemena Assets.
- Post installation coating integrity check
- Reinstatement

Overall alignment is shown on the next page.


NATURAL GAS PIPELINE - PRESSURE REDUCTION STATION - SHOALHAVEN STARCHES PROJECT
TP, HP AND LP PIPELINE ALIGNMENT
BOMADERRY
DRAWING TITLE
OVERALL PIPELINE ALIGNMENT
DRAWING NO
NGP-PRS-ALGN-01
REV 0
LEGEND
NGP-SS Alignment
Bored Crossing
NATIONAL AUSTRALIAN PIPELINES PTY. LTD.
REV
DESCRIPTION
DATE
DRAWN
CHECKED
APPROVED
0
NGP-PRS SHEET 1
27/09/2021
MB
KM
AK
Pestells Lane
Meroo Road
Fletchers Lane
Road Reserve
Railway St
Bolong Rd
5690.27 m
182.66 m
364.62 m
Meroo Meadow
Cambewarra Village
Cambewarra
Bangalee
Bomaderry
Bolong
Bomaderry Regional Park
Artie Smith Oval
Drexel Park
Horseshoe Creek
Broughton Creek
Hanigans Ln
Jennings Ln
Sopers Rd
Meroo Rd
Illaroo Rd
Bolong Rd
North

1.3 ABREVIATIONS AND DEFINITIONS

ALARP	As Low As Reasonable Practical
Checklist	A document that records or defines the actions that must be undertaken for a given task.
CEMP	Construction Environmental Management Plan
DBYD	Dial Before You Dig 1100
EGP	Eastern Gas Pipeline
Hazard	Any operation or task that places personnel or equipment at risk to death, injury and or damage
HDD	Horizontal Directional Drilling
JSEA	Job Safety Environmental Analysis
NCR	Non-Conformance Report
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
ROW	Right of Way
NAP	National Australia Pipeline Pty Ltd
Supervisor	The responsible person who oversees, or directs control of works being undertaken during the construction of the pipeline

1.4 REFERENCES

1. Project Approval (MP10_018 MOD1) SHOALHAVEN STARCHES GAS PIPELINE PROJECT - INCREASE IN PIPELINE DIAMETER AND ASSOCIATED WORKS.
2. GAS-960-GL-PL-001 – Designing and constructing near Jemena Gas Pipelines
3. Shoalhaven Starches Natural Gas Pipeline IFC drawings
4. Shoalhaven Starches Natural Gas Pipeline Construction Environmental Management Plan (CEMP)
5. Shoalhaven Starches Natural Gas Pipeline Construction Safety Management Plan (CSMP)

1.5 PERMITS

The following approvals/permits need to be in place before commencement of site works.

1. Development Application Approval - Minister for Planning and Infrastructure has approved the Development Application 10_0108-Mod-1 on 21 January 2022.'
2. Jemena Approval of Method Statement
3. Obtaining Jemena Permit to Work/PIO as required

2.0 PROJECT CONTACTS

NAP KEY PERSONNEL

Role	Name	Phone	Email
Operations Manager	Martin Moran	0417 510 070	mmoran@nataustpipe.com.au
Commercial Manager	Brad Keele	0414 389 744	bkeele@nataustpipe.com.au
Senior Engineer/Project Manager	Ajay Kesavan	0427 510 075	akesavan@nataustpipe.com.au
HSE Officer	Martin Moran Jnr	0433 627 894	ops@nataustpipe.com.au
Construction Manager	Colin Field	0419 559 427	cfield@nataustpipe.com.au
Site Engineer	Mukesh Bhatia	0408 564 163	mbhatia@nataustpipe.com.au
Site Supervisor	Tony Hall	0427 680 347	thall@nataustpipe.com.au
Site Supervisor	Eamish Moran	0418 699 691	emoran@nataustpipe.com.au

Shoalhaven Starches KEY PERSONNEL

Role	Name	Phone	Email
Project Manager	Paul Whisson	0438 814 750	paul.whisson@manildra.com.au
Manager, Energy & Sustainability	Brian Hanley	0412 672 783	brian.hanley@manildra.com.au
Quality Assurance & Environmental Coordinator	John Studdert	0417 209 851	John.Studdert@manildra.com.au

3.0 RESPONSIBILITIES

The Project Management Team – Project Manager, Engineer, Construction Supervisor and HSE Officer – shall ensure that all project staff are adequately skilled to perform their assigned tasks and are aware of their obligations and responsibilities with regards to OH&S, Environmental Management, Quality Assurance, Industrial Relations and Administrative Functions.

The Crew Supervisor shall be responsible for the coordination of the personnel, equipment, and materials to complete the works in accordance with the relevant specifications.

All site personnel will have a formal job description. Detailed job descriptions for personnel have been developed and approved by the Project Manager. Please refer to the Project Execution Plan for detailed job descriptions.

3.1.1 Construction Manager

The Construction Manger's responsibilities include:

- On site Project Supervisory and Management activities
- Supporting site supervisors with the implementation of the Project Execution Plan
- Responsible for Construction Supervision
- Developing and fostering relationships with Principal and their representatives
- Ensuring effective communication channels between company and project personnel
- Project Planning
- Compliance with the requirements of the contract specification
- Authorizing project specific procedures
- Ensuring all subcontractors have full understanding of the Project Execution Plan
- Implementing the project Policy objectives.
- Recommending and appointing appropriately qualified personnel to the project

3.1.2 Engineer's

The Project Engineers responsibilities include:
- Preparing management plans and appropriate Inspection & Test Plans.
- Implementing the project Policy objectives.
- Identifying potentially hazardous site activities and implementation of appropriate procedures and controls.
- Recommending and appointing appropriately qualified personnel to the project.
- Ensuring sufficient resources are provided to implement works programs including emergency response.
- Supporting site supervisors with the implementation of the management plans.
- Utilising industry best practice unless otherwise stated in the specification.
- Ensuring effective communication channels between company and project personnel.
- Ensuring induction training is provided for all project employees including subcontractors before commencing any work on the site.
- Authorizing project specific procedures.
- Participating in project meetings, programs, and reviews of the management plans.
- Review accident and incident reports, meeting minutes, non-conformance / corrective action reports and inspection reports/audits for the project.
- Ensuring all subcontractors have full understanding of the use of specific management plan and that all relevant sections are covered in site inductions.
- Ensure compliance with cultural heritage and environmental requirements.
- Ensure compliance with the contract specification and drawings.

3.1.3 Site Supervisor

The Site Supervisors responsibilities include:
- Reporting to the NAP Operations Manager/Project Engineer.
- Implementing the management plan and ensuring all personnel possess a sound knowledge of the plan and procedures.
- Compliance with all legal and statutory requirements.
- Compliance with the requirements of the contract specification.
- Promoting HS&E awareness.

- Provide advice and assistance to employees on HS&E.
- In consultation with employees, assess the planned works for potential hazards & risks.
- Plan work activities in accordance with the client's procedures, hazard workshop mitigation measures and the traffic management plan to ensure the identified hazards will be effectively controlled.
- Assist in the identification and preparation of project specific procedures.
- Ensure safe plant and equipment is provided and maintained.
- Implement scheduled work practices and worksite HS&E monitoring programs including hazard identification and reporting.
- Assist in site inspections and auditing activities as per this plan.
- Raise, handle or manage, as directed, non-conformance and corrective actions.
- Participate in accident, and incident investigation.
- Assist in identification of further training needs.
- Assist in rehabilitation activities as and if required.
- Assess competency of Employees/Sub Contractor for Specific Tasks.
- Conduct Project induction programs and Tool Box Meetings for all site personnel and visitors.
- Initiate accident/incident investigations.
- Maintain injury registers.
- Ensure appropriate first aid equipment and amenities at the project site are available and maintained.
- Store records and documentation in respect of workplace and work practice inspections, permits to work, provision of personal protective equipment, induction, training etc.
- Compliance with cultural heritage and environmental requirements.
- Assess competency of Employees/Sub Contractor for Specific Tasks.

3.1.4 HSE Officer

The HSE Officers responsibilities include:

- On-site implementation and updating of management plans.
- Act as Site Emergency & Critical Incident Co-ordinator.
- Ensure health and safety requirements are in compliance with all current statutory obligations.
- Ensure copies of relevant legislation, codes of practice, codes and standards are readily accessible.
- Ensure that all legislations, codes of practices, acts and standards we refer to are current.
- Ensure potential subcontractors have suitable experience and knowledge to conduct any potential work scope in compliance with project health and safety requirements.
- Action safety matters as required by the Project representatives.
- Ensure all project team employees arriving on location comply with the appropriate licensing, permit and/or certification requirements of the relevant statutory authorities.
- Review training records and qualifications to ensure each person is competent to perform tasks associated with their position.
- Maintain an onsite access to the current training and competency matrix register of Project specific personnel training.
- Arrange for site induction, certification and approval of prospective employees.
- Mentor and assist Foreman to implement risk assessment procedures (SWMS).
- Conduct daily site inspections.

- Reporting, recording, investigating and closing out health incident and near miss reports as applicable.
- Ensuring a list of qualified first aiders is established, updated and displayed on notice boards and in the Emergency Response Plan.
- Ensure all first aid kits contain compressions bandages for the treatment of snake bites.
- Liaise closely with the Client and Sub-contractors on matters of safety.
- Undertake accident investigation and reporting in conjunction with the Project Engineer.
- Report all accidents / incidents to the Client's Representative and NAP's Project Manager.
- Collate and report accident / incident statistics to NAP's Project Engineer and the Client.
- Organise and present tool box talks for site employees.
- Participate in hazard analysis and accident / incident prevention programs in conjunction with the Project Engineer.
- Liaise with statutory authorities on safety matters.
- Co-ordinate the development, implementation and monitoring of project safety procedures.
- Attend Safety Committee Meetings.
- Where tasks relating to the maintenance of documentation, files, forms and other records are transferred to the Administration Officer or others these tasks are understood and carried out satisfactorily
- The internal review process is scheduled, coordinated and carried out in an appropriate and independent manner.
- Initiate accident/incident investigations.
- Maintain injury registers.
- Ensure appropriate first aid equipment and amenities at the project site are available and maintained.
- Reports are presented to the Management Review on the effectiveness of the application of the IMS in our business.
- All defect reports are investigated rectified and if necessary referred to the business improvement process.

3.1.5 Surveyor

The Surveyors responsibilities include:

- Taking shots of all crossing assets during the positive identification phase.
- Complete design checks to ensure that the designed HDD path will obtain the necessary clearances.
- Pegging out the HDD path in accordance with the IFC drawings
- Pegging out the location and depth of the entry/exit pits and slot trenches
- Verifying pit/slot trench depths once completed.
- Completing asbuilt drawings based on the bore longs.

3.1.6 NAP Crew

- Planning/Scheduling of works
- Welding, hydro testing and coating of the crossing string.
- Traffic Management
- Electronically locating all services
- Positively identify crossing services

- Excavation of entry/exit pits and/or slot trenches
- Survey and setout of the HDD design
- Lifting and Handling of the drill string during pullback.
- Coating continuity testing.
- Tie-in of HDD String
- Backfilling of entry/exit pits
- Overall management of site

3.1.7 HDD Contractor

- Establishment of the HDD Rig, Tool Truck and Vacuum Trucks
- Tool selection based on ground conditions
- Mud selection depending on ground conditions
- Pilot hole drilling
- Reaming and cleaning of the bore hole
- Extraction and disposal of the drill slurry as required
- Pull back of the drill string in conjunction with NAP
- Demobilisation
- HDD Site Safety

4.0 HAZARD IDENTIFICATION AND RISK MANAGEMENT

The NAP shall, so far as reasonably practicable, ensure that any manager or supervisor is provided with such information, instruction, and training as are necessary to ensure that each employee under their management or supervision is, while at work, so far as is reasonably practicable, safe from injury and risks to health.

All personnel must be committed to achieving a safe working environment and strive to fulfill the objectives of the Project Health, Safety and Environment policy with compliance to the Safety Management Plan and the Environmental Management Plan.

4.1 MANAGEMENT CONTROLS

4.1.1 Risk Assessment

A full project risk assessment has been undertaken and the mitigation measures identified in this have been incorporated into this Work Method Statement. A JSEA will be produced by carrying out a risk assessment on this Work Method Statement and incorporating input from work crews. Each Crew member will be required to review this JSEA.

4.1.2 JSEA

The base JSEA shall be developed with input from the Project Manager, Construction Manager and HSE Advisor. The JSEA shall be reviewed and added to, as required by each crew, utilizing their experience in conducting the task. All crew personnel are to review and sign onto the JSEA before work begins.

4.1.3 Pre-Start

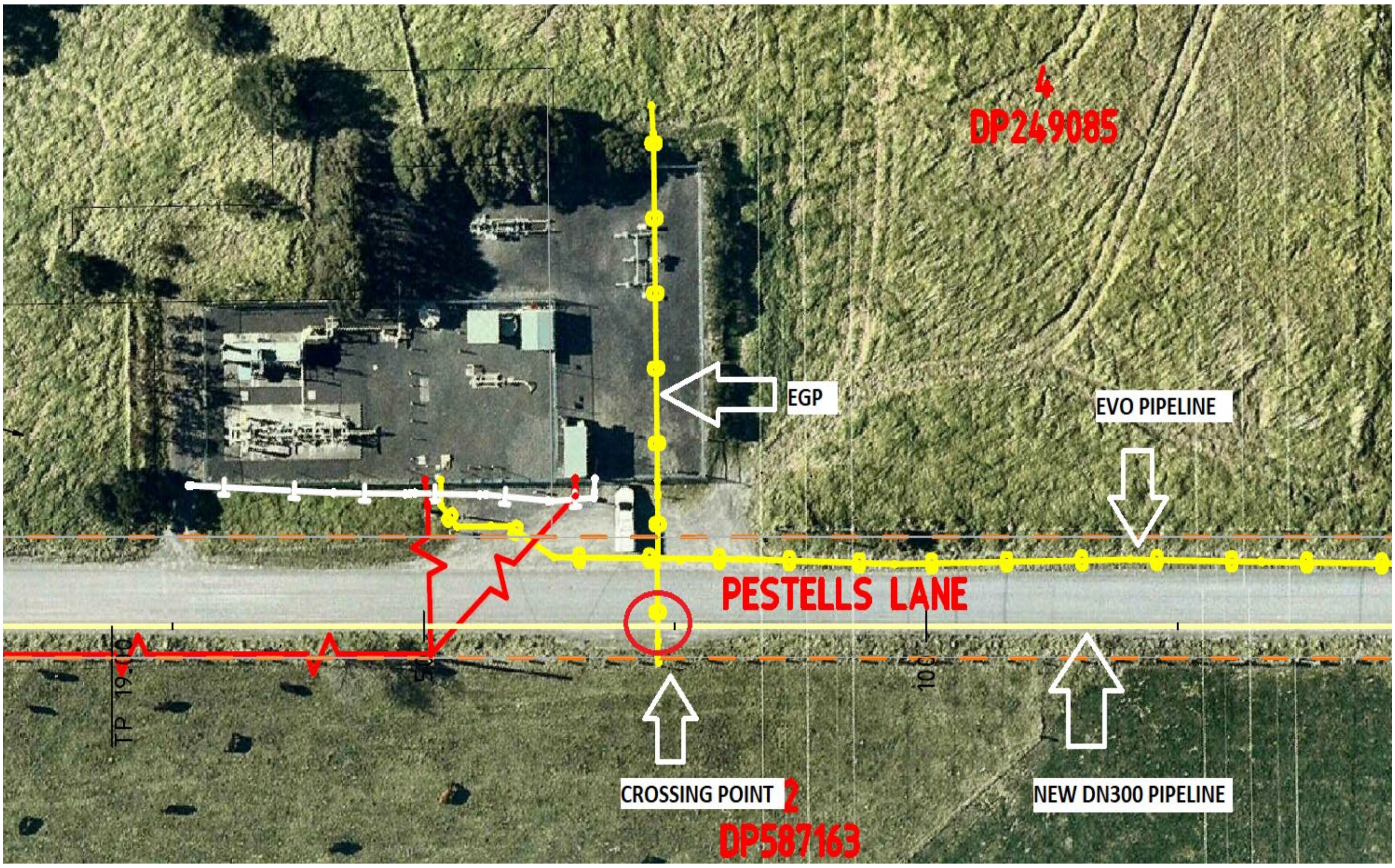
Supervisors shall ensure that meetings are held prior to starting each shift, and/or whenever the work scope changes. The meetings should:

- Review the state of the works as left by the previous shift
- The target progress for the current shift
- The means of achieving the target progress
- The state of works required at the end of the shift
- Any additional safety hazards (changing conditions as work progresses)
- Any environmental hazards

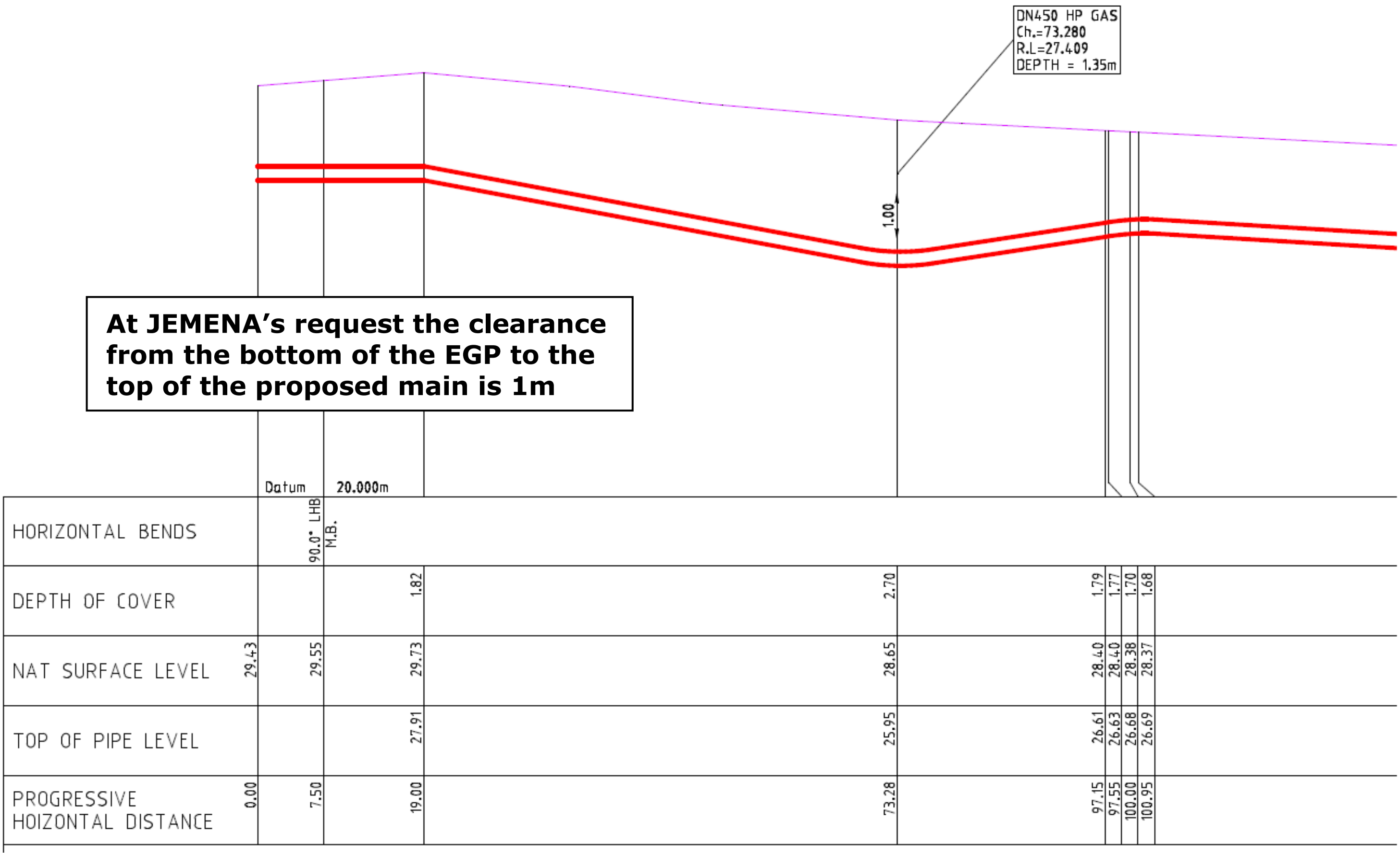
4.1.4 Tool Box Meeting

Tool box meetings will be held weekly. The tool box meetings will be used to relay information such as hazard alerts between crews and make all crews aware of larger issues and general hazards.

5.0 LOCATION OF CROSSING



6.0 CROSS SECTION OF CROSSING POINT



7.0 HDD CONSTRUCTION METHODLOGY

7.1 PLANT/RESOURCES

The plant and equipment required for completing the HDD is as per below.

- Excavator 21 ton, & bucket
- Excavator 25 ton, & bucket
- Loader
- Utes
- Welding Trucks
- Tipper Truck
- Water pump 2" or 3"
- Spill kits
- Trench Shields
- HDD Drill Rig
- Mud Mixing Station
- Vacuum Truck
- Coating Truck

7.2 PIPELINE ALIGNMENT SURVEY

The pipeline alignment will be set out by NAP's surveyor. NAP's surveyor will install offset markers clearly identifying the pipeline alignment by means of pegs. These pegs will also have information on depth of cover and chainage. Pegs or nails on the road will be installed every 5m and at every service crossing.

7.3 TRAFFIC MANAGEMENT

The crossing of Jemena's EGP is located within Pestell Lane road reserve. Appropriate traffic management will be in place for the duration of the works.

7.4 EQUIPMENT CHECKS

Plant risk assessment will be in place for the plant/machines engaged in completing the above-mentioned works. This is to ensure that plant proposed is fit for use and has been regularly maintained. All plant arriving onsite will also be checked to ensure absence of weeds.

7.5 UNDERGROUND SERVICES LOCATING PROCEDURE

A Dial Before You Dig request was performed all assets including Jemena's EGP asset was proved. This information has been used to design the crossing. The following assets will need to be crossed when conducting the mini-HDD at Pestells Lane

Jemena's EGP – DN450 Steel FBE – 1,350mm cover

Accordingly, the minimum cover of the new DN300 main when crossing the EGP will be 2,800mm.

7.6 PIPELINE WELDING AND STRINGING

The proposed pipeline is DN300 API 5L X65 PSL2 3LPE Coated WT 12.7mm.

The pipeline crossing string will be fabricated in accordance with AS2885 and Shoalhaven Starches Construction Specification. The joints will be X-Rayed and coated with cold applied polymeric tap and an abrasion resistant overcoat. The pipe string will be placed outside the EGP easement on the southern side of Pestels Lane.

7.7 TRENCHLESS INSTALLATION

NAP proposes to construct the DN300 gas pipeline by trenchless technique.

A minimum clearance of 1000mm will be maintained between the invert of the EGP to the obvert of the new pipeline.

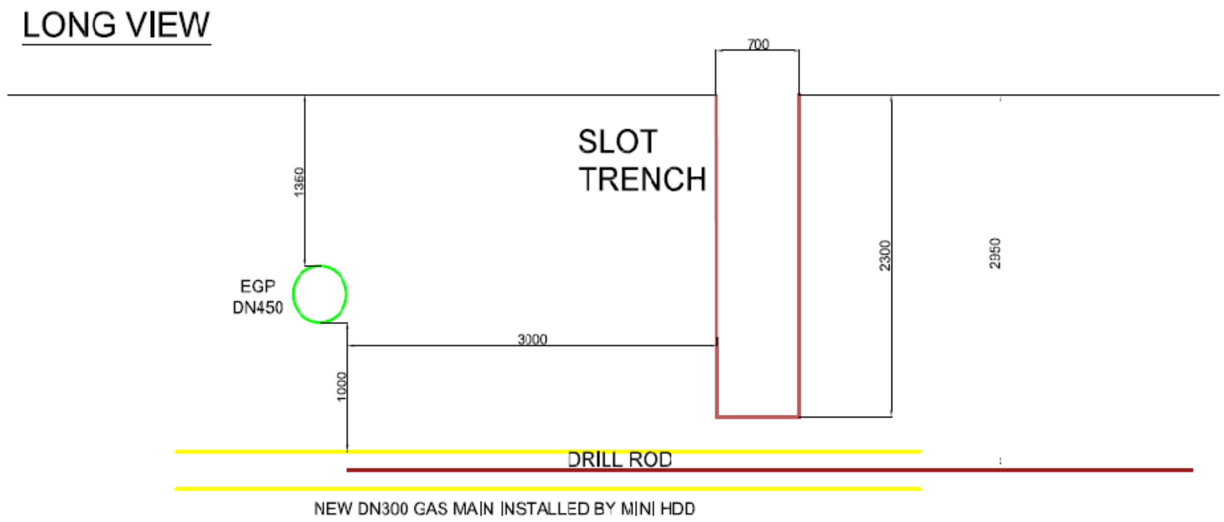
No mechanical excavation, apart from the boring itself, will take place within 3m of the EGP.

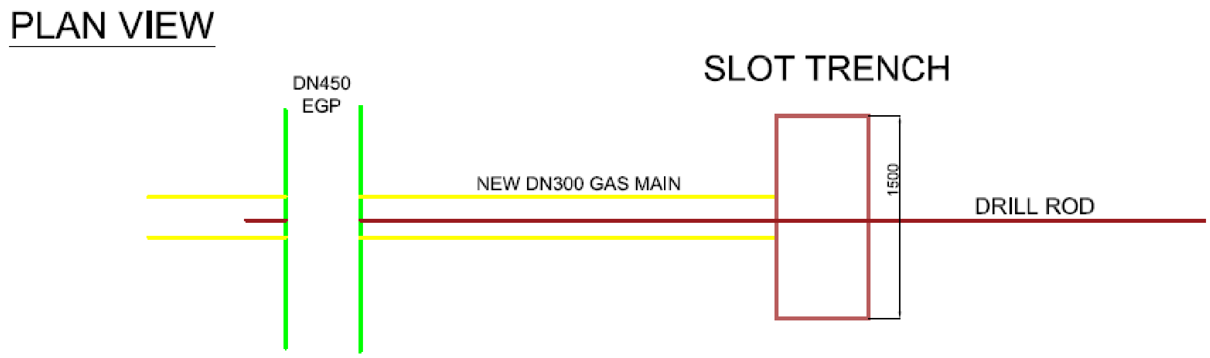
Prior to the commencement of the mini-HDD. The EGP will be positively verified again at the crossing point by means of vacuum potholing (max NDD pressure being less than 2,000 psi)

The pilot-hole drilling will be conducted from East to West.

Accordingly, a slot trench will be excavated

- On the eastern side of the EGP
- The slot trench will be centred over the proposed pipe centreline
- The slot trench will be 3m to the east of the EGP
- The slot trench will be 500mm deeper than the invert of the EGP. Accordingly, the slot trench will be 2.1m deep. This is to confirm the drill path prior to passing under the EGP. Note: In a 2.1m deep trench the drill head shouldn't be visible. The drill head is expected to be at a depth of 2.95m.
- The slot trench will be excavated using an excavator or a NDD truck depending on ground conditions.
- Post completion of drilling works, the slot trench will be backfilled with select excavated material (i.e. if the slot is located in the nature strip) or with crushed rock (if the slot is loaded in the pavement).





8.0 HORIZONTAL DIRECTIONAL DRILLING METHODOLOGY

8.1 PLANT/RESOURCES

The plant and equipment required for completing the water crossing is as per below.

Excavator 21 ton, & bucket

Excavator 25 ton, & bucket

Loader

Utes

Welding Trucks

Tipper Truck

Water pump 2" or 3"

Spill kits

Trench Shields

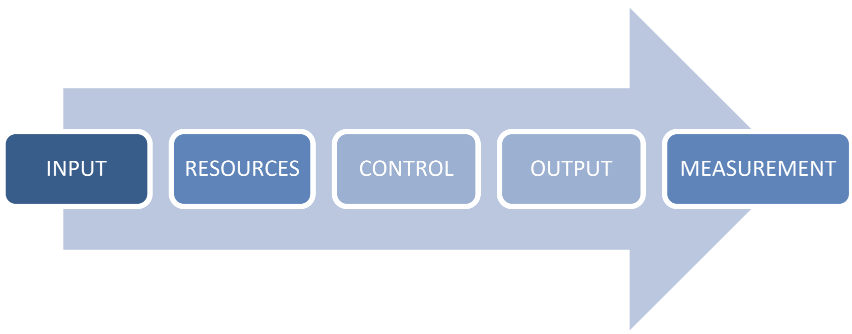
HDD Drill Rig

Mud Mixing Station

Vacuum Truck

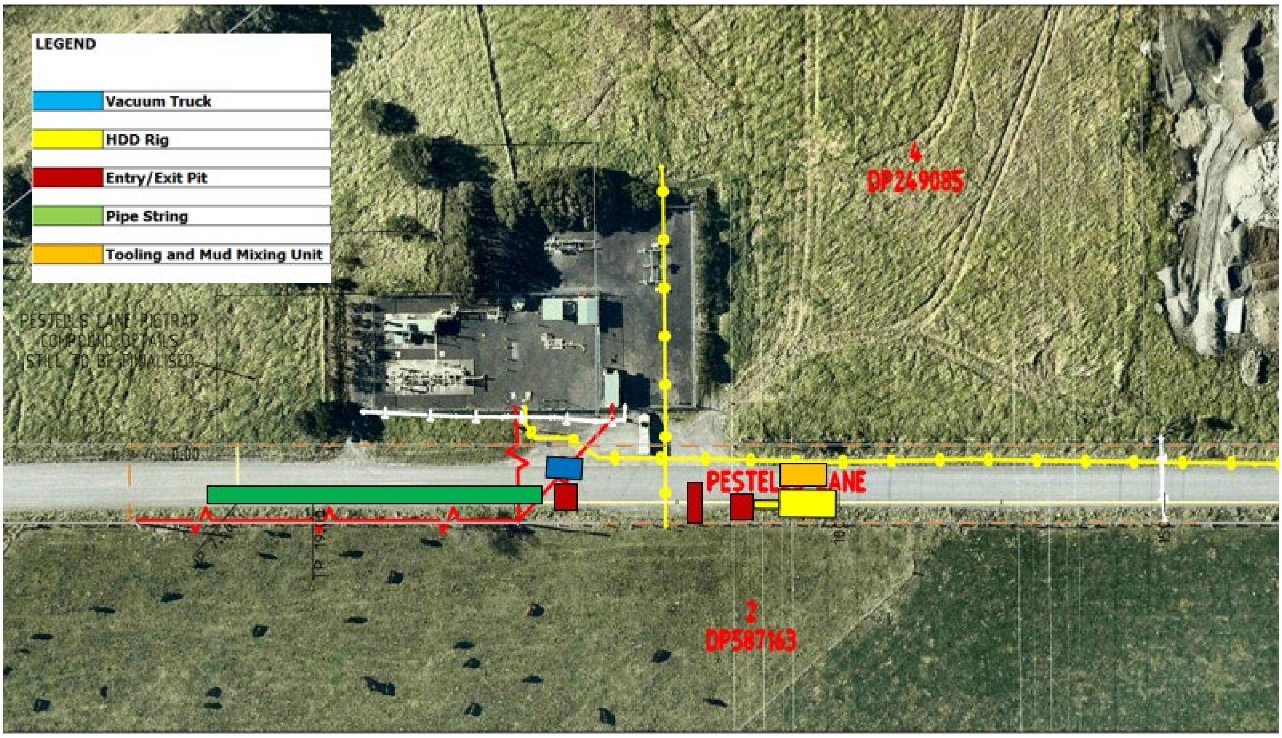
Coating Truck

8.2 PROCESS DIAGRAM



INPUT	RESOURCES	CONTROL	OUTPUT	MEASUREMENT
Pipes strung Group Other materials	Equipment Operators	Inspection Permits Surveyed Alignment Management Plans	Installed pipeline Pipeline naturally grouted Entry & Exit point reinstated As built Survey Data	QSE Key Performance Indicators No outstanding NCR's or Client queries

8.3 HDD LAYOUT



8.4 GEOLOGY

The HDD is likely to be in Sandy Clay as per Geotechnical Investigation Report. The ground profile under EGP is likely to be Very Stiff to Hard Ground conditions.
See CTP 25 and 26 in the attached report.
Accordingly, there will be hole stability or frac out related issues.

8.5 LENGTH OF BORE AND PROFILE

Bore length – 48m
Pipe Radius – 300m
Depth under EGP – Minimum 1m.

8.6 DESIGN CONSIDERATIONS

The expected pipeline stresses are minimised by:

- Short bore length design
- Pull loads are much lower than the allowable stresses
- Pull loads are monitored

Frac out risk has been minimised by:

- Drill profile is within competent strata.
- The drill pressures are monitored and regulated
- Appropriate mud mixes are selected
- The bore hole is reamed to at least 1.3 times the diameter of the pipeline
- Ensuring that appropriate mitigation measures are in place in the event of frac out i.e. vacuum trucks, pumps, silt fencing, traffic management etc.
- Visual inspection/monitoring of ground above drill head during drilling.

8.7 CONSTRUCTION STEPS

1. Obtain Jemena permit and ensure Jemena PIO's in place for all works within Jemena easement
2. Establish Drill unit
3. Existing Assets located and proved prior to bore commencing
4. Entry & exit points pre excavated.
5. Install silt controls at bore entry and exit points in order to prevent any produced drill slurry or ground water from entry to drainage systems, these fluids will be removed via Vacuum trucks for appropriate disposal to an accredited EPA site.
6. Recheck detail of all existing assets to ensure they have been proven and located prior to commencement
7. Scan bore path for interference prior to commencement
8. Excavate the slot trench to the specified dimensions
9. Entry and exit points of bore to be excavated 500mm below invert to capture and retain produced bore slurry for removal via vac unit

10. Commence pilot to designed bore plan recording invert & alignment on route – pilot process cuts the soil and utilises drill muds to carry cuttings to entry/exit points for removal via vac unit. (approx. Diameter of Drill head Cutting edge = 125mm)
11. As the bore is being piloted the tracker monitors bore alignment and invert throughout the progression of the bore in order to construct as per design – As the tracker checks this data the drill operator can see on a screen in real time – The driller and tracker are in contact via UHF Radio – specific frequency throughout the entire process.
12. Upon pilot reaching destined exit point / pipe pullback point the drill head will be removed and a reamer (approx. 300mm, followed by 450mm) will be installed, reaming of bore continues for full length of the alignment, during which drilling muds are introduced which seal the bore walls hence permitting the naturally reamed product to blend with the drilling enhancing muds which flow to the entry exit points for removal via vac unit.
13. Throughout all piloting and reaming processes the entry and exit points are monitored for adequate mud flows at each point to ensure that a pressure point does not develop in bore.
14. Throughout all piloting and reaming processes, the bore is left flooded with drill slurry which consists of naturally reamed and introduced bore enhancing products which fills void and supports the constructed bore.
15. Once the borehole is fully reamed, a pulling device is connected to the pipeline string via a swivel. The pullback then commences at a controlled speed.
16. The swivel between the pipe being installed and the drill string permits the pipe to rotate as friction requires between the drill slurry in bore and the 300NB pipe being installed.
17. The bore being full of drill slurry will be naturally displaced as the pipe is installed into the bore hole, the excess slurry transfers to both entry & exit points, which will be removed via vac units for disposal
18. As a result the annular space becomes fully grouted with naturally and introduced product resultant from the drilling process.
19. All surplus drilling slurry is removed from site and disposed of at an EPA registered disposal site

8.7.1 Risks regarding HDD process & Control Plan

Risk	Controls
Heave of Surface	Throughout Piloting, Reaming and pullback the entry and exit shafts as well as bore path are monitored to ensure muds are flowing

	and no pressure point develops within the bore. If pressure develops, work ceases and re swabbing commences to loosen up any blockage to recommence mud flows then restart the relevant process.
Frac Out	Can occur due to the geological conditions i.e. if not consistent or if geotechnical bore holes are too close to the HDD path. In the event this occurs, cease work, contain fluids, remove with vac unit, consider additional additives and action, alternatively excavate and use as a relief point for extraction of muds via a vac unit. Controls in order to eliminate this risk are by utilizing a sealing mud mix, together with at all times having a fully fluid charged bore. This risk is also mitigated due to the depth of the bore being >2m below scour depth to which the risk of Frac out or surface disruption is negligible.
Subsidence / Collapsing bore	Point 1 : the bore at all times will be fully charged with a heavy mud mix therefore a void never exists Point 2: Upon Pullback the annular space is naturally grouted with Naturally occurring spoils and Enhancing products Point 3 : at the design depths due to a fully charged bore at all times with Bore wall sealing products moisture and solids will remain in bore resulting in a supported bore at all times
Loss of Drill head (breakage)	Prior to commencing the bore the Drill head will be checked for fatigue to threads any cracking or distortion, If any of the above is evident the Drill head will be replaced by a conforming tool.

	The starter rod and hex collar to which the drill head connects to the drill rods will also be inspected for fatigue, distortion and cracks, if any of the above is evident this item of tooling will be replaced with a new unit. The hex collar (locking device between the starter rod and Drill head) will be checked for cracking, fatigue and distortion; if any of the above is evident a new unit will be supplemented. The Grub screw (hex collar retaining device) will be inspected for fatigue, thread damage, should any of the above be evident then the grub screw will be replaced by a new item. All the above ensure that the drill head and affiliated tooling are suitable to perform the required tasks. If the drill head breaks away from the drill string sub surface the drill string will be withdrawn and the drill head will remain in soil at this location. The pilot bore will be full of natural product from cuttings, this will be capped at surface to ensure no voids are present. New tooling will be installed and a new pilot will be performed, while abandoning the broken tooling. Should a breakage such as this occur outside the creek bed and banks the point of breakage would be excavated to retrieve the broken tooling and backfilled to standard excavation and backfilling practices.

	New tooling will be installed, and the bore construction will continue in the exiting pilot bore and achieve the desired pilot prior to reaming

8.7.2 Mud Mix:

- A bentonite mix of 1 bag per 1000 litres is nominated to be used
- This product ensures the bore walls are sealed retaining fluids to bore hole and to suspend the drill cuttings which is transferred to the exit point, reducing friction while ensuring good flows are maintained throughout drilling and reaming processes.
- By utilizing the nominated Mud Mix this ensures a filter cake is built to seal and support the bore, the bore retains integrity due to this filter cake and the bore full of slurry prevents any collapse of the bore hole.
- Throughout the entire process drilling fluid /slurry is always ahead of and behind the tooling, at no time does a void exist.

APPENDIX

- Fluid Management Plan
- Geotech Report
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS

FLUID MANAGEMENT PLAN

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.
ABN 88 005 339 211

SHOALHAVEN STARCHES

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATION

FLUID MANAGEMENT PLAN & FRAC OUT MANAGEMENT

P.O. BOX 190 WHITTLESEA, VIC 3757 PH: 03 9716 3277 FAX: 03 9716 3244

National Australian Pipelines Pty. Ltd.

Natural Gas Pipeline and Pressure Reduction Station

Client: Shoalhaven Starches

Revision:	Issue Date:	Approved by:
Rev.0	20/01/2022	Martin J. Moran

Table of Contents

1 INTRODUCTION

It is recognised by National Australian Pipelines (NAP) that the consequences of any drilling fluid escaping the HDD drilling site compounds could be significant.

This Drilling Fluid Management Plan (FMP) addresses the following issues:

- The Purpose and Properties of Drilling Fluid;
- The Use of Drilling Fluid during a HDD operation;
- The Possible Paths by which Drilling Fluid could be lost to the environment;
- Safeguards the drilling contractor will put in place to minimise the chance of Drilling Fluid being lost to the environment;
- Inspection Procedures the drilling contractor will implement to ensure the safeguards are adequately maintained;
- Drilling Fluid Volume Tracking Procedures the drilling contractor will use to ensure that drilling fluid volumes are being checked;
- Drilling Fluid Loss Incident Management Procedure that will be used if Drilling Fluid Loss has been detected;
- Management of ground water ingress.

NAP believes the implementation of this Management Plan will:

- Ensure all practical safeguards are put in place to minimise the chance of Drilling Fluid being lost to the environment.
- Inspection Procedures will be in operation to maintain the integrity of the safeguards.
- Volumetric Drilling Fluid Tracking Procedures will be in operation to ensure that if Drilling Fluid is being lost or gained is detected and action taken.

2 CONTROL & DISTRIBUTION

The NAP Project Engineer controls this document. The Project Engineer shall ensure all persons named below are issued with a current copy.

REV NO.	CONTROLLED COPY ISSUED TO	ORGANISATION
Rev 0	Paul Whisson	Shoalhaven Starches
Rev 0	Colin Field	NAP (Site Copy)

3 GEOTECHNICAL AND HYDROLOGICAL ENVIRONMENT

The geotechnical investigation report indicates that majority of the borehole length shall be drilled through competent strata. This formation is inherently stable and is ideal for maintaining an open hole.

4 DRILLING FLUID

Drilling Fluid is a major factor in the success of any directional drilling program, and as such deserves careful consideration. The principal functions of the drilling fluid during a successful Directional Drilling operation are:

- To drive downhole motors, drill bits and reamers.
- To remove the cuttings from the bottom of the hole and carry them to the entry point.
- To cool and lubricate the drill string and drill bit.
- To line, support and protect the walls of the hole.

For a Horizontal Directional Drilling operation, the fluid demands are different from those required for drilling vertical wells. Hole cleaning ability or the ability of the drilling fluid to suspend cuttings is a much more critical factor for Horizontal Directional Drilling. Gel strength is the measure of this property.

For Horizontal Directional Drilling, low viscosity and high gel strength are required to ensure the cuttings are effectively suspended in the slurry and returned to the entry point. The drilling contractor is very experienced in Horizontal Directional Drilling operations and will be using some of the following products to mix the Drilling Fluid and guarantee these properties are met:

- BENTONITE
- KLA BORE
- POLY VIS HV

- SODA ASH
- STAR GEL

These products produce a drilling fluid with low viscosity, high gel strength and sufficient Bentonite content. The Bentonite content of the drilling fluid is critical for drilling boreholes through rock. The fine particles of Bentonite form a thin, low-permeability filter cake around the walls of the borehole. This filter cake seals the pores and other openings in rock preventing the escape of drilling fluid through the rock and the inflow of formation fluids.

The Material Safety Data Sheets (MSDS's) for these products are kept on site.

5 DRILLING FLUID CIRCULATION

It is important to gain an understanding of how drilling fluid is circulated during horizontal directional drilling, to better understand the safeguards and inspection procedures drilling contractor intends to implement to manage drilling fluid during the drilling operations.

The mud gets mixed in the mixing tank. Once the mud has been mixed adequately it is transferred to the active tank. From the active tank the drilling fluid is pumped to the drilling rig, through the drill pipe, into the borehole and onto the cutting face. The drilling fluid then suspends the cuttings and travels out of the borehole and into the borehole returns pit. The borehole returns pit is positioned directly behind the hole entry point. From returns pits the excess mud is extracted using vacuum trucks and disposed offsite.

The site set up plan shown in the work method statement should be referred to for containment facilities such as the site sedimentation fencing, sumps & bunds as this plan only refers to directional drilling fluid related controls.

6 HAZARD PATH IDENTIFICATION

NAP considers any risk to the environment of the area to be unacceptable. To reduce the risk of drilling fluid escaping to the environment NAP has identified the following paths by which it is possible that drilling fluid could enter these sensitive areas.

a) Runoff or surface water could escape the drilling compound during periods of rainfall.
b) Drilling Fluid could escape the drilling compound and potentially find its way into the environment.
c) Drilling Fluid could potentially escape the borehole during drilling through inconsistencies (cracks & fissures) in the rock. This could result in drilling fluid being deposited into underground aquifers or breaking out to the surface.
d) Groundwater could seep into the borehole during the drilling operation. This ingress will result in increased drilling fluid volume and could cause drilling fluid containment facilities to become filled to capacity and possibly overloaded.

These are the only paths by which drilling fluid could be potentially lost to the environment. Therefore it is the goal of this Management Plan to minimise the chance of drilling fluid escaping via these paths through the use of safeguards and the implementation of inspection procedures.

7 SAFEGUARDS

This section deals with the safeguards that the drilling contractor will use during the execution of this project, to control the previously identified potential drilling fluid escape paths.

The following mitigation measures will be put in place to counteract the hazards identified above:

- Earth bunds and drainage channels will be placed around the upper edges of the drill site and work area, to divert natural runoff around and away from the site so that it doesn't mix with drilling compound runoff. Necessary erosion and sedimentation control measures will be in place.

- All facilities utilised in the surface mud handling (mixing, cleaning & pumping) shall be bunded. This shall ensure natural / clean runoff contained within the compound is not mixed with drilling fluid or contaminated by oil/fuel.

- A sump pit will be constructed at the bottom of the drill site. The sump pit will be positioned (during site planning) so as all runoff from the drilling compound will flow into it. The sump pit is of such dimensions to provide a buffer for the drilling fluid returns.

- An earth bund or silt fencing will be placed on the downstream side of the bund to contain any spillage. The sump pit will be pumped out using vacuum trucks in an as required basis during the drilling operation. This will ensure that any rain event, whilst the drilling crew is not onsite, won't lead to a sump pit overflow.

- All products used to mix the drilling fluid will be covered before they are used to mix the drilling fluid. The unmixed drilling mud shall be stored on pallets keeping them off the ground and not stored within drainage lines. This will prevent the chance of any drilling fluid components escaping the drilling compound and becoming contaminants to the environment.

- All stationery plant & equipment on site is inspected on a daily basis to ensure it is in good working order to minimise the chance of fuel/oil/grease leakage.

- Adequate spill control kits containing absorbent materials, to cleanup spills from mobile equipment outside bunds shall be on site at all times.

- All excess oils and greases shall be contained within the fuel bund in order prevent any chance of leakage. The fuel bund is a fuel tank (4500L capacity) with an inbuilt steel bund able to contain 1.5 times storage capacity of the tank.

- All used oil or grease taken from machinery during services is stored within the fuel bund. The fuel bund is regularly emptied by a licensed contractor

- By designing the drill profile using the best geotechnical information available, the drilling contractor can ensure that an adequate amount of cover can be provided beneath the surface.

- The products selected to mix the drilling fluid have been carefully selected to provide the drilling fluid with sufficient Bentonite content. The Bentonite content of the drilling fluid will ensure a thin, low-permeability filter cake forms on the walls of the borehole. This will ensure no drilling fluid is lost through the walls of the borehole.

- Chances of drilling fluid seeping in the ground through storage pits (returns pits & sump pit) are minimal. Just as the drilling fluid lines the inside of the borehole it will also line the inside pits and provides an impermeable barrier hence stopping fluid from seeping into ground.

8 INSPECTION PLAN

This section deals with the inspection procedures by which NAP intends to ensure the adequacy and integrity of the safeguard measures.

8.1 DRILLING COMPOUND RUNOFF

Earth bunds/drainage channels or silt fencing placed on the downstream side of the drilling compound will be inspected on a daily basis and/or during & after any significant rain event to ensure their adequacy and integrity.

Earth bunding placed around the sump pit will also be inspected on a daily basis and/or after any significant rain event to ensure its adequacy and integrity.

Before the commencement of drilling and at the close down each day, all components of the mud mixing system will be visually inspected to check for signs of drilling fluid loss and to ensure its adequacy for the containment of drilling fluid.

8.2 INGRESS OF GROUND WATER

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected.

8.3 DOWNHOLE FLUID LOSS TO GROUND

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected. Nominated cored holes will also be checked to see if there are any indicators that suggest where the fluid may be lost to.

The bore path will also be visually monitored from the surface for any signs of surface frac-out. In the event of a surface frac-out occurring, all drilling operations will cease and all efforts will be made to contain the frac-out to a localised area. Sand bags will be available on site to bund the area. Excess fluids will be removed from the area using a vacuum truck. If a vacuum truck cannot access the area of frac-out, manual pumping will be used to remediate the area surrounding the frac-out.

9 DRILLING FLUID VOLUME TRACKING PROCEDURE

The drilling fluid volume tracking procedure for the drilling operations is quick and easy. It has been designed this way so that regular and accurate checks can be made throughout each day to ensure that any groundwater ingress or downhole drilling fluid loss is detected quickly. This will minimise the volume of any drilling fluid loss from the compound due to overload of containment facilities (i.e. groundwater ingress) or drilling fluid loss to the ground through the borehole (i.e. downhole drilling fluid loss) and allow remediation activities to start promptly.

The drilling fluid tracking procedure involves a simple volumetric balance between measuring the volume of drilling fluid mixed and comparing it to the volume that the drilling fluid is occupying in the borehole and entry pit (this is dependent of the length of hole drilled and the volume in surface containment facilities). These two values can readily be measured onsite and comparison

of the values will quickly determine the volume of drilling fluid gained due to groundwater ingress or lost due to downhole fluid loss.

It is true that if groundwater ingress were to equal the downhole drilling fluid loss then the drilling fluid volume tracking procedure would not detect any loss. However this situation is extremely unlikely. During normal drilling operations we expect to be pumping 19L/s to 25L/s of drilling fluid up the borehole whilst groundwater water ingress, if any, is expected to be less than 1 L/s.

The measurement of the drilling fluid volume mixed can easily be measured by making the assumption that the volume of drilling fluid produced is equal to the amount of water added to the drilling fluid tank.

The theoretical volume that the drilling fluid is occupying is also a value that can be easily calculated. Two components contribute to this value. The first is the volume of drilling fluid occupying the drilled hole and the second is the volume of drilling fluid contained within the sump pits.

The volume of drilling fluid downhole is a simple calculation knowing the diameter and the length of hole drilled. The volume of drilling fluid contained within the sump pit can also be measured easily onsite. A measurement needs to be taken of the level of drilling fluid within the drilling fluid tank. Knowing this value and knowing the dimension of the containment vessel (vacuum truck) the volume can again be calculated easily.

The drilling contractor will be making this volumetric comparison regularly each day and a minimum of three checks shall be made each shift for the duration of drilling the pilot hole.

Should inconsistent ground material be found during drilling operations (this is unlikely due to the depth of profile beneath the ground and the geotechnical information supplied) the monitoring frequency will be increased to one reading for every 10m drilled.

10 DRILLING FLUID LOSS REPORTING SYSTEM

At this stage it is important to understand that it is normal to expect some drilling fluid loss during a horizontal directional drilling operation. Some losses are expected because the fluid is filling the borehole annulus (between the pipe and the bore walls), because the fluid is lining the edges of the borehole and sump pits. Therefore, it is important that normal drilling fluid losses are taken into account in the reporting system. The reporting system proposed for this project is summarised in the following table:

Drilling Fluid Loss	Situation	Action
0-15%	Normal	Continue Drilling One Reading in 30m Drilled
15-25%	Alarm	Continue Drilling Increase Monitoring Frequency One Reading in 10m Drilled
>25%	Emergency	Cease Drilling Follow Emergency Response Plan Notify Shoalhaven Starches and DPIE before recommencing HDD

10.1 DRILLING FLUID LOSS 0-15%

The volumetric drilling fluid balance has shown 0-15% drilling fluid loss. It is normal to expect some drilling fluid loss during a horizontal directional drilling operation. The situation within this zone is quite acceptable and work should continue on as normal.

10.2 DRILLING FLUID LOSS 15-25%

The volumetric drilling fluid balance has shown 15-25% drilling fluid loss. The loss of drilling fluid has now become a concern. The volumetric balance is immediately recalculated and the drilling compound is checked to ensure there is no other reason for drilling fluid loss besides downhole loss. The drilling fluid volume tracking procedure is increased from normal (three times a day) to hourly checks until the level of drilling fluid loss exceeds 25% or decreases below 10%.

10.3 DRILLING FLUID LOSS > 25%

The drilling fluid tracking procedure has shown that drilling fluid loss has exceeded 25%. It has been checked that the only reason for this drilling fluid loss is downhole drilling fluid losses. The drilling of the borehole is immediately ceased. An incident is declared and incident response procedures implemented as described in the following section 11 . The incident response plan identifies the procedure to be used when Loss of Drilling Fluid (>25%) is experienced.

11 INCIDENT RESPONSE PLAN

Refer to the Incident Management Plan for complete details on incident response procedures. The response to loss downhole drilling fluid loss in general terms will be:

1: Cease Drilling: When downhole loss exceeds 25%

2: Notify Shoalhaven Starches immediately

3: Drilling contractor to co-ordinate sealing of the borehole.

4: Notify DPIE of issue.

5: Notify DPIE prior to recommencing HDD operations.

Possible solutions are as follows:

- Pump Extremely High Viscosity Drilling Fluid in to borehole in order to attempt to gel up the leakage.
- Utilise leak sealing mud additives into the drilling fluid in order to attempt to seal the leakage.
- Addition of loss circulation products such as rice husks, cotton or shredded paper into the drilling fluid in order to attempt to seal the leakage.
- Grouting the borehole at the leakage location and drilling through the grout and continue the hole.
- Using bentonite forms filter around the borehole walls which stops water coming in the hole due to higher annular pressure as compared to the pore pressure.

The response to containment facilities failure in general terms will be:

1: Cease Drilling: When containment failure is detected

2: Notify Shoalhaven Starches immediately

3: NAP and the drilling contractor to co-ordinate containment and cleanup of the drilling fluid leakage.

Possible solutions are as follows:

- Mobilise transportable pumps on the worksite to the location of the spill and transfer the mud to a contained area.
- Utilise the excavator on site to form windrows in order to divert the flow back into contained areas.
- Utilise the excavator on site to dig a temporary hole in order for escaping drilling fluid to gather in and mobilise transportable pumps to transfer mud to a contained area.
- Mobilise additional vacuum trucks to the worksite in case there are no more effective contained areas on the site for the mud to be stored within i.e. cannot utilise transportable pumps to transfer the mud.

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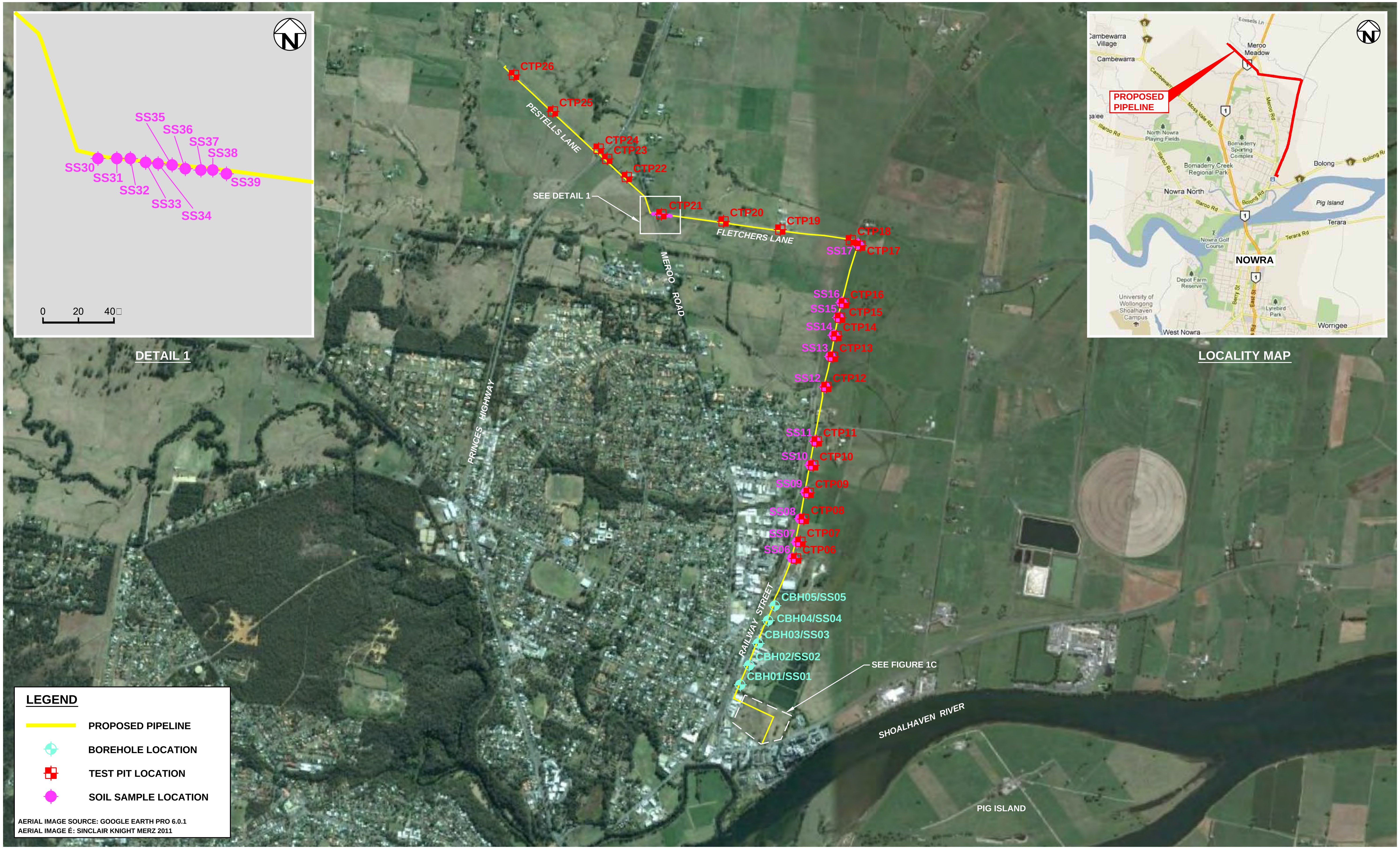

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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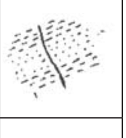
Soil Description Explanation Sheet (2 of 2)

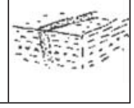
SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							**USC**	**PRIMARY NAME**
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
			DRY STRENGTH		**DILATANCY**	**TOUGHNESS**		
		SILTS & CLAYS Liquid limit less than 50	None to Low		Quick to slow	None	ML	SILT
			Medium to High		None	Medium	CL	CLAY
			Low to medium		Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium		Slow to very slow	Low to medium	MH	SILT
			High		None	High	CH	CLAY
			Medium to High		None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	**DEFINITION**	**DIAGRAM**
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	**DEFINITION**	**DIAGRAM**
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.

Defect Discontinuity or break in the continuity of a substance or substances.

Mass Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

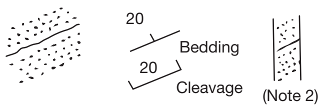
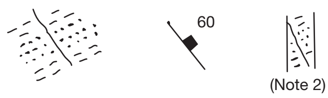
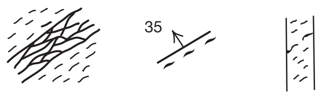
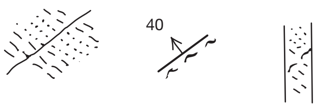
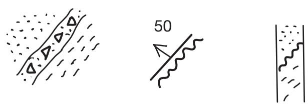
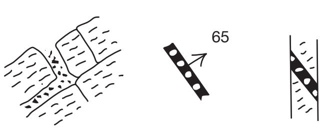
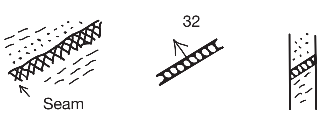
Term	Abbreviation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram / Map Symbol / Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.	
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.	
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.	
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.	
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.	
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.	
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.	

DEFECT SHAPE — TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

72710 / 07-06

coffey environments

Engineering Log - Excavation

Excavation No.	CTP25
Sheet	1 of 1
Office Job No.:	ENAUWOLL04006AA
Date started:	4.5.2011
Date completed:	4.5.2011
Logged by:	CA
Checked by:	SM

Client: MANILDRA GROUP

Principal:

Project: CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT

Test pit location: PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541

equipment type and model:	7T CAT BACKHOE	Pit Orientation:	E-W	Easting:	280550 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	1.5m long 0.45m wide			Northing:	6144015 m	datum:	WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	NONE OBSERVED						**FILL; CLAY:** Medium to high plasticity, brown, with some roots and silt, with a trace of fine to medium grained sand and fine to medium grained gravel.	<Wp	St		TOPSOIL FILL (road cuttings)
				E		0.5		CH	**CLAY:** High plasticity, brown, with some silt, and a trace of fine to medium grained sand and roots.	>Wp	VSt		ALLUVIAL SOIL
						1.0					St/VSt		
						1.5		CL	**Sandy CLAY:** Medium plasticity, mottled dark grey, orange, red/brown and yellow, with a trace of fine roots.	<Wp	H		
						2.0							
						2.5			Test pit CTP25 terminated at 2.5m				CTP25 Terminated at 2.5m on steady progress
						3.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

drawn	**RB**	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client: **MANILDRA GROUP PTY LTD**	
approved	**CA**		project: **ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**	
date	**19/07/2011**			
scale	**NTS**		title: **PHOTO OF TEST PIT CTP25**	
original size	**A4**		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **29**

coffey environments

Engineering Log - Excavation

Excavation No. **CTP26**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**4.5.2011**
Principal:		Date completed:	**4.5.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model: 7T CAT BACKHOE | Pit Orientation: E-W | Easting: 280330 m | R.L. Surface: NOT MEASURED

excavation dimensions: 1.5m long 0.45m wide | Northing: 6144221 m | datum: WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material — soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED	E, E		0.0–0.5			**FILL; Sandy Gravelly CLAY:** Medium plasticity, brown, fine to coarse grained angular basalt/siltstone, fine to coarse grained sand, and some roots.	<Wp	VSt	×	FILL: ROAD SHOULDER
				E		0.5–1.4		CL/CH	**CLAY:** Medium to high plasticity, mottled orange/brown and grey, with some fine roots and fine grained sand, and a trace of fine to medium grained angular ironstone gravel and silt.			× ×	ALLUVIAL SOIL
						1.4–2.5		CL	**Sandy CLAY:** Medium plasticity, mottled dark grey, orange, red/brown and yellow, with a trace of fine roots.		H	× 550×	
						2.5–3.0			Test pit CTP26 terminated at 2.5m				CTP26 Terminated at 2.5m on steady progress

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

drawn	**RB**	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client: **MANILDRA GROUP PTY LTD**
approved	**CA**		project: **ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION** **PROPOSED GAS PIPELINE** **BOMADERRY NSW**
date	**19/07/2011**		
scale	**NTS**		title: **PHOTO OF TEST PIT CTP26**
original size	**A4**		project no: **ENAUWOLL04006AA-AA** — Photo Plate: **30**

HEAD

TRACKING

TOOL

DigiTrak
Falcon F5®
Directional Drilling Guidance System

- Wideband technology evaluates hundreds of frequencies for the best possible performance around active interference
- Ultra-low frequency options for battling passive interference on the jobsite
- Scan for interference, select optimum frequencies, and pair transmitter at the jobsite
- Switch between paired bands mid-bore
- Full Scale Sensitive Pitch provides 0.1% resolution through ±99.9% slope for precision grade work
- Max Mode filters noise to boost weak data signals and stabilize depth readings
- Standard warranty for 19- and 15-inch transmitters is 3 years/500 hours

Falcon F5 Is Now *Passive Aggressive*

The ability to choose the right transmitter frequency is more important than power in overcoming the effect of active interference. In October of 2015, DCI introduced Falcon technology, a significant new approach to overcoming active interference on HDD jobsites. DCI now introduces a new approach to addressing the problem of passive interference: sub-kilohertz frequencies. Falcon F5 with Sub-k Rebar capability allows a locating specialist to scan the jobsite and select the best frequency in the ultra-low frequency range of 0.33–0.75 kHz to combat passive interference.

Falcon Innovation Continues

Falcon is the HDD industry's only walkover guidance system able to specifically address both active and passive interference. Transmitter frequencies below 1 kHz are proven most effective for jobsites where passive interference is a problem. In addition, the new Falcon F5 receiver supports Full Scale Sensitive Pitch (FSSP) for 0.1% resolution through ±99.9% slope for precision grade work.

The Falcon F5 receiver offers the industry's first fully integrated GPS capability using the DigiTrak iGPS module. Snap on the iGPS module and it automatically powers on to receive and record satellite GPS data.

Use the free LWD Mobile app to view the progress of the bore and overlay the iGPS locate points on your smart device.

The Falcon F5 Wideband Transmitter

A Falcon F5 transmitter provides versatility in all types of active interference at frequencies of 4.5–45 kHz. The Falcon F5 wideband design vastly outperforms single-frequency transmitters of past generations. It also comes standard with fluid pressure measurement. No other guidance system allows an operator to scan for active interference and then pair optimized frequencies to a transmitter at every jobsite. This provides substantial cost savings and increases pilot bore productivity.

The Falcon F5 Sub-k Rebar Transmitter

The newest entrant into the Falcon F5 wideband transmitter lineup is the Sub-k Rebar transmitter. It uses frequencies below 1 kHz and provides frequency selection options from 0.33–0.75 kHz. This frequency range is ideal for addressing project scenarios that exhibit passive interference. Whether sidewalk, roadway, or runway, the Sub-k outperforms other options above 1 kHz. These transmitters include fluid pressure measurement as a standard feature.

Wideband Sub-k Rebar

Falcon Frequency Optimizer

DIGITAL CONTROL INCORPORATED
dci@digital-control.com ▪ www.DigiTrak.com ▪ 1.425.251.0559, 1.800.288.3610 (US/CAN)

Jul 402-1025-21-C metric

	DigiTrak Sub-kHz			The other guys	DigiTrak Wideband								
Band Number	0.3	0.5	0.7		7	11	16	20	25	29	34	38	43
Range in kHz	.33 – .40	.40 – .58	.58 – .75	1.5 – 4.0	4.5 – 9.0	9.0 – 13.5	13.5 – 18	18 – 22.5	22.5 – 27	27 – 31.5	31.5 – 36	36 – 40.5	40.5 – 45

Ease of Use

Falcon F5 raises the bar on walkover locating system capability and ease of use. Our customers have always relied on the Falcon F5's color, icon-driven screen for easy menu navigation. *Ball-in-the-Box* has never been more powerful and still provides a real-time status of the bore in progress. Minimize downtime caused by alternative products that claim to get the job done but often fall short. Keep your project on DigiTrak and maximize your productivity.

3 Year/500 Hour Warranty

Register your new Falcon 19- or 15-inch transmitter within 90 days for an enhanced warranty of 3 years or 500 hours, whichever occurs first. Ask your dealer about an extended warranty option that provides 5 year/750 hour coverage.

Transmitter Specifications

See the separate Falcon F5 Transmitter Specification Sheet for details on the six different 19-, 15-, and 8-inch wideband options for active interference and Sub-k Rebar options for combating passive interference. Falcon F5 also supports our popular DucTrak transmitters.

Receiver Specifications

Product ID	FF5
Model number	FAR5
Receiving frequencies	0.33–45.0 kHz
Telemetry channels[1]	4
Telemetry range[2]	defined by remote display
Power source	Lithium-ion battery pack
Battery life	8–12 hrs
Functions	Menu-driven
Controls	Trigger and toggle switches
Graphic display	Full-color LCD
Audio output	Beeper
Accuracy	±5%
Voltage, current	14.4 VDC nominal, 390 mA max
Operating temperature	-20–60° C
Dimensions	27.94 x 13.97 x 38.1 cm
Weight (with battery)	3.9 kg

Aurora Touchscreen Display Specifications

Product ID and model number	AF8, AF10
Power source - cabled	10–28 VDC
Current	1.75, 2.1 A maximum
Controls	21.3, 26.4 cm touchscreen
Graphic display	LCD
Audio output	Speaker
Telemetry channels[1]	4
Telemetry range[2]	500 m
Operating temperature	-20–60° C
Dimensions[3]	24.9 x 16.8 x 8.1, 29.2 x 23.7 x 5.8 cm
Weight	1.9, 2.9 kg

[1] Local telemetry frequencies and power levels available at www.DigiTrak.com.
[2] Telemetry range can be increased with an optional external receiving antenna.
[3] Dimensions do not include external mounting hardware.

PRE-COM

RISK

ASSESSMENT

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
		ENTER ASSESSMENT DATA				**Procedural Mitigation, Codes of Practice, Australian Standards, Training and Induction Programmes, Physical Mitigation**	ENTER ASSESSMENT DATA				
Horizontal Directional Drilling	Stakeholder impact - injuries and supply/service disruption	3	4	12	High	• Establish Exclusion zone and signage to isolate drill area • Fencing HDD excavation to ensure restricted access • Warning signage • Hazard lights • SWMS for HDD • Entry and exit pits safe distance from access • Traffic Management, if required • Review Drilling and HDD management plan in conjunction with Shoalhaven Starches	2	3	6	Low	Y
	Handling/Bulk Storage/transporting hazardous or dangerous goods - spills, contamination, skin irritation and burns	3	4	12	High	• Ensuring containers labelled and sealed • Register of Dangerous Goods, MSDS in Site Office • Appropriate lift location • Appropriate equipment for handling/transfer • Correct PPE to be worn in accordance with Shoalhaven Starches and NAP induction as well as MSDS requirements • Spill kits in site yard and on refuelling vehicle • MSDS on file and upto date • Employee trained and competent. • Induction. • Shoalhaven Starches Audits • Licensed operator to carry bulk dangerous goods. • All transport done In accordance with EPA guidelines	2	3	6	Low	Y
	Entanglement occurs during drilling - Unauthorised personnel to work area Automated Actions, Pinch points from rod loading and jaw clamps - Soft tissue injuries	3	4	12	High	• Exclusion zone around drill identified • Authorised Persons Only Signage. • Visitor sign on Log. • Obtain Work permit • SWMS for HDD • Machinery guarding • Trained competent operators verified for employees / subcontractors • No loose clothing allowed • Isolation & tag out protocols for maintenance	2	4	8	Moderate	Y
	Noise emitted from drilling plant - OH&S issues	5	3	15	High	• All plant to be risk assessed and have scheduled maintenance / servicing • Selection of equipment to provide noise attenuation • Appropriate PPE • Job rotation to reduce exposure limit (Where required)	2	2	4	Negligible	Y
	Impact with an existing services - injuries	3	4	12	High	• Approved Boring Procedure and HDD Management Plan in conjunction with NAP and Shoalhaven Starches requirements • Tracking of the bore during drilling • Exposure of services where possible, with spotter when borer is in proximity. • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipelines • DBYD and service register to be developed to ascertain risk of impact to services	2	4	8	Moderate	Y
	Drilling Failure - major supply/service issues	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan.	2	4	8	Moderate	Y

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
						• Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline • Emergency response plan (Frac out management plan)					
	Frac out occurring impacting roadways / environment	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan • Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline / impact to road • Emergency response plan (Frac out management plan)	2	4	8	Moderate	Y

SWMS

Jelmac Industries Pty Ltd
2 Jeanette Maree Court
Kilsyth VIC 3137
Phone: 0417 351 908
ABN: 60 165 118 972

Jelmac Industries Pty Ltd
SWMS
Safe Work Method Statement

THIS FORM IS TO IDENTIFY TASK / SITE HAZARDS AND TO MINIMISE THE RISKS TO PERSONS AND/OR DAMAGE TO PROPERTY.					
Project:	National Australia Pipelines				
Site Address:	Jemena Pipe Crossing				
Site Muster Point:		**Start Date:**		**Supervisor**	Brad Boote
Specific Task:	Directional Drilling & Vacuum Truck	**Finish Date:**		**Phone:**	0417351908
Plant & Equipment:	Directional Drill, Vacuum Truck, Support Vehicle. Hand tools.				
Hazardous Materials:					
Personal Protective Equipment Required:	Uniform; Footwear ☑; Hi Visibility ☑; Hard Hat ☑; Eyewear ☑; Fall Arrest ☐; Gloves ☑; Hearing ☑; Dust Mask ☑; First Aid ☑				
Managers Approval:	Brad Boote	**Signed:**		**Date:**	20-01-2022

CONSEQUENCES	POSSIBLE COURSES OF ACTION	LIKELIHOOD	MINOR (1)	SERIOUS (2)	SEVERE (3)	MAJOR (4)	CATASTROPHIC (5)
MINOR	First Aid, No Medical Treatment required. Spillages, leaks or other escapes, which occur and are contained. Supervisor to report and monitor.	(A)...ALMOST CERTAIN Will likely occur once or more every couple of years. Expected to or occurs regularly.	Medium	High	High	Extreme	Extreme
SERIOUS	Lost time injury/medical treatment required. Spillages or leakages, which have migrated offsite. Supervisor to report and manage by routine procedures. Immediate reparative/first aid action required.	(B)...LIKELY Will likely occur once or more in 10 years.	Low	Medium	High	High	Extreme
SEVERE	Single permanent or partial disability. Discharge of any substance from site, which has the potential to harm the environment. Supervisor to report and manage by specific monitoring plan or procedures. Stop work, immediate reparative/first aid action required.	(C)...POSSIBLE Could occur but not probable. Has not occurred at Jelmac.	Low	Low	Medium	High	High
MAJOR	Total permanent disability. Actual material harm to the environment on or off site with short-term effects and reparable by remedial action. Supervisor to report and allocate responsibility to appropriate senior manager. Stop work, immediate attention needed urgently.	(D)...UNLIKELY Not expected to occur. Has not occurred at Jelmac but has occurred within the industry in Australia.	Negligible	Low	Low	Medium	High
CATASTROPHIC	Multiple fatalities or total permanent disability. Actual material harm to the environment on or offsite with long term or irreparable effects. Supervisor to report and notify appropriate senior manager to manage via detailed control plan. Stop work, quarantine site, supervisor to contact relevant emergency services.	(E)...RARE May occur in exceptional circumstances. Has occurred in known history in the industry.	Negligible	Negligible	Low	Low	Medium

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

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Standards & Requirements	Occupation Health & Safety (OHS) Act 2004, Occupation Health & Safety (OHS) Regulations 2007,	FSR1: Temporary works, excavations and underground and overhead services FSR 02: Plant Equipment NAP Ground Penetration Permit	NAE PTW Certificates of Competency TM Plan

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Safety Management	Lack of safe work practices places workers, public and wildlife at risk.	A	5	E	All Jelmac Directional Drilling staff members are issued upon acceptance of employment a Safety Folder containing all occupational health and safety procedures. Staff members are expected to refer to and follow these procedures to ensure safe work practices. Staff and emergency contact details are provided at the rear of the folder. Site-specific forms SWMS and JSA are available.	E	3	L	Management/ Supervisors/ All Personnel
	First Aid	Lack of sufficient first aid can significantly increase injury.	C	3	M	All vehicles are equipped with a Standard Workplace First Aid Kit. Injury is to be assessed and medical assistance sought if required. Follow Emergency Procedures if required and consult Emergency Contact Details if necessary.	C	2	L	Management/ Supervisors/ All Personnel
	Environmental Management	Wildlife, significant vegetation, noxious weeds, waste, hazardous chemicals and materials.	C	3	M	Identify Environmental Management procedure. Inspect, identify and assess risks. Ensure compliance with local, state or EPA guidelines. Ensure safe removal or avoidance of any wildlife and or vegetation. Ensure wash down of plant and machinery to avoid transfer of any noxious weeds. If asbestos is encountered, stop works immediately and contact engineer or supervisor. Control of Drill slurry , erect silt controls at Bore entry & exit, Remove excess via Vac unit for disposal to EPA accredited site	E	1	N	Management/ Supervisors/ All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Emergency Preparedness	Fire, explosion, flood, bush fire, bomb threats.	E	5	M	Plant and LV Inductions need to be completed. Identify Emergency Procedures procedure. Assess location and impending weather conditions and forecast. All trucks and plant are equipped with fire extinguishers, which are all current with tags as per legislative requirements. Ensure any hoses are clearly labelled and accessible, ensure work areas suitable, secure and clear, avoid creating fire hazards and consider evacuation plans. Identify Emergency Contact Details form. Ensure all staff are identified and accounted for in the event of an emergency.	E	3	L	Management/ Supervisors/ All Personnel
	Weather	Exposure to UV radiation, extreme weather conditions (Extreme heat, Rain, Storms), Visibility.	C	2	L	Identify and assess impending weather conditions and forecast. Use sunscreen, hats/protective brims, long sleeve shirts, and neck flaps. Reassess site and work conditions in extreme weather conditions or poor visibility. Source extra equipment; modify safe work practices or hours of work as necessary.	E	2	N	Management/ Supervisors/ All Personnel
	PPE (Personal Protective Equipment)	Inappropriate or inadequate personal protective equipment can result in injury, overexposure to elements and lack of identification to the public or co-workers.	C	2	L	Issue of appropriate personal protective equipment prior to works or as required per task – long sleeves and trousers to be worn at all times. All staff must wear high visibility clothing and/or vests and approved safety boots wherever applicable. Hard hats and safety glasses are issued at employment and are to be worn at all times. Sunscreen is available to all staff at all times. Staff members are expected to return worn/damaged items to management for replacement.	E	2	N	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Drive to or from site and site access	Vehicular and Pedestrian Traffic. Collisions with other vehicles. Collisions with static structures. Collisions with pedestrians.	A	5	E	Driver must be appropriately licenced for the class of vehicle being driven/operated. Driver must abide all road rules. Driver must ensure vehicle is fit for task, road worthy, registered and must complete a Daily Plant Checklist prior to use. All personnel are to be made aware of the "Safe Entry and Exit of Worksite" procedure and be pre-started prior to entering site.	B	5	E	Driver
	Establish correct location	Time Wastage / economic loss.	B	1	L	Correct documentation and plans, effective communication. Refer to engineers construction pack,	E	1	N	Site Supervisor
	Traffic Management	Struck By Traffic Pedestrian Interface Non Compliance	B	3	H	No works within 7 metres of road without Traffic Management in place. Must have a spotter/observer to monitor pedestrian traffic and any site movement. Pedestrians to be escorted around works where required. Ensure a No Go Zone around Directional Drill and points of drill head entry and exit by placement of Temporary fencing for full perimeter of work zones to ensure public and personnel safety. Works in shared user path, access to be maintained at all times. Beware of pedestrians and implement exclusion zone. Refer to vehicle access plan	E	2	N	Site Supervisor / All Personnel
	Manual Handling	Physical Injury	C	2	L	Determine position, size and weight of object. Consider use of mechanical aids or extra personnel for task. Ensure appropriate personal protective equipment is worn. Adopt good posture and movement technique. Two persons required to reposition temporary timber stairs for batter access. Report any injuries or near miss and always consider any relevant improvements.	D	1	N	Site Supervisor / All Personnel

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Kilsyth VIC 3137
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ABN: 60 165 118 972

Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Using hand tools	Manual Handling, condition and maintenance, incorrect usage, risk of injury, use as a weapon.	C	2	L	Ensure manual handling advice and techniques are employed. Consider and ensure you are using the appropriate tool for the task. Ensure tools are inspected and maintained, replace if damaged. Ensure all tools are accounted for and secure.	E	2	N	Site Supervisor / All Personnel
	Working with chemicals	Spillage, Explosion, Inhalation, Absorption & Ingestion	D	3	L	All chemicals to be used in conjunction with appropriate SDS, which are attached to the back of the SWMS. Ensure compliance with EPA guidelines. Ensure suitable storage and transport. SDS available at hand. Ensure user competency, adequate signage, and chemical spill / clean-up kits available, personal protective equipment available. Identify Emergency Contact Details.	E	3	L	Site Supervisor / All Personnel
	Presence of existing services	Striking of services	B	4	H	Identify and assess location. NAP Ground Penetration Permit Action Dial Before You Dig information. Identify asset owners. Pothole, hand expose and sight all high-risk services outside of rail corridor on each side of the proposed alignment in order to ascertain inverts and alignments of assets in the design vicinity so the bore design can be considered in relation to existing assets. Modify route and or employ safe work practices to avoid disturbance or damages to at risk services.	E	3	L	Management/ Site Supervisor

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Plant, machinery and equipment	Compliance/ Failure	**D**	**2**	**L**	All plant and equipment to be site inspected. Ensure all plant and equipment is inspected and cleared for use. Pre-start equipment checks, Regular service and maintenance checks and records.	**E**	**1**	**N**	All Personnel
		Movement of vehicles and machinery	**B**	**4**	**H**	Ensure machinery is equipped with suitable warning and hazard identifying devices (e.g. signs, lights, and alarms) and appropriately maintained. All operators hold appropriate license/s, to be VOC'd and comply with plant manufacturers operating guidelines. Ensure site awareness and security is maintained prior to operation. Exclusion zone of 5m to be maintained from drill head when operational.	**D**	**4**	**M**	All Personnel
		Spillage of diesel fuel and/or oil and lubricants	**D**	**2**	**L**	Refuelling to occur at properly designated area e.g. service station or depot refuelling area. Vehicle to carry Spills Kit to absorb any accidental leakage.	**D**	**1**	**N**	All Personnel
		Presence of existing overhead services	**C**	**3**	**M**	Identify any overhead services and ensure safe working distance from service is maintained.	**E**	**3**	**L**	All Personnel
	Unloading and Set Up Of Machinery.	Unloading plant from truck	**C**	**3**	**M**	Assess area for potential hazards i.e. uneven ground, overhead obstacles, safe deployment of ramps. No standing or climbing on the back of trucks without handrails.	**E**	**1**	**N**	All Personnel
		Overhead obstacles	**C**	**3**	**M**	Move to safer location.	**E**	**1**	**N**	All Personnel
		Ramps	**C**	**2**	**L**	Ensure appropriate ramps are installed and maintained.	**E**	**2**	**N**	All Personnel

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL L	PRE-RISK LEVEL C	PRE-RISK LEVEL R	SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK L	RESIDUAL RISK C	RESIDUAL RISK R	RESPONSIBLE
	Boring.	Machine Failure	C	1	L	Pre-start equipment checks, regular service and maintenance checks and records.	E	1	N	All Personnel
		Slipping from batter	C	5	H	No walking on batter. Access only using the stairs provided.	E	2	N	All Personnel
		Excess Drill Mud	C	1	L	Use vacuum truck to remove sludge during the drilling process. Dispose of excess Drilling slurry to an EPA accredited facility	D	1	N	All Personnel
		Frac out	C	1	L	Stop and assess immediate risk and secure if necessary. Use Vac Truck to remove sludge. Erect Silt Controls Prevent any flows to Drainage system, inclusive of Ground water. All clean up via vac unit	D	1	N	All Personnel
		Pipe pull back	C	3	M	Ensure effective communication with drill rig operator. Monitor Mud flows as annular space is filled, Removing excess via vac unit for disposal to an EPA facility.	E	3	L	All Personnel
	Site Reinstatement	Open excavations / Open pits	C	3	M	Backfill or secure. Ensure all lids are replaced or open pits secured.	E	2	N	All Personnel
		Trip Hazards	C	2	L	Remove.	E	1	N	All Personnel
		Heavy equipment, tools, products	C	2	L	Correct manual handling techniques.	D	1	N	All Personnel

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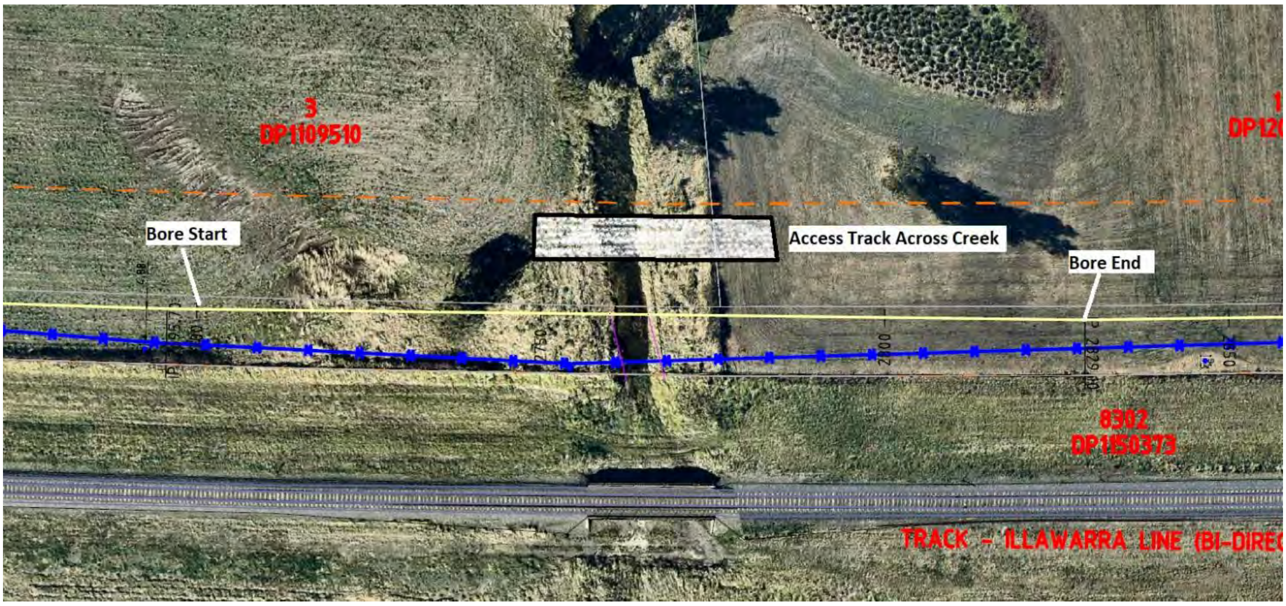
EMPLOYEE SIGN OFF

I have read and understood all tasks, hazards and control measures described within this document and agree to comply with the controls prescribed herein.

No.	Name of Employee	Date	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

SHOALHAVEN STARCHES PTY LTD
NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS – SHOALHAVEN STARCHES BOMADERRY



CREEK/WATERWAY CROSSING – TP GAS PIPELINE – MOD 1

Work Method Statement

Document No.		NAP-SS-WMS-04		
Revision:	**Date:**	**Prepared**	**Checked**	**Approved**
Rev A	7/02/22	Mukesh Bhatia	Ajay Kesavan	Martin Moran

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APPENDIX

- Fluid Management Plan
- Erosion and Sediment Control Plan
- Geotech Report
- Frac-out Calculations
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS

1.1 INTRODUCTION

The purpose of this method statement is to provide specific instruction for the following work scope to ensure the works are adequately planned and delivered in accordance with Construction Specifications.

1.2 SCOPE

The scope of work applicable to this method statement is associated with

A) Installation of the gas pipeline under the creek/waterways by way of Horizontal Directional Drilling (HDD) as part of the Shoalhaven Starches – Natural Gas Pipeline and Pressure Reduction Stations Project.

There is a requirement to install the gas pipeline under the following creeks and waterways.

1. Drainage Channel – Flowing onto Tullian Creek – Image 1
2. Tributary of Tullian Creek – Image 2
3. Abernethys Creek – Image 3
4. Mulgen Creek – Image 4

1.3 ABREVIATIONS AND DEFINITIONS

ALARP	As Low As Reasonable Practical
Checklist	A document that records or defines the actions that must be undertaken for a given task.
CEMP	Construction Environmental Management Plan
DBYD	Dial Before You Dig 1100
Hazard	Any operation or task that places personnel or equipment at risk to death, injury and or damage
HDD	Horizontal Directional Drilling
JSEA	Job Safety Environmental Analysis
NCR	Non-Conformance Report
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
ROW	Right of Way
NAP	National Australia Pipeline Pty Ltd
Supervisor	The responsible person who oversees, or directs control of works being undertaken during the construction of the pipeline

1.4 REFERENCES

1. Project Approval (MP10_018 MOD1) SHOALHAVEN STARCHES GAS PIPELINE PROJECT - INCREASE IN PIPELINE DIAMETER AND ASSOCIATED WORKS.
2. Shoalhaven Starches Natural Gas Pipeline IFC drawings
3. Shoalhaven Starches Natural Gas Pipeline Construction Environmental Management Plan (CEMP)
4. Shoalhaven Starches Natural Gas Pipeline Construction Safety Management Plan (CSMP)
5. ESCP – APA Ref 24710
6. Geotechnical Investigation Report

1.5 PERMITS

The following approvals/permits need to be in place before commencement of site works.

1. Development Application Approval - Minister for Planning and Infrastructure has approved the Development Application 10_0108-Mod-1 on 21 January 2022.'
2. NRAR Creek/Waterway Crossing Approval
3. DPIE Approval

2.0 RESPONSIBILITIES

The Project Management Team – Project Manager, Engineer, Construction Supervisor and HSE Officer – shall ensure that all project staff are adequately skilled to perform their assigned tasks and are aware of their obligations and responsibilities with regards to OH&S, Environmental Management, Quality Assurance, Industrial Relations and Administrative Functions.

The Crew Supervisor shall be responsible for the coordination of the personnel, equipment, and materials to complete the works in accordance with the relevant specifications.

2.1 JOB DESCRIPTIONS

All site personnel will have a formal job description. Detailed job descriptions for personnel have been developed and approved by the Project Manager. Please refer to the Project Execution Plan for detailed job descriptions.

To ensure that the Project is managed in accordance with the requirements of the Project and that of the contract the following key personnel have the following responsibilities.

3.0 HAZARD IDENTIFICATION AND RISK MANAGEMENT

The NAP shall, so far as reasonably practicable, ensure that any manager or supervisor is provided with such information, instruction, and training as are necessary to ensure that each employee under their management or supervision is, while at work, so far as is reasonably practicable, safe from injury and risks to health.

All personnel must be committed to achieving a safe working environment and strive to fulfill the objectives of the Project Health, Safety and Environment policy with compliance to the Safety Management Plan and the Environmental Management Plan.

3.1 MANAGEMENT CONTROLS

3.1.1 Risk Assessment

A full project risk assessment has been undertaken and the mitigation measures identified in this have been incorporated into this Work Method Statement. A JSEA will be produced by carrying out a risk assessment on this Work Method Statement and incorporating input from work crews. Each Crew member will be required to review this JSEA.

3.1.2 JSEA

The base JSEA shall be developed with input from the Project Manager, Construction Manager and HSE Advisor. The JSEA shall be reviewed and added to, as required by each crew, utilizing their experience in conducting the task. All crew personnel are to review and sign onto the JSEA before work begins.

3.1.3 Pre-Start

Supervisors shall ensure that meetings are held prior to starting each shift, and/or whenever the work scope changes. The meetings should:

- Review the state of the works as left by the previous shift
- The target progress for the current shift
- The means of achieving the target progress
- The state of works required at the end of the shift
- Any additional safety hazards (changing conditions as work progresses)
- Any environmental hazards

3.1.4 Tool Box Meeting

Tool box meetings shall be held at regular intervals. The tool box meetings will be used to relay information such as hazard alerts between crews and make all crews aware of larger issues and general hazards.

4.0 LOCATION OF WATERWAYS

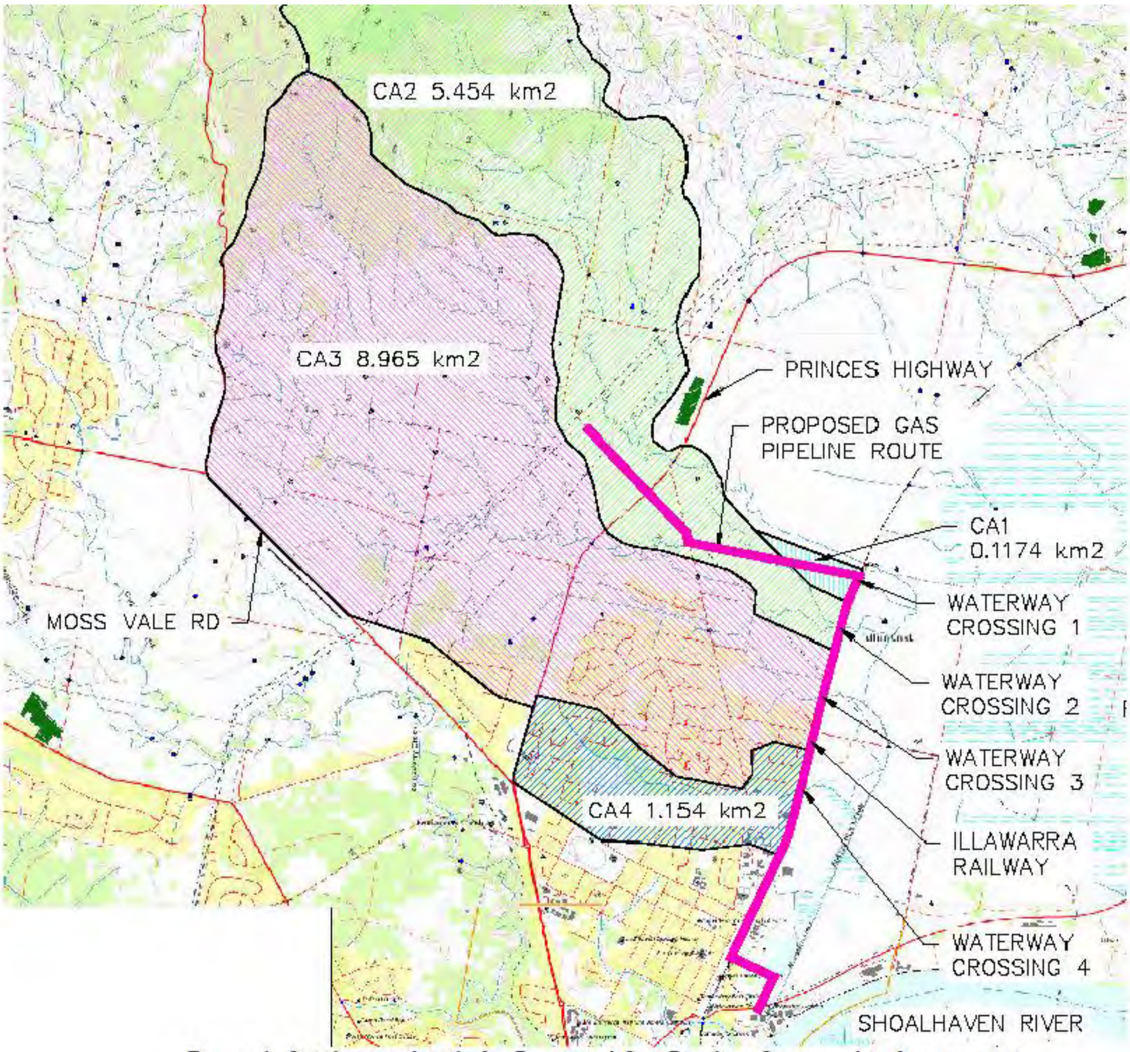


Figure 1: Catchment details for Proposed Gas Pipeline Geomorphic Assessment

Scour modelling has been completed for each of the creek crossings by Allen, Price and Associates – See Appendix 1 – ESCP Section 3.10 - Table 1

The creek crossings have been designed to be a minimum of 2m below the scour depth.

Gas pipe installation under creeks will be by means of Horizontal Directional Drilling (HDD), with entry/exit pits being >20m away from major creek banks and >10m away from banks of minor water way crossings.

The details of each creek crossing with the plan view and proposed HDD cross section has been listed in the next section.

4.1 Drainage Channel – Flowing onto Tullian Creek

A small drainage channel, at the outlet of the first culvert immediately downstream of Fletchers Lane, flowing onto the floodplain and eventually into the Tullian Creek

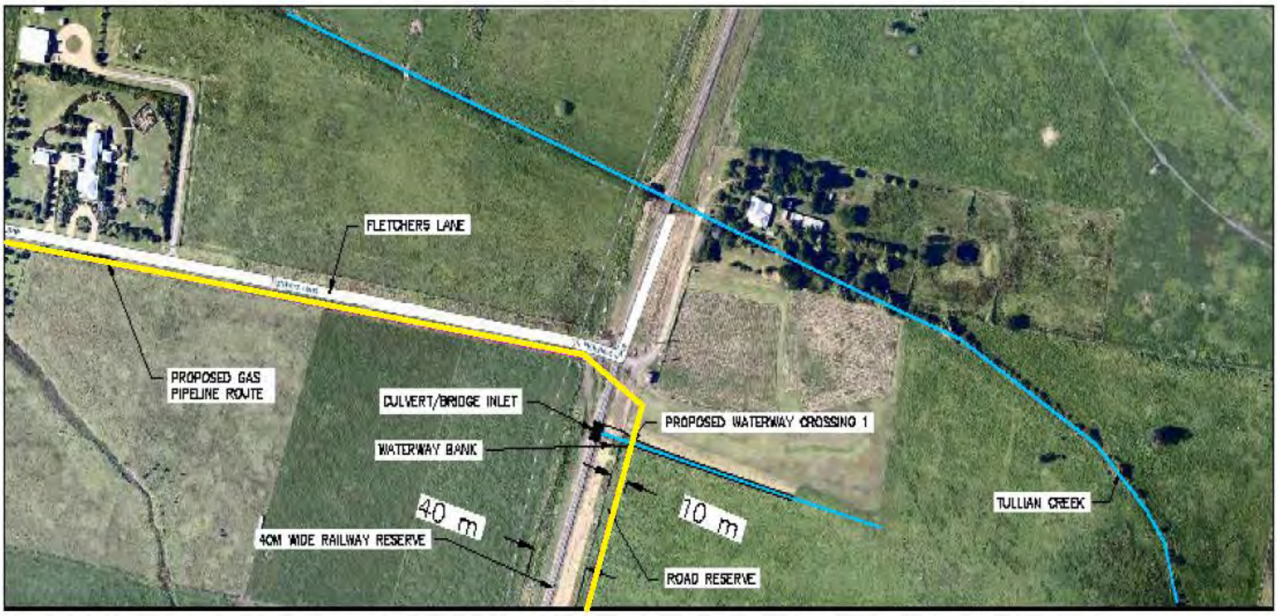


Image 1: Plan view of waterway crossing 1

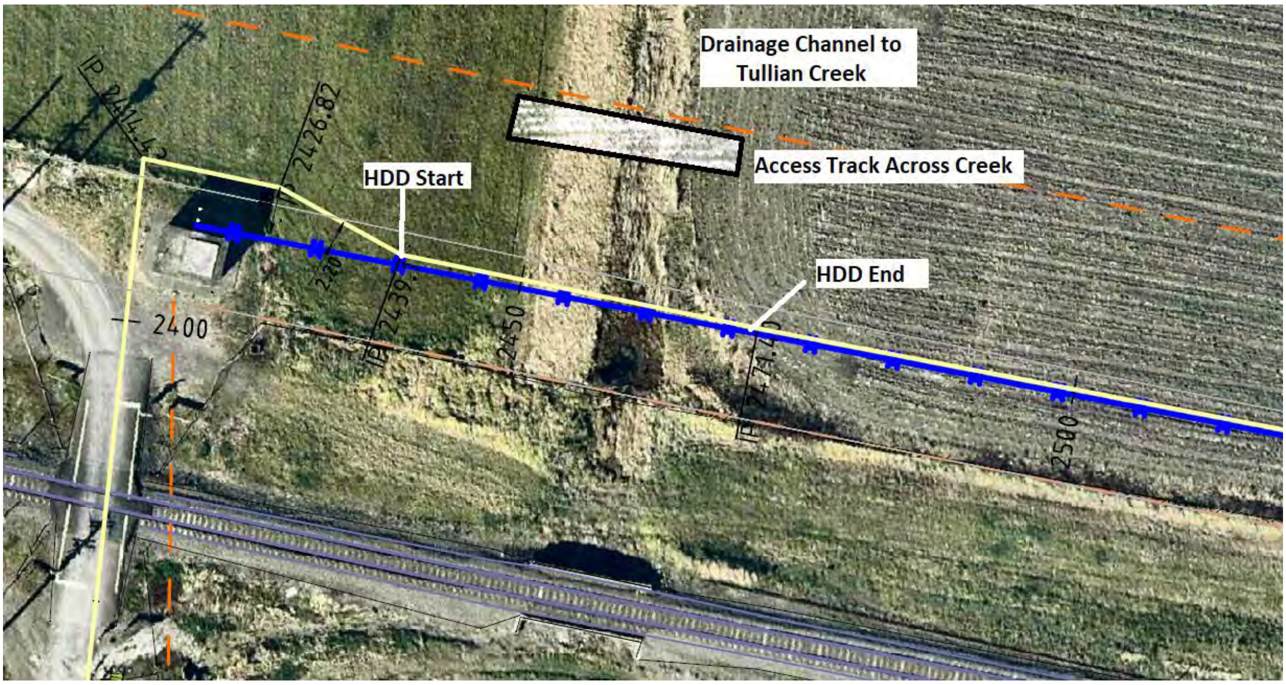


Image 1.1 – Plan view with HDD Location and Access Track Location

HDD Start and Finish is > 10m from the Creek Banks

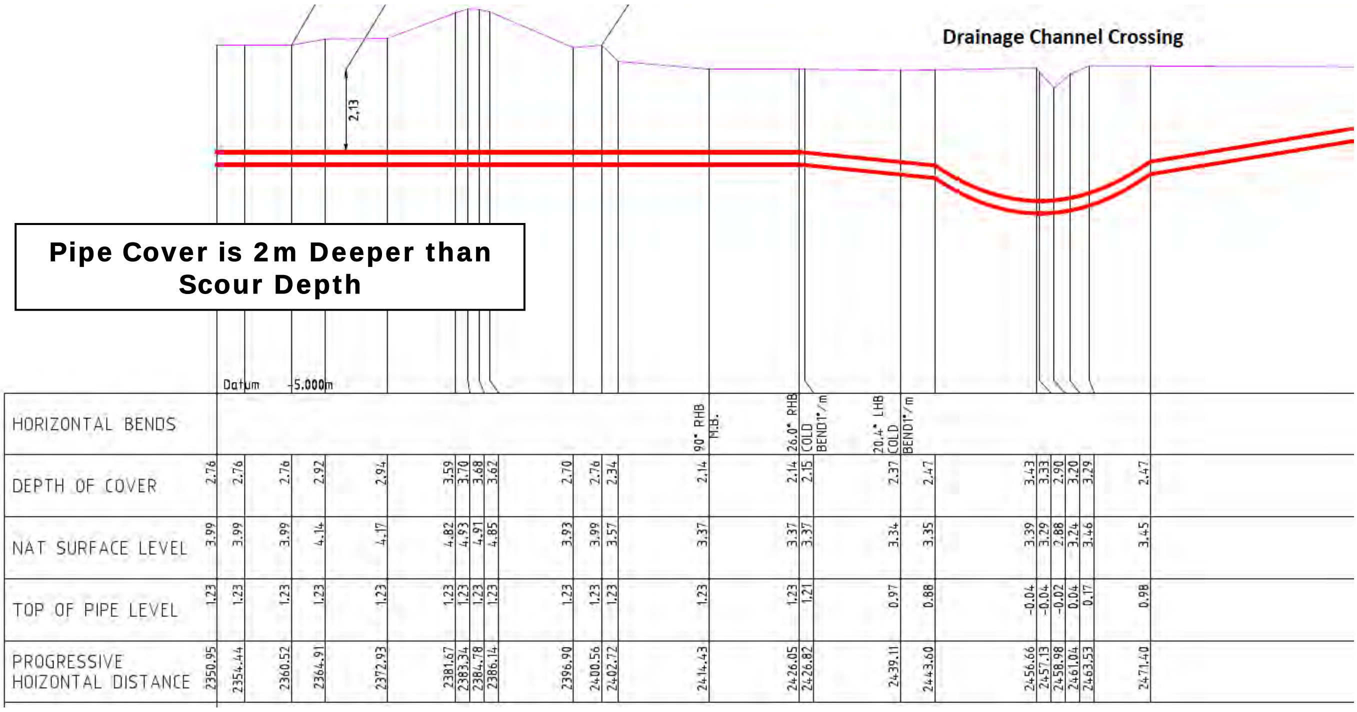


Image 1.2 –Cross Sectional View of Creek Crossing

4.2 TRIBUTARY OF TULLIAN CREEK

A small tributary waterway of Tullian Creek, flowing through the 2nd main bridge/culvert south of Fletchers lane.

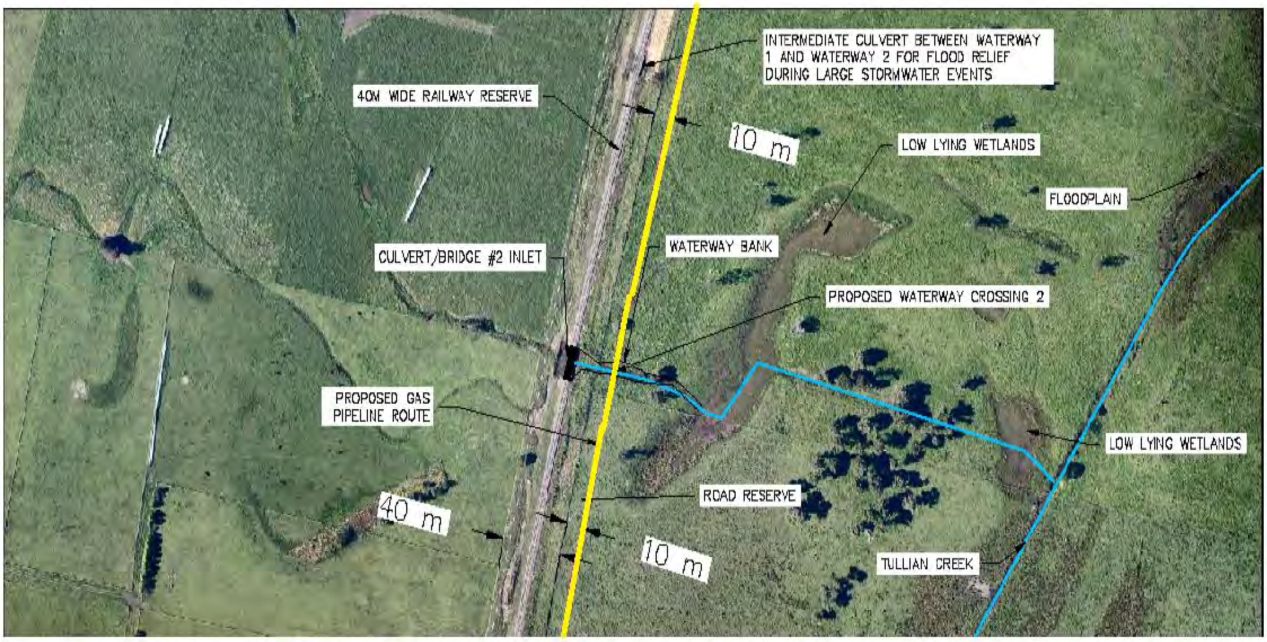


Image 2: Plan view of waterway crossing 2.

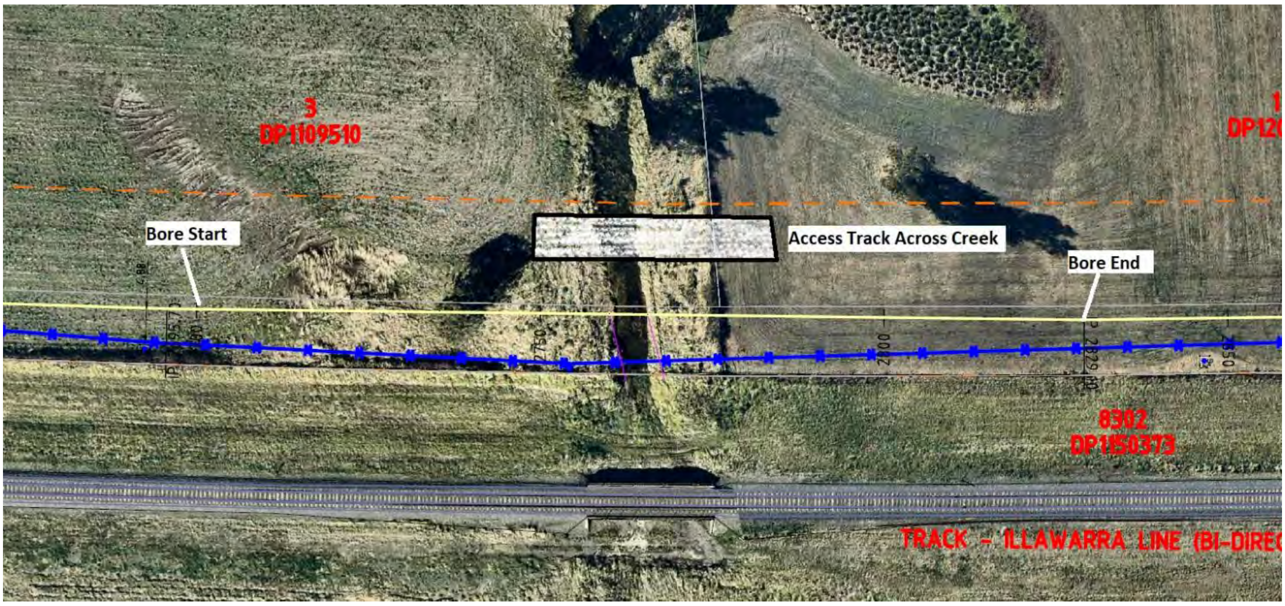


Image 2.1 – Plan view with HDD Location and Access Track Location

HORIZONTAL BENDS																	
DEPTH OF COVER	1.20	1.20	1.20	3.06	3.25	4.07	4.13	4.45	5.42	4.30	5.15	5.49	5.32	5.29	4.38	1.97	1.20
NAT SURFACE LEVEL	3.31	3.29	3.31	3.33	3.29	3.15	3.13	2.97	3.58	2.47	3.31	3.66	3.51	3.51	3.39	3.23	3.40
TOP OF PIPE LEVEL	2.11	2.09	2.11	0.26	0.04	-0.92	-0.99	-1.48	-1.83	-1.83	-1.83	-1.83	-1.81	-1.77	-0.99	1.25	2.20
PROGRESSIVE HOIZONTAL DISTANCE	2650.95	2670.26	2695.70	2711.07	2713.33	2724.96	2726.03	2735.25	2756.67	2760.06	2765.57	2766.87	2776.04	2778.97	2798.07	2821.76	2829.10

Image 2.2 –Cross Sectional View of Creek Crossing

HDD Start and Finish is > 20m from the Creek Banks

4.3 ABERNETHYS CREEK

Approx 200m north of Edwards Avenue

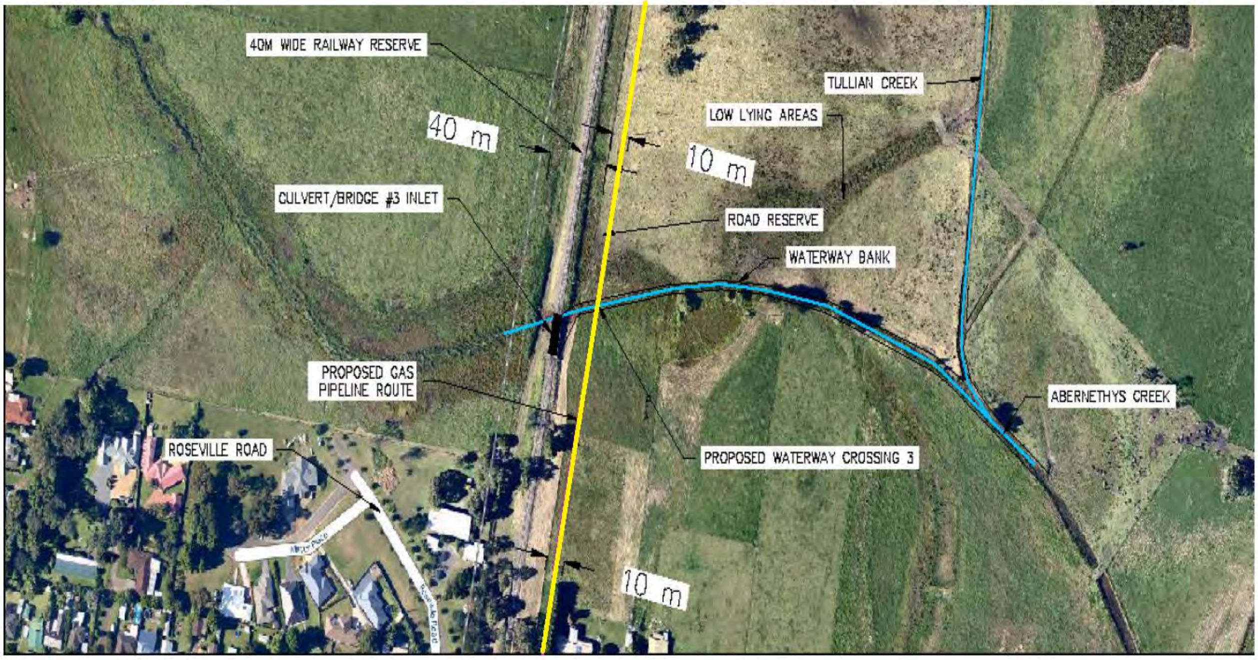


Image 3: Plan view of waterway crossing 3

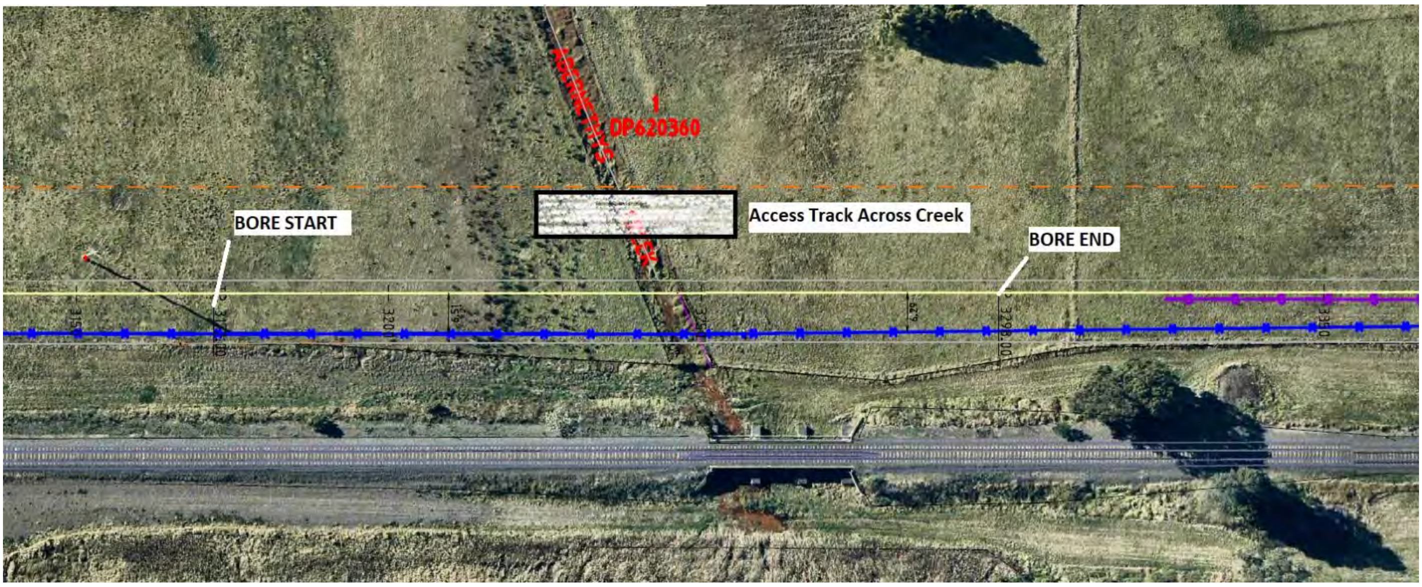
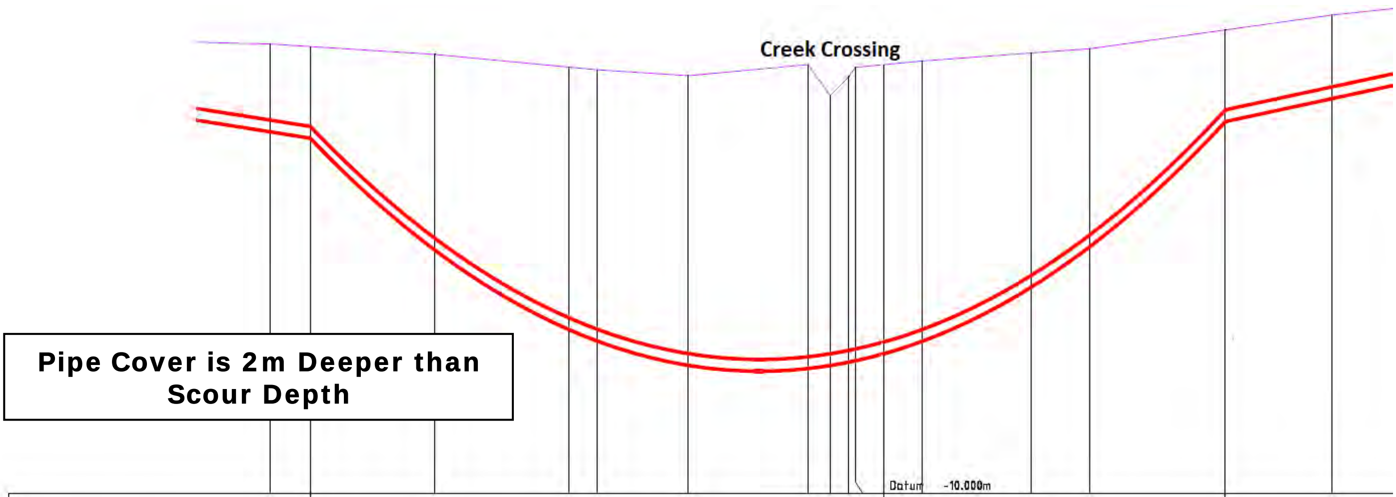


Image 3.1 – Plan view with HDD Location and Access Track Location

HDD Start and Finish is > 20m from the Creek Banks



HORIZONTAL BENDS																
DEPTH OF COVER	2.09	2.20	5.07	6.90	7.14	7.65	8.04	7.11	7.54	7.75	7.63	7.39	6.12	5.12	2.20	1.98
NAT SURFACE LEVEL	2.37	2.30	2.08	1.73	1.66	1.49	1.80	0.95	1.47	1.72	1.80	1.90	2.12	2.24	2.75	3.16
TOP OF PIPE LEVEL	0.27	0.10	-2.99	-5.17	-5.48	-6.16	-6.24	-6.16	-6.07	-6.03	-5.84	-5.49	-4.00	-2.88	0.55	1.18
PROGRESSIVE HOIZONTAL DISTANCE	3166.48	3172.00	3189.20	3207.61	3211.48	3224.09	3240.55	3243.61	3246.21	3247.09	3250.95	3256.21	3271.29	3279.34	3298.00	3312.64

Image 3.2–Cross Sectional View of Creek Crossing

4.4 MULGEN CREEK

Approx 400m south of Edwards Avenue

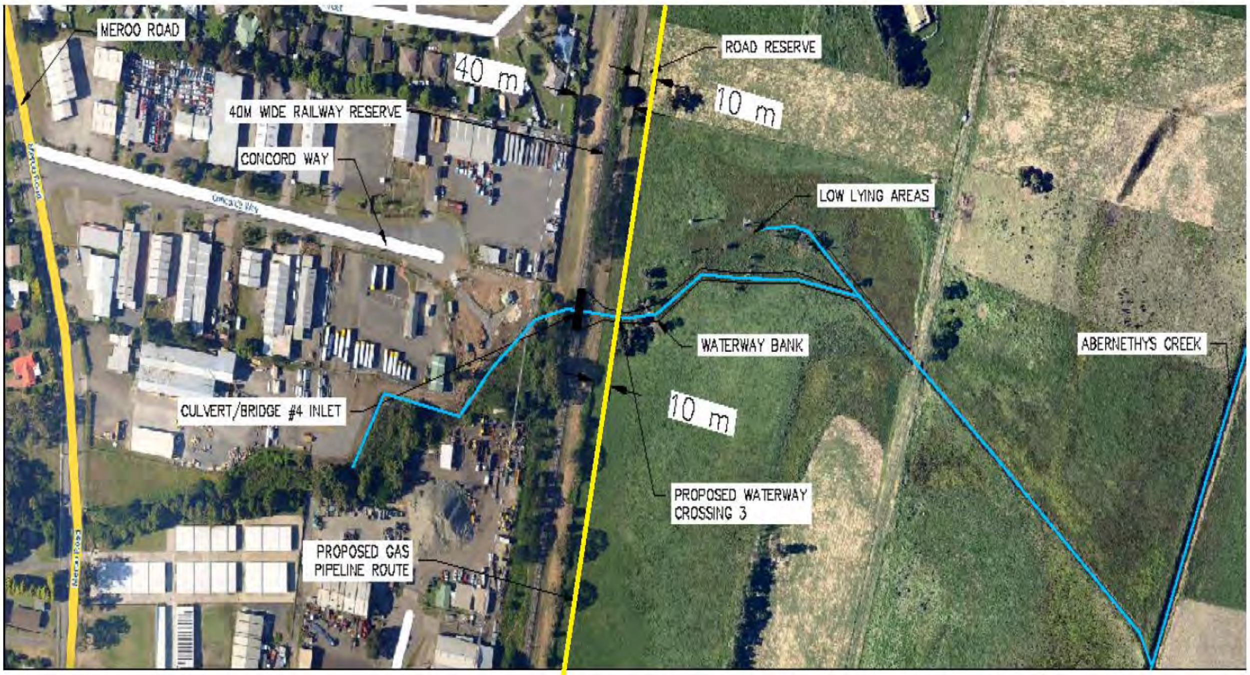
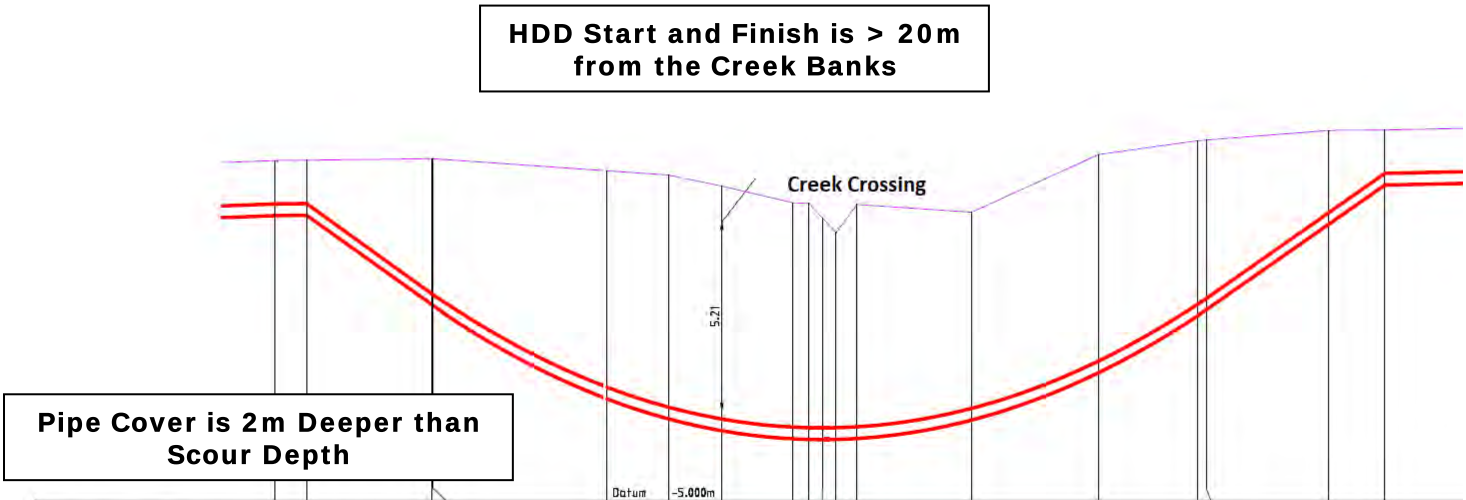


Image 4: Plan view of waterway crossing 4

Image 4.1 – Plan view with HDD Location and Access Track Location



HORIZONTAL BENDS																		
DEPTH OF COVER	1.20	1.20	3.75	3.77	5.99	6.42	6.45	6.21	6.20	5.81	5.40	6.15	5.43	5.71	4.53	4.38	2.27	1.20
NAT SURFACE LEVEL	4.40	4.41	4.46	4.45	4.12	4.00	3.70	3.24	3.21	2.82	2.41	3.19	2.97	4.57	4.95	4.97	5.24	5.25
TOP OF PIPE LEVEL	3.20	3.21	0.71	0.68	-1.87	-2.42	-2.75	-2.97	-2.99	-2.99	-2.99	-2.97	-2.46	-1.15	0.42	0.58	2.96	4.05
PROGRESSIVE HOIZONTAL DISTANCE	3804.70	3809.10	3826.55	3826.73	3850.95	3859.52	3866.92	3876.81	3879.07	3880.92	3882.84	3885.74	3901.66	3919.33	3933.09	3934.34	3951.39	3959.16

Image 4.2–Cross Sectional View of Creek Crossing

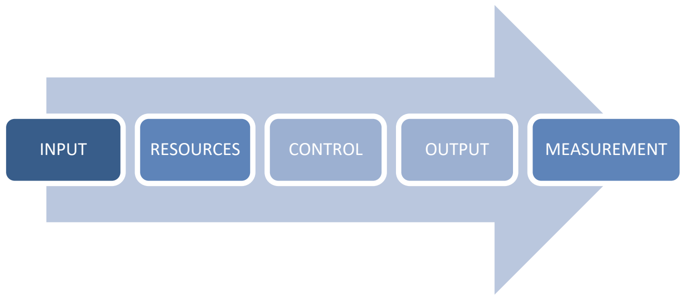
5.0 HORIZONTAL DIRECTIONAL DRILLING METHODOLOGY

5.1 PLANT / RESOURCES

The plant and equipment required for completing the water crossing is as per below.

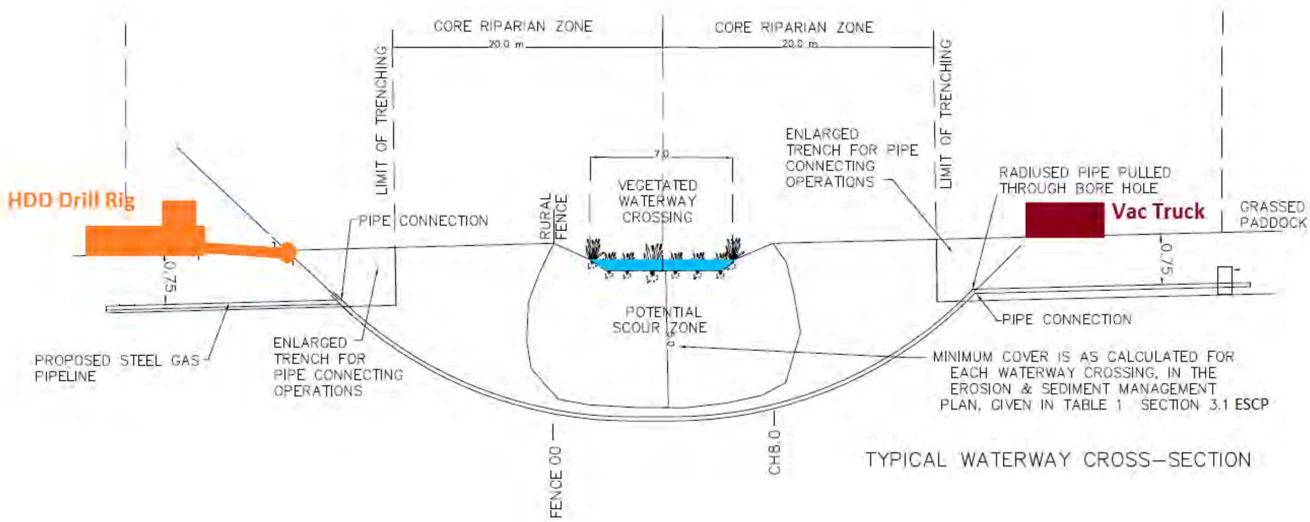
Excavator 21 ton, & bucket
Excavator 25 ton, & bucket
Loader
Utes
Welding Trucks
Tipper Truck
Water pump 2″ or 3″
Spill kits
Trench Shields
HDD Drill Rig
Mud Mixing Station
Vacuum Truck
Coating Truck

5.2 PROCESS DIAGRAM



INPUT	RESOURCES	CONTROL	OUTPUT	MEASUREMENT
Pipes strung Group Other materials	Equipment Operators	Inspection Permits Surveyed Alignment Management Plans	Installed pipeline Pipeline naturally grouted Entry & Exit point reinstated As built Survey Data	QSE Key Performance Indicators No outstanding NCR's or Client queries

5.3 HDD LAYOUT



5.4 GEOLOGY

The HDD is likely to be in Clay, Sandy Clay or Sandstone as per Geotechnical Investigation Report. The ground profile under the creek bed and banks is likely to be Stiff, Very Stiff to Hard Ground conditions. Accordingly, at the depth we propose to HDD we will have no issue with bore hole collapse or frac out.

For Drainage Channel (Flowing onto Tullian Creek) HDD

- Refer to CTP 17 and CTP 18

For Tributary of Tullian Creek HDD

- Refer to CTP 16 and CTP 14, 15

For Abernethys Creek HDD

- Refer to CTP 12

For Mulgen Creek HDD

- Refer to CTP 9 and CTP 8, 10

Frac calculations were completed at bed level and either side of banks for each of the above creeks, details can be found in the Appendix.

Note: For frac-out calculations, even though stiff/very stiff and hard soils were encountered at depths of 2.5m, we've used parameters of soft estuarine soils (Cohesion factor of 2, Soil Friction Angle of 25 Deg, Lower Unit Weight etc) to be on the conservative side.

In a nutshell, provided the permissible bore annulus pressures are not exceeded the chance of a frac out is remote.

5.5 LENGTH OF BORE AND PROFILE

Bore length – 60m to 160m
Bore profile – Refer to Section 4 above
Depth to top of pipe under creek bed – Ranges from 2.9m to 7.1m

5.6 DESIGN CONSIDERATIONS

NAP has completed the following:

- Pipeline installation stress analysis has been completed
- Frac Out Management Plan
- Overbend Stress Calculations

On a general note, based on the pipeline calculations the expected pipeline stresses are well within the Specified Minimum Yield Stress with large safety margins.

Frac out risk has been minimised by:

- Ensuring that the bore is deep under creeks within Firm, Stiff or very Stiff Soils
- The drill pressures are monitored and regulated
- Appropriate mud mixes are selected
- The bore hole is reamed to at least 1.5 times the diameter of the pipeline
- Ensuring that appropriate mitigation measures are in place in the event of frac out i.e. vacuum trucks, pumps, silt fencing etc.

5.7 CONSTRUCTION STEPS

1. Establish Drill unit
2. Existing Assets located and proved prior to bore commencing
3. Entry & exit points pre excavated.
4. Install silt controls at bore entry and exit points in order to prevent any produced drill slurry or ground water from entry to drainage systems, these fluids will be removed via Vacuum trucks for appropriate disposal to an accredited EPA site.
5. Recheck detail of all existing assets to ensure they have been proven and located prior to commencement
6. Scan bore path for interference prior to commencement

7. Entry and exit points of bore to be excavated 500mm below invert to capture and retain produced bore slurry for removal via vac unit
8. Commence pilot to designed bore plan recording invert & alignment on route – pilot process cuts the soil and utilises drill muds to carry cuttings to entry/exit points for removal via vac unit. (approx. Diameter of Drill head Cutting edge = 125mm)
9. As the bore is being piloted the tracker monitors bore alignment and invert throughout the progression of the bore in order to construct as per design – As the tracker checks this data the drill operator can see on a screen in real time – The driller and tracker are in contact via UHF Radio – specific frequency throughout the entire process.
10. Upon pilot reaching destined exit point / pipe pullback point the drill head will be removed and a reamer (approx. 300mm, followed by 450mm) will be installed, reaming of bore continues for full length of the alignment, during which drilling muds are introduced which seal the bore walls hence permitting the naturally reamed product to blend with the drilling enhancing muds which flow to the entry exit points for removal via vac unit.
11. Throughout all piloting and reaming processes the entry and exit points are monitored for adequate mud flows at each point to ensure that a pressure point does not develop in bore.
12. Throughout all piloting and reaming processes, the bore is left flooded with drill slurry which consists of naturally reamed and introduced bore enhancing products which fills void and supports the constructed bore.
13. Once the borehole is fully reamed, a pulling device is connected to the pipeline string via a swivel. The pullback then commences at a controlled speed.
14. The swivel between the pipe being installed and the drill string permits the pipe to rotate as friction requires between the drill slurry in bore and the 300NB pipe being installed.
15. The bore being full of drill slurry will be naturally displaced as the pipe is installed into the bore hole, the excess slurry transfers to both entry & exit points, which will be removed via vac units for disposal
16. As a result the annular space becomes fully grouted with naturally and introduced product resultant from the drilling process.
17. All surplus drilling slurry is removed from site and disposed of at an EPA registered disposal site

5.7.1 Risks regarding HDD process & Control Plan

Risk	Controls
Heave of Surface	Throughout Piloting, Reaming and pullback the entry and exit shafts as well as bore path are monitored to ensure muds are flowing and no pressure point develops within the bore. If pressure develops, work ceases and re swabbing commences to loosen up any blockage to recommence mud flows then restart the relevant process.
Frac Out	Can occur due to the geological conditions i.e. if not consistent or if geotechnical bore holes are too close to the HDD path. In the event this occurs, cease work, contain fluids, remove with vac unit, consider additional additives and action, alternatively excavate and use as a relief point for extraction of muds via a vac unit. Controls in order to eliminate this risk are by utilizing a sealing mud mix, together with at all times having a fully fluid charged bore. This risk is also mitigated due to the depth of the bore being >2m below scour depth to which the risk of Frac out or surface disruption is negligible.
Subsidence / Collapsing bore	Point 1 : the bore at all times will be fully charged with a heavy mud mix therefore a void never exists Point 2: Upon Pullback the annular space is naturally grouted with Naturally occurring spoils and Enhancing products Point 3 : at the design depths due to a fully charged bore at all times with Bore wall sealing products moisture and solids will

	remain in bore resulting in a supported bore at all times
Loss of Drill head (breakage)	Prior to commencing the bore the Drill head will be checked for fatigue to threads any cracking or distortion, If any of the above is evident the Drill head will be replaced by a conforming tool. The starter rod and hex collar to which the drill head connects to the drill rods will also be inspected for fatigue, distortion and cracks, if any of the above is evident this item of tooling will be replaced with a new unit. The hex collar (locking device between the starter rod and Drill head) will be checked for cracking, fatigue and distortion; if any of the above is evident a new unit will be supplemented. The Grub screw (hex collar retaining device) will be inspected for fatigue, thread damage, should any of the above be evident then the grub screw will be replaced by a new item. All the above ensure that the drill head and affiliated tooling are suitable to perform the required tasks. If the drill head breaks away from the drill string sub surface the drill string will be withdrawn and the drill head will remain in soil at this location. The pilot bore will be full of natural product from cuttings, this will be capped at surface to ensure no voids are present. New tooling will be installed and a

	new pilot will be performed, while abandoning the broken tooling. Should a breakage such as this occur outside the creek bed and banks the point of breakage would be excavated to retrieve the broken tooling and backfilled to standard excavation and backfilling practices. New tooling will be installed, and the bore construction will continue in the exiting pilot bore and achieve the desired pilot prior to reaming

5.7.2 Mud Mix:

- A bentonite mix of 1 bag per 1000 litres is nominated to be used
- This product ensures the bore walls are sealed retaining fluids to bore hole and to suspend the drill cuttings which is transferred to the exit point, reducing friction while ensuring good flows are maintained throughout drilling and reaming processes.
- By utilizing the nominated Mud Mix this ensures a filter cake is built to seal and support the bore, the bore retains integrity due to this filter cake and the bore full of slurry prevents any collapse of the bore hole.
- Throughout the entire process drilling fluid /slurry is always ahead of and behind the tooling, at no time does a void exist.

APPENDIX

- Fluid Management Plan
- Extract of Erosion and Sediment Control Plan
- Geotech Report
- Frac Out Calculations
- Head Tracking Tool
- Pre-Com Risk Assessment
- SWMS

FLUID MANAGEMENT PLAN

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.
ABN 88 005 339 211

SHOALHAVEN STARCHES

NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATION

FLUID MANAGEMENT PLAN & FRAC OUT MANAGEMENT

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National Australian Pipelines Pty. Ltd.

Natural Gas Pipeline and Pressure Reduction Station

Client: Shoalhaven Starches

Revision:	Issue Date:	Approved by:
Rev.0	20/01/2022	Martin J. Moran

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1 INTRODUCTION

It is recognised by National Australian Pipelines (NAP) that the consequences of any drilling fluid escaping the HDD drilling site compounds could be significant.

This Drilling Fluid Management Plan (FMP) addresses the following issues:

- The Purpose and Properties of Drilling Fluid;
- The Use of Drilling Fluid during a HDD operation;
- The Possible Paths by which Drilling Fluid could be lost to the environment;
- Safeguards the drilling contractor will put in place to minimise the chance of Drilling Fluid being lost to the environment;
- Inspection Procedures the drilling contractor will implement to ensure the safeguards are adequately maintained;
- Drilling Fluid Volume Tracking Procedures the drilling contractor will use to ensure that drilling fluid volumes are being checked;
- Drilling Fluid Loss Incident Management Procedure that will be used if Drilling Fluid Loss has been detected;
- Management of ground water ingress.

NAP believes the implementation of this Management Plan will:

- Ensure all practical safeguards are put in place to minimise the chance of Drilling Fluid being lost to the environment.
- Inspection Procedures will be in operation to maintain the integrity of the safeguards.
- Volumetric Drilling Fluid Tracking Procedures will be in operation to ensure that if Drilling Fluid is being lost or gained is detected and action taken.

2 CONTROL & DISTRIBUTION

The NAP Project Engineer controls this document. The Project Engineer shall ensure all persons named below are issued with a current copy.

REV NO.	CONTROLLED COPY ISSUED TO	ORGANISATION
Rev 0	Paul Whisson	Shoalhaven Starches
Rev 0	Colin Field	NAP (Site Copy)

3 GEOTECHNICAL AND HYDROLOGICAL ENVIRONMENT

The geotechnical investigation report indicates that majority of the borehole length shall be drilled through competent strata. This formation is inherently stable and is ideal for maintaining an open hole.

4 DRILLING FLUID

Drilling Fluid is a major factor in the success of any directional drilling program, and as such deserves careful consideration. The principal functions of the drilling fluid during a successful Directional Drilling operation are:

- To drive downhole motors, drill bits and reamers.
- To remove the cuttings from the bottom of the hole and carry them to the entry point.
- To cool and lubricate the drill string and drill bit.
- To line, support and protect the walls of the hole.

For a Horizontal Directional Drilling operation, the fluid demands are different from those required for drilling vertical wells. Hole cleaning ability or the ability of the drilling fluid to suspend cuttings is a much more critical factor for Horizontal Directional Drilling. Gel strength is the measure of this property.

For Horizontal Directional Drilling, low viscosity and high gel strength are required to ensure the cuttings are effectively suspended in the slurry and returned to the entry point. The drilling contractor is very experienced in Horizontal Directional Drilling operations and will be using some of the following products to mix the Drilling Fluid and guarantee these properties are met:

- BENTONITE
- KLA BORE
- POLY VIS HV

- SODA ASH
- STAR GEL

These products produce a drilling fluid with low viscosity, high gel strength and sufficient Bentonite content. The Bentonite content of the drilling fluid is critical for drilling boreholes through rock. The fine particles of Bentonite form a thin, low-permeability filter cake around the walls of the borehole. This filter cake seals the pores and other openings in rock preventing the escape of drilling fluid through the rock and the inflow of formation fluids.

The Material Safety Data Sheets (MSDS's) for these products are kept on site.

5 DRILLING FLUID CIRCULATION

It is important to gain an understanding of how drilling fluid is circulated during horizontal directional drilling, to better understand the safeguards and inspection procedures drilling contractor intends to implement to manage drilling fluid during the drilling operations.

The mud gets mixed in the mixing tank. Once the mud has been mixed adequately it is transferred to the active tank. From the active tank the drilling fluid is pumped to the drilling rig, through the drill pipe, into the borehole and onto the cutting face. The drilling fluid then suspends the cuttings and travels out of the borehole and into the borehole returns pit. The borehole returns pit is positioned directly behind the hole entry point. From returns pits the excess mud is extracted using vacuum trucks and disposed offsite.

The site set up plan shown in the work method statement should be referred to for containment facilities such as the site sedimentation fencing, sumps & bunds as this plan only refers to directional drilling fluid related controls.

6 HAZARD PATH IDENTIFICATION

NAP considers any risk to the environment of the area to be unacceptable. To reduce the risk of drilling fluid escaping to the environment NAP has identified the following paths by which it is possible that drilling fluid could enter these sensitive areas.

a) Runoff or surface water could escape the drilling compound during periods of rainfall.
b) Drilling Fluid could escape the drilling compound and potentially find its way into the environment.
c) Drilling Fluid could potentially escape the borehole during drilling through inconsistencies (cracks & fissures) in the rock. This could result in drilling fluid being deposited into underground aquifers or breaking out to the surface.
d) Groundwater could seep into the borehole during the drilling operation. This ingress will result in increased drilling fluid volume and could cause drilling fluid containment facilities to become filled to capacity and possibly overloaded.

These are the only paths by which drilling fluid could be potentially lost to the environment. Therefore it is the goal of this Management Plan to minimise the chance of drilling fluid escaping via these paths through the use of safeguards and the implementation of inspection procedures.

7 SAFEGUARDS

This section deals with the safeguards that the drilling contractor will use during the execution of this project, to control the previously identified potential drilling fluid escape paths.

The following mitigation measures will be put in place to counteract the hazards identified above:

- Earth bunds and drainage channels will be placed around the upper edges of the drill site and work area, to divert natural runoff around and away from the site so that it doesn’t mix with drilling compound runoff. Necessary erosion and sedimentation control measures will be in place.

- All facilities utilised in the surface mud handling (mixing, cleaning & pumping) shall be bunded. This shall ensure natural / clean runoff contained within the compound is not mixed with drilling fluid or contaminated by oil/fuel.

- A sump pit will be constructed at the bottom of the drill site. The sump pit will be positioned (during site planning) so as all runoff from the drilling compound will flow into it. The sump pit is of such dimensions to provide a buffer for the drilling fluid returns.

- An earth bund or silt fencing will be placed on the downstream side of the bund to contain any spillage. The sump pit will be pumped out using vacuum trucks in an as required basis during the drilling operation. This will ensure that any rain event, whilst the drilling crew is not onsite, won’t lead to a sump pit overflow.

- All products used to mix the drilling fluid will be covered before they are used to mix the drilling fluid. The unmixed drilling mud shall be stored on pallets keeping them off the ground and not stored within drainage lines. This will prevent the chance of any drilling fluid components escaping the drilling compound and becoming contaminants to the environment.

- All stationery plant & equipment on site is inspected on a daily basis to ensure it is in good working order to minimise the chance of fuel/oil/grease leakage.

- Adequate spill control kits containing absorbent materials, to cleanup spills from mobile equipment outside bunds shall be on site at all times.

- All excess oils and greases shall be contained within the fuel bund in order prevent any chance of leakage. The fuel bund is a fuel tank (4500L capacity) with an inbuilt steel bund able to contain 1.5 times storage capacity of the tank.

- All used oil or grease taken from machinery during services is stored within the fuel bund. The fuel bund is regularly emptied by a licensed contractor

- By designing the drill profile using the best geotechnical information available, the drilling contractor can ensure that an adequate amount of cover can be provided beneath the surface.

- The products selected to mix the drilling fluid have been carefully selected to provide the drilling fluid with sufficient Bentonite content. The Bentonite content of the drilling fluid will ensure a thin, low-permeability filter cake forms on the walls of the borehole. This will ensure no drilling fluid is lost through the walls of the borehole.

- Chances of drilling fluid seeping in the ground through storage pits (returns pits & sump pit) are minimal. Just as the drilling fluid lines the inside of the borehole it will also line the inside pits and provides an impermeable barrier hence stopping fluid from seeping into ground.

8 INSPECTION PLAN

This section deals with the inspection procedures by which NAP intends to ensure the adequacy and integrity of the safeguard measures.

8.1 DRILLING COMPOUND RUNOFF

Earth bunds/drainage channels or silt fencing placed on the downstream side of the drilling compound will be inspected on a daily basis and/or during & after any significant rain event to ensure their adequacy and integrity.

Earth bunding placed around the sump pit will also be inspected on a daily basis and/or after any significant rain event to ensure its adequacy and integrity.

Before the commencement of drilling and at the close down each day, all components of the mud mixing system will be visually inspected to check for signs of drilling fluid loss and to ensure its adequacy for the containment of drilling fluid.

8.2 INGRESS OF GROUND WATER

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected.

8.3 DOWNHOLE FLUID LOSS TO GROUND

The Drilling Fluid Volumetric Tracking procedure shall be utilised. This tracking procedure will be regularly updated to ensure that any ingress of groundwater into the borehole is quickly detected. Nominated cored holes will also be checked to see if there are any indicators that suggest where the fluid may be lost to.

The bore path will also be visually monitored from the surface for any signs of surface frac-out. In the event of a surface frac-out occurring, all drilling operations will cease and all efforts will be made to contain the frac-out to a localised area. Sand bags will be available on site to bund the area. Excess fluids will be removed from the area using a vacuum truck. If a vacuum truck cannot access the area of frac-out, manual pumping will be used to remediate the area surrounding the frac-out.

9 DRILLING FLUID VOLUME TRACKING PROCEDURE

The drilling fluid volume tracking procedure for the drilling operations is quick and easy. It has been designed this way so that regular and accurate checks can be made throughout each day to ensure that any groundwater ingress or downhole drilling fluid loss is detected quickly. This will minimise the volume of any drilling fluid loss from the compound due to overload of containment facilities (i.e. groundwater ingress) or drilling fluid loss to the ground through the borehole (i.e. downhole drilling fluid loss) and allow remediation activities to start promptly.

The drilling fluid tracking procedure involves a simple volumetric balance between measuring the volume of drilling fluid mixed and comparing it to the volume that the drilling fluid is occupying in the borehole and entry pit (this is dependent of the length of hole drilled and the volume in surface containment facilities). These two values can readily be measured onsite and comparison

of the values will quickly determine the volume of drilling fluid gained due to groundwater ingress or lost due to downhole fluid loss.

It is true that if groundwater ingress were to equal the downhole drilling fluid loss then the drilling fluid volume tracking procedure would not detect any loss. However this situation is extremely unlikely. During normal drilling operations we expect to be pumping 19L/s to 25L/s of drilling fluid up the borehole whilst groundwater water ingress, if any, is expected to be less than 1 L/s.

The measurement of the drilling fluid volume mixed can easily be measured by making the assumption that the volume of drilling fluid produced is equal to the amount of water added to the drilling fluid tank.

The theoretical volume that the drilling fluid is occupying is also a value that can be easily calculated. Two components contribute to this value. The first is the volume of drilling fluid occupying the drilled hole and the second is the volume of drilling fluid contained within the sump pits.

The volume of drilling fluid downhole is a simple calculation knowing the diameter and the length of hole drilled. The volume of drilling fluid contained within the sump pit can also be measured easily onsite. A measurement needs to be taken of the level of drilling fluid within the drilling fluid tank. Knowing this value and knowing the dimension of the containment vessel (vacuum truck) the volume can again be calculated easily.

The drilling contractor will be making this volumetric comparison regularly each day and a minimum of three checks shall be made each shift for the duration of drilling the pilot hole.

Should inconsistent ground material be found during drilling operations (this is unlikely due to the depth of profile beneath the ground and the geotechnical information supplied) the monitoring frequency will be increased to one reading for every 10m drilled.

10 DRILLING FLUID LOSS REPORTING SYSTEM

At this stage it is important to understand that it is normal to expect some drilling fluid loss during a horizontal directional drilling operation. Some losses are expected because the fluid is filling the borehole annulus (between the pipe and the bore walls), because the fluid is lining the edges of the borehole and sump pits. Therefore, it is important that normal drilling fluid losses are taken into account in the reporting system. The reporting system proposed for this project is summarised in the following table:

Drilling Fluid Loss	Situation	Action
0-15%	Normal	Continue Drilling One Reading in 30m Drilled
15-25%	Alarm	Continue Drilling Increase Monitoring Frequency One Reading in 10m Drilled
>25%	Emergency	Cease Drilling Follow Emergency Response Plan Notify Shoalhaven Starches and DPIE before recommencing HDD

10.1 DRILLING FLUID LOSS 0-15%

The volumetric drilling fluid balance has shown 0-15% drilling fluid loss. It is normal to expect some drilling fluid loss during a horizontal directional drilling operation. The situation within this zone is quite acceptable and work should continue on as normal.

10.2 DRILLING FLUID LOSS 15-25%

The volumetric drilling fluid balance has shown 15-25% drilling fluid loss. The loss of drilling fluid has now become a concern. The volumetric balance is immediately recalculated and the drilling compound is checked to ensure there is no other reason for drilling fluid loss besides downhole loss. The drilling fluid volume tracking procedure is increased from normal (three times a day) to hourly checks until the level of drilling fluid loss exceeds 25% or decreases below 10%.

10.3 DRILLING FLUID LOSS > 25%

The drilling fluid tracking procedure has shown that drilling fluid loss has exceeded 25%. It has been checked that the only reason for this drilling fluid loss is downhole drilling fluid losses. The drilling of the borehole is immediately ceased. An incident is declared and incident response procedures implemented as described in the following section 11 . The incident response plan identifies the procedure to be used when Loss of Drilling Fluid (>25%) is experienced.

11 INCIDENT RESPONSE PLAN

Refer to the Incident Management Plan for complete details on incident response procedures. The response to loss downhole drilling fluid loss in general terms will be:

1: Cease Drilling: When downhole loss exceeds 25%

2: Notify Shoalhaven Starches immediately

3: Drilling contractor to co-ordinate sealing of the borehole.

4: Notify DPIE of issue.

5: Notify DPIE prior to recommencing HDD operations.

Possible solutions are as follows:

- Pump Extremely High Viscosity Drilling Fluid in to borehole in order to attempt to gel up the leakage.
- Utilise leak sealing mud additives into the drilling fluid in order to attempt to seal the leakage.
- Addition of loss circulation products such as rice husks, cotton or shredded paper into the drilling fluid in order to attempt to seal the leakage.
- Grouting the borehole at the leakage location and drilling through the grout and continue the hole.
- Using bentonite forms filter around the borehole walls which stops water coming in the hole due to higher annular pressure as compared to the pore pressure.

The response to containment facilities failure in general terms will be:

1: Cease Drilling: When containment failure is detected

2: Notify Shoalhaven Starches immediately

3: NAP and the drilling contractor to co-ordinate containment and cleanup of the drilling fluid leakage.

Possible solutions are as follows:

- Mobilise transportable pumps on the worksite to the location of the spill and transfer the mud to a contained area.
- Utilise the excavator on site to form windrows in order to divert the flow back into contained areas.
- Utilise the excavator on site to dig a temporary hole in order for escaping drilling fluid to gather in and mobilise transportable pumps to transfer mud to a contained area.
- Mobilise additional vacuum trucks to the worksite in case there are no more effective contained areas on the site for the mud to be stored within i.e. cannot utilise transportable pumps to transfer the mud.

EROSION AND SEDIMENT CONTROL PLAN

EROSION & SEDIMENT CONTROL

MANAGEMENT PLAN

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for the

PROPOSED

SHOALHAVEN STARCHES PTY LTD

GAS PIPELINE

at

Meroo Meadow & Bomaderry, NSW

allen, price & associates
land and development consultants

APA Ref: 24710

DATE: February 2012

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Table of Revisions

Rev	Date	Details
00	06/02/12	For client review
01	13/02/12	Final Report for Client

Report prepared by:

Date: 13 February 2012

Adam Urszulak

MEng (Civil Engineering), BTech (Marine Engineering)

1 Introduction

The Shoalhaven Starches expansion project was approved in 2009 by the Minister of Planning and includes general expansion of the factory to increase ethanol production output, and a proposed gas fired co-generation plant to supply electricity and steam to the factory. To allow competively priced gas supplies to be sourced and to meet any increased energy demand, the company proposes to construct and operate their own gas pipeline. This report examines the management of erosion and sediment control for the proposed Shoalhaven Starches gas pipeline.

A new natural gas main, to be privately owned and operated by Shoalhaven Starches, is proposed to enable the company to source competitively priced gas supplies for its manufacturing operations and contribute to the preservation of the environment by increasing the efficiency of the factory including through a proposed co-generation power plant. Natural gas is currently obtained from via an ActewAGL owned gas pipeline connected to the Eastern Gas Main. The Shoalhaven Starches factory currently sources energy from a combination of coal, natural gas, diesel and electricity. ??

Construction will impact the environment to varying degrees along the proposed 5.5km route. A number of alternative routes for the proposed gas main were assessed by Shoalhaven Starches through a number of consultants including Allen, Price and Associates. This was done to determine the route most likely to minimise possible impacts to the environment. The route described in this report was assessed to have the lowest possibility of environmental impact, especially on sensitive areas which include; local wetlands, waterways, agricultural pasture, road & rail reserves, and Council infrastructure.

The proposed gas main route begins at an existing connection to the Eastern Gas Line (EGL) at Pestells Lane, Meroo Meadow. It will be built mainly in road reserves along the proposed route, through to a proposed gas pressure reduction station on land privately owned by Shoalhaven Starches, on the northern side of Bolong Road at Bomaderry. From this point, the gas main will continue under Bolong Road to the opposite side and into another property owned by Shoalhaven Starches, and will then be distributed for use within the factory.

1.1 Aim & Scope

The aim of this report is to broadly address erosion and sediment control issues outlined in the Director General's requirements, under the heading of Soil and Water, for the Shoalhaven Starches Project (MP 10_0108), issued on 8th November 2010. The specific requirements include providing;

- "specific reference to erosion and sedimentation management during construction".
- "detailed information describing how water bodies or water courses would be traversed and proposed measures to avoid or minimise any predicted impacts".

The Director General's Requirements are addressed in this report in accordance with the guidelines, principles and recommended standards for managing erosion and sediment control, outlined in Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition (The Blue Book), and Volume 2A- Installation of Services. These are comprehensive erosion and sediment control guides used throughout NSW, and will be referred to frequently throughout this report.

This report provides information for project administrators and managers to gain a better understanding of the erosion and sediment control issues and requirements specifically for the proposed Shoalhaven Starches gas pipeline project. Information is general in nature and does not take place of an erosion and sediment control plan (ESCP), which is required to be produced prior to construction. This report gives guidance for the future completion of the ESCP.

The main aims of erosion and sediment control (ESC) for this project are;

- Protect disturbed areas from the eroding action of stormwater runoff.
- Prevent sediment from disturbed soils entering into waterways and stormwater systems by providing filtration to remove sediment from stormwater..
- Divert clean stormwater runoff that would naturally flow through the proposed construction areas, preventing it from becoming polluted by sediment from soils that have been disturbed during excavation.
- Aid in rehabilitating disturbed soils, riparian zones and waterways.

Traffic control measures are required at certain sections along the proposed route during construction. This report does not take into consideration the need for traffic control, which may impact on the installation and maintenance of erosion and sediment controls outlined. The traffic management plan (TMP) is to take into consideration ESC where required.

Erosion and sediment controls will impact on public and privates services and infrastructure adjacent to the proposed gas pipeline. Impacts to infrastructure are not assessed in this report. A separate report has been written for this purpose by Allen, Price and Associates, titled 'Infrastructure Impacts Report'.

2 Erosion and Sediment Control Management

Effective project development through efficient process management is a significant factor of ecological sustainable development. Erosion and sediment control is a legislated requirement of all work sites, therefore effective management principals is an essential part of the project development process for developing adequate erosion and sediment control on linear service installation projects. This ensures environmental protection.

The following topics are briefly discussed in this section;

- erosion and sediment (E & S) control legislation.
- project planning methods for erosion and sediment control.
- general (E & S) control principals used on service installation projects.

2.1 Legislation

The legislation relating to erosion and sediment control of service installation projects fall under the development assessment framework and provisions of the Environmental Planning and Assessment Act 1979. These include;

- Protection of the Environment Operations Act 1997.
- Rivers and Foreshores Improvement Act 1948.
- Fisheries Management Act 1984.

Other Acts that may require consideration based on the route of the proposed gas pipeline include;

- National Parks and Wildlife Act 2003
- Native Vegetation Act 2003
- Roads Act 1993
- Soil conservation Act 1938
- Threatened Species Conservation Act 1995
- Water Management Act 2000

The first three pieces of Legislation will now be briefly summarized.

2.1.1 Protection of the Environment Operations Act 1997

The Environment Protection Authority (EPA) regulates; any activity listed in schedule 1 of the Protection of the Environment Act 1997 (POEO Act), state or public authority activities, and other activities where a license regulating water pollution is issued. Any other activity, under this Act, falls under the regulatory authority of the local Council.

Water pollution is prohibited under this Act unless it is in accordance with the provision of an 'environment protection license, as issued under this Act.

The Shoalhaven Starches gas pipeline route crosses minor waterways that eventually lead into major waterways.

2.1.2 Water Management Act 2000 and Controlled Activities

The NSW Office of Water administers the Water Management Act 2000 and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity. under the Water Management Act 2000, a controlled activity means:

- the erection of a building or the carrying out of a work (within the meaning of the *Environmental Planning and Assessment Act 1979*), or
- the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or
- the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or
- the carrying out of any other activity that affects the quantity or flow of water in a water source.

Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 m of the highest bank of the river, lake or estuary.

Laying of gas pipes in or across watercourses and adjoining waterfront land constitutes a controlled activity under the Water Management Act 2000. The Shoalhaven Starches gas main crosses a number of minor waterways. As the proposed gas pipeline comprises a 'major project' pursuant to the provisions of Part 3A of the EP&A Act, controlled activity approval is not required pursuant to Section 75U of this act.

2.1.3 Fisheries Management Act 1994

Activities relating to the installation of services that involve dredging or reclamation of waterways have the potential to block the passage of fish and harm marine vegetation, and therefore require a permit, to be issued under this Act by the Department of Primary Industries (DPI). As outlined above the proposed gas pipeline comprises a 'major project' pursuant to the provisions of Part 3A of the EP&A Act, approvals required pursuant to Sections 201, 205 and 209 of the Fisheries Management Act are not required pursuant to Section 75U of the EP&A Act

2.2 Project Planning for Erosion and Sediment Control

Volume 2A of Landcoms Managing Urban Stormwater-Soil and Construction indicates that effective management of erosion and sediment control on linear service installation projects requires systematically addressing the following five main planning activities;

- Developing systems for documentation and communication.
- Assessing constraints and opportunities.
- Preparing an ESCP.
- Restoring and remediating sites.
- Other planning considerations.

2.3 General Soil and Water Management Principals for Service Installation Projects

There are seven general principles of effective soil and water management for land disturbance associated with urban development, according to section 1.5 of Landcoms Managing Urban Stormwater; Soils and Construction, Volume 2A. These broadly apply to the planning, design and construction of most service installation projects. They provide the framework for the application of more specific erosion and sediment controls required on for the proposed gas main project. The seven general principals include;

1. Assess soil and water implications of a project at the planning stage.
2. Plan for erosion and sediment control and assess site constraints during the design phase and before any earthworks begin.
3. Minimise the area of soil disturbed and exposed to erosion.
4. Conserve topsoil for later site rehabilitation/regeneration.
5. Control water flows from the top and through the project area – divert up-slope 'clean' water away from disturbed areas and ensure concentrated flows are below erosive levels.
6. Rehabilitate disturbed lands quickly.
7. Maintain erosion and control measures appropriately

2.4 Developing Systems for Documentation and Communication.

The project principal will be responsible for ensuring all personnel working on the project are made aware of their individual responsibilities for proper environmental management and care. The systems that facilitate this require planning, implementation and control, and make up the Environmental Management System (EMS). The principal and/or contractor(s) are required to develop an EMS, which is presented as part of a Construction Environmental Management Plan (CEMP).[1]

The CEMP outlines environmental objectives and targets, and describes how the contractor(s) will manage and control the environmental aspects of the project to meet these. It must interface with all other plans, describe the overall project management system, and expand on the environmental section of the project business plan.[1]

The CEMP is an active document which is revised and updated as construction progresses. It provides all relevant site personnel, including superintendeant, construction managers, foreman and subcontractors, practical and up to date information on all environmental aspects of the project.

The following key components should be the minimum included in the CEMP, as they identify the aims, actions and outcomes required to meet the project's environmental objectives;

- Description of the principal or contractor's environmental management system.
- CEMP objectives and targets.
- Risk Assessment.
- Constraints.
- Roles, responsibilities and contact details.
- Environmental controls.
- Monitoring and Compliance. [1]

Regular audits or compliance inspections are to be made by the principal or their representative to ensure compliance with environmental conditions specified in the CEMP. This includes ensuring rapid project completion incentives do not promote environmentally harmful practices.[1]

The CEMP should also ensure the contractor's EMS conforms to;

- AS/NZS ISO 14001:2004. Environmental Management Systems – Requirements and guidance for use.

- NSW Construction Policy Steering Committee Environmental management systems guidelines, 1998.[1]

2.5 Assessing constraints and opportunities.

This report was written based on a site assessment of the proposed gas pipeline route. Consideration was given to providing adequate control of erosion and sedimentation with minimum expenditure, and identifying constraints and opportunities. These are explored in more detail in relation to the proposed gas pipeline route.

The proposed gas pipeline route, shown in Figure 1 (Appendix A), was selected based on desktop studies, field work and consultation with Shoalhaven Starches Pty Ltd, Cowmann Stoddart, URS Australia Pty Ltd, Allen, Price and Associates and Shoalhaven City Council. The aim was to avoid environmentally sensitive areas. An area of sensitivity was found along the route. It is shown as a black hatch in Figure 1 (Appendix A), which shows the sensitive coastal location through Bomaderry.

Section 3.3.2 of -Volume 2A gives a list of site characteristics and constraints that were generally considered during the site investigation. The following site characteristics and constraints were investigated during the site inspection along the proposed route;

- Existing exposed areas and likely areas of soil disturbance
- Existing vegetation
- Site topography
- Location of potential drainage lines and waterways.
- Landscape constraints including flood hazard, water logging and rock outcrops.
- Acid sulphate contaminated soils
- Opportunity to repair previous or existing areas of land degradation
- Disposal of surplus excavated material.
- Susceptibility to tunnel erosion

Soil constraints such as erodibility, erosion hazard, dispersibility, salinity, fertility or expansive and reactive soil types were not assessed in this report. These need to be determined during detailed design of the E&SC plan.

Since much of the route is located over land with negligible grade, minimal land degradation was observed. Areas along the banks of waterways where the proposed gas main will cross were found to be susceptible to erosion and degradation. There are no areas along the route that were found to require stabilisation due to past erosion and sediment control issues.

The majority of vegetation along the route is grass and weed found within the road reserves. Native trees were found in all road reserves along the route. Some of these will require removal to facilitate pipeline construction.

The proposed route is mainly flat with a 'gentle' slope to the south east, toward Abernethys Creek and the Shoalhaven River. Some areas are steeper along the route, although generally short in length. These areas require greater erosion and sediment control. Further details are provided in section 3 of this report.

There are a number of waterways and drainage lines that can be used to facilitate erosion and sediment control. These are shown on APA drawing 24710-04 (Appendix C).

Based on information obtained from Shoalhaven City Council, there are minimal areas where acid sulphate soils will pose a problem. The area is classed to have a low probability of acid sulphate soils.

Tunnel erosion may pose a problem on the steeper sections along the route, which are adjacent to a number of waterways. These areas will need further investigation during detailed design. Trench stops and bulk heads may need to be used to stop erosion and damage to the gas pipe or other related issues from occurring.

No areas were observed that could take surplus excavated materials since the majority of the route is within road reserves or adjacent to prime agricultural land.

Erosion and sediment control measures chosen need to minimise adverse impacts to existing vegetation and local wildlife. The passage of native animals through the site shall be allowed and the effect of erosion and sediment controls on native vegetation be considered when selecting controls.

The proposed route was originally selected to minimize disturbance to wildlife and sensitive environmental areas. Correct selection and placement of erosion and sediment controls will minimize impacts to the environment.

Opportunity exists for minor route alteration during detailed design. This aim would be to avoid specific areas along the route that constrain the construction of the proposed gas pipeline, and save time and money by reducing the amount of erosion and sediment control required. These areas are shown in Appendix C, on APA drawing 24710-04, indicated by the words 'Minor route Alteration?".

2.6 Erosion and Sediment Control Management Procedures

The following list describes general erosion and sediment control procedures, to be incorporated into the CEMP of the Shoalhaven Starches gas pipeline project;

- All works are to be carried out in accordance with Landcoms Managing Urban Strormwater; Soils and Construction Volume 1, 4th Edition, March 2004 & Volume 2A.
- The contractor shall take all reasonable measures to minimise the effects of dust emissions from the site including the spreading of mulch in areas where construction has been completed.
- All topsoil from the construction areas is to be stripped and stockpiled. Stockpiles are to be located outside areas of concentrated stormwater runoff and are required to be grass seeded or mulched if they are to remain for longer than fourteen (14) days.
- The movement of machinery over the site should be limited to the construction areas to avoid disturbance to existing vegetated areas. No-go areas are to be marked off prior to commencement of works. Machinery should be inspected prior to exiting construction area to ensure excess mud and debris is not tracked onto roadways. During and on completion of the workday contractors should inspect to insure the roadways adjacent to the project site are free of excess mud/debris and clean if necessary.
- Areas of the site that are disturbed by construction works are to be topsoiled, seeded and fertilised immediately after construction works in the particular area have finished and not left till the end of the overall construction.
- Construction areas shall not be left in an open and disturbed state for more than fourteen (14) days. Areas expected to be left open for periods longer than this are to be seeded.
- Filter fences are to be removed only after all disturbed areas have established a good grass covering, minimum 70%.
- Any existing bare or disturbed areas of the site not affected by the construction works are to be topsoiled, seeded and fertilised as soon as practicable after each phase of work.
- Sediment & erosion control structures are to be maintained on a daily basis during construction and on a minimum of weekly basis during the six month liability period (or as required

depending upon weather conditions). All material removed from the traps is to be spread and grass seeded or disposed of, off site in an approved manner.

- All imported fill is assumed to be a material other than dispersive clay. All fill material is to be tested for dispersability prior to placement on the site and if found to be dispersive the superintendent is to be notified prior to placement of any fill for advice on treatment of dispersive soils.
- Sediment fence/filter can be used as E & S control around stockpiles, adjacent to the main trench, around areas where underboring of waterways will occur and be installed around the perimeter of wetlands, and should be installed at all drainage structures receiving stormwater runoff from excavated areas. Filter/sediment fences are to be constructed from an approved filter material and erected in accordance with the manufacturer's instructions.
- Swales and table drains along the route should have staked straw bale or socked mesh dams installed on road reserve shoulders that receive runoff stormwater runoff from excavated soils.
- Waste generated by the construction process should be collected and retained on site in appropriate containers and be removed offsite to a licensed landfill when appropriate
- Washing out of concrete truck chutes should occur at specific locations pre-determined prior to construction. Bermed pits with a large enough volume to take multiple pours should be excavated for this purpose. Material from the pits shall be disposed of and the pits regraded when all concrete work is complete.
- Materials that may be brought on site for construction of the proposed gas main include:
    - Aggregate of various sizes for trench backfill, bedding, and other applications.
    - Pipe and associated fittings.
    - Wood in various forms for staking, marking alignment and forming for concrete work.
    - Paint for marking alignments and the location of various utilities.
    - Where possible materials should be placed above ground on pallets or alternative.

3 Site Specific Erosion & Sediment Control Management

This section of the report provides a general assessment of the erosion and sedimentation controls required at specific locations along the proposed gas pipeline route. Recommended control measures are based on a site assessment conducted by staff of Allen, Price and Associates, and recommendations from Volume 2A of Managing Urban Stormwater – Soils and Construction - Installation of services, available from the Environment Protection Authority.

The road and rail reserves that the proposed gas pipeline will lay in are used as headings in this section of the report. The reserves were systematically assessed, with greater attention given to locations within road reserves that contain a waterway crossing. This is due to the potential for increased erosion and sediment control issues at these locations, when compared to the majority of the route which is over land that is mostly flat.

3.1 Route

A site assessment was undertaken by staff of Allen, Price and Associates to better understand the erosion and sediment issues caused by the proposed pipeline construction. The full length of the route was inspected and photographed so that the site was well identified for the purpose of writing this report.

The proposed Shoalhaven Starches gas main route is through two rural areas; Meroo Meadow and Bomaderry, approximately 7km and 5km respectively north of the Nowra Township in NSW. It will be constructed mainly through the following road reserves, which include the positions as given in Figure 1 (Appendix A);

- Pestells Lane (from 1 to 4).
- Princes Highway (3).
- Meroo Road (4).
- Fletchers Lane (from 5 to 6).
- An un-named road reserve adjacent to the railway reserve (from 7 to 13).
- Edwards Lane (10).
- Railway Street (from 13 to 15).
- Bolong Road (15).

The route is described in more detail below:

- Begin at tie-in station of the existing ActewAGL gas pipeline to the Eastern Gas Pipeline, on Pestells Lane. This is the proposed location for the Shoalhaven Starches gas pipeline meter and valve block arrangement (1).
- Continue south east along the southern road shoulder of Pestells Lane (2).
- Continue through the Princes Highway intersection, into the east shoulder of the Princes Highway road reserve (3).
- Continue south-east along the unformed section of Pestells Lane (3).
- Continue through the Pestells Lane/Meroo Rd intersection, to the east shoulder of Meroo Road (4).
- Change direction and continue south - south east along Meroo Road (4).
- Continue through the intersection of Meroo Road/Fletchers Lane, to the south shoulder of Fletchers Lane (4).
- Change direction and continue east along Fletchers Lane (5).
- Change direction at the intersection between Fletchers Lane and Railcorps rail reserve, and continue south for approximately 50m, just beyond the large culvert under the railway track (6).
- Change direction within the rail reserve and continue south east under the track ballast to the eastern side of the rail reserve. Continue through to the un-named road reserve adjacent to the rail reserve (7).
- Change direction and continue south through the un-named road reserve, parallel to the railway reserve (7).
- Cross waterway (8) (9).
- Continue south, through Edwards Ave intersection, back into the un-named road reserve adjacent to the railway reserve (10).
- Cross waterway (11).
- Continue south along the un-named road reserve into the east shoulder of the un-sealed section of Railway Street (12).
- Continue south along Railway St, transitioning from the un-sealed section to the sealed section of Railway Street into the east side road reserve (13).
- Continue past the intersection between Railway Street and Cambewarra Road (14).
- Continue along the east shoulder of Railway Street past the Cambewarra Road intersection until Lot 16 DP572583 on Railway St is reached (15).
- Change direction toward the east and follow the open channel drain along the north boundary of Lot 16 DP572583

- Change direction toward the south at a point that provides a 100m buffer between the proposed gas main and Abernethys creek. This is the approximate boundary of a sensitive coastal area, shown hatched in black criss-cross in Figure 1 (Appendix A) (15).
- Continue parallel along the 100m buffer boundary, until reaching the position of the proposed gas pressure reduction station on lot 16 DP572583 (15).
- Exit the pressure reduction station and continue south along the 100m buffer boundary (15).
- Cross Bolong Road into Manildra Factory Land (15).

3.2 Trenching

There are differing requirements for erosion and sediment control depending on whether the proposed trench runs across grade, down grade or obliquely. The gradient of the land is also an important factor. Much of the proposed gas main route is flat with exceptions at waterway crossings, Edwards Avenue and Railway Street. General erosion and sediment control techniques useful for these areas can be observed in Figures 2 and 3 of Appendix D

Across grade:

- Heaped soil from trench to be placed on up-hill side to form an earth bank

Down grade:

- Measures to be taken to filter sediment laden water downstream.
- Sediment fences can be used at the majority of steep sections on the proposed site to catch silt.
- Earth banks can be used across backfilled sections of the trench to slow moving water down and direct it out away from trench.
- Trench stops may be required on slopes that grade down to waterway crossings.

Obliquely:

- Heaped soil from trench to be placed on up-hill side to form an earth bank.
- Steep grades may require trench stops.

See section 6 of the DECCs Managing Urban Stormwater-Soils and Construction, Volume 2A, for further details.

3.3 Soil and Stockpile Management

Stockpiles will be required along the proposed route to store materials, excavated soil and top soil. The minimum depth of pipeline cover is 0.75m giving a total trench depth of approximately 1m. Minimum width of trench is 0.6m. Therefore the calculated volume of soil to be excavated per meter length of pipe is 0.6m^3. The required depth of cover is greater at waterway crossings. There is to be no trenching of waterway crossings, hence the volume of soil removed at these points along the route is reduced in comparison to trenched areas.

The most suitable location for stockpiles would most likely be over the backfilled trench of the previously completed stage or on the opposite side of the road reserve within the verge or footpath area. The stockpile size and spread needs to be limited to allow machinery to pass, and also to reduce the mass sitting above the newly installed gas main and other existing services.

Erosion and sediment control will consist of sediment fence and straw bale filters on the low side of the stockpile. Dust emissions need to be minimized. Due to the relatively short construction period required during staged construction, stockpiles would most likely not be in place for more than a one week, although it may be possible to utilize one stockpile location for consecutive stages of construction, increasing the time that disturbed soils are exposed.

Section 4.3 of the Blue Book contains further information on stockpile construction. A typical stockpile detail is available in Appendix D (SD4-1).

3.4 Road Reserves

A number of road reserves will be impacted by construction of the proposed gas pipeline. This section assesses each systematically and addresses general erosion and sediment controls required.

A small portion of Railcorps land (20-50m) will be used for the proposed gas main, located at position 7 in Figure 1 (Appendix A). The track in the reserve is active with passenger and freight trains passing through each day to the nearby Bomaderry Railway Station and Manildra Factory. Manildra's private rail reserve will also require underboring, adjacent to Bolong Road.

Under each road reserve heading in this section, the areas in the given road reserve requiring erosion and sediment control, and the proposed erosion and sediment control have a unique identification number from 1 to 51, that corresponds to with the same number used in APA drawing 24710-04 (Appendix C) to show the position being discussed. For example, area 1 corresponds to the proposed valve and meter station on Pestells Lane, with a sediment fence and straw bale filter proposed as the possible control measure, as shown below. In APA drawing 24710-04 (Appendix C), this is shown as "E

& S (1):" followed by a blue book identification number, for example "SD6-7, SD6-8, SD6-14", corresponding to the construction guide in the Blue Book for the recommended control.

3.4.1 Pestells Lane

The proposed gas pipe line begins on Pestells Lane as shown at position 1 in Figure 1 (Appendix A). This location corresponds to sheet 2 and 3 of APA drawing 24710-04 (Appendix C) in Appendix C.

The majority of the gas main route in Pestells Lane will be open trenched. Staged construction of the pipeline along Pestells Lane is recommended to allow adequate room for storage of topsoil and material stockpiles within the road reserve, behind the section of pipe being trenched.

The exit out of the proposed valve/metering block, across Pestells Lane into south side verge could be underbored to minimize disturbance to the road and reduce erosion and sediment controls required.

Erosion and sediment control

Areas requiring erosion and sediment control;

1. Proposed and existing valve/metering station
2. Table drain along boundary of road and southern shoulder of Pestells Lane.
3. Cattle yard gravel access driveway on the south side of Pestells Lane.
4. Culvert and table drains at south west corner of Princes Highway.

Proposed erosion and sediment control;

1) Sediment fence and Straw bale filter.
2) Sediment fence.
3) Sediment fence and Straw bale filter.
4) Sediment fence and Straw bale filter.

3.4.2 Princes Highway

The proposed gas pipeline will cross the Princes Highway at position 5 in Figure 1 (Appendix A). This location corresponds to sheet 4 of APA drawing 24710-04 (Appendix C) in Appendix C.

To mitigate impacts to the road surface and pavement, the crossing of the Princes Highway shall be by underbore. A stabilised access and storage facility approximately 20m x 40m will be required in the south west side of the road reserve for underbore operations.

Erosion and sediment control

The following areas will require erosion and sediment control;

5. Large culvert and headwalls passing stormwater under the highway.
6. Table drain on the south side of the intersection, flowing parallel to the Princes Highway and feeding into and out of the culvert inlet and outlet.
7. Table drain on south side of Pestells Lane where proposed gas main approaches the intersection.
8. Soil and construction material stockpiles to possibly be located on south west shoulder of Princes Highway road reserve.
9. Marsh area at culvert outlet on east side of Princes Highway road reserve.

Proposed erosion and sediment control for the given areas include;

5) Sediment fence and straw bale filter.
6) Sediment fence and straw bale filter as check dams.
7) Straw bale or rock check dams in table drain to prevent sediment flowing along table drains.
8) Sediment fence around base of stockpiles.
9) Sediment fence around perimeter of reed bed/marsh. Temporary culvert to outlet into table drain on Pestells Lane

3.4.3 Pestells Lane (Unformed Section)

The un-formed section of Pestells Lane intersects the Princes Highway and Meroo Road, as shown at position 4 in Figure 1 (Appendix A). This location corresponds to sheet 5 of APA drawing 24710-04 (Appendix C).

The unformed section of Pestells Lane on the east side of the Princes Highway is relatively flat. It contains a table drain on the north side.

Waterway Crossings

There is no waterway crossing through the unformed section of Pestells Lane.

Erosion and sediment control

The following areas require erosion and sediment control;

10. Table drain parallel to boundary on northern side of road reserve.
11. Soil and construction material stockpiles.

Proposed erosion and sediment control for the given areas include;

10. Straw bale or rock check dam to be laid inside table drain.
11. Sediment fence around soil and material stockpiles.

3.4.4 Meroo Road

The proposed gas main will cross Meroo Road at position 4 in Figure 1 (Appendix A). This location corresponds to sheet 5 of APA drawing 24710-04 (Appendix C). Associated photographs shown on this sheet are found in Appendix B.

An underbore would be the best option for crossing Meroo Road in order to minimize damage to the road and prevent associated traffic control issues. A stabilised site will be required for machinery, the most likely position being the west side of the intersection in the un-formed portion of Pestells Lane, where the underbore will be made.

Erosion and sediment control

The following areas will require erosion and sediment control;

12. Table drains and culvert downstream of proposed underbore inlet, on west side of Meroo Road.
13. Table drain downstream of proposed underbore outlet, on east side of Meroo Road.
14. Culvert entrance on east side of Meroo Road, at intersection with Fletchers Lane.
15. Soil and construction material stockpiles.

Proposed erosion and sediment control for the given areas include;

12. Straw bale filter laid across table drains and surrounding culvert headwall.
13. Straw bale filter laid across table drain. Ensure excavated material laid on high side of trench.
14. Straw bale and Sediment fence filter at entrance of culvert
15. Sediment fence around soil and material stockpiles.

3.4.5 Fletchers Lane

Fletchers Lane extends from position 4 to position 7, and intersects Meroo Road at position 4, as shown in Figure 1 (Appendix A).This location corresponds to sheets 5, 6, 7 and 8 of APA drawing 24710-04 (Appendix C) in Appendix C.

A large culvert takes water from the west side of Meroo Road, and outlets at the south west side of the Fletchers Lane and Meroo Road intersection, which leads to an open channel drain. An underbore crossing of Fletchers Lane would limit the excavation in that area, lessening the chance of sediment and erosion.

A stabilised site will be required for machinery, the most likely position being the north side of the intersection in the verge of Fletchers Lane, where the underbore will be made.

Erosion and sediment

The following areas will require erosion and sediment control;

16. Position of proposed Fletchers Lane underbore.
17. Large culvert inlet and outlet, fed by table drain on Meroo Road's west side shoulder.
18. Diversion drains situated on the south side of Fletchers Lane that leads into the open channel drain.
19. Culverts under Fletchers Lane.
20. Table drain in Fletchers Lane south side road shoulder.
21. Soil and construction material stockpiles.

Proposed erosion and sediment control for these areas include;

16. Sediment fence or straw bales along edge of bitumen on inlet side of underbore construction area and straw bale sediment filters in table drain on north side road shoulder.
17. Sediment fence and straw bale filters in table drains and at inlet of culvert.
18. Divert stormwater runoff in the south side table drain via a geo-textile lined swale adjacent to road, to prevent stormwater flowing through diversion drains.
19. Straw bale filter at ends of diversion drains.
20. Straw bale filter in table drain at inlet to culverts.
21. Sediment fence around soil and material stockpiles.

3.4.6 Railcorp land and un-named road reserve

The intersection of Railcorps land and the un-named road reserve adjacent, with Fletchers Lane, is located at position 7 in Figure 1 (Appendix A). This location corresponds to sheet 8, 9, 10, 11, 12 and 13 of APA drawing 24710-04 (Appendix C) in Appendix C.

Erosion and sediment control

The following areas require the erosion and sediment control;

22. Table drain parallel to train track for approx 50m on west side of rail reserve.

23. Stabilised site access for underbore of train tracks.
24. Stockpiles for topsoil and materials.
25. Large culvert under train tracks.
26. Waterway crossing through intermittent creek that flows onto flood prone land, and into the Tullian Creek, at position 7 in Figure 1 (Appendix A).
27. Large swale on the south side of Fletchers Lane that flows into Tullian Creek at position 8 in Figure 1 (Appendix A).
28. Abernethys Creek at position 9 in Figure 1 (Appendix A).
29. Mulgen Creek at position 11 in Figure 1 (Appendix A).
30. Steep land sloping downgrade toward waterway crossing at position 9 and 11 in Figure 1 (Appendix A).

Proposed erosion and sediment control for these areas include;

22. Sediment fence along and straw bale filters laid across table drain.
23. Compacted rock, sediment fence, straw bale filters, temporary culvert/pipe.
24. Stockpiles will require sediment fence around base.
25. Straw bale filter and sediment fence at culvert inlet and outlet.
26. Mechanical underbore, sediment fence, trench stop.
27. Mechanical underbore, sediment fence, trench stop.
28. Mechanical underbore, sediment fence, trench stop.
29. Mechanical underbore, sediment fence, trench stop.
30. Check dams and trench stops along steep section of trench toward Edwards Avenue and area along route between Edwards Avenue and Railway Street.

3.4.7 Edwards Avenue Intersection

Edwards Avenue intersects the un-named road reserve at position 10, as shown in Figure 1 (Appendix A).This location corresponds to sheet 11 of APA drawing 24710-04 (Appendix C).

The proposed gas main is to be routed perpendicularly through Edwards Ave, which sits on the northern side of a small hill, in an east-west direction. Significant Erosion and sediment controls, especially along the trench will be needed to prevent erosion and pollution of the roadway, stormwater runoff and nearby creeks. An underbore crossing will be required at this point to minimize erosion and sediment control issues and prevent traffic management problems. A stabilised work site will be required either side of Edwards Ave for the underbore machine.

Erosion and sediment

The following areas of the Edwards Ave require erosion and sediment control;

31. Stabilised access for underbore machinery and access to un-named road reserve.
32. Table drains on north and south side of road reserve.
33. Trench on south side of Edwards Avenue.

Proposed erosion and sediment control for the given areas along Fletchers Lane include;

31. Compacted rock, sediment fence, straw bale filters, temporary culvert/pipe.
32. Sediment fence along and straw bale filters laid across table drain.
33. Trench stop or collar. Stop trench 3m before road reserve boundary.

3.4.8 Railway Street and Lot 16 DP1121337

Railway Street continues on from the un-named road reserve and runs parallel to the train tracks on Railcorps land. Railway Street begins at position 12, as shown in Figure 1 (Appendix A).This location corresponds to sheet 13, 14 and 15 of APA drawing 24710-04 (Appendix C).

Greater attention to erosion and sediment control is required here due to it being;

- Mainly Bitumen sealed with numerous traffic movements, and pedestrians
- Connected to the Shoalhaven Councils urban stormwater system through kerb & gutter, pits and pipes which lead to the Shoalhaven River.
- Numerous services and concrete or gravel driveways
- Open view of proposed works to the public.

There is limited room to store materials and excavated soil on Railway Street. A more suitable location would be the large vacant lot 16 DP1121337 where the proposed gas pipeline is to lay. A haul road is required to construct the proposed pipeline in this location, the material and topsoil stockpiles could be positioned in proximity to the proposed route.

Erosion and sediment

The following areas of the Railway St will require erosion and sediment control;

34. East side boundary of Railway Street.
35. Outlet of culvert.
36. Table drain.

37. Underbore of driveways.
38. Trench through east side of un-formed section of Railway Street.
39. Trench through east side of sealed section along Railway Street.
40. Kerb and Gutter.
41. Stormwater pits.
42. Large culvert and open drain through lot 16 DP1121337.
43. Haul road through Lot 16 DP 1121337

Proposed erosion and sediment control for the given areas include;

34. Provide temporary geo-textile lined table drain and sediment fence.
35. Sediment fence and straw bale filter over and around headwall of culvert outlet.
36. Straw bale check dams in table drain.
37. Sediment fence on boundary of property and along kerb and gutter.
38. Excavated material placed on high side of trench with temporary geo-textile lined table drain provided, and drained to table drain further behind stage being completed.
39. If excavated material to be stored in road reserve, enclose in sediment fence.
40. Gravel mesh check dams laid inside kerb and gutter.
41. Straw bale and gravel mesh filters placed around pit inlet.
42. Sediment fence, strawbale filter check dams
43. Stabilised site, sediment fence, strawbale filters, temporary geo-textile lined table drain

3.4.9 Bolong Road

Bolong Road is located at position 15 in Figure 1 (Appendix A). This location corresponds to sheet 16 of APA drawing 24710-04 (Appendix C).

The proposed crossing of the Shoalhaven Starches gas main at Bolong Road will require an underbore of Manildra's privately owned railway reserve, will continue under Bolong Road, and exit into the Shoalhaven Starches Interim Packing Plant. There is no possibility of open trenching due to the volume of traffic on Bolong Road and the number of services underground.

<u>Erosion and sediment</u>

The following areas will require erosion and sediment control;

44. Right of way (haul road) along route.
45. Proposed gas pressure reducing station.

46. Boundary of sensitive environmental area buffer zone.
47. Underbore location at railway pedestrian crossing.
48. Underbore outlet at Interim Packing Plant.
49. Culverts and headwalls.
50. Topsoil and material stockpiles.
51. Downstream gutter inlet pits
52. Stormwater pit
53. Shoalhaven Starches Railway reserve

Proposed erosion and sediment control for the given areas include;

42. Stabilised site access.
43. Stabilised site access, sediment fence and straw bale filter
44. Sediment fence.
45. Sediment fence and straw bale check dams in table drain.
46. Sediment fence and straw bale check dams in table drain.
47. Sediment fence and straw bale filters.
48. Sediment fence and straw bale filters.
49. Mesh and gravel filters.
50. Sediment fence or strawbale inlet filters.
51. Sediment fence.

3.5 Waterway Crossings

Four waterway crossings have been identified, in accordance with the Director General's requirements. These are located at positions 7, 8, 9 and 11 along the route as shown in Figure 1 (Appendix A). The water ways to be crossed include;

1. A small drainage channel, at the outlet of the first culvert/bridge immediately downstream of Fletchers Lane, flowing onto the floodplain and eventually into the Tullian Creek (position 7)

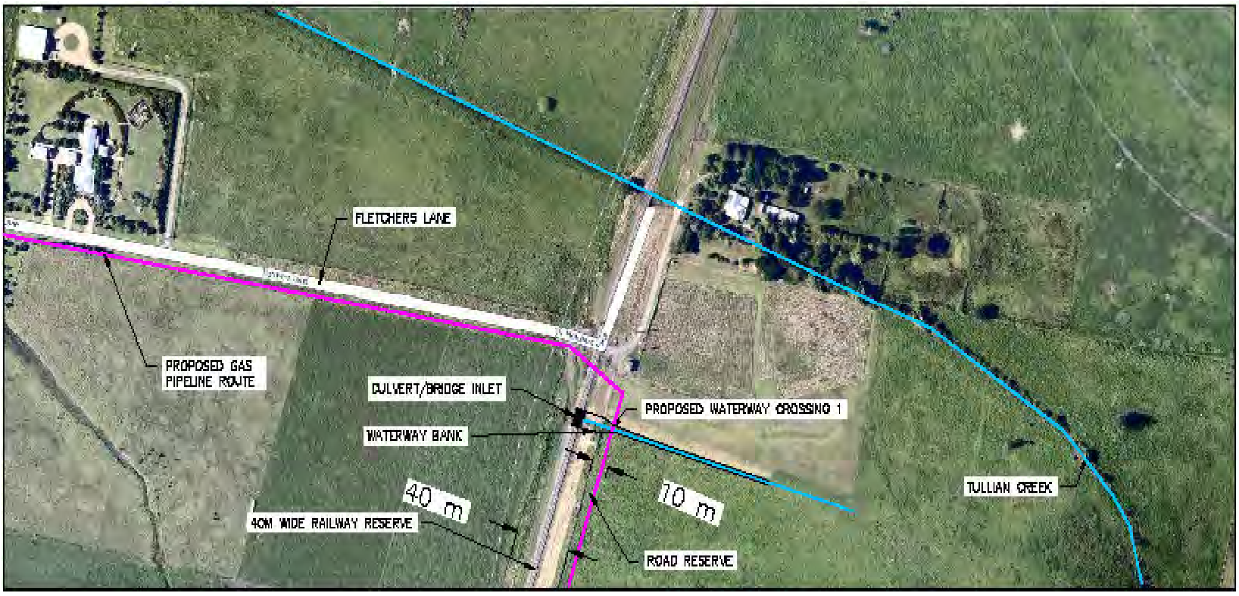

Image 1: Plan view of waterway crossing 1

2. A small tributary waterway of Tullian Creek, flowing through the 2nd main railway bridge/culvert south of Fletchers Lane. An intermediate culvert with no waterway is located between waterway 1 and waterway 2 (position 8)

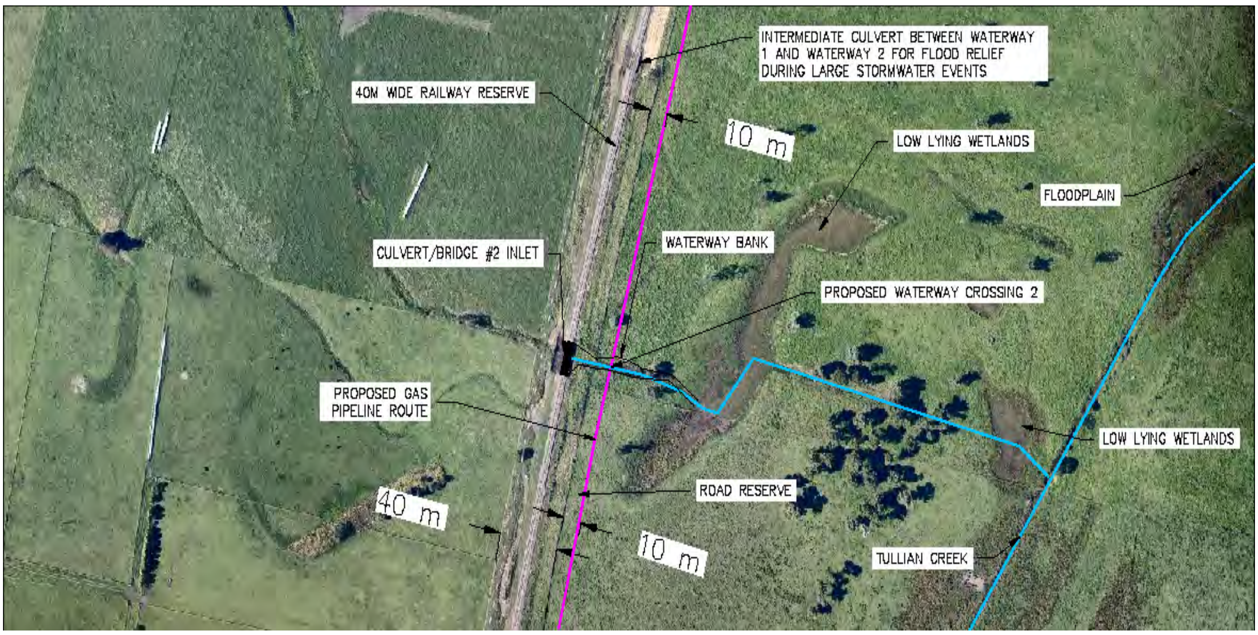

Image 2: Plan view of waterway crossing 2.

3. Abernethys Creek (position 9). Culvert/bridge #3 is located just upstream of the crossing point in the railway reserve.

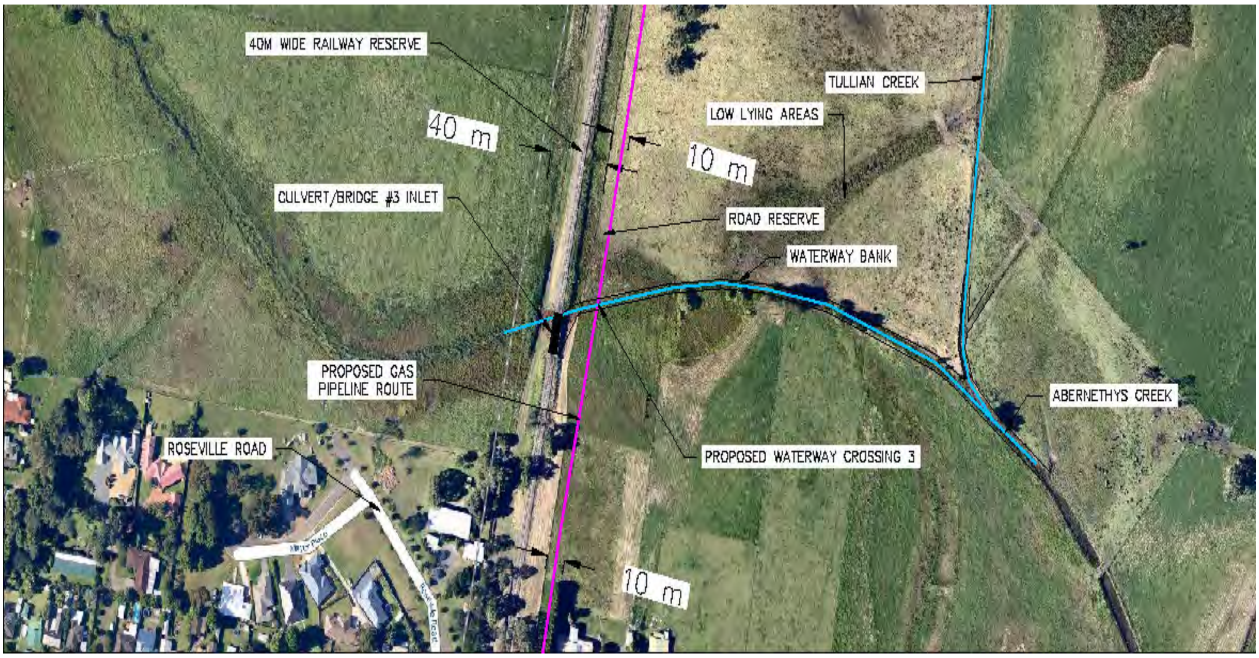

Image 3: Plan view of waterway crossing 3

4. Mulgen Creek (position 11). Culvert/bridge #4 is located just upstream of the crossing point in the railway reserve.

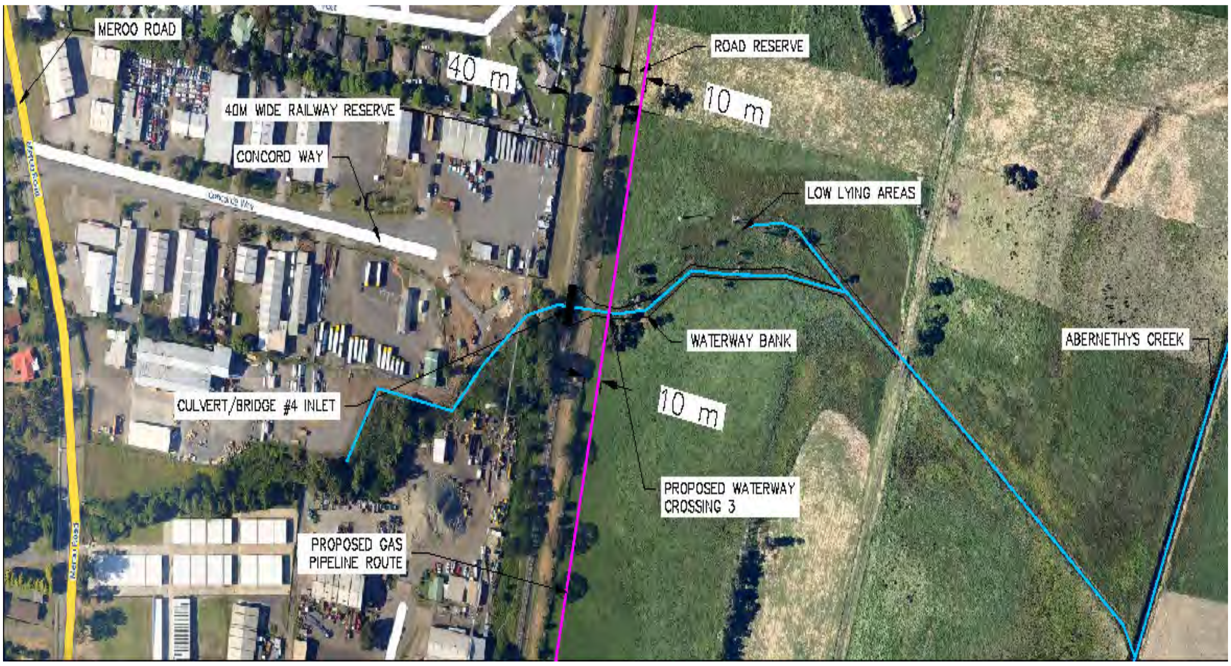

Image 4: Plan view of waterway crossing 4

The proposed waterway crossings are also shown in detail in APA drawing 24710-04 sheets 1 – 16 (Appendix C) with references given to photographs in Appendix B, taken at the waterway crossing sites. Typical long and cross sections of waterway 3 is available in Appendix E.

The immediate area surrounding waterways (Riparian zones) are susceptible to erosion and sedimentation due to the increased possibility of flowing water in these areas. The four waterways are minor and flow intermittently throughout the year, depending on the size of the storm event affecting the associated catchment. Erosion and sediment control management for waterway crossings will depend on the weather preceding, during and after proposed construction period. The ESCP should provide alternative controls based on weather forecasts and size of storm events expected.

Waterway crossings shall not be made by open trenching. All waterways shall be crossed by mechanical underbore, to mitigate impacts on waterways and surrounding riparian zones. Open trenching shall be stopped at the boundary of the core riparian zone waterway and trench stops put in place until a suitable waterway crossing has been made. The width and boundaries of waterway riparian zone are addressed in the geomorphic assessment that follows this section of the report.

Waterways will require temporary vehicle crossings for stabilised machinery access over the 5 m – 7 m wide right-of-way to be built within un-formed road reserves. Significant erosion and sedimentation is possible at waterway crossings and adequate control measures are needed to mitigate impacts to soils, vegetation and waterway geomorphic condition. Detail SD5-1 in Appendix D shows a typical construction method for a temporary waterway vehicle crossing.

Stabilised work sites approximately 20m x 40m are to be positioned at either side of waterway crossings for underbore machinery to be positioned to lay pipe under the bed of the waterways. Stabilised work sites are also require at other locations along the proposed route where underboring is required and other machinery will be best positioned during non-work periods. Stabilised work sites are to be built only when required as staged construction of the pipeline progresses along the route. Rehabilitation is to begin immediately when trenches and waterway crossings are backfilled and completed, respectively.

The proposed gas pipeline is to be buried under waterway beds with a minimum depth of cover from the bed to the top of pipe equal to 2.0m minimum. This value will increase if scour is an issue at the waterway crossing.

There is potential for fluvial geomorphic impacts on the proposed gas pipeline at waterway crossings. Changes may occur to the waterway characteristics, especially from the scouring action of flowing water at the outlet of the culverts and bridges immediately upstream of the proposed waterway crossings. A geomorphic assessment was made of the waterway crossings and associated core riparian zones to assess this potential..

To mitigate impacts on the pipeline due to fluvial geomorphic changes, the effect of scour on the waterway crossing was determined and the scour depth at each waterway crossing calculated to determine the depth of cover required under each waterway bed being crossed.

3.6 Fluvial Geomorphic Assessment

To assist in the environmental assessment procedure and to ensure on-going stability of the creeks being crossed by the proposed pipeline, a geomorphic assessment of the four proposed waterway crossings was made, in order of the waterways as identified in figure 1 (Appendix A), from location 7 to 11, by a photographic study obtained from site inspections and desktop study.

Over time, the shape, size and behavior of active waterways change, which increases the potential for significant impacts to the proposed gas pipeline at the waterway crossing points. This section of the report assesses the degree of impact that is likely to occur to the pipeline at the waterway crossings.

The objectives of the geomorphic assessment are;

- determine current geomorphic condition of the waterways and their associated riparian zones.
- determine geomorphic history of the proposed waterway crossings.
- determine future geomorphic effects on the waterways and impacts on the pipeline at the waterway crossings.
- provide machinery and construction site setbacks from waterways.
- Provide recommendations to mitigate potential geomorphic impacts to the pipeline, and to mitigate impacts of construction on riparian zone and bank stability.

To meet the objectives, the following aims were addressed:

- Site inspections of waterways and riparian zones.
- Determine waterway categories for riparian zone distance classification of waterway crossings.

- Modelling to determine characteristic behaviour of waterways and floodplain due to stormwater runoff.
- Determine culvert and bridge flood outlet velocities
- Calculate depth of scour at outlet of culverts and bridges
- Outline pipeline construction impacts to the waterway and riparian zones and mitigation measures.

Site Setting

Four proposed waterway crossings are to be made, between Fletchers Lane and Railway Street, on the northern bank of the Shoalhaven River, and Lower Shoalhaven River Floodplain, within the 10m wide unformed road reserve directly adjacent the Illawarra Railway Reserve and Railway track. These are located along the proposed route as shown in Figure 1 of Appendix A, with each waterway crossing location numbered 7, 8, 9 and 11.

Figure 1 below shows the boundaries of four catchments (CA1 to CA4) that flow into local waterways, and more specifically into the culverts and bridges at proposed pipeline waterway crossings. The catchments are bounded by Cambewarra Road, Moss Vale Road, Tourist Road and Cambewarra Lookout Road. Stormwater runoff flows into tributaries over Cambewarra Mountain, into the Tullian and Abernethys Creeks and eventually onto the Lower Shoalhaven River Floodplain. Appendix H contains catchment peak flow rate calculations.

An elevated railway track formed fill and capped with blue metal ballast approx 2-3m above the natural surface level, is located centrally in a 40m wide rail reserve running in a north-south direction, on the Lower Shoalhaven River Floodplain.

Flood water from Abernethys Creek and Tullian Creek are prevented from building up behind the elevated railway track by a number of concrete box culverts and steel bridges. The proposed gas pipeline route runs parallel to the railway line, within the un-named road reserve positioned directly downstream of the track on the Lower Shoalhaven River floodplain.

See APA plan 24710 sheets 1-16 for further details and Appendix B for photographs taken of the proposed route

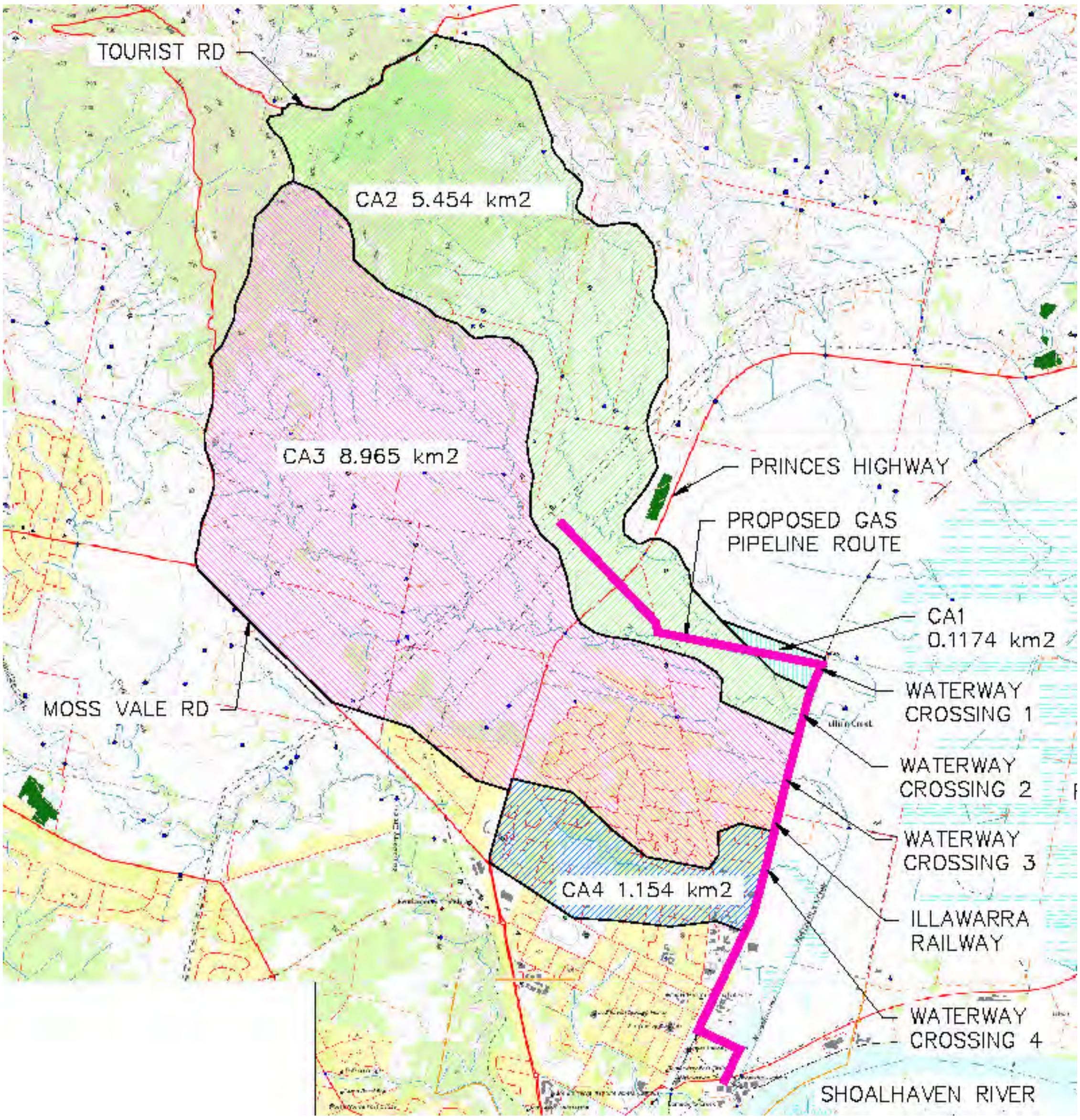

Figure 1: Catchment details for Proposed Gas Pipeline Geomorphic Assessment

3.7 Photographic Study of Waterway Crossings

3.7.1 Waterway Crossing 1

Figure 2: Culvert /Bridge #1 upstream of waterway crossing, and South of Fletchers Lane.

Figure 3: Looking South along the proposed pipeline route at waterway crossing 1, in the un-named road reserve between Fletchers Lane and Edwards Ave.

Figure 4: Looking downstream of waterway crossing 1, notice the reducing waterway cross section.

Figure 5: Looking upstream of waterway crossing 1, toward proposed crossing location and culvert/bridge

Figure 6: Waterway 1 vegetation at proposed crossing point

Figure 7: Looking downstream of waterway 1, toward floodplain and Tullian Creek (trees in background delineate creek)

Figure 8: Low lying wet area at intermediate culvert between waterway 1 and waterway 2

Figure 9: Intermediate Culvert at low lying area between waterway crossing 1 and waterway crossing 2

Figure 10: Looking South along proposed pipeline route, toward waterway crossing 1, whilst standing at the intermediate culvert outlet, with in the un-named road reserve.

3.7.2 Waterway Crossing 2

Figure 11: Culvert #2 and downstream reach of waterway crossing 2

Figure 12: Heavy weed infestation at boundary of road and rail reserves, at outlet of culvert/bridge #2

Figure 13: Looking south along proposed route in the road reserve at waterway crossing 2.

Figure 14: Bank Instability and Erosion at waterway crossing 2.

Figure 15: Looking east toward low lying area downstream of waterway crossing 2

Figure 16: Looking north toward waterway crossing 1, showing riffle zone and secondary waterway at waterway crossing 2

Figure 17: Riffle zone between main waterway 2 and secondary waterway 2, looking east toward floodplain

Figure 18: Water main infrastructure within road reserve, between waterway crossing 1 and waterway crossing 2

Figure 19: Wild life and vegetation at low lying area on the floodplain downstream of waterway 2

Figure 20: Wildlife and vegetation in riffle zone downstream of waterway 2 crossing

Figure 21: Merge of waterway 2 into low lying area and floodplain downstream of culvert/bridge #2

3.7.3 Waterway Crossing 3

Figure 22: Looking north toward culvert/ bridge #3 and proposed waterway crossing 3 at Abernethys Creek

Figure 23: Looking east toward floodplain and Abernethys Creek, downstream of waterway crossing 3.

Figure 24: Railway Bridge #3 showing main flow path of Abernethys creek with waterway 3 flowing under one cell

Figure 25: Heavy weed infestation at waterway crossing 3, looking upstream.

Figure 26: Vegetation in downstream reach, looking east toward floodplain

Figure 27: Looking south toward Edwards Avenue, at waterway crossing 3

Figure 28: Looking south toward steep section leading down to waterway 3.

3.7.4 Waterway Crossing 4

Figure 29: Looking south along proposed gas pipeline route, on crest of hill before relatively steep down grade to waterway crossing 4, along un-named road reserve.

Figure 30: Looking south down un-named road reserve, toward waterway crossing 4

Figure 31: Large bridge #4 just upstream of waterway crossing 4.

Figure 32: Heavy weed infestation at waterway 4 crossing

Figure 33: Existing stabilised vehicle crossing over waterway 4, immediately upstream of proposed pipeline crossing point

Figure 34: Looking South along un-named road reserve at proposed waterway crossing 4, with vegetation types shown

Figure 35: Waterway crossing 4, showing terrestrial and aquatic vegetation.

Figure 36: Floodplain and downstream reach of waterway crossing 4

Figure 37: Looking East over floodplain (northern bank of Shoalhaven River), downstream of waterway crossing 4

Figure 38: Low lying area downstream of waterway crossing 4

3.7.5 Waterway History

Changes to the waterways seem to have occurred only recently from European settlement in the area. An early Parish map obtained from the Department of Lands was proclaimed on the 31st of May 1895, (Appendix F) and discontinued in December 1916. From this it can be seen that the waterways are approximately in the same locations as they can be seen today.

Information obtained from the NSW Office of Environment and Heritage shows the single track, Illawarra Railway continued from Kiama Station and terminated at Bomaderry Station on the 2nd of June 1893.

It would seem that the culverts and bridges located just upstream of the waterway crossings were built for natural waterways that existed prior to construction of the elevated railway.

The configuration of the waterways, upstream of the railway line was observed to have changed based on the differences noticed between the latest 1:4000 topographic map of the area (Appendix F) and a 1:4000 topographic map dated 31st of May 1895 (Appendix J). It is most likely that natural waterways leading into low lying areas were extended as modified drainage channels and continued through to the Tullian and Abernethys Creeks.

Although these findings show that the waterways being crossed by the gas pipeline have changed slightly over the last 116 years, it is unlikely that significant changes will occur at the waterway crossing positions due to upstream varying conditions. Most of the areas immediately upstream of the waterway crossings are stable due to being occupied and utilized for farming or residential housing. The culverts and bridges at these positions are fixed and are likely to remain fixed points of impact for the lifespan of the pipeline.

3.7.1 Soil and Land

Meroo Meadow and Bomaderry are situated adjacent to and partly on the Lower Shoalhaven River floodplain. Main soils types in this area originate from Permian siltstone and shales of the Berry Formation, and Gerringong Volcanics (mainly west of the Princes Hwy), with quaternary river alluvium in the Shoalhaven floodplain (mainly east of the Princes Hwy).

Soils are typical of the area and do not require special treatment during excavation, except where acid sulphate soils are disturbed. The main component of significance in these soils is iron sulphide, which reacts with the atmosphere to form sulphuric acid. Erosion and excavation provides the means by which

the iron sulphide is uncovered or disturbed and therefore exposed to the atmosphere. The area surrounding Meroo Meadow and Bomaderry contains small wetland areas prone to flooding with a low probability of disturbing acid sulphate soils along the proposed gas main route. These areas are shown in the Shoalhaven LEP and should be identified in the ESCP, with appropriate treatment procedures developed.

Rainfall erosivity factor (R) for soils in the region is approximately 4250 mm/ha.hr.yr, as shown on Map 11: Rainfall Erosivity of the Wollongong 1:250,000 topographic Sheet, obtained from Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition, March 2004. The soils are described as having 'low permeability and low wet bearing strength, High run-on; localized shallow soils with localized rock outcrop'[(1)].

The proposed route follows a path mainly over 'prime agricultural land'. The current Shoalhaven Local Environmental Plan (1985) states that land classified as 1, 2 or 3 under the Department of Primary Industry's land classification system is regarded as 'prime crop and pasture' land. The proposed route is situated mainly through class 2 classified areas. Even though the proposed route is through prime agricultural land, it is located over existing formed and unformed road reserves, and a small portion of the railway reserve.

The longitudinal and transverse grade of the proposed route is generally flat, with gentle fall predominately toward the south-east. A number of areas along the route are relatively steep both longitudinally and transversely (greater than 1:4). Fortunately the longitudinal grades of waterways at proposed crossings are relatively flat and grade back toward the north and north-west. These positions are located generally at the Edwards Ave intersection, and along the un-named road reserve and Railway Street, adjacent to the train track.

The waterway cross sections at crossing points are trapezoidal, with flat bottomed beds. The longitudinal grade of the waterway beds at proposed crossings points are 0.4%, 0.5%, 0.5% and 0.8% respectively. Gradients were determined from 1:4000 topographic map contours.

The transverse gradient of land at the crossings is flat along the un-named road reserve, except for the land to the south of proposed waterway crossing at position 9, which falls relatively steeply back toward

the waterway from Edwards Avenue. The waterway crossing at position 11 is situated in a gully, with two steep sections either side grading back toward the waterway.

The potential for sedimentation and erosion issues is greatest at the steeper locations of the proposed gas pipeline route, especially adjacent to waterways, table drains, culverts and the Shoalhaven City Council stormwater system.

3.8 Waterway and Riparian Zone Assessment

Riparian lands are transition zones between terrestrial and aquatic environments. Section 5.2 of the Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1 Fourth Edition (Blue Book) describes three broad categories for riparian land. These include;
Category 1 – Environmental Corridor
Category 2 – Terrestrial and Aquatic habitat
Category 3 – Bank stability and water quality

Depending on the category, different management regimes apply to each. Site investigation, and study of the draft Shoalhaven LEP has determined that the riparian zones of the waterways at the crossing locations, as given in Figure 1 Appendix A, are categorised as follows;

- Waterway crossing 1 : Category 3
- Waterway crossing 2 : Category 3
- Waterway crossing 3 : Category 2
- Waterway crossing 4 : Category 2

Although waterway crossings 1 and 2 could be classed as category 2, since they have the potential to allow animals to cross over from one side of the floodplain to the other side, the waterways are greatly modified and located mainly on grazed agricultural land.

Waterway classification is used to identify minimum riparian corridor widths along waterways. Category 2 – Terrestrial and Aquatic Habitat classification aims to provide for a viable and robust node or reach of riparian habitat (both aquatic and terrestrial), with minimum CRZ width of 20m (measure from top of bank) along both sides of the watercourse with a 10m vegetated buffer zone either side.
The aim of maintenance and restoration of Category 2 waterways is to maintain native riparian vegetations, water quality, bank stability and provide suitable native animal habitats.

Due to the nature of these category 2 waterways, at the crossing locations with cattle grazing within the 20m wide CRZ over both banks, and the lack of existing diversified vegetation, the 10m wide vegetation buffer is not considered necessary.

Waterways classified as Category 3 require minimisation of sediment and nutrient transfer to provide bank stability, water quality and native vegetation protection. These are generally achieved where possible by emulating a naturally functioning stream, providing terrestrial and aquatic vegetated habitat refuges, using pipes and other engineering devices as a last resort and treating stormwater runoff before discharging to riparian zones or waterway.

The two Category 3 waterways are highly modified from natural conditions with a lack of diversified native vegetation. Cattle grazes within the 10m wide core riparian zones on either bank.

See Appendix E for further Details

3.8.1 Sea Level Rise

Shoalhaven City Council has commissioned revised flood modeling of the Lower Shoalhaven River Floodplain to assess the impacts on climate change induced sea level rise on flood levels. The information that follows was obtained from their recently made available climate change assessment report titled 'Lower Shoalhaven River Floodplain Management Study and Plan – Climate Change Assessment (CCA).

Based on the following information using the 1% AEP flood event for comparison, during the proposed gas pipeline's minimum service design life of 30 years the amount of flood level rise at the proposed development site due to sea level rise is insignificant. The possible increase in flood levels across the proposed gas main site due to sea level rise is comparatively small with respect to current flood levels during the 1% AEP flood event (0.36% max). Due to this, erosion and sediment control during construction of the proposed gas pipeline will not be affected by sea level rise, nor will there be need to tailor erosion and sediment control to compensate for sea level rise.

The proposed development is located approximately 12 to 15 km from the entrance of the Shoalhaven River. The proposed position of the gas main corresponds to cells 8 & 14 of Figure 1 in the CCA report. Referring to Figure 3 of the CCA report, by 2050 the anticipated benchmark 400mm rise in sea level will possibly cause a corresponding maximum 10 mm flood level rise during the 1%AEP flood event. By

2100 the increase to the flood level during the 1%AEP flood event across the site from an anticipated 900mm rise in sea level will be approximately 20mm.

Figure 46 of the Lower Shoalhaven River Flood Study (April 1990) shows the peak flood level during the 1% AEP flood event to be approximately 5.6m AHD. Comparing Figure 1 of the CCA report which shows the existing 1% AEP flood extent, to figures 2 and 4, the anticipated 1% AEP flood event in the years 2050 and 2100 respectively show there is no significant change to the flood extent across the proposed gas pipeline site.

Referring to figure 3 of the CCA report, the flood hazard category in the year 2050 over the area where the proposed gas pipeline will be situated remains consistent with the existing flood hazard category of 'High Hazard Flood Storage' as shown in figure 2 of the 'Lower Shoalhaven River Floodplain Risk Management Plan'.

Since over half of the proposed gas main will be situated in High Hazard flood storage area on the Shoalhaven River flood plane, an assessment of sea level rise on the proposed gas pipeline was made. It was found that there will be insignificant impacts to the gas pipeline, with respect to erosion and sediment control.

NSW Government Policy on Sea Level Rise

The NSW Department of Planning has issued a policy statement entitled "NSW Sea Level Rise Policy Statement" October 2009 which outlines the NSW Government's attitude towards the impacts of sea level rise on regional planning and new development.

The policy states the following:

The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100, with the two benchmarks allowing for consideration of sea level rise over different timeframes. The benchmarks were established by considering the most credible national and international projections of sea level rise and take into consideration the uncertainty associated with sea level rise projections. The Government will continue to monitor sea level rise observations and projections and will periodically review these planning benchmarks, with the next review likely to coincide with the release of the fifth IPCC report, due in 2014.

and

The sea level rise planning benchmarks will support consistent consideration of the influence of sea level rise on any coastal hazards and flooding risks that may influence a development or redevelopment site. The benchmarks are not intended to be used to preclude development of land that is projected to be affected by sea level rise. The goal is to ensure that such development recognises and can appropriately accommodate the projected impacts of sea level rise on coastal hazards and flooding over time, through appropriate site planning, design and development control.

Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments

The NSW Department of Environment, Climate Change and Water has issued a report entitled "*Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments",* August 2010.

The report adopts the planning benchmarks of the *NSW Government Policy on Sea level Rise* and provides guidance as to how to apply sea level rise benchmarks to flood risk assessments which are undertaken for flood affected areas.

The Guide states the following:

This guide applies to areas where projected sea level rise is likely to have a discernable impact on predicted flood levels. This includes the NSW Coastal Zone and areas in the vicinity of lower coastal waterways, including rivers, creeks, estuaries and ICOLLs. In particular, this is likely to apply if the land is:

- *likely to be inundated if water levels were 1.0 m above the upper limit of the current tidal range, generally defined by mean high water springs*
- *likely to be inundated if water levels were 1.0 m above the current flood planning level*
- *within 1.5 m of the maximum historic height of the entrance berm or the upper limit for management intervention identified in entrance management plans for any ocean entrance to the waterway which controls flooding (this commonly applies to ICOLLs)*
- *below 4 m AHD.*

The Guide also states:

Where a flood investigation has been prepared, the modeling can be updated to include sea level rise projections or a conservative assumption can be made about sea level rise impacts. Where the site is below 4 m AHD, an appropriate conservative assumption to estimate the 1-in-100 year ARI flood level is to add the sea level rise benchmarks to the 1-in-100 year ARI flood level relevant to the site.

3.8.2 Soil Analysis

Soil data was obtained from a borehole log report prepared by Coffey Environments on the 21-06-2011. Boreholes 17, 16, 12 and 10 correspond to waterway crossing locations 7, 8, 9 and 11 respectively and are available in Appendix G.

In general, the soils at proposed waterway crossings were fine grained, cohesive, highly plastic, clays and sandy clays, with shear saturated shear strengths between 100 and 400 kPa.

A soil sieve analysis for grain size was not made.

3.8.3 Vegetation

Vegetation within the waterways and riparian zones were found to be common between the four waterway crossings. Remnant vegetation adjacent the proposed gas pipeline route on the Shoalhaven floodplain is most likely from forested or saline wetlands, which would have been removed to make way for the railway reserve, train track and agriculture (dairy farming).

Overall condition of existing riparian vegetation was poor with low structural and floristic diversity, significant weed infestation, and exposed soils observed along stream banks.

The main vegetation type found in riparian zones was kikuyu grass with sporadic plantings of native trees and shrubs, mainly at low lying areas downstream on the floodplain.

Waterway vegetation consists mainly of aquatic weeds and reed beds that have grown through the grass lined waterways.

Extensive weed infestations were identified along all of the proposed waterway crossings, which included a number of noxious weeds, listed under class 4 and 5 of the Shoalhaven Local Government Area.

Lantana and blackberry was found at number of locations along the un-named road reserve and waterway crossings. It is recommended that these be removed during work site and haul road preparation to improve overall ecosystem health and allow the re-establishment of native species.

Lantana can be removed by cutting and mulching back into the ground. This method will provide some soil protection following weed removal to reduce both erosion and further weed infestation.

A vegetation management plan (VMP) is generally required to ensure riparian areas are managed appropriately and in accordance with strategic objectives. The VMP outlines management zones and establish guidelines for riparian management, focusing on the required actions to carry out the above recommendations. In addition, the VMP also incorporates site specific measures relating to personnel access, weed management, incident management, ASS, surface drainage and erosion controls.

For the Shoalhaven Starches gas pipeline project, a VMP is not considered necessary due to the proposed route being mainly in road reserves with little to no native vegetation along the route being disturbed. The majority of vegetation being disturbed is Kikuyu grass, which can be replaced by seeding or turfing.

To counteract the lack of a VMP, the ESCP should go into greater detail than normal regarding rehabilitation of disturbed vegetation, making every effort to ensure that disturbed areas are rehabilitated to existing conditions. Areas along the proposed route with native vegetation, such as waterways and road verges that contain shrubs and trees, should be identified in the ESCP and details given of how removed native vegetation will be replaced.

3.9 Erosion and Scour

Fluvial scour and bank erosion was observed at all waterway crossing locations. The majority of scour and erosion has occurred between the proposed waterway crossings and the culvert or bridge in the railway reserve immediately upstream of the crossing points. Limited erosion and scour has occurred downstream of the waterway crossings.

Outlets of culverts and bridges are known areas of significant scour and erosion. The waterway crossings were modelled to estimate the maximum scour depth due to a 1 in 100 year flood event. This is to determine the minimum depth of cover required to mitigate scour impacts on the gas pipeline under the waterway crossings. It should be noted that over time, a balance is reached at scour holes, where the depth remains constant and does not keep on growing, unless a significant morphologic change occurs to the waterway. Eroded sediment is transported from upstream and gets deposited at the scour hole. The 1 in 100 year storm event was chosen since it is used by Shoalhaven Starches for their planning policies.

3.9.1 Scour Depth

There is potential for a buried pipeline to be uncovered at waterway crossings. The minimum depth of burial, or soil cover over the pipeline is stipulated so that damage is prevented to the pipeline. Once buried, the pipeline is to remain in its covered state unless specifically removed.

Determining an adequate amount of cover over a pipeline that crosses under the bed of a waterway requires consideration of the effect of scour caused by the flooding characteristics of the waterway and the floodplain immediately in the vicinity of the crossings. As water flows through a waterway or over a surface, scour or erosion of the surface will occur when conditions are suitable. This is generally dependant on the characteristics of the waterway; materials used to construct the waterway; flow velocity and soil type.

Information from site inspections and desktop studies was used with HY-8 software form the United States Department of Transportation – Federal Highway Administration, to determine the scour potential and minimum depth of cover required between the beds of each waterway crossing. This software is based on the document, 'Hydraulic Design of Energy Dissipaters for Culverts and Channels', Publication No. FHWA-NHI-06-086 July 2006 Hydraulic Engineering Circular No. 14 Third Edition which is also used as a reference manual for the Australian Rainfall and Runoff Manual.

This report presents preliminary scour depth modelling results obtained from a simplified deterministic analysis. Sstatistical variance of the storm events, sediment transport, flow rates etc is not considered. Modelling was determined to be feasible, without the need for detailed survey data of the flood plain and waterways, by obtaining relative measurements of bridges and culverts, waterways, railway track and ballast, and undertaking a desktop study to obtain interpolated data from existing topographic maps and soil test results.

It is recommended that probabilistic modelling of scour depth be undertaken as part of the detailed design of the gas pipeline, and results compared with those presented in this report.

The most significant form of scour occurring at the waterway crossings is localised scour at the outlet of bridge/culverts, due to the large catchment coupled with the size of the bridge/culverts, and constriction of the waterways as they flow under the railway track, increasing the velocity through the opening. Peak flow rate calculations for catchments are available in Appendix H

The following assumptions were made for scour depth modelling presented in this report;

- All culverts are 5m wide.
- There is zero fall through bridge/culverts.
- Railway deck above bridge/culvert is level.
- Mannings is constant for banks and channels.
- Waterway cross sections are trapezoidal and level
- Culvert invert is at the same level as the waterway invert.
- Sub-catchments do not join together during large stormwater events.

A sensitivity analysis was made on important waterway variables including longitudinal waterway gradient, waterway bank and channel Mannings numbers, soil Plasticity Index and saturated shear stress. It was found that the most significant variables to affect scour depth are soil Plasticity Index and saturated soil shear stress.

HY-8 recommends an Atterberg limits test to determine the plasticity index (PI) by using the procedure outlined in ASTM D423-36. This test was not done as part of Coffey Environments Soil Analysis Report. The report does give descriptions of the plasticity of the soil. For all waterway crossings the soils were of

medium to high plasticity'. HY-8 requires an input between the limits of 5-15 for the Plasticity Index, which corresponds to medium and high plasticity soils.

It is also recommended to obtain Saturated Shear Stress values from a test done in accordance with ASTM D211-66-76. The Coffey Environments soil analysis report shows a pocket petrometer test being done, with values of shear stress ranging from approximately 50kPa to 400kPa along the route. This is an equivalent test to the recommended HY-8 test, ASTM D211-66-76.

A sensitivity test of the Plasticity Index (PI) and Saturated Shear Stress (SSS) with respect to scour depth was made between PI values of 10 and 15, and SSS values from +50 and -50 kPa from values given in the Coffey Environments Bore hole log report. The results of the sensitivity analysis showed that incrementing the HY-8 plasticity Index from 10 to the upper limit of 15 caused the modelled scour depth to increase by approximately 200mm, (5.7%). By altering the SSS results, a 180mm (5.5%) change in scour depth resulted. This can be considered insignificant as a factor of safety will need to be considered which will result in the depth of covers increasing well beyond these values.

Scour depth results are available in Appendix I. A summary table of each waterway crossing is provided in the following section, including calculated scour depth.

3.10 Geomorphic Assessment Conclusions and Recommendations

- Changes to waterway morphology is limited with no major changes to waterways observed in 116 year period.
- Minor morphological changes are occurring at outlets of bridges/culverts under railway tracks, just upstream of proposed waterway crossings.
- The major cause of morphological change is erosion occurring at proposed waterway crossings, from localised fluvial scour at outlet of culvert/bridges.
- Velocity of flow over proposed waterway crossings is above 2.0m/s, at three of the four waterway crossings, meaning there is a very high chance of scour occurring at these locations.
- The lack of healthy, diverse and continuous riparian vegetation along the bank of each waterway within the unnamed road reserve is contributing to bank erosion and instability.
- It is likely that revegetation works within the riparian zone will prevent bank recession continuing due to fluvial scour during small stormwater events.

- Protecting the toe and banks of waterway crossings along the width of the road reserve, increasing groundcover and promoting binding root growth as close to the toe of the bank as possible may be adequate to resist scour.
- The Core Riparian Zones of all waterways at their proposed crossings are highly degraded due to weed infestation, large flows and velocities, and the lack of an appropriate cattle grazing setback. It is recommended that waterway crossings 1 and 2 be classified as Category 3, and waterway crossings 3 and 4 be classified as Category 2, as per the draft Shoalhaven LEP, and section 5.2 of Landcoms Blue Book;
- Category 3 waterways have no CRZ width requirements, whilst Category 2 waterways require a 40m wide CRZ over the waterways with 10m wide vegetation buffer zone either side of the CRZ.
- Table 1 below shows scour depths and expected length of scour hole in meters downstream of culvert/bridge outlet. It can be seen that the calculated scour depths may not be reached at the pipeline crossing, especially if the proposed crossing points are at the outer boundary of the un-named road reserve. Since there is approximately 15m of railway reserve between the culvert/bridge and the common boundary between railway reserve and road reserve, it is estimated that greatest amount of scour will occur mainly within the railway reserve, and possibly decrease in depth as it approaches the waterway crossings.
- From the scour depth results, the minimum pipeline depth of cover at waterway crossing 3 will need to be increased from the minimum 2.0m, to a minimum of 5.1m. The minimum 2m depth of cover under the waterway beds at waterway crossings 1, 2, and 4 should be satisfactory.
- Further variance based modelling of scour at the waterway crossings is required, during detailed design, to take into consideration statistical variance of scour depth variables. The estimated scour hole lengths show that the calculated scour depths may be reached at waterway crossings 2 and 4. See Appendix E for further Detail

Table 1: Summary of Waterway Crossings and Scour Results

Water-way	*Waterway cross-section*			*Long-Grade*	*1%AEP Flow Rate*	*Soil Shear Strength*	*Culvert Outlet Velocity*	*Scour Depth*	*Scour Hole length*
	Depth (m)	*Bed Width (m)*	*Bank Widths (m)*	*%*	*(m^3/s)*	*(kPa)*	*(m/s)*	*(m)*	*From Culvert outlet (m)*
1	0.5	5.0	1	0.3	2.84	100	1.20	0.9	4
2	1.5	6.5	2	0.5	64.4	200	3.06	2.3	12
3	1.0	7.0	1	0.5	132	100	3.72	5.1	30
4	0.8	5.0	1	0.8	30.0	400	2.72	3.4	14

3.11 Site Rehabilitation, Maintenance and Monitoring

Continual site remediation and restoration is required during the proposed pipeline construction process. Progressive re-vegetation, removal of temporary erosion & sediment control measures, and site stabilization requires detailed planning.

Rehabilitation, maintenance and monitoring of the pipeline route shall be established as part of the ESCP. The photographic evidence presented in this report can be used to aid rehabilitation of disturbed sites, back to pre-existing conditions shown in the photos.

A vegetation management plan (VMP) should not be required from a qualified Landscape Architect shall due to the lack of diversified vegetation found along the proposed route and waterway crossings. To ensure adequate rehabilitation of each waterway's CRZ, vegetation rehabilitation and maintenance should be included as part of the ESCP, with all native trees and shrubs along the proposed route identified, and all native trees requiring removal to facilitate pipeline construction identified on the plan. For those areas requiring removal of native species, the ESCP should outline replacement species and their proposed location.

Top soils removed for trenching and work site preparation shall be stockpiled and reutilised over backfilled trenches and at rehabilitated work sites. If required, a top soil mix shall be prepared and approved by a qualified Landscape architect if further topsoil is required for adequate site rehabilitation.

Vehicle waterway crossings are to remain in place for the full rehabilitation period. Once rehabilitation has been established, vehicle crossings shall be removed and the waterways filled and regarded to match upstream and downstream conditions. Jute mesh is to be laid and secured over disturbed waterway crossing locations and the area re-vegetated through the jute mesh. If heavy flows are expected through re-vegetated waterways before adequate vegetation is established to protect the waterway, a temporary bypass around the disturbed waterway may be required, which is to be installed in accordance with the blue book.

Staged construction provides favorable conditions for re-vegetation. Progressive re-vegetation aims to minimize the area of disturbance during construction. Works should be staged and each stage stabilised immediately on completion of trench backfilling, or on removal of stockpiles placed over previously backfilled trenches. Since the majority of disturbed soils are within agricultural land (pasture), the

predominant vegetation affected is grass (kikuyu). The most immediately effective method of stabilization is to seed the disturbed area. More information regarding re-vegetation and site stabilization is available in Volume 1, section 7 of the Blue Book.

Maintenance and monitoring of erosion and sediment controls and rehabilitated areas is required on a periodic basis, to ensure the effectiveness of any mitigation measures implemented during and following the completion of the construction phase. Erosion and sediment controls are to remain in place after site works are officially completed, for a period not less than 6 months, or until 75% of the site has been adequately rehabilitated. This is to be decided by the superintendant of the project. The following table gives Monitoring requirements, frequency of monitoring and the person responsible for monitoring and maintenance;

Table 2: Rehabilitation Monitoring Requirements

Monitoring Requirement	Frequency	Responsibility
Erosion & Sediment Control Inspections	Weekly during construction and rehabilitation periods, and immediately after any storm event	Project Environmental Officer
Inspection of Waterways	Fortnightly until completion of entire project	Project Environmental Officer
Inspection of Vegetation	As per Vegetation Management Plan	Landscape Architect
Photographic Evidence (Riparian Zones and Waterways)	Fortnightly	Project Environmental Officer

4 Conclusion

Shoalhaven Starches have proposed to construct a 5.5km coated mild steel gas main to enable competitively priced gas to be sourced for the manufacturing operations at Bomaderry including a proposed gas co-generation plant,. The proposed pipeline will also provide for any future expansion at the Bomaderry site.

This report was written to address erosion and sediment control issues outlined under the heading of Soil and Water in the Director General's Requirements, Shoalhaven Starches Project (MP 10_0108), dated 8th November 2010, as part of the development application process.

Details of legislative requirements, project planning principles, documentation requirements, assessment of constraints and opportunities, site restoration and remediation, and general erosion and sediment control management procedures have been provided in this report.

Erosion and sediment control of linear service projects, such as the Shoalhaven Starches gas main, is legislated in NSW. The legislation relating to erosion and sediment control of service installation projects fall under the development assessment framework and provisions of the Environmental Planning and Assessment Act 1979 which include; Protection of the Environment Operations Act 1997, Water Management Act 2000, and the Fisheries Management Act 1984. Other legislation may affect the project which is listed in section 2.1.
Effective management of erosion and sediment control on linear service installation projects requires addressing planning activities which include developing systems for documentation and communication, assessing constraints and opportunities, preparing an ESCP, restoring and remediating sites and other planning considerations.

The project principal is responsible for ensuring all personnel are made aware of responsibilities for proper environmental management and care. The is achieved through the Environmental Management System (EMS).The principal and/or contractor(s) are required to develop an EMS, which is presented as part of the developers construction environmental management plan (CEMP). The CEMP is an active document, constantly being updated that; outlines environmental objectives and targets, describes how to manage and control the environmental aspects of the project, interfaces with all other plans, describes the overall project management system, and expands on the environmental section of the project business plan.

The CEMP should include the following to identify the aims, actions and outcomes required to meet the project’s environmental objectives;

- Description of the principal’s or contractor’s environmental management system.
- CEMP objectives and targets.
- Risk Assessment.
- Constraints.
- Roles, responsibilities and contact details.
- Environmental controls.
- Monitoring and Compliance. [1]

Stabilised haul roads and machinery storage and stockpile sites are required along the route. These constrain pipeline construction. They require large surface areas to be disturbed and their position is critical for the efficient construction of the gas pipeline. Their location should be planed during the detailed erosion and sediment control plan construction stage. Stabilised work sites will be required at all waterway crossings, with adequate erosion and sediment controls put in place as per the Blue Book.

Since the majority of the proposed gas main route is over flat land, the use of simple erosion and sediment controls can be used. This includes sediment fence and straw bale filters which can be made to form almost any shape or follow any contour, and will divert and filter stormwater runoff. Geo-textile material placed to form temporary table drains can be used to divert water around work sites, and can be reused during later stages of the project.

Steeper sections along the route will also incorporate the same simple controls although additional controls will be required to adequately control runoff. This will depend on the steepness of the trench and how the contours grade around it. On steep sections along the route, check dams, trench stops and bulkheads placed within the trench will stop transportation of sediment and water toward the waterways. Trenches shall be stopped and a check dam installed at the boundary of all CRZs, before reaching the waterways. Appropriate waterway crossing techniques as described in Chapter 2 of this report, which were obtained from Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1 , 4th Edition are to be used.

It is recommended that where possible, excavated soil is placed adjacent to the proposed main trench on the upstream side, so that stormwater runoff will push the soil back into the trench and not into any adjacent waterways. The mound can be used as a diversion drain by placing geo-textile material at the base of the stockpiles.

Location of waterway crossings was discussed. The recommended method of pipeline waterway crossing is by underbore as it will minimize the disturbance to the waterway and surrounding areas, and reduce the re-vegetation and stabilization stages. Trenching across waterways shall not occur.

Staged construction of the proposed gas main is recommended and should be planned for as it not only benefits re-vegetation and re-stabilisation of disturbed areas, it enables efficient management of topsoil, and material stockpiles along the route.

A geomorphic assessment of the four proposed pipeline waterway crossings determined that the waterways had not changed significantly over a 116 year period, and would not likely change during the lifespan of the gas pipeline.

Waterway crossings lacked adequate riparian zones, with cattle allowed to graze right up to the bank of waterways, contributing to the lack of diverse vegetation, and outbreak of weed varieties. Waterways were also choked with aquatic weeds. An adequate core riparian zone should be established at all waterway crossings, in accordance with the Blue Book, as a Category 2 – Terrestrial and Aquatic habitat, to increase bank stability thereby reducing the erosion potential at the site.

An assessment of scour at the waterway crossings was made with HY-8 modeling software. It was found that velocities through the culverts and bridges just upstream of the crossings were high enough to cause scour at the crossing points along the route. The minimum 2.0m depth of cover needs to be increased to take scour into consideration, in accordance with the scour depths calculated and presented under the Heading of Geomorphic Assessment Conclusions and Recommendations.

A rehabilitation, maintenance and monitoring program is to be established prior to construction, utilizing a vegetation management plan to ensure the environment along the route is returned to the same if not better condition it was in before construction commenced. Erosion and sediment controls will need to be maintained for a minimum period of 6 months, and regular site visits also made to monitor the condition of the erosion and sediment controls and determine when the site has stabilised.

5 Recommendations

Based on the site investigation conducted by Allen, Price and Associates, the Shoalhaven Starches gas pipeline project is achievable with the installation and maintenance off simple erosion and sediment controls during construction. To move the project forward with regards to erosion and sediment control of the proposed project, the following recommendations are made ;

- Determine the exact route that the proposed gas pipeline will follow.
- Begin development of the Environmental Management System, and the Construction Environmental Management Plan.

- Prepare Erosion and Sediment Control Plan for the site.
- Prepare Vegetation Management Plan.
- Obtain detailed survey of the entire site, including upstream and downstream floodplain and waterways, and areas beyond the road reserves where sediment laden waters may be carried.
- Undertake variance based modelling to determine scour depth at waterway crossings.
- Ensure all erosion and sediment control requirements will be met by becoming familiar with the legislative requirements relating to Erosion and sediment management of linear service projects.
- Notify land owners along the proposed route of any erosion and sediment controls that require construction on their property. Obtain written permission.
- Discuss requirements with Shoalhaven City Council.

Allen, Price & Associates

13 February 2012

6 References

1. *2008, Managing Urban Stormwater-Soils and Construction, Volume 2A-Installation of Services*, Department of Environment and Climate Change, Sydney, NSW.
2. *2004, Managing Urban Stormwater-Soils and Construction, Volume 1- 4th Edition*, Landcom, Sydney, NSW
3. Coffey Environments (2011). *Engineering Log – Borehole CBH100, CBH103 and CBH104*. Additional
4. Cowman Stoddart (2007). Preliminary *Environmental Assessment Report, Proposed Ethanol Production Upgrade*. Prepared for Shoalhaven Starches, Bomaderry, NSW.
5. DLWC (2000). *Soil and Landscape Issues in Environmental Impact Assessment, Technical Report*
6. DNR (2008). *Water legislation and policies: NSW Government Natural Resource*.
7. http://naturalresources.nsw.gov.au/water/wma2000.shtml, accessed 15 March 2008.
8. DIPNR (2004). *Riparian Corridor Management Study Guidelines*. Former Dept. of Water
9. DWE (2008a). *Guidelines for Controlled Activities: Riparian Corridors*. Water Management Act 2000. NSW Dept. of Water and Energy.
10. DWE (2008b). *Guidelines for Controlled Activities: Vegetation Management Plans*. Water Management, Act 2000. NSW Dept. of Water and Energy.
11. Weeds Australia, (n.d.). *Weed Identification, Kikuyu grass Pennisetum clandestinum*.
12. http://www.weeds.org.au/cgi-bin/weedident.cgi?tpl=plant.tpl&ibra=all&card=E27, accessed 10 Jan 2012

Appendix A – Figure 1

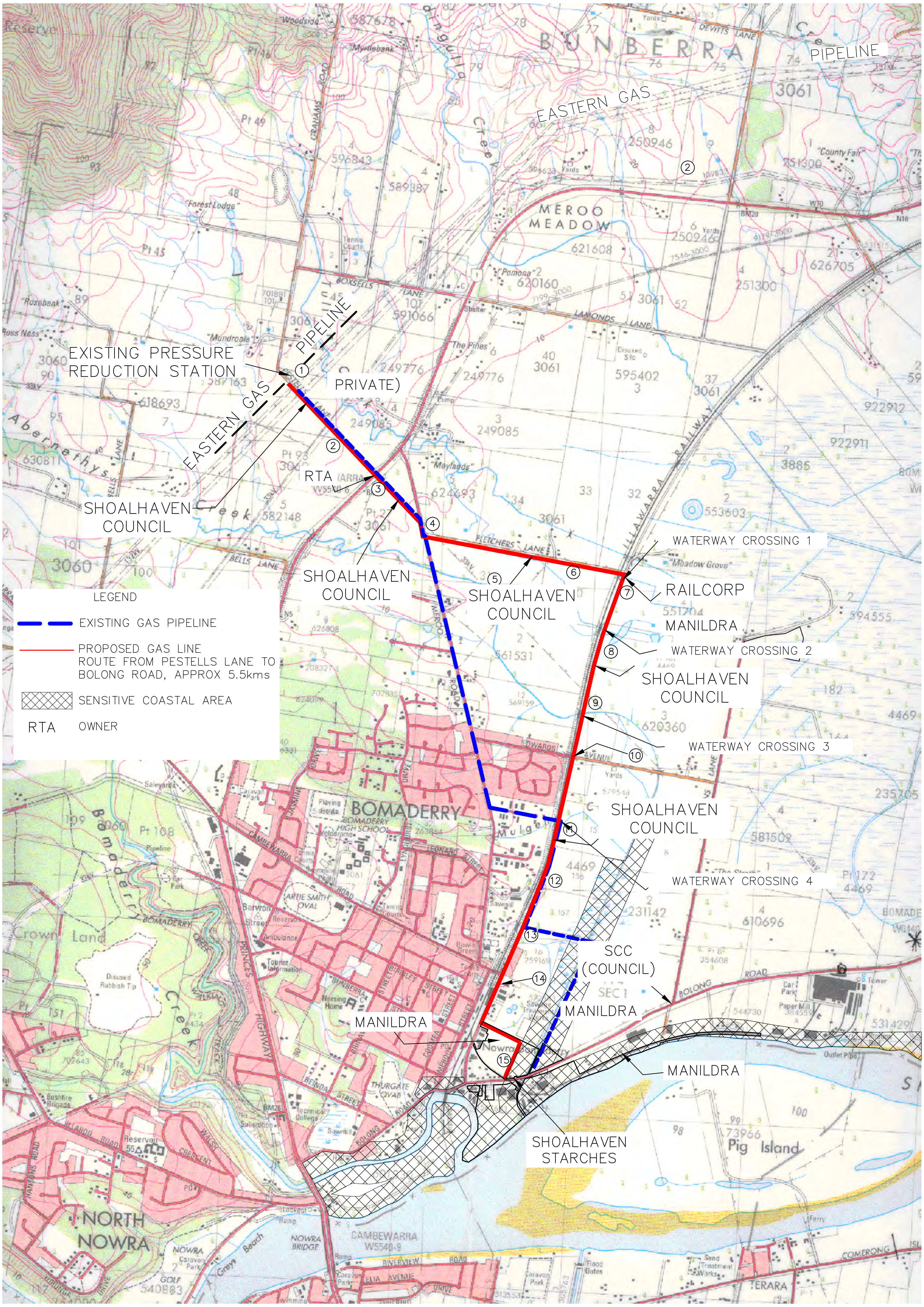

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FIGURE 1

FIGURE SHOWING, PROPERTY OWNERS & WATERWAY CROSSINGS ALONG THE PROPOSED GAS LINE ROUTE, FROM EXISTING EASTERN GAS LINE TO SHOALHAVEN STARCHES BOLONG ROAD FACTORY

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Appendix B – Photographic Investigation of Proposed Route

Appendix B

Photo 1- Eastern Gas Pipeline tie-in point at Pestells Lane (valve and meter station)

Photo 2 Eastern Gas Pipeline tie-in point for existing ActewAGL gas pipeline at Pestells Lane

Photo 3-Pestells Lane verge (south side)

Photo 4-Cattle Loading Station and driveway on Pestells Lane

Photo 5- Existing ActewAGL gas main marker adjacent rural fence at Princes Highway Intersection

Photo 6- Proposed gas main route across Princes Highway

Photo 7- Table drain and culvert on Princes Highway intersection with Pestells Lane

Photo 8- Unformed section of Pestells Lane


Photo 9- Looking down embankment of Princess Highway, along existing gas pipe route

Photo 10- Un-formed Pestells Lane

Photo 11-Intersection of Pestells Lane with Meroo Road

Photo 12-Table drain along Meroo Road

Photo 13- Culvert headwall (bottom right) on Meroo Road and Fletchers lane intersection

Photo 14-Fletchers Lane intersection with Meroo Road

Photo 15-Possible stabilised machinery access and storage area on Fletchers lane intersection

Photo 16- Culvert Headwall and drain leading in Paddock

Photo 17-Open channel drain through paddock on south side of Fletchers Lane

Photo 18- Example of tail-out drains on south side of Fletchers Lane, leading into Open channel drain

Photo 19- Middle of Fletchers Lane

Photo 20-End of Fletchers Lane toward Railcorp railway reserve

Photo 21- Ramp crossing over train tracks at intersection of Fletchers lane and un-named road reserve

Photo 22-Large culvert in Railcorp railway reserve, beyond proposed railway track under-bore location

Photo 23- Gates to Railcorp railway reserve and un-named road reserve

Photo 24a- First waterway crossing, approximately 50m south of ramp over train tracks at end of Fletchers Lane

Photo 24b- First waterway crossing, showing culvert under railway tracks

Photo 24c- First waterway crossing, showing boundary between road reserve and Railcorp rail reserve

Photo 25a-Culvert between first and second waterway crossings for low lying area in rail reserve, adjacent to road reserve

Photo 25b-Vegetation within rail reserve at between first and second waterway crossings

Photo 26a-Low lying area at outlet of second waterway crossing, adjacent to Railcorp rail reserve

Photo 26b-Second waterway crossing, adjacent to Railcorp rail reserve

Photo 26c-Low lying area on approach of proposed gas main toward second waterway crossing

Photo 27a-Scour valve in un-named road reserve adjacent to third proposed waterway crossing, north of Edwards Avenue

Photo 27b-Third proposed waterway crossing, looking north along proposed gas main alignment

Photo 27c- Large railway bridge/culvert at third proposed waterway crossing

Photo 27d- Overhead view of third proposed waterway crossing

Photo 28- Looking north from third waterway crossing, along proposed gas main route

Photo 29- Water main marker at steep approach to Edwards Avenue, in un-named road reserve

Photo 30- Looking north along proposed gas main route in un-named road reserve, toward water main marker

Photo 31- Edwards Avenue crossing point on north side

Photo 32- South side Edwards Avenue crossing in un-named road reserve

Photo 33- Water main infrastructure in un-named road reserve

Photo 34- At gate on crest in un-named road reserve, looking south down into gully to the south of Edwards Ave

Photo 35a- Fourth waterway crossing, looking north, along proposed gas main route

Photo 35a- Approach to fourth waterway crossing, looking north

Photo 35b- Fourth waterway crossing

Photo 35c- Looking along stabilised vehicle track that crosses waterway number three

Photo 36- ActewAGL existing gas main marker on boundary of un-named road reserve, looking south along proposed gas pipeline alignment

Photo 37- Rural fence and gate at end of un-named road reserve and beginning of Railway Street

Photo 38- un-formed section of Railway Street, looking at ActewAGL existing gas main testing station

Photo 39- Railway Street

Photo 40- Water main infrastructure in Railway Street road reserve

Photo 41-Sewer rising main manhole and vent pipe

Photo 42- Water main infrastructure in Railway Street road reserve

Photo 43-Water main, power pole and existing gas main infrastructure in Railway Street

Photo 44- Beginning of sealed section of Railway Street

Photo 45- Stormwater headwall and culvert in Railway Street

Photo 46a- Scour valve shown with Large pipe culvert in background leading into drainage system under Railway Street

Photo 46b- Large pipe culvert in rail reserve on west side of Railway Street

Photo 46c- Small headwall for pipe culvert under Railway Street, taking stormwater from large pipe culvert shown in previous photo.

Photo 47- East side Railway Street road reserve-

Photo 48- West side Railway Street road reserve showing water main marker

Photo 49- Railway Street

Photo 50- Looking at Cambewarra Road intersection with Railway Street

Photo 51- Infrastructure at intersection between Cambewarra Road and Railway Street, on west side road reserve

Photo 52- Example of Railway Street Infrastructure in west side of road reserve

Photo 53a- Stormwater infrastructure in rail reserve on west side of Railway Street

Photo 53b- Stormwater infrastructure under road reserve beginning on west side of Railway Street, leading into pit on east, shown in following photo 53c

Photo 53c- Stormwater pit on east side of Railway Street

Photo 54- Open channel drain through lot 1 DP825808 Railway Street, taking water from pit shown in previous Photo.

Photo 55- Headwall and culvert under Railway Street, at direction change of proposed gas main

Photo 56- Sewer pipe through open channel drain in lot 1 DP825808

Photo 57- Culvert and support for sewer pipe accross open channel drain in lot 1 DP825808

Photo 58-Open channel drain in Lot 1 DP 825808

Photo 59- Sewer man hole in open drain along north boundary of Lot1 DP 825808

Photo 60- North boundary of Lot1 DP825808

Photo 61-Proposed gas main route in Shoalhaven Starches property lot 1 DP 825808

Photo 62- Looking toward Shoalhaven Starches Factory (Manildra), along existing sewer rising main alignment

Photo 63- Proposed gas main route through Shoalhaven Starches paddock, looking toward interim packing plant

Photo 64- Sewer pump station on Shoalhaven Starches land, with location of proposed gas main route and pressure reduction station in background

Photo 65- Civil works at most likely position of proposed gas main crossing of Bolong Road

Photo 66 - Bolong Road showing infrastructure in vicinity of proposed gas main crossing

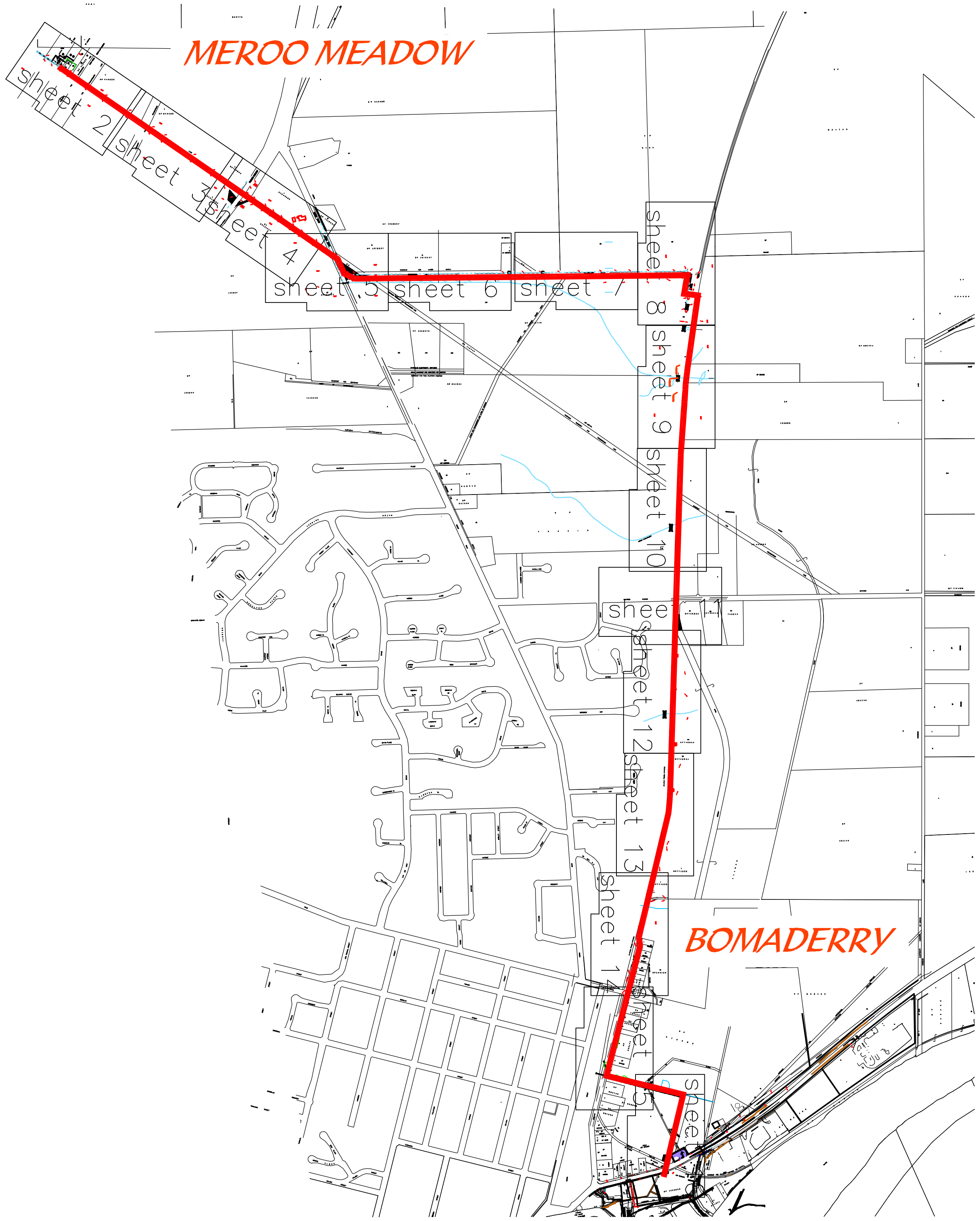
Photo 67-Bolong Road showing infrastructure in vicinity of proposed gas main crossing

Photo 68- Shoalhaven Starches interim packing plant on south side of Bolong Road

Appendix C – APA Drawing 24710-04 Sheets 1 to 16

SHOALHAVEN STARCHES PROPOSED GAS PIPELINE

AT MEROO MEADOW AND BOMADERRY, NSW



APPENDIX C

This drawing complements two reports written by Allen, Price and Associates for the proposed Shoalhaven Starches gas pipeline project. To better understand the content of this drawing, the reports titled, 'Impacts on Infrastructure Report' and 'Erosion and Sediment Control Management Plan' should be read prior. This drawing is located in Appendix C of both reports.

Items shown on these sheets have not been located by detailed survey. They are indicatively shown based on field observation and measurement, and information given by service and infrastructure owners and operators.

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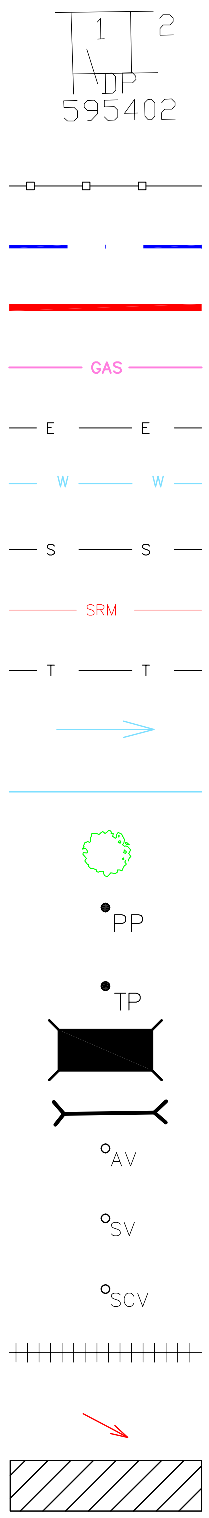

	EXISTING BOUNDARY FENCE (SCC CADASTRE)
	EXISTING RURAL FENCE
	EXISTING GAS MAIN
	PROPOSED GAS MAIN
	EASTERN GAS LINE
	EXISTING OVERHEAD ELECTRICAL POWER SERVICE
	EXISTING WATER MAIN
	EXISTING SEWER MAIN
	EXISTING SEWER RISING MAIN
	EXISTING UNDERGROUND TELSTRA LINE
	EXISTING TAIL-OUT OR TABLE DRAIN
	EXISTING CREEK OR SWALE DRAIN LESS THAN 5m WIDE
	EXISTING TREE SHOWING APPROX. DRIP LINE
	POWER POLE (SCC INFRASTRUCTURE)
	TELEGRAPH POLE (RAIL INFRASTRUCTURE)
	EXISTING BRIDGE
	EXISTING CULVERT
	EXISTING AIR VALVE FOR WATER MAIN
	EXISTING STOP VALVE FOR WATER MAIN
	SCOUR VALVE
	RAILWAY TRACK
	LAND SLOPE
	TEMPORARY STABILISED SITE AND ACCESS FOR MACHINERY STORAGE AND UNDERBORE OPERATIONS

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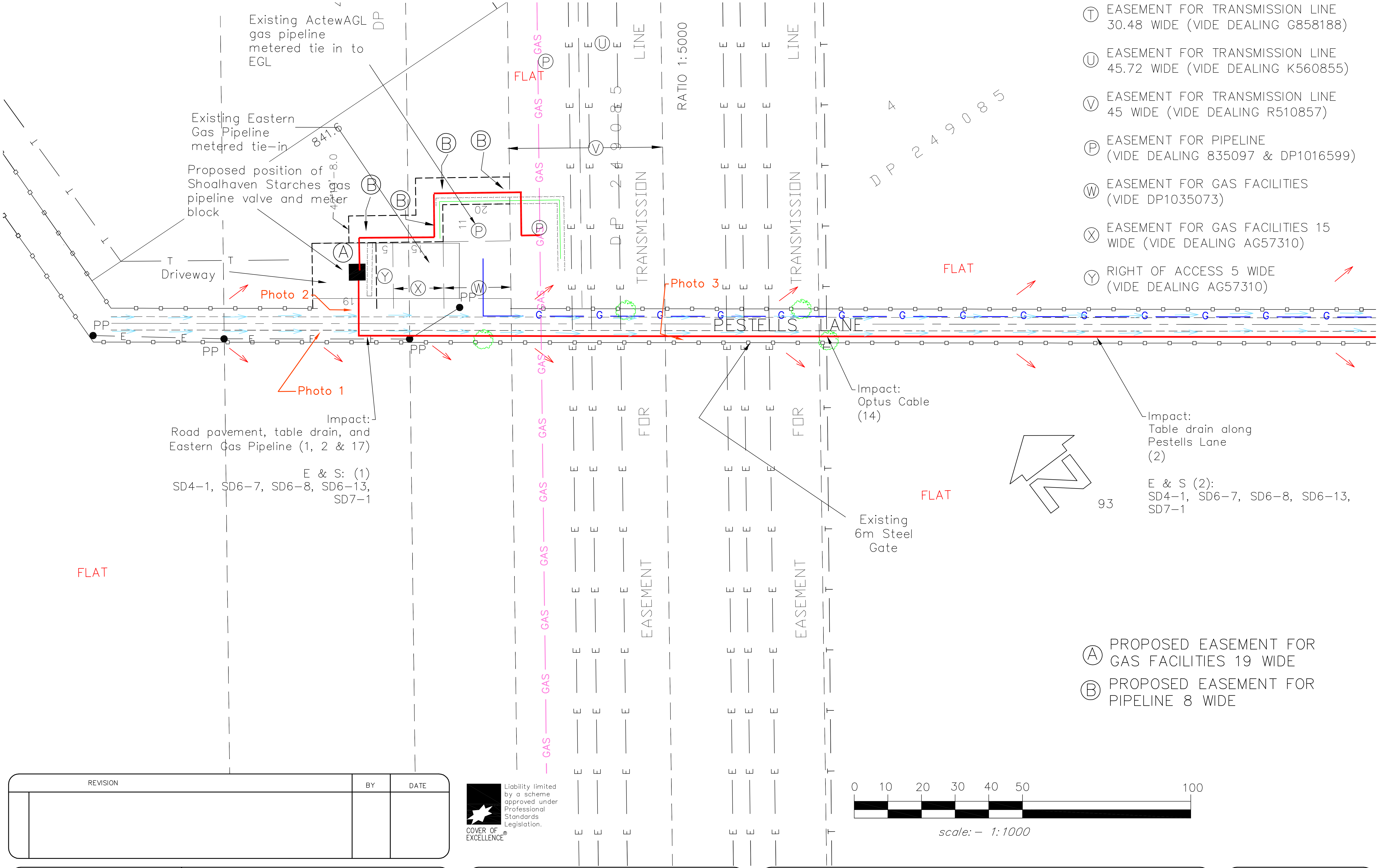

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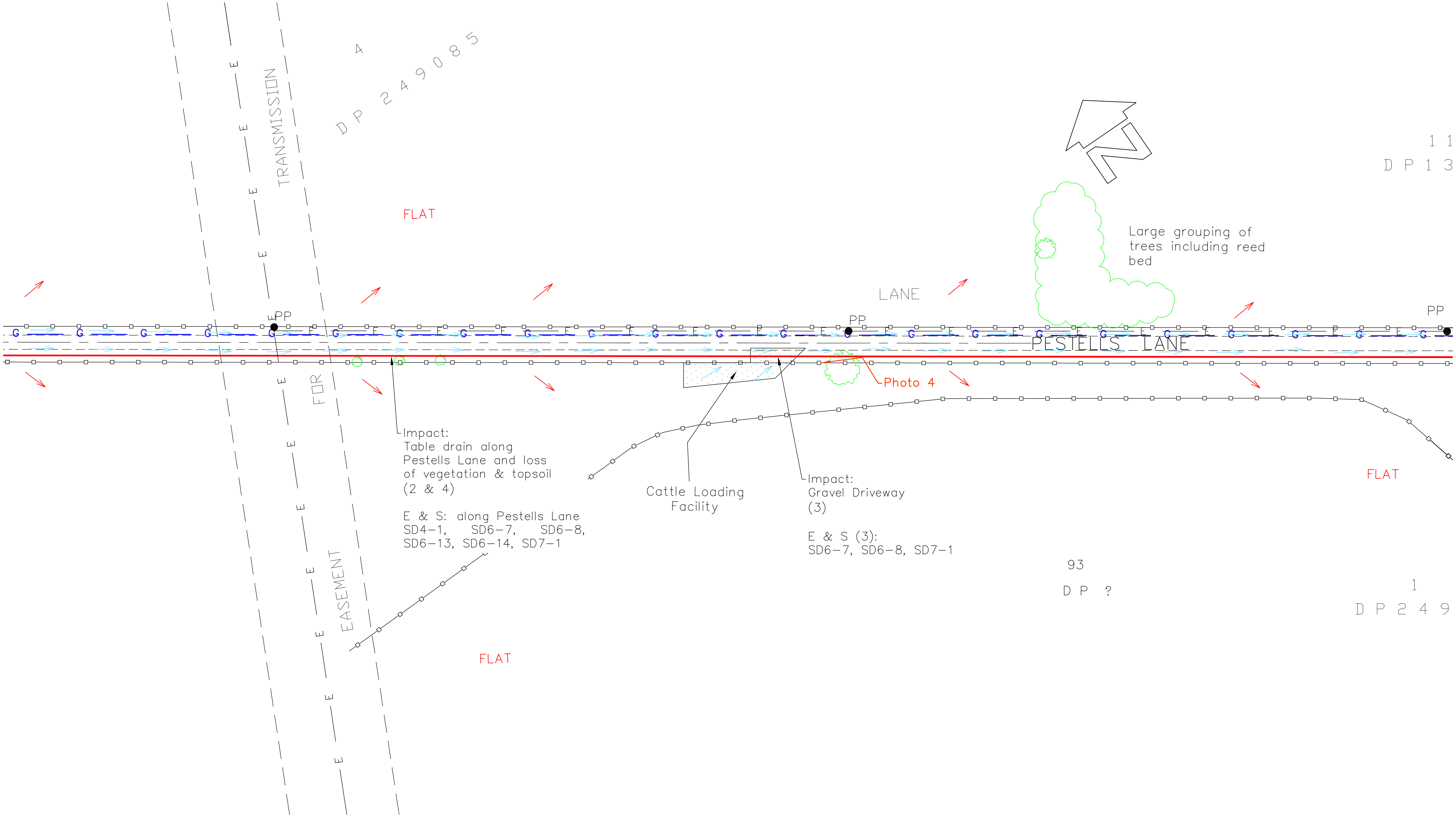

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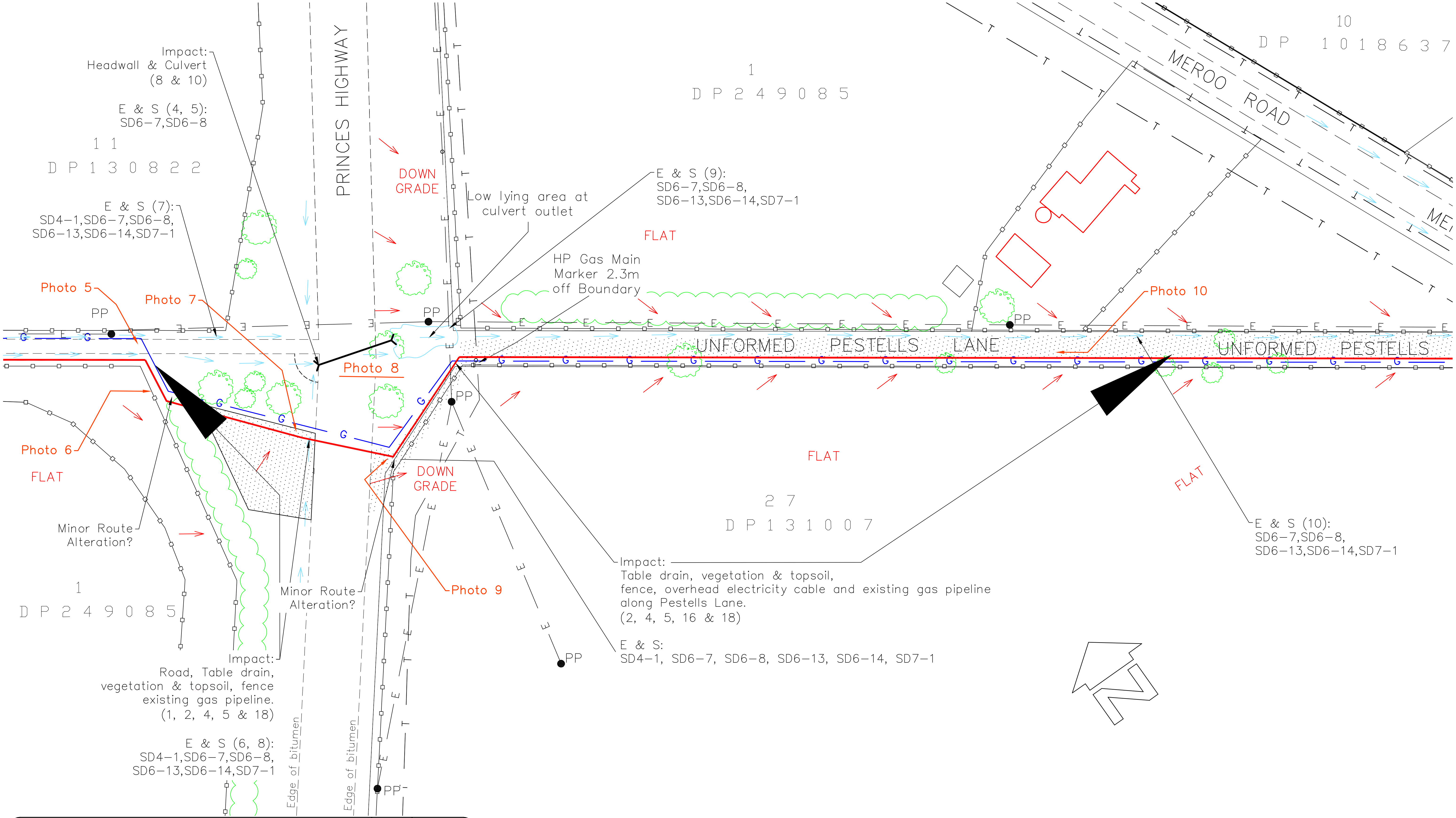

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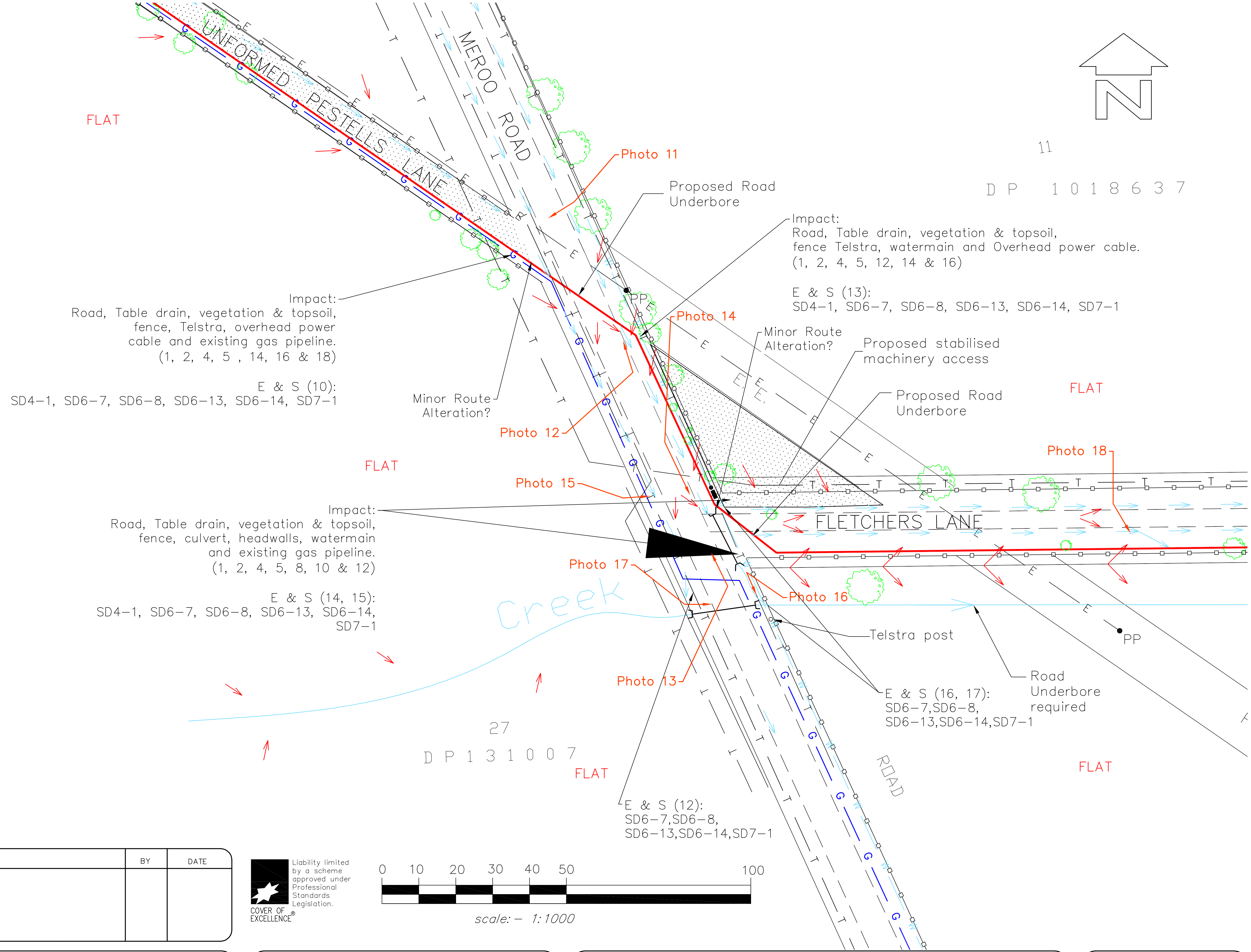

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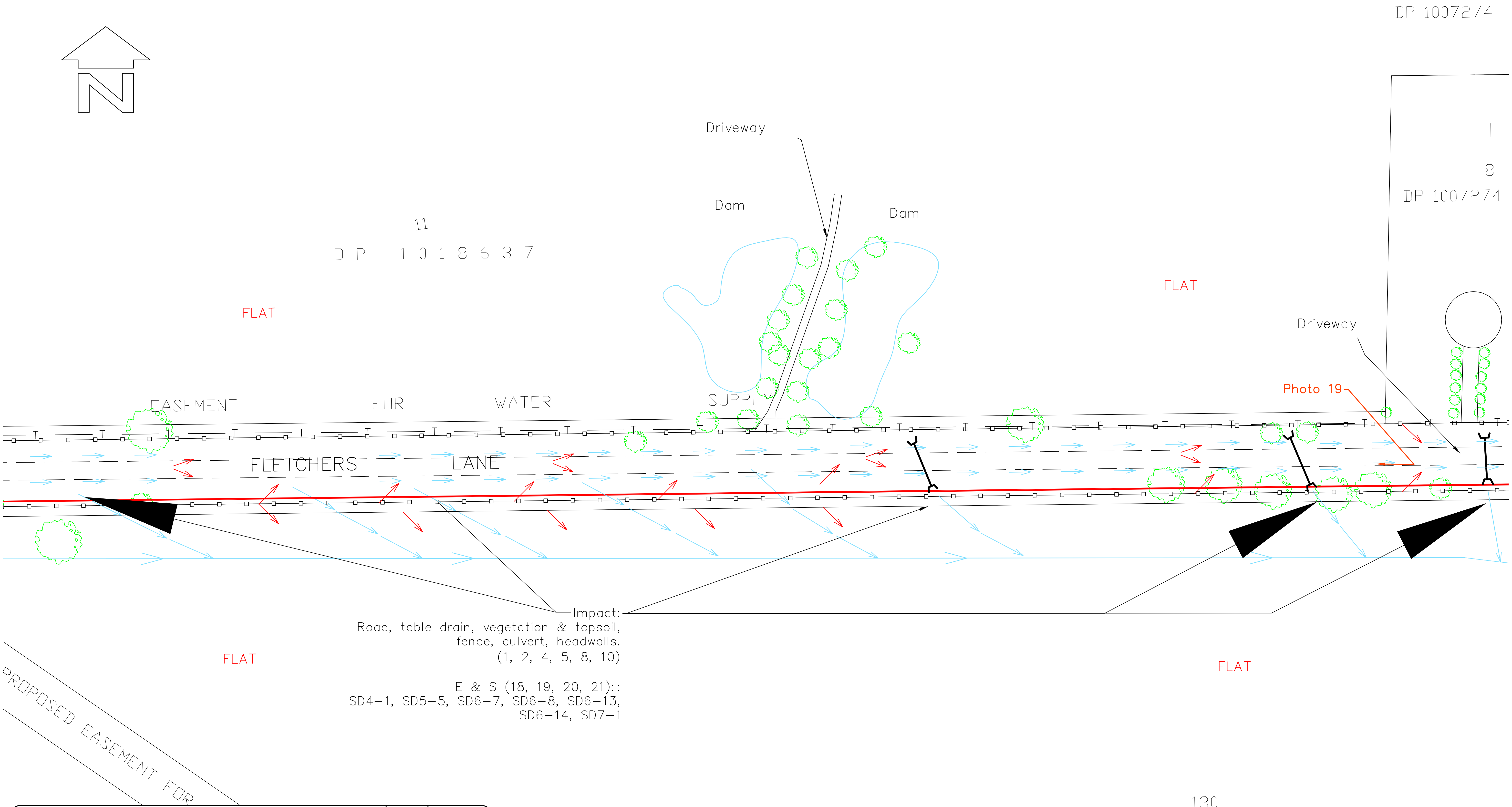

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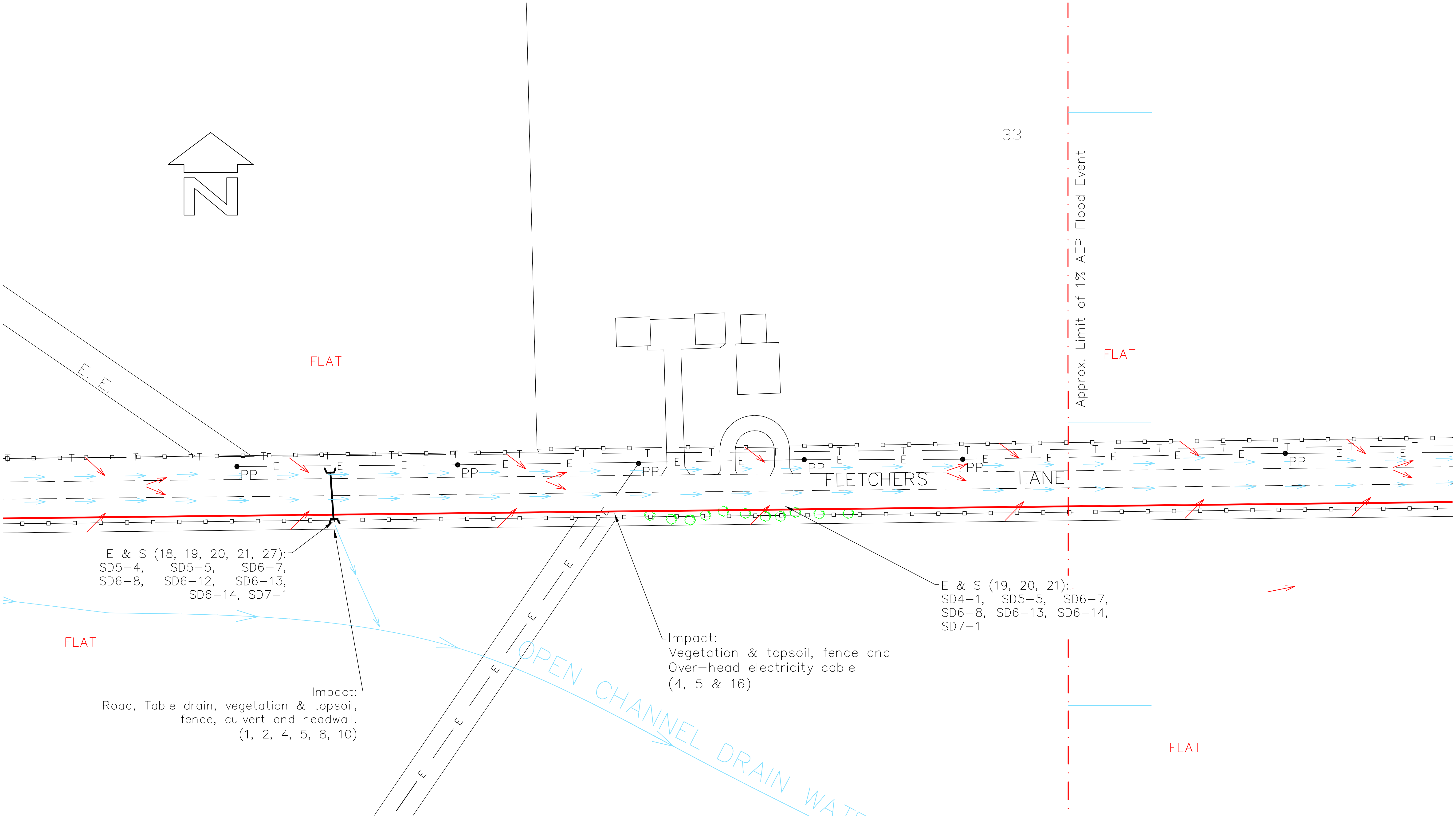

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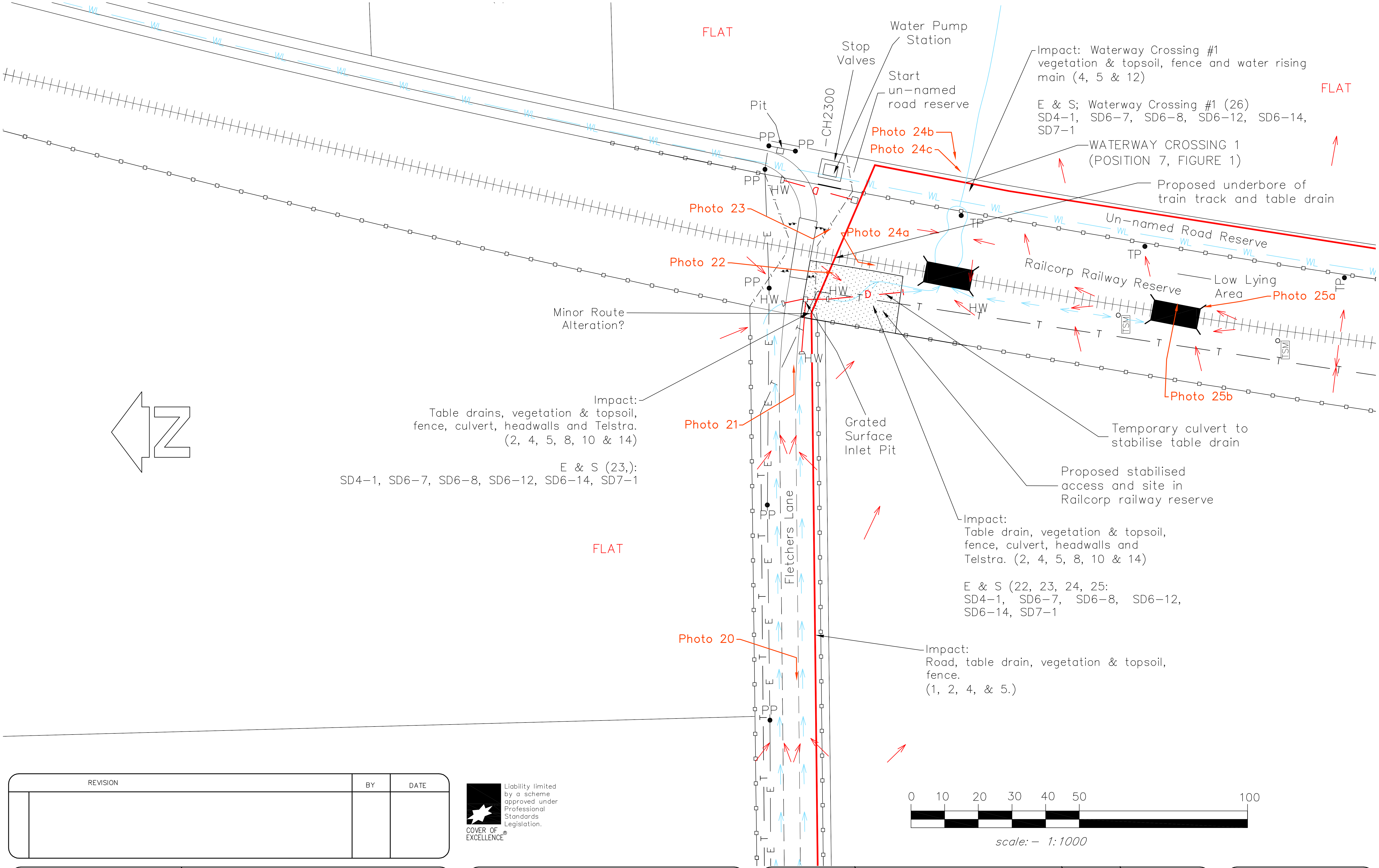

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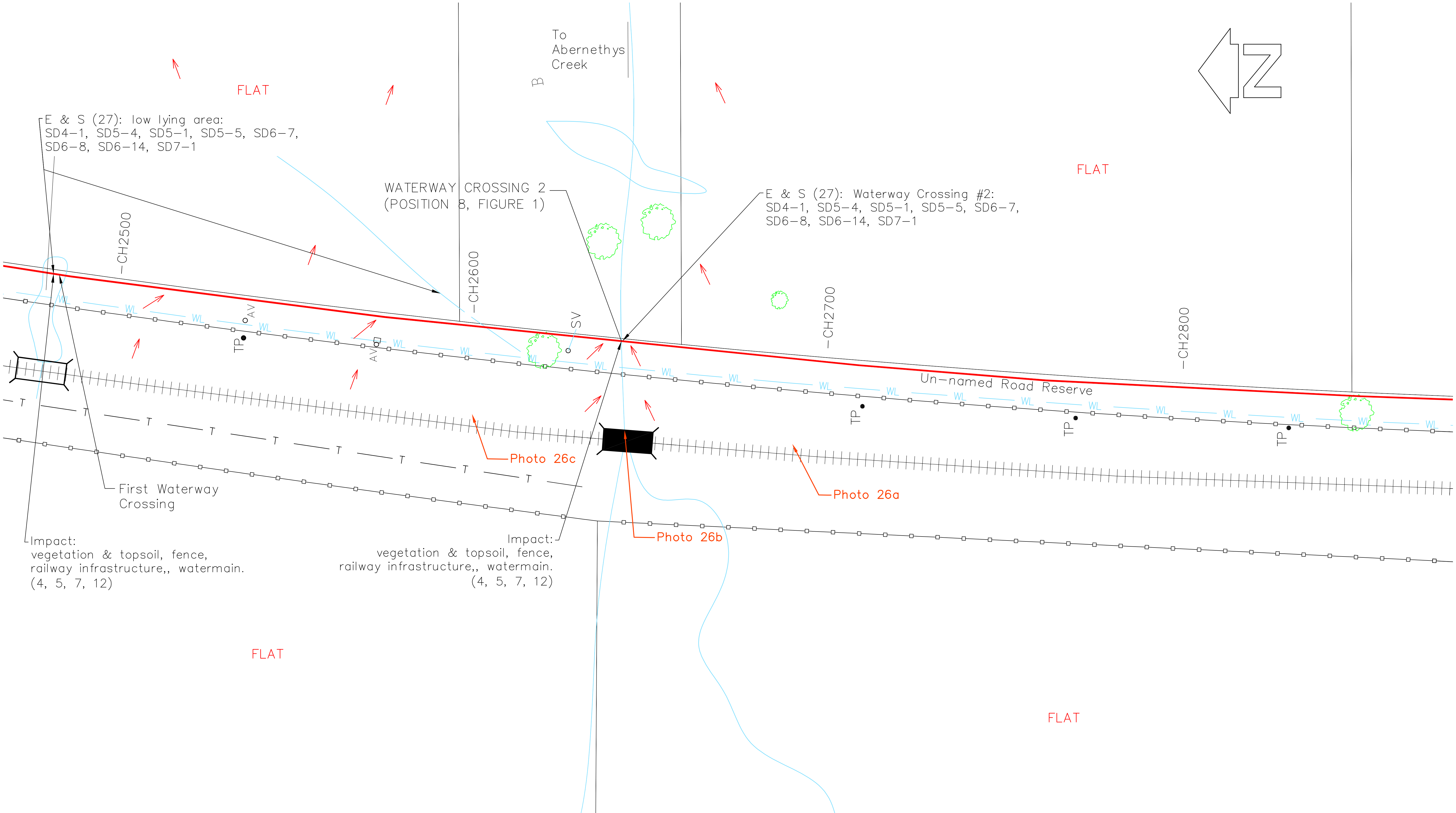

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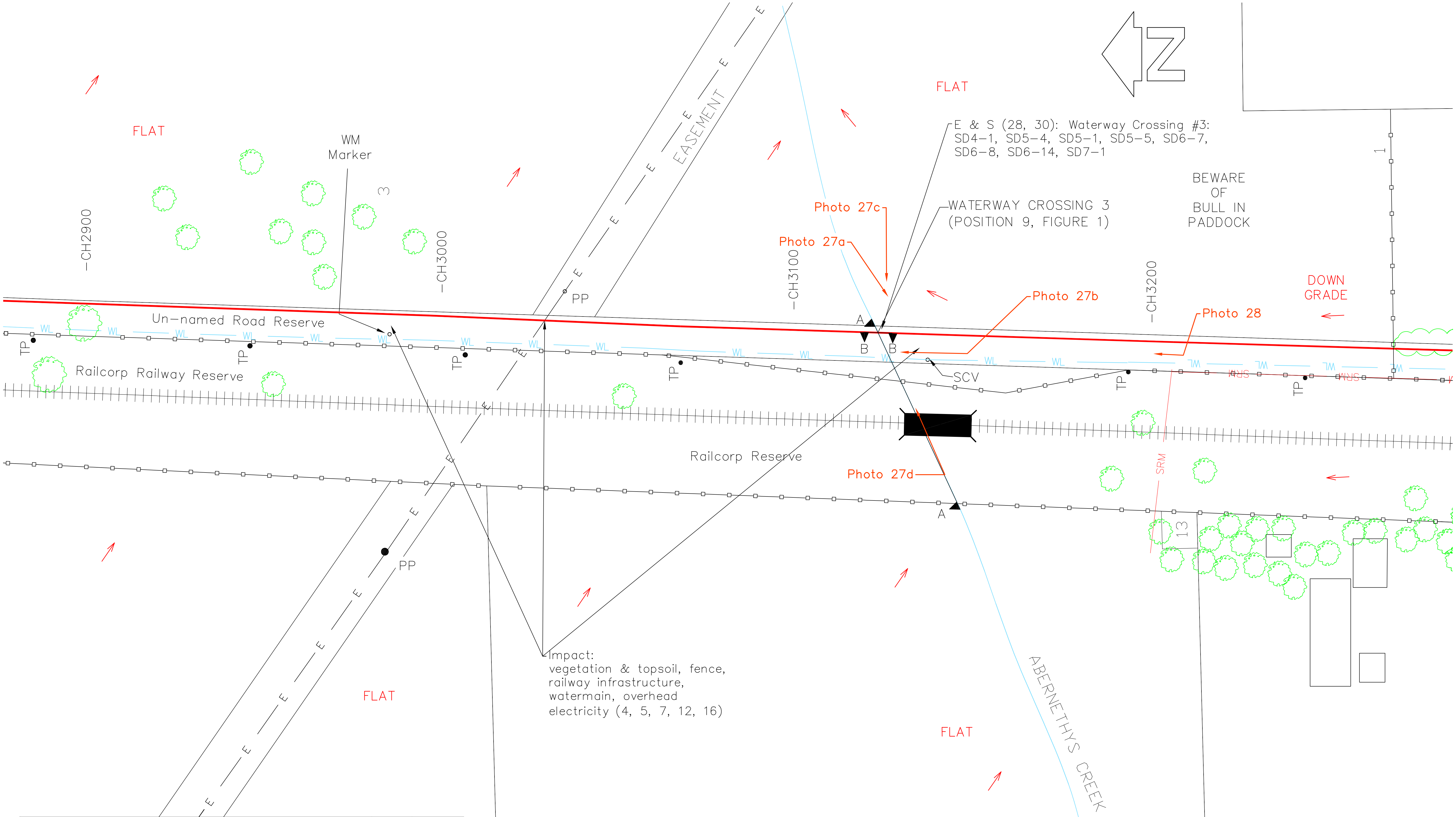

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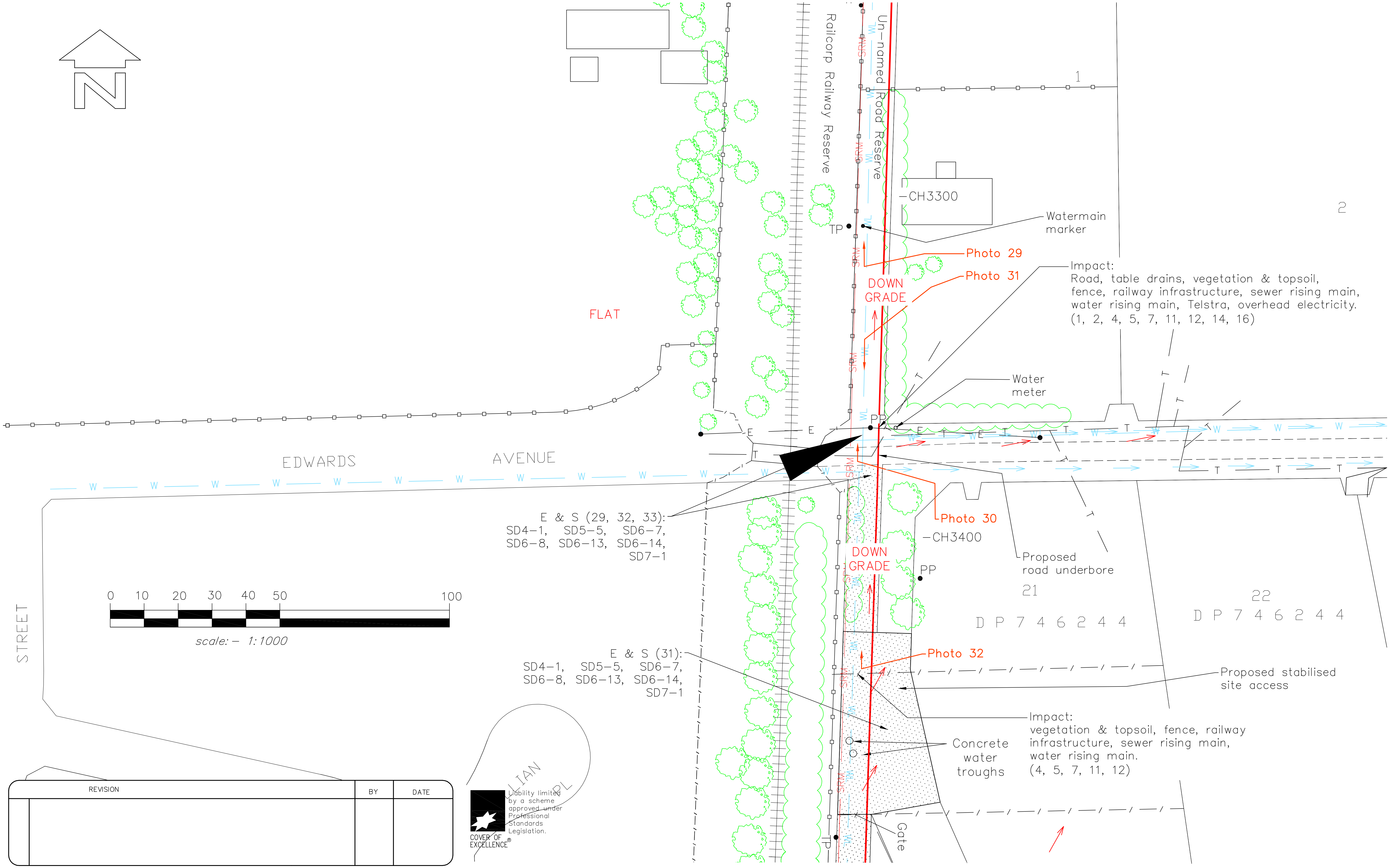

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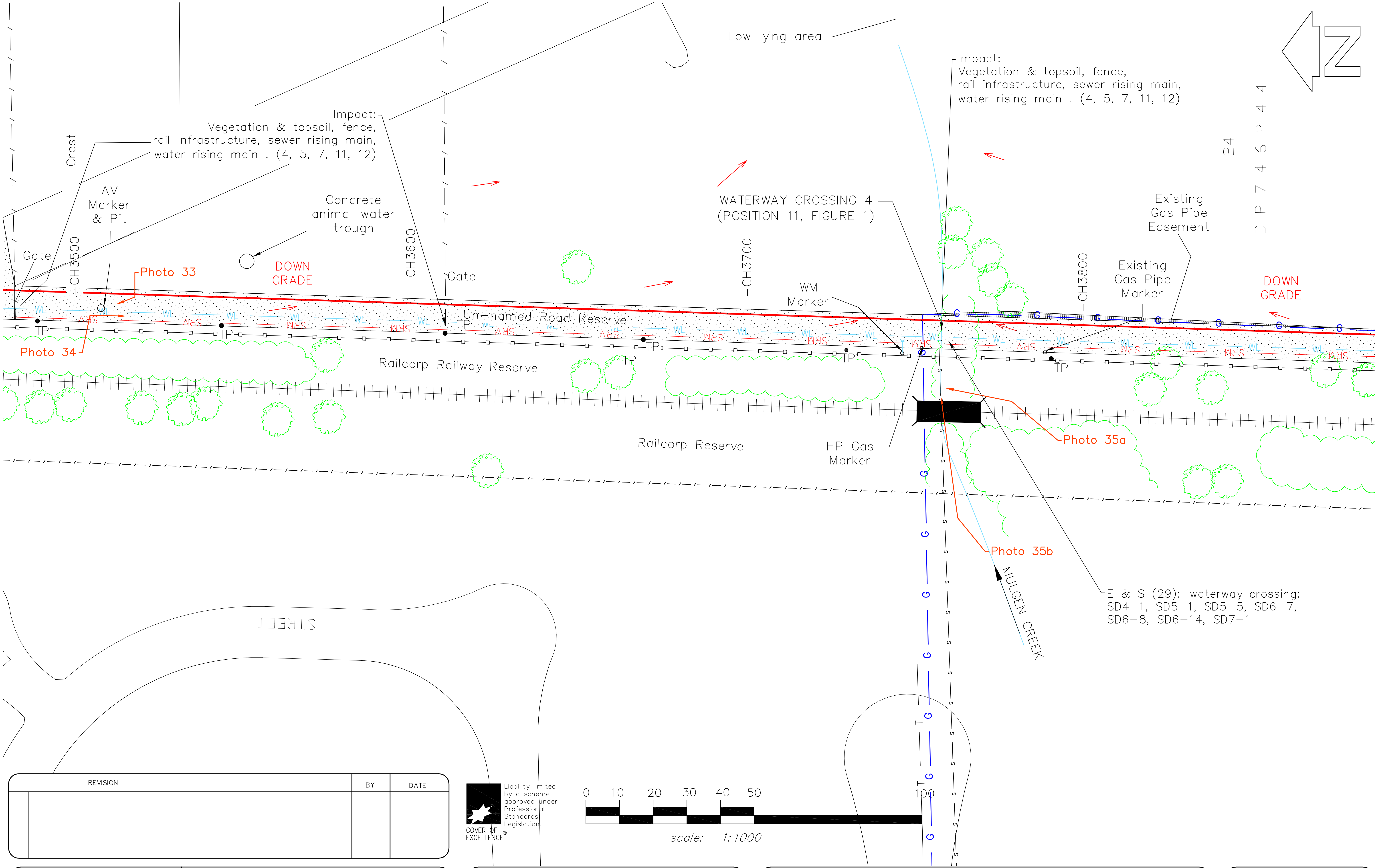
Plan for 'Infrastructure Impacts' and 'Erosion and Sediment Control Management' Reports for the proposed Shoalhaven Starches Gas Pipeline project at Meroo Meadow and Bomaderry, NSW

REF. No. 24710-04
sheet 11 of 16
REVISION 00



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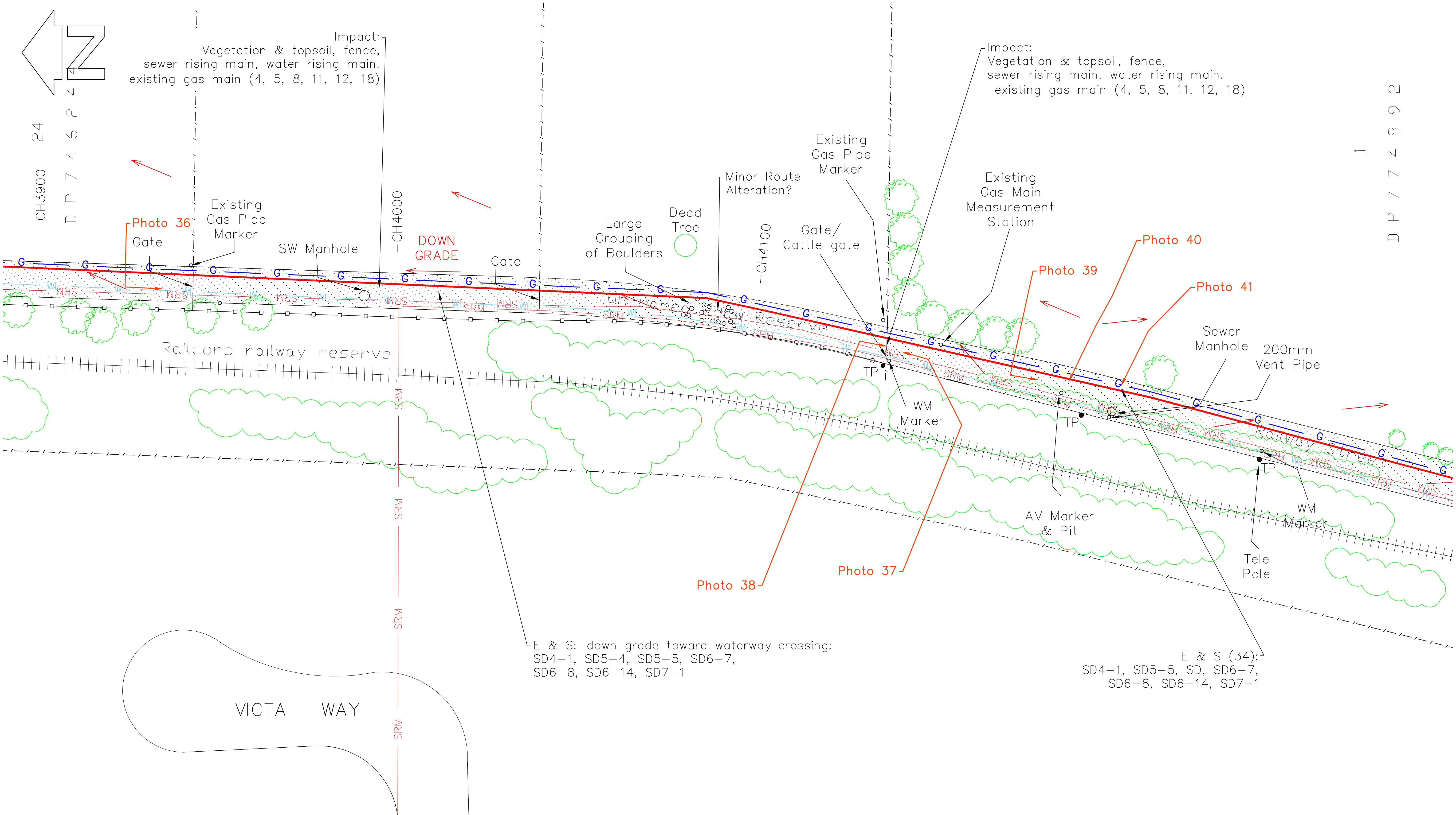
EROSION & SEDIMENT CONTROL MANAGEMENT PLAN FOR PROPOSED SHOALHAVEN STARCHES GAS PIPELINE, FROM PESTELLS LANE TO THE BOLONG ROAD FACTORY

REF. No. 24710-04
sheet 12 of 16
REVISION 01



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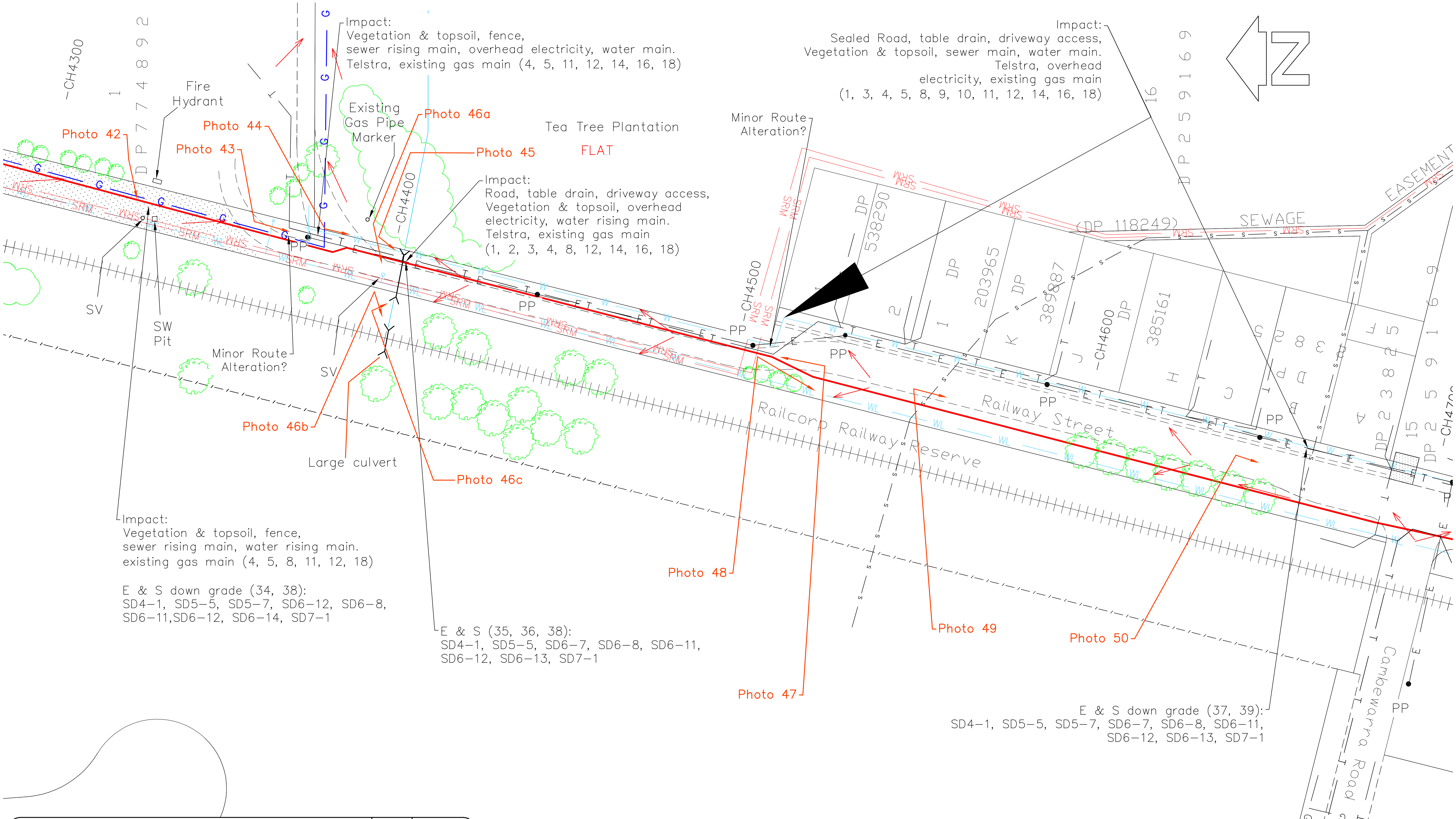

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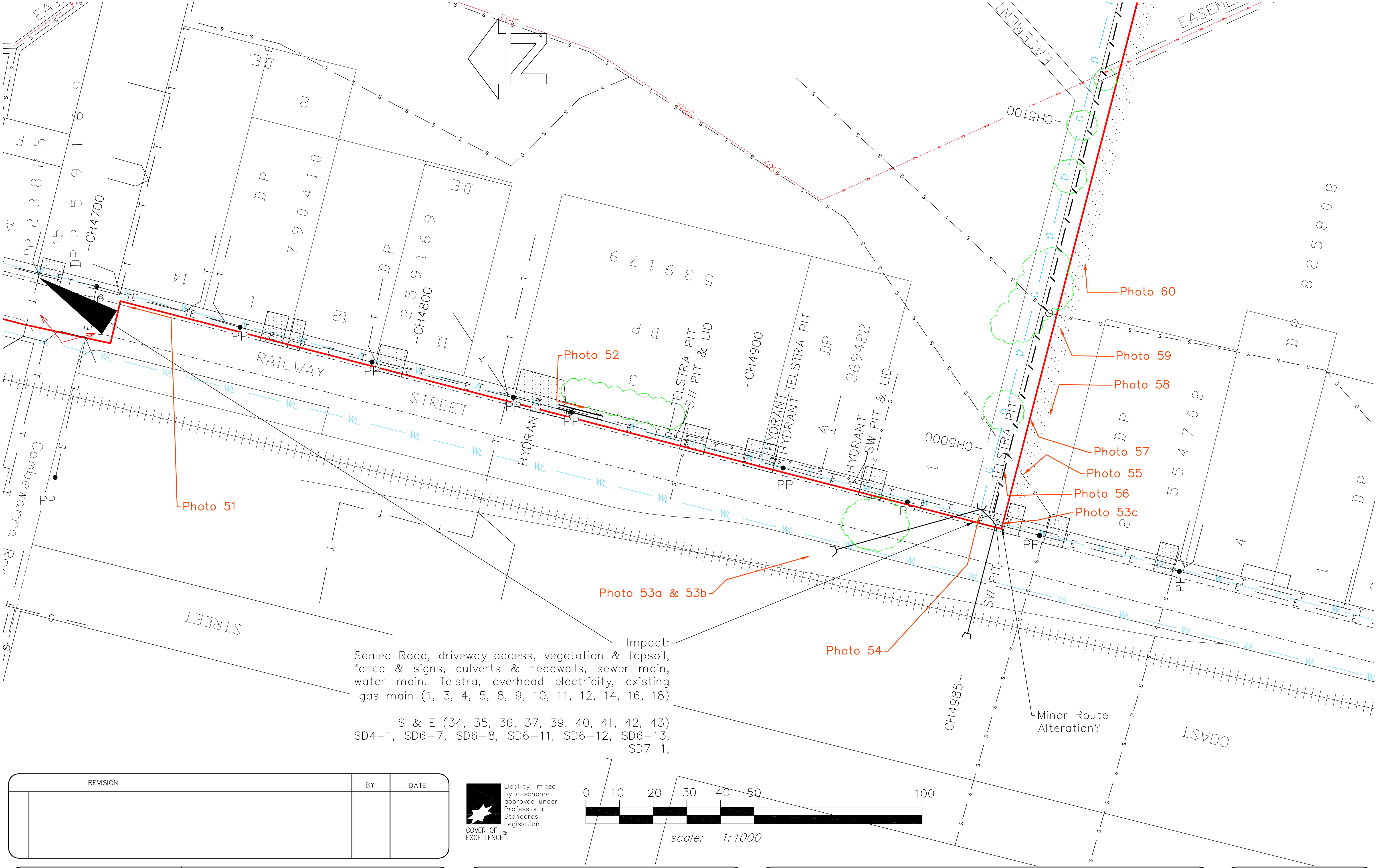

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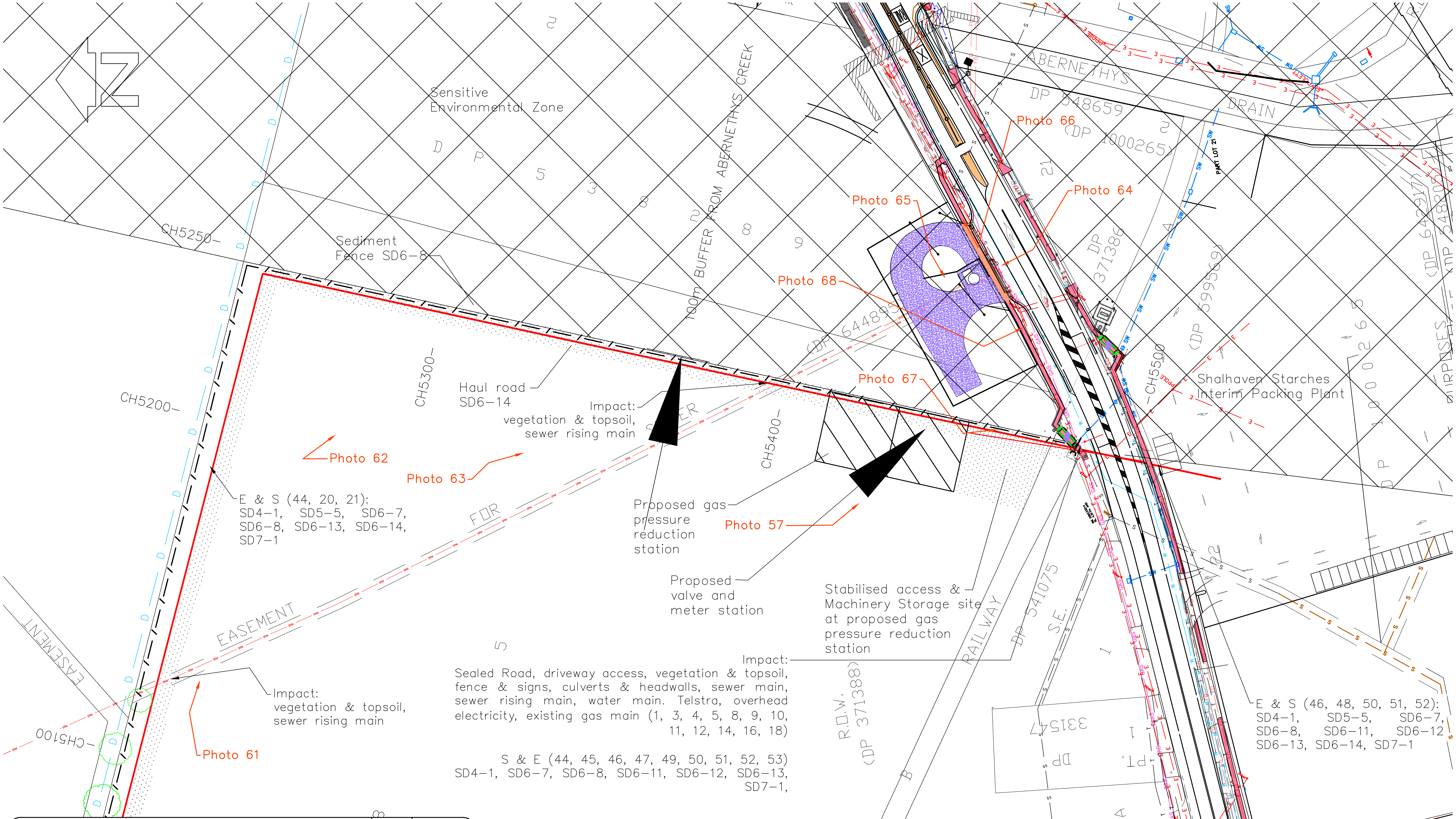

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REF. No. 24710–04

sheet 16 of 16

REVISION 00

Appendix D – Erosion and Sediment Control Figures

Appendix D:

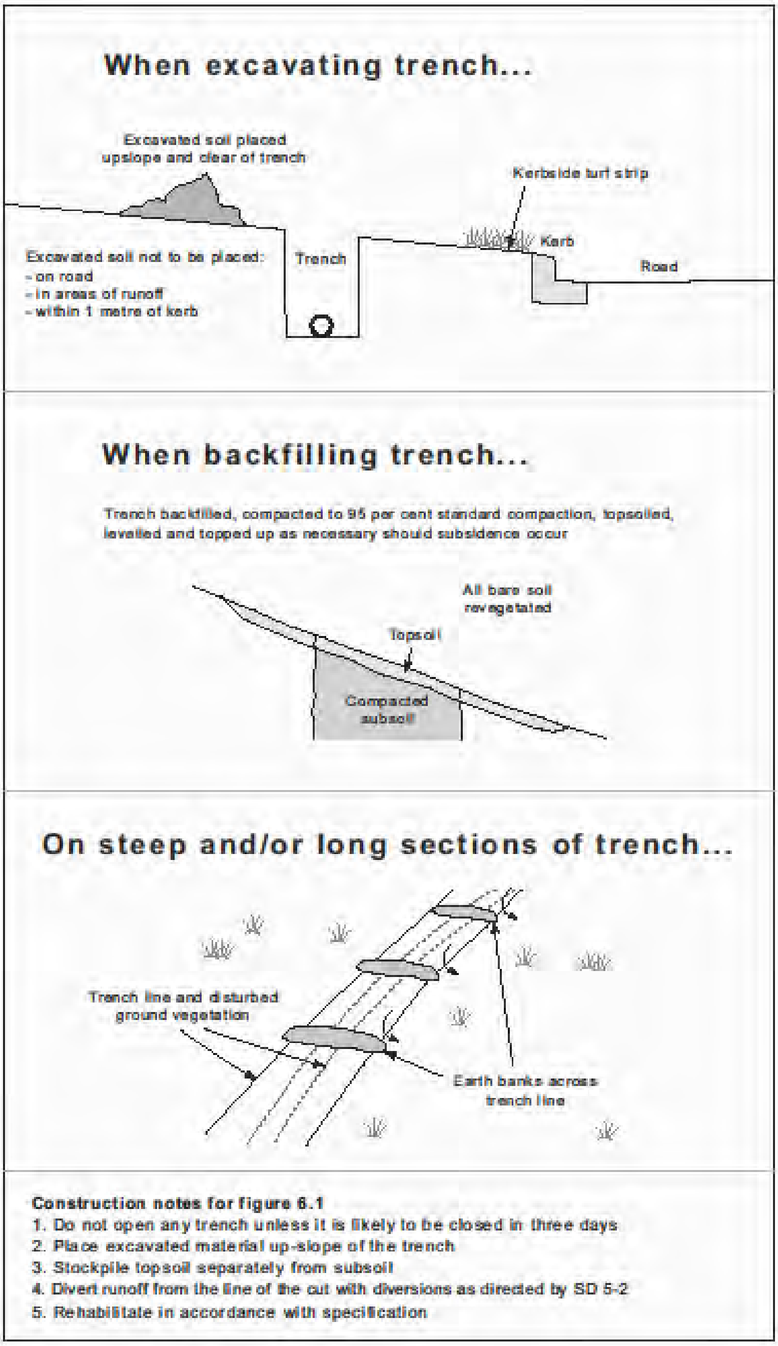


Figure 2: Erosion and sediment control details for trench construction on steep sites

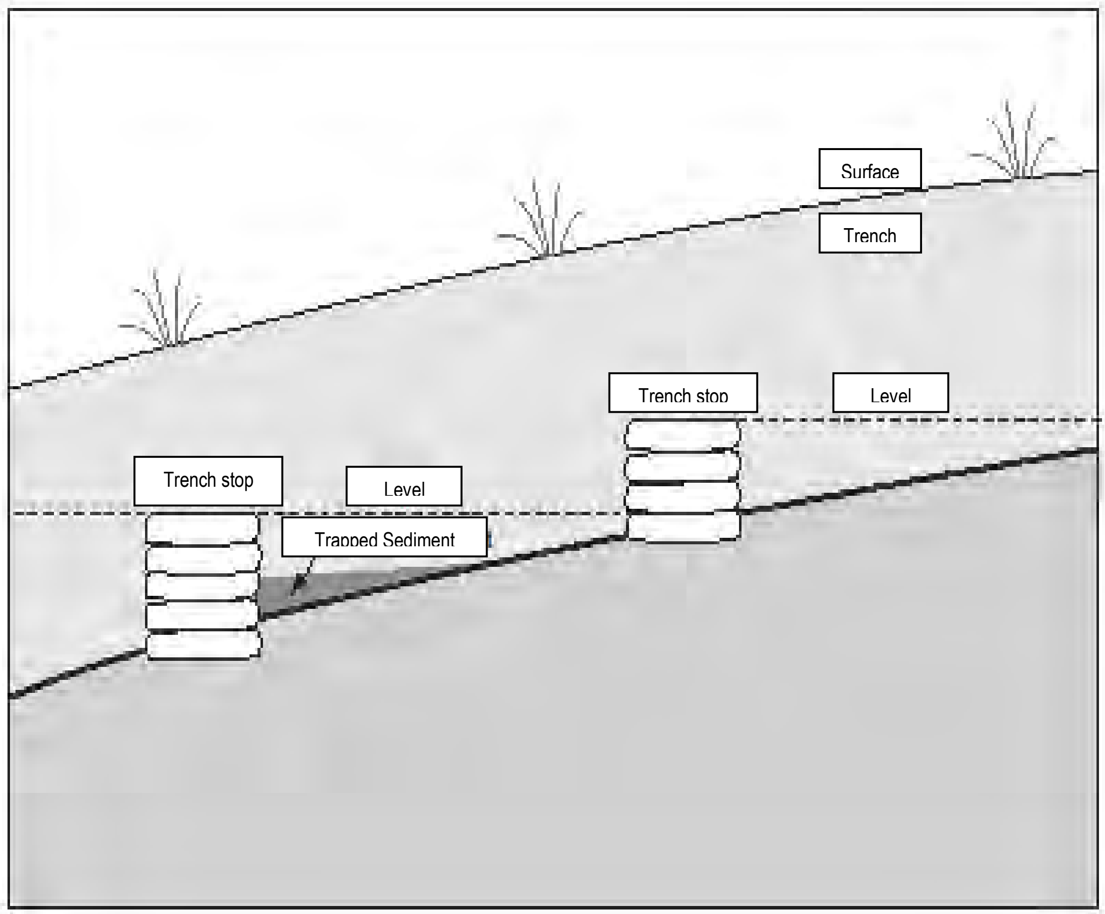
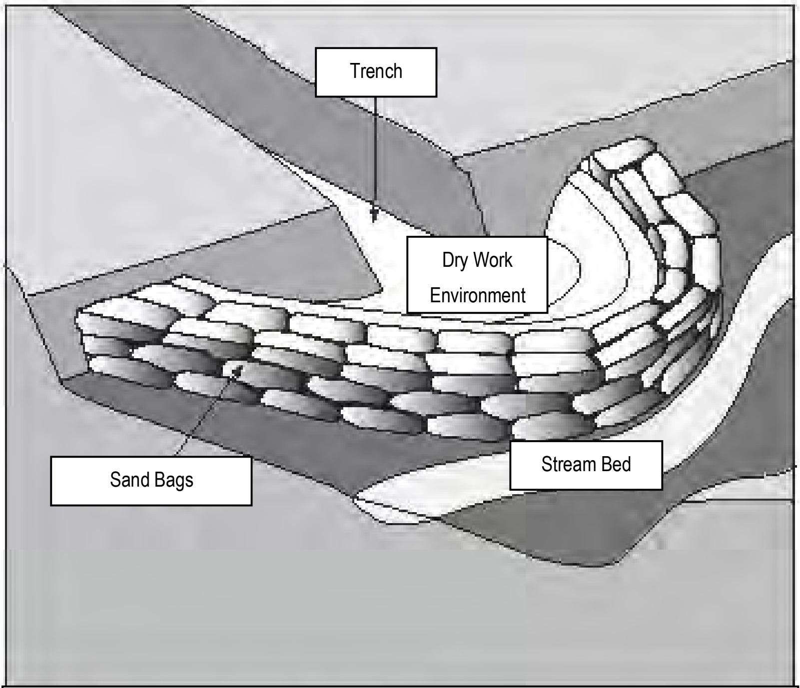
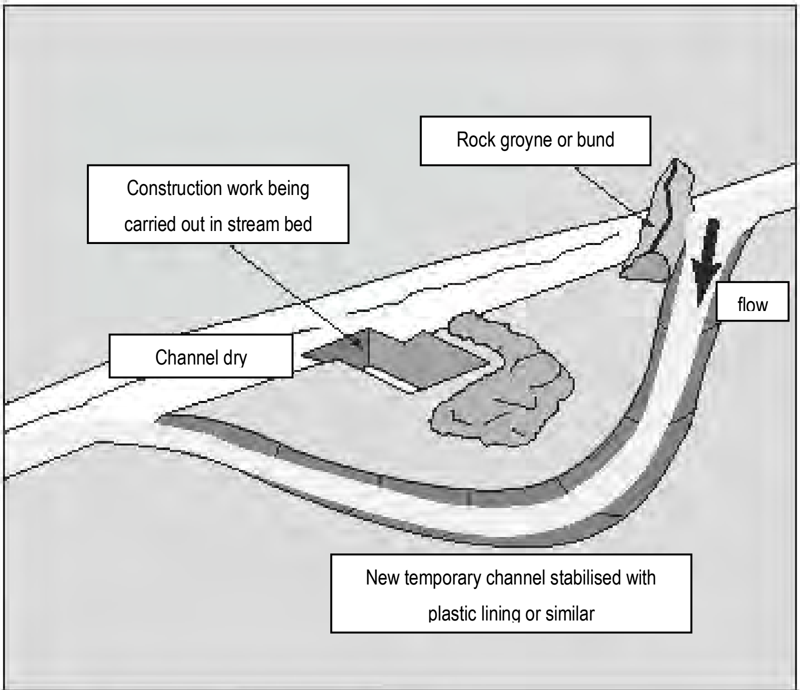


Figure 3: Typical trench stop detail for steep grades

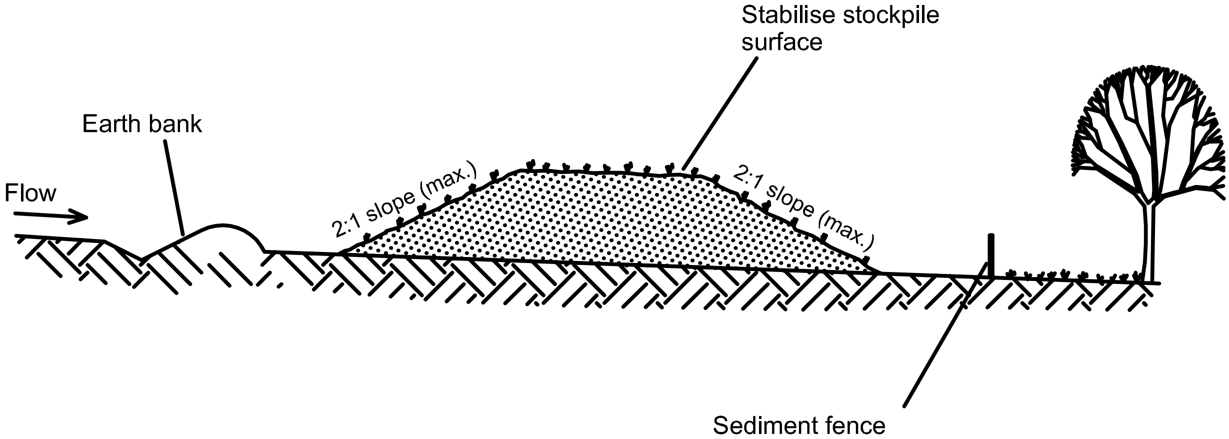


Option 1 – Stream diversion located within stream bed



Option 2 – Stream diversion via a new excavated channel

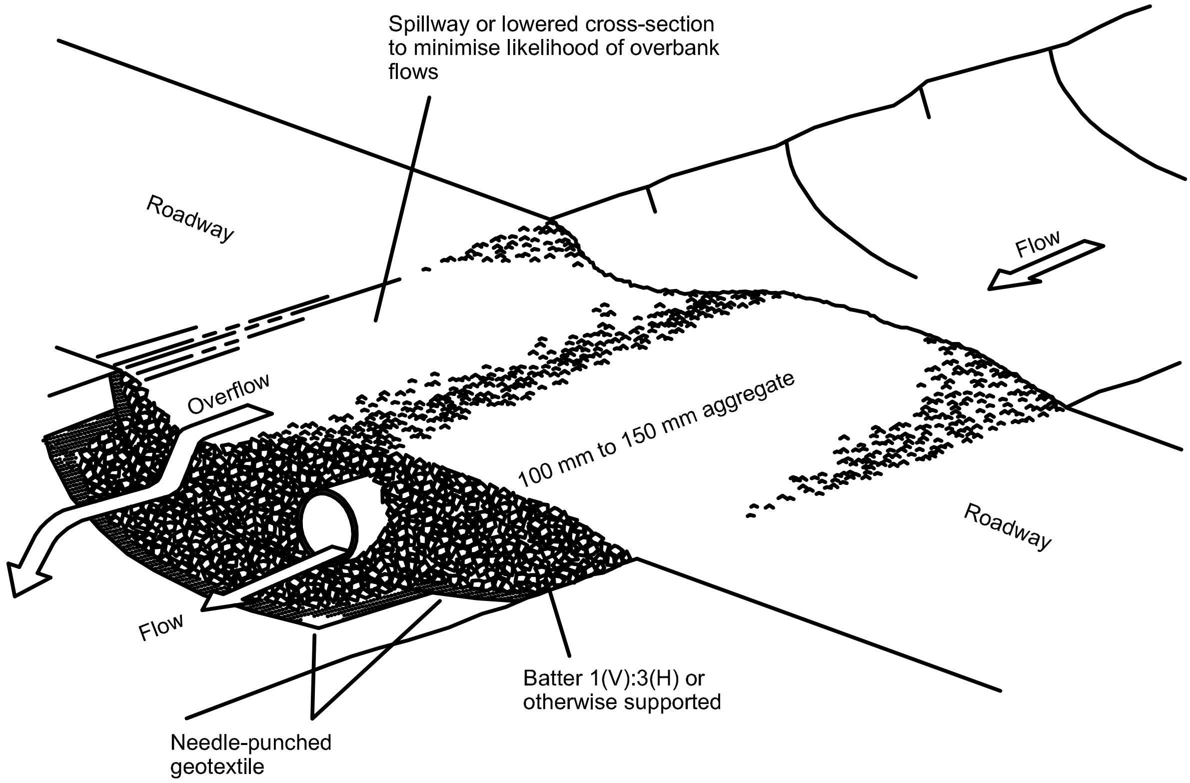
Figure 4: Typical options for waterway crossings



Construction Notes

1. Place stockpiles more than 2 (preferably 5) metres from existing vegetation, concentrated water flow, roads and hazard areas.
2. Construct on the contour as low, flat, elongated mounds.
3. Where there is sufficient area, topsoil stockpiles shall be less than 2 metres in height.
4. Where they are to be in place for more than 10 days, stabilise following the approved ESCP or SWMP to reduce the C-factor to less than 0.10.
5. Construct earth banks (Standard Drawing 5-5) on the upslope side to divert water around stockpiles and sediment fences (Standard Drawing 6-8) 1 to 2 metres downslope.

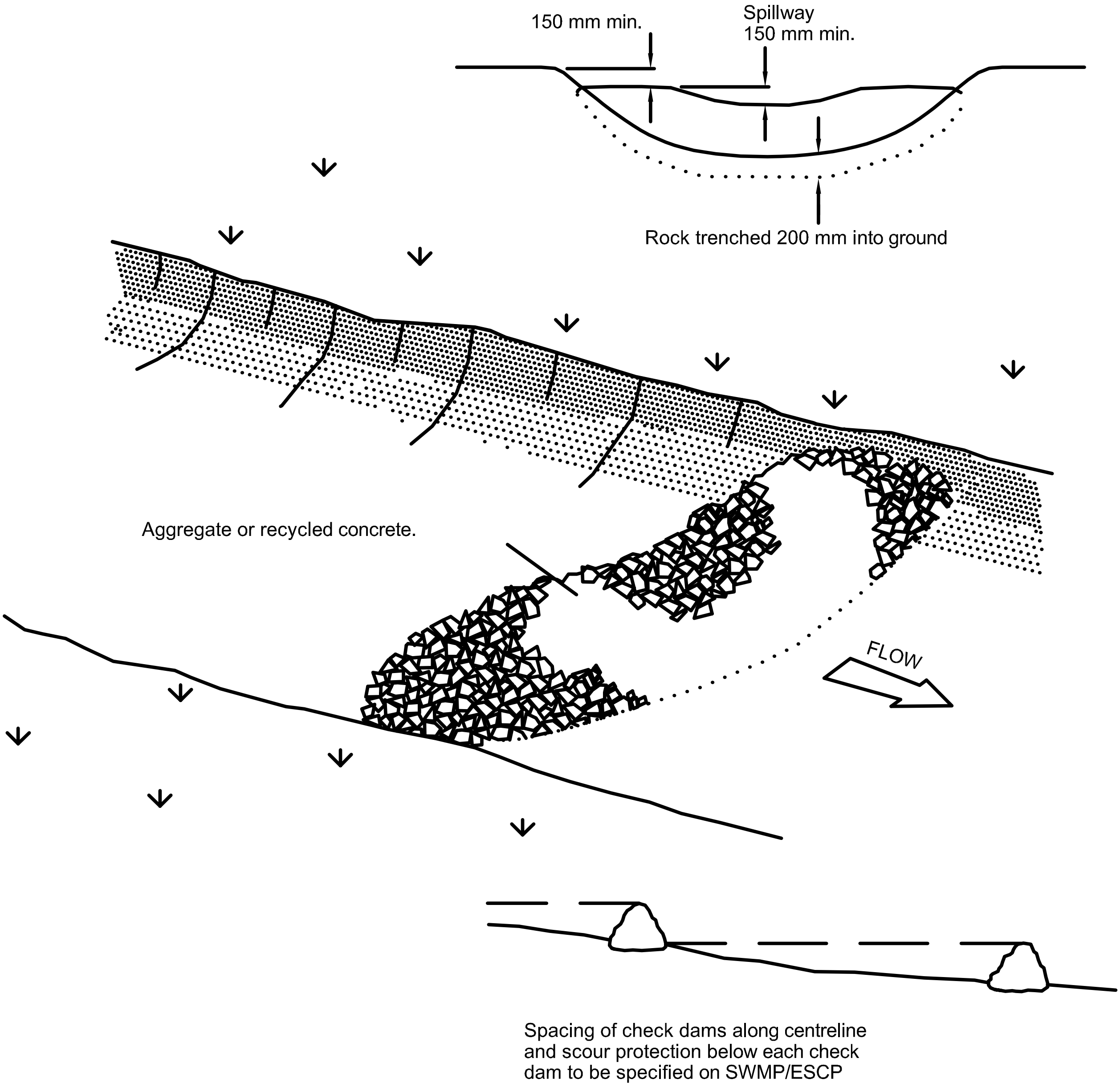
STOCKPILES SD 4-1



Construction Notes

1. Prohibit all traffic until the access way is constructed.
2. Strip any topsoil and place a needle-punched textile over the base of the crossing.
3. Place clean, rigid, non polluting aggregate or gravel in the 100 mm to 150 mm size class over the fabric to a minimum depth of 200 mm.
4. Provide a 3-metre wide carriageway with sufficient length of culvert pipe to allow less than a 3(H): 1 (V) slope on side batters.
5. Install a lower section to act as an emergency spillway in greater than design storm events.
6. Ensure that culvert outlets extend beyond the toe of fill embankments.

TEMPORARY WATERWAY CROSSING SD 5-1

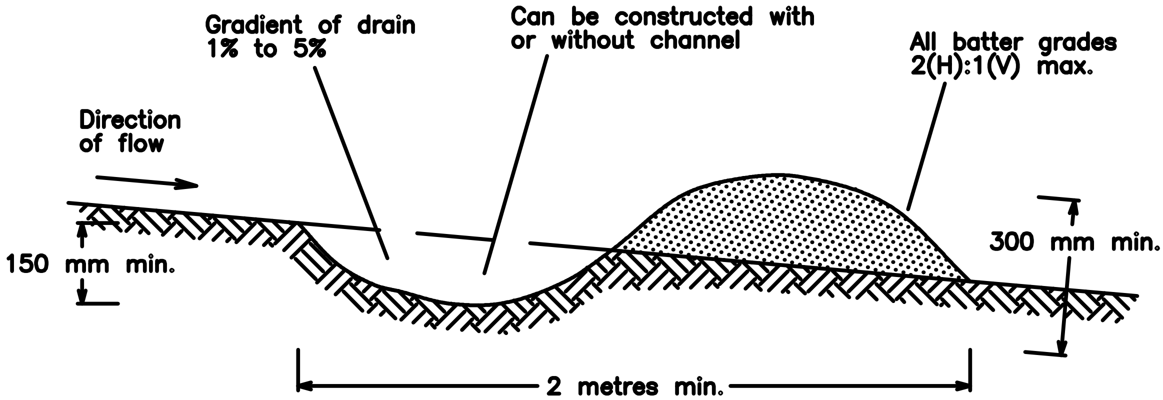


Construction Notes

1. Check dams can be built with various materials, including rocks, logs, sandbags and straw bales. The maintenance program should ensure their integrity is retained, especially where constructed with straw bales. In the case of bales, this might require their replacement each two to four months.
2. Trench the check dam 200 mm into the ground across its whole width. Where rock is used, fill the trenches to at least 100 mm above the ground surface to reduce the risk of undercutting.
3. Normally, their maximum height should not exceed 600 mm above the gully floor. The centre should act as a spillway, being at least 150 mm lower than the outer edges.
4. Space the dams so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM

SD 5-4



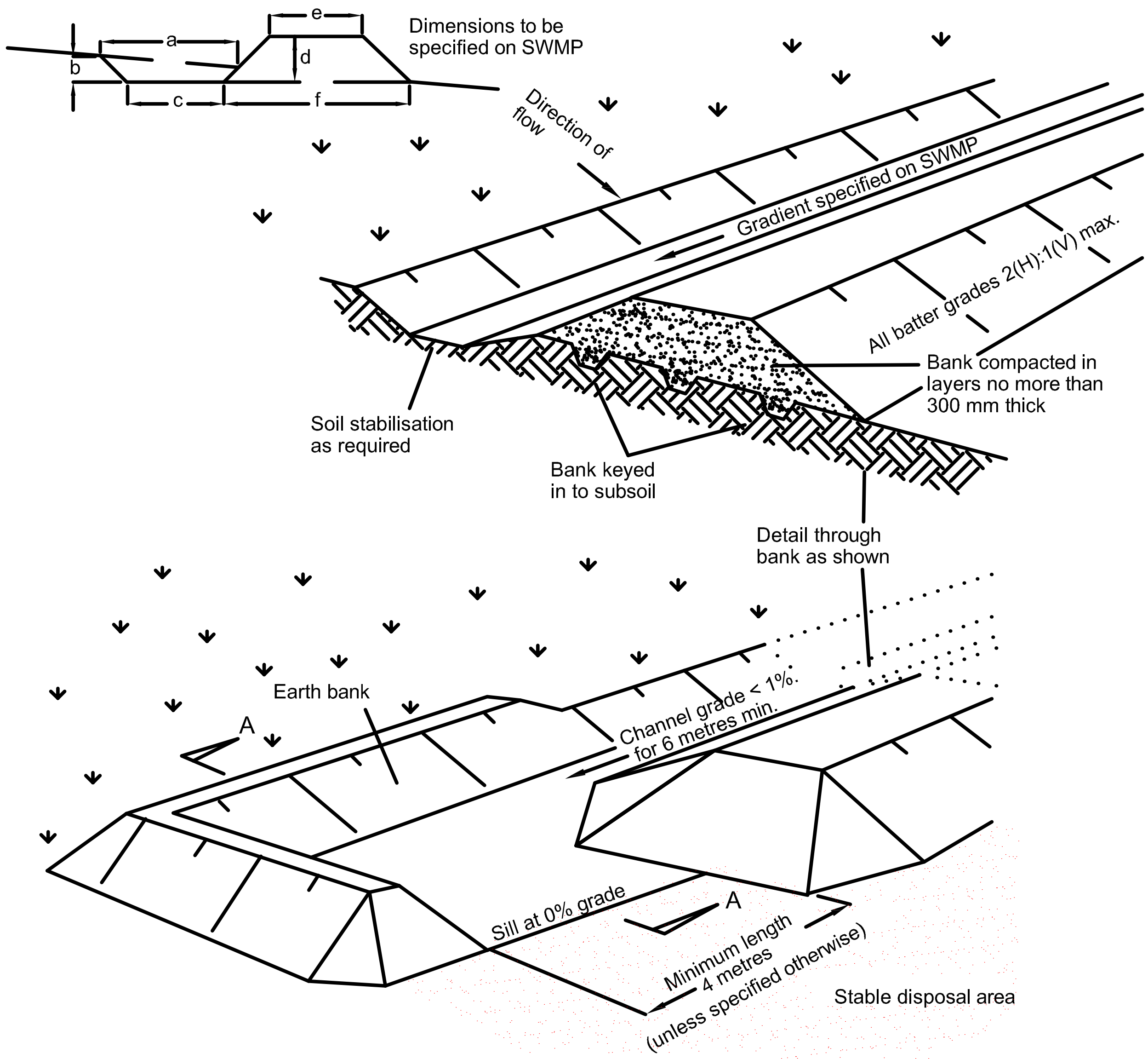
NOTE: Only to be used as temporary bank where maximum upslope length is 80 metres.

Construction Notes

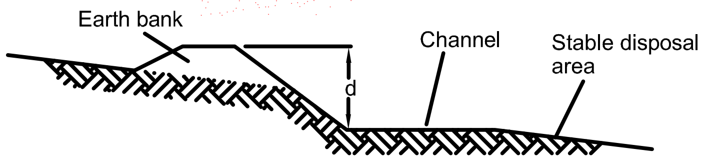
1. Build with gradients between 1 percent and 5 percent.
2. Avoid removing trees and shrubs if possible - work around them.

3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V shaped.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction.

EARTH BANK (LOW FLOW) SD 5-5



Level Spreader (or Sill)

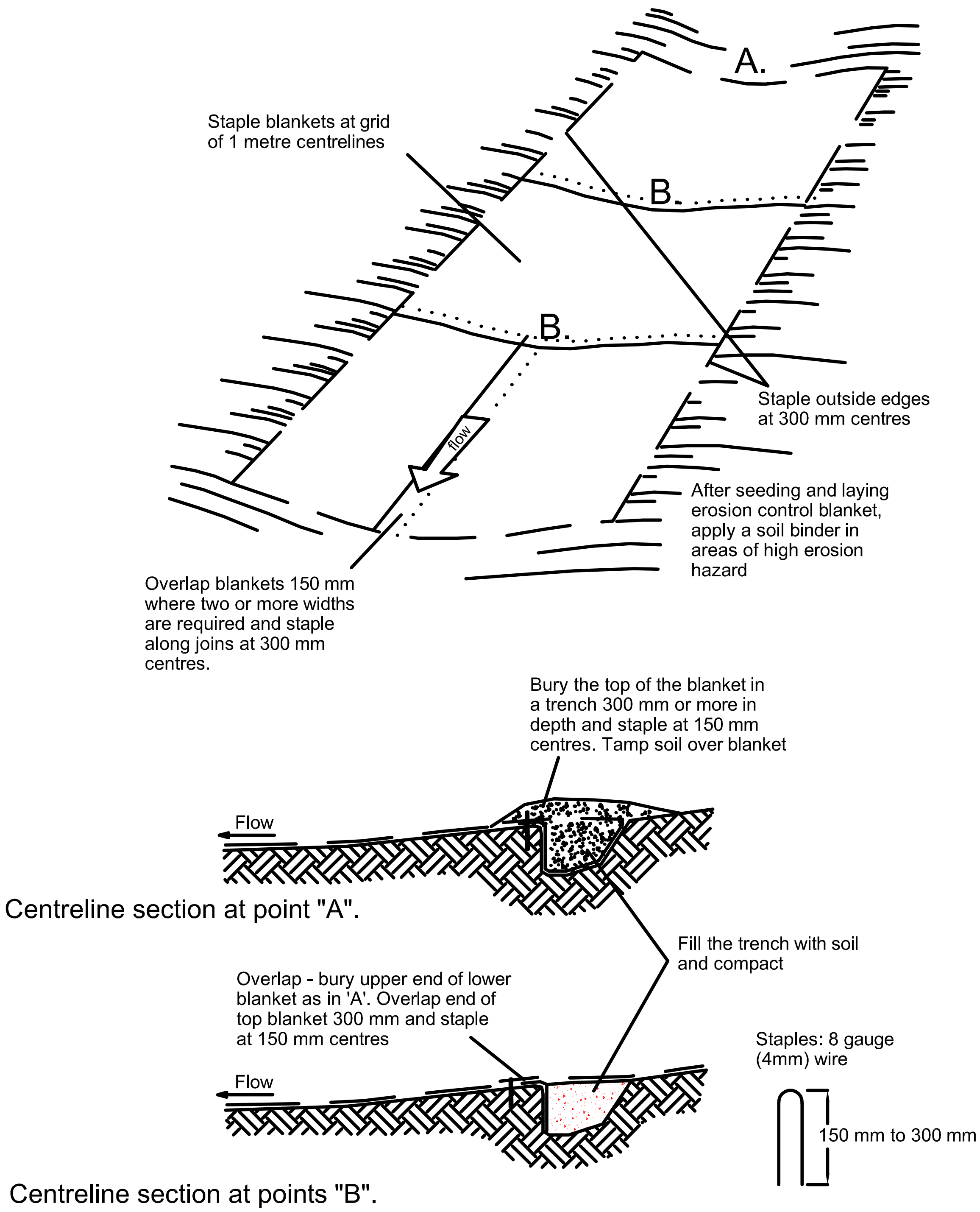


Section AA

Construction Notes

1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V-shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

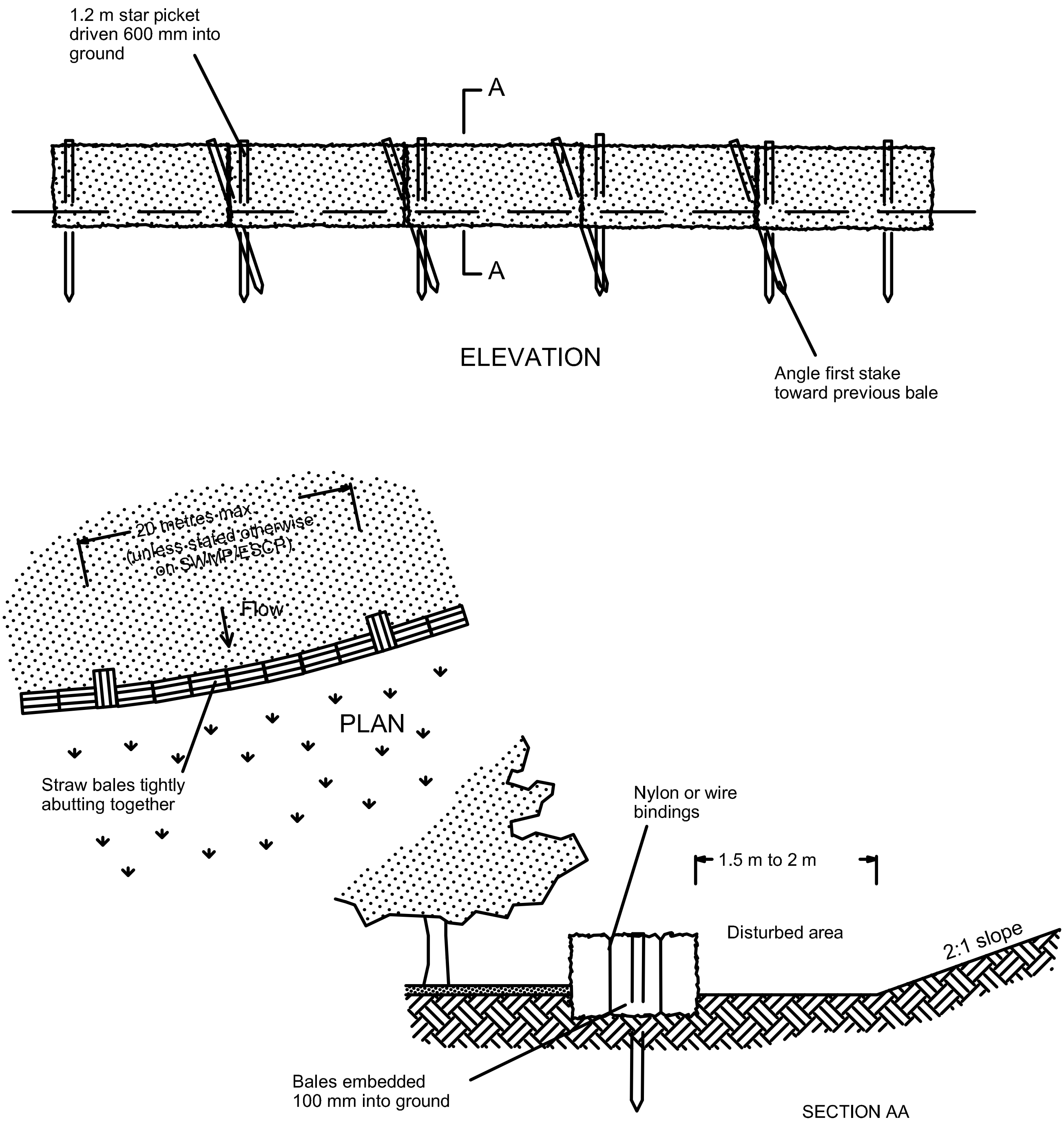
EARTH BANK (HIGH FLOWS) SD 5-6



Construction Notes

1. Remove any rocks, clods, sticks or grass from the surface before laying matting
2. Ensure that topsoil is at least 75 mm deep.
3. Complete fertilising and seeding before laying the matting.
4. Ensure fabric will be continuously in contact with the soil by grading the surface carefully first.
5. Lay the fabric in "shingle-fashion", with the end of each upstream roll overlapping those downstream. Ensure each roll is anchored properly at its upslope end (Standard Drawing 5-7b).
6. Ensure that the full width of flow in the channel is covered by the matting up to the design storm event, usually in the 10-year ARI time of concentration storm event.
7. Divert water from the structure until vegetation is stabilised properly.

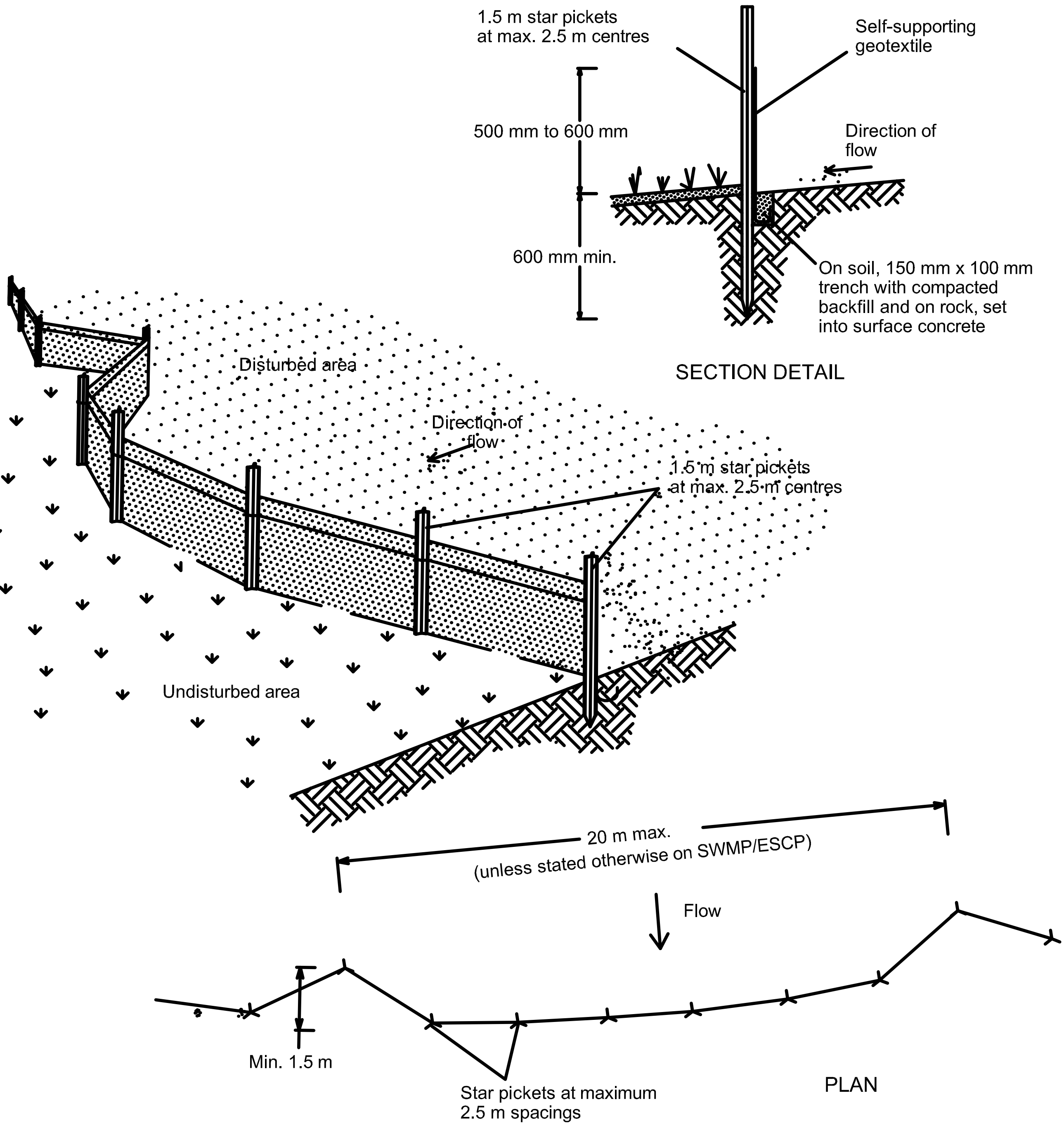
RECP : CONCENTRATED FLOW SD 5-7



Construction Notes

1. Construct the straw bale filter as close as possible to being parallel to the contours of the site.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws are to be placed parallel to ground.
3. Ensure that the maximum height of the filter is one bale.
4. Embed each bale in the ground 75 mm to 100 mm and anchor with two 1.2 metre star pickets or stakes. Angle the first star picket or stake in each bale towards the previously laid bale. Drive them 600 mm into the ground and, if possible, flush with the top of the bales. Where star pickets are used and they protrude above the bales, ensure they are fitted with safety caps.
5. Where a straw bale filter is constructed downslope from a disturbed batter, ensure the bales are placed 1 to 2 metres downslope from the toe.
6. Establish a maintenance program that ensures the integrity of the bales is retained - they could require replacement each two to four months.

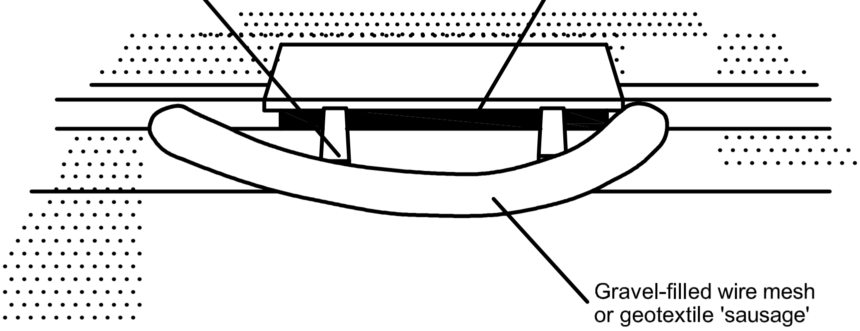
STRAW BALE FILTER SD 6-7

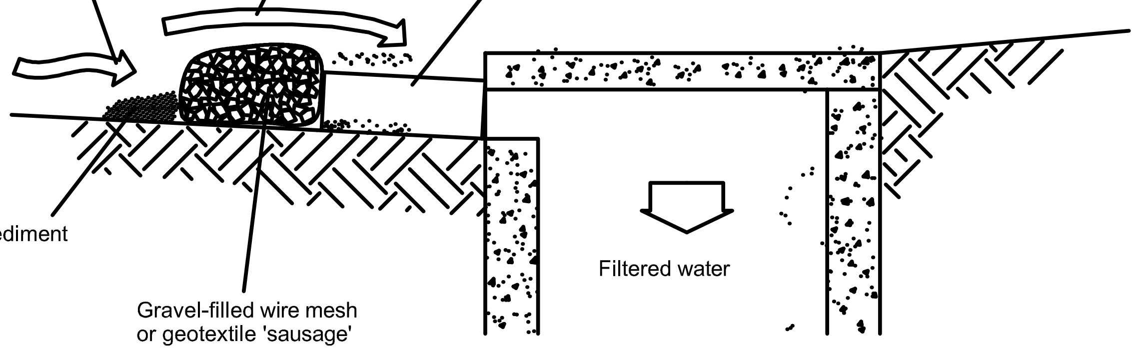


Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE SD 6-8



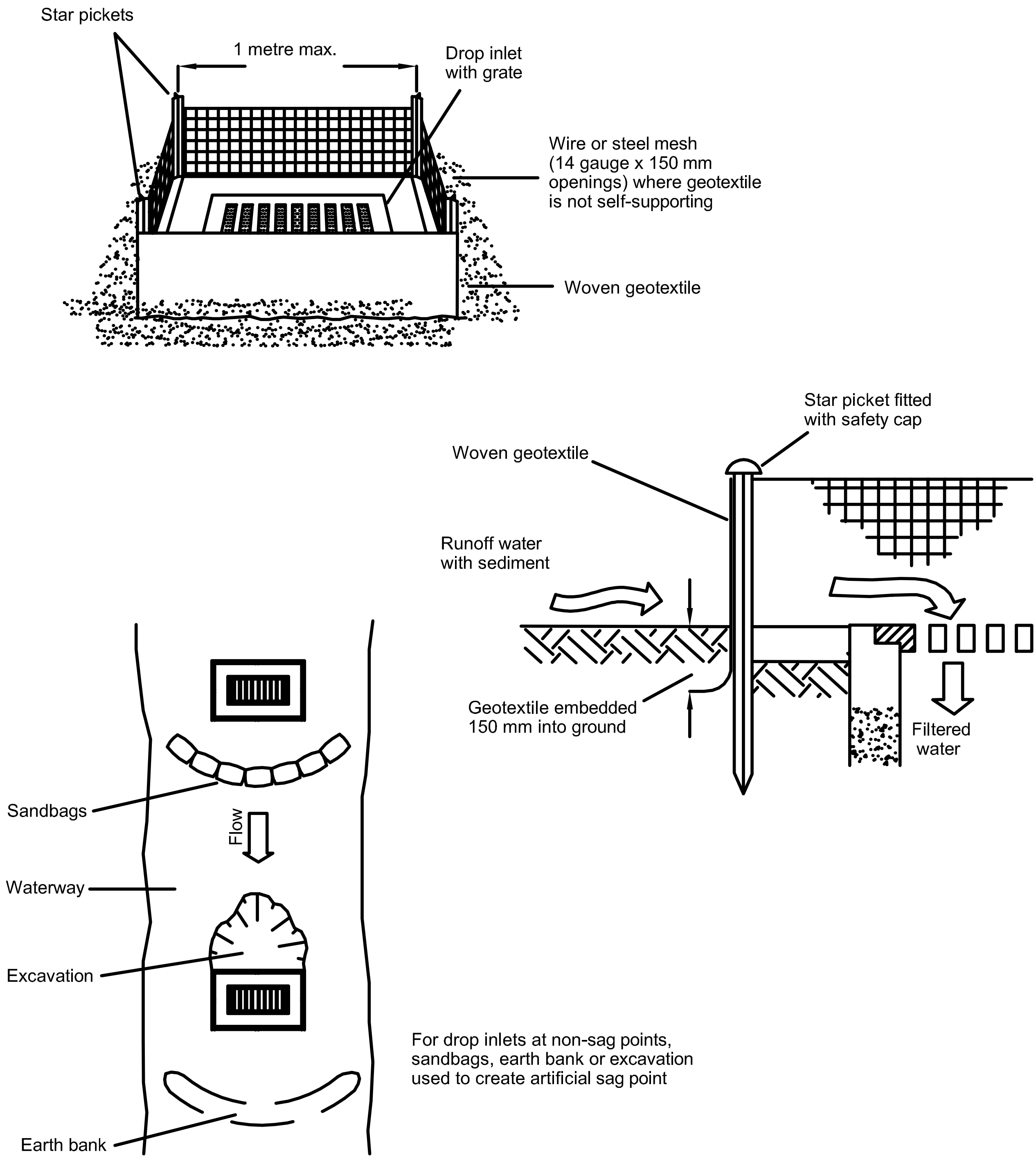


NOTE: This practice only to be used where specified in an approved SWMP/ESCP.

Construction Notes

1. Install filters to kerb inlets only at sag points.
2. Fabricate a sleeve made from geotextile or wire mesh longer than the length of the inlet pit and fill it with 25 mm to 50 mm gravel.
3. Form an elliptical cross-section about 150 mm high x 400 mm wide.
4. Place the filter at the opening leaving at least a 100-mm space between it and the kerb inlet. Maintain the opening with spacer blocks.
5. Form a seal with the kerb to prevent sediment bypassing the filter.
6. Sandbags filled with gravel can substitute for the mesh or geotextile providing they are placed so that they firmly abut each other and sediment-laden waters cannot pass between.

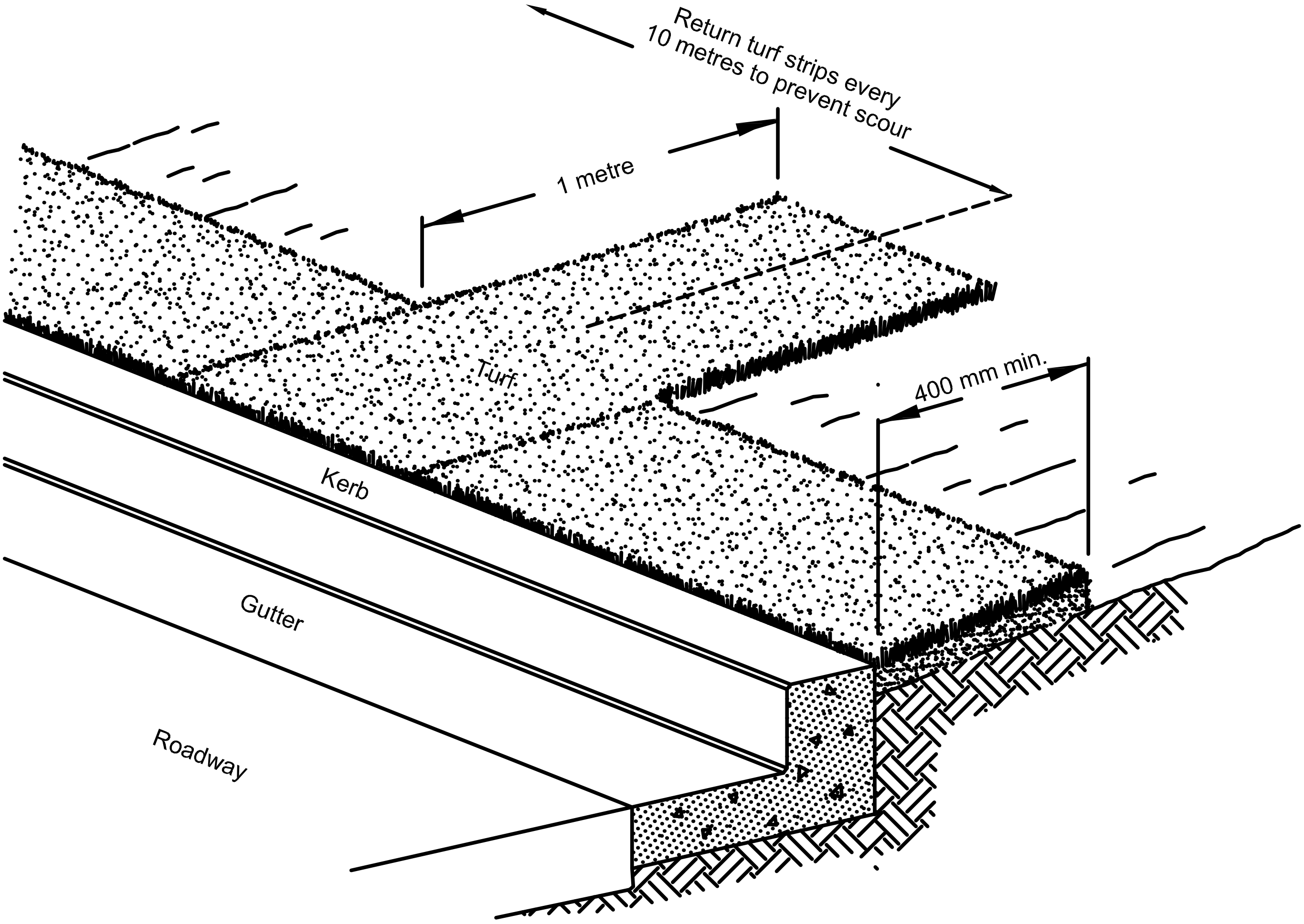
MESH AND GRAVEL INLET FILTER SD 6-11



Construction Notes

1. Fabricate a sediment barrier made from geotextile or straw bales.
2. Follow Standard Drawing 6-7 and Standard Drawing 6-8 for installation procedures for the straw bales or geofabric. Reduce the picket spacing to 1 metre centres.
3. In waterways, artificial sag points can be created with sandbags or earth banks as shown in the drawing.
4. Do not cover the inlet with geotextile unless the design is adequate to allow for all waters to bypass it.

GEOTEXTILE INLET FILTER SD 6-12

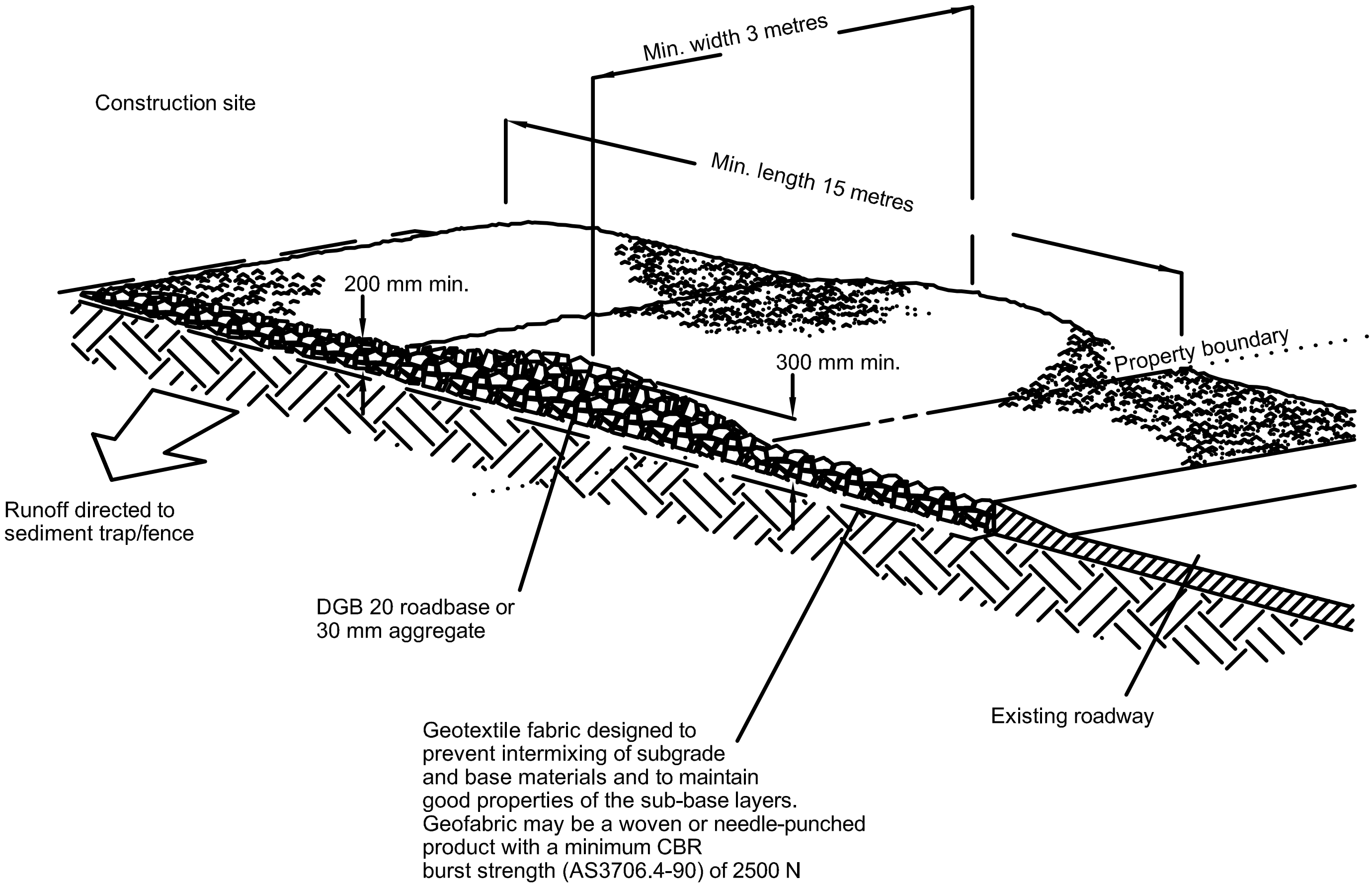


Construction Notes

1. Install a 400 mm minimum wide roll of turf on the footpath next to the kerb and at the same level as the top of the kerb.
2. Lay 1.4 metre long turf strips normal to the kerb every 10 metres.
3. Rehabilitate disturbed soil behind the turf strip following the ESCP/SWMP.

KERBSIDE TURF STRIP

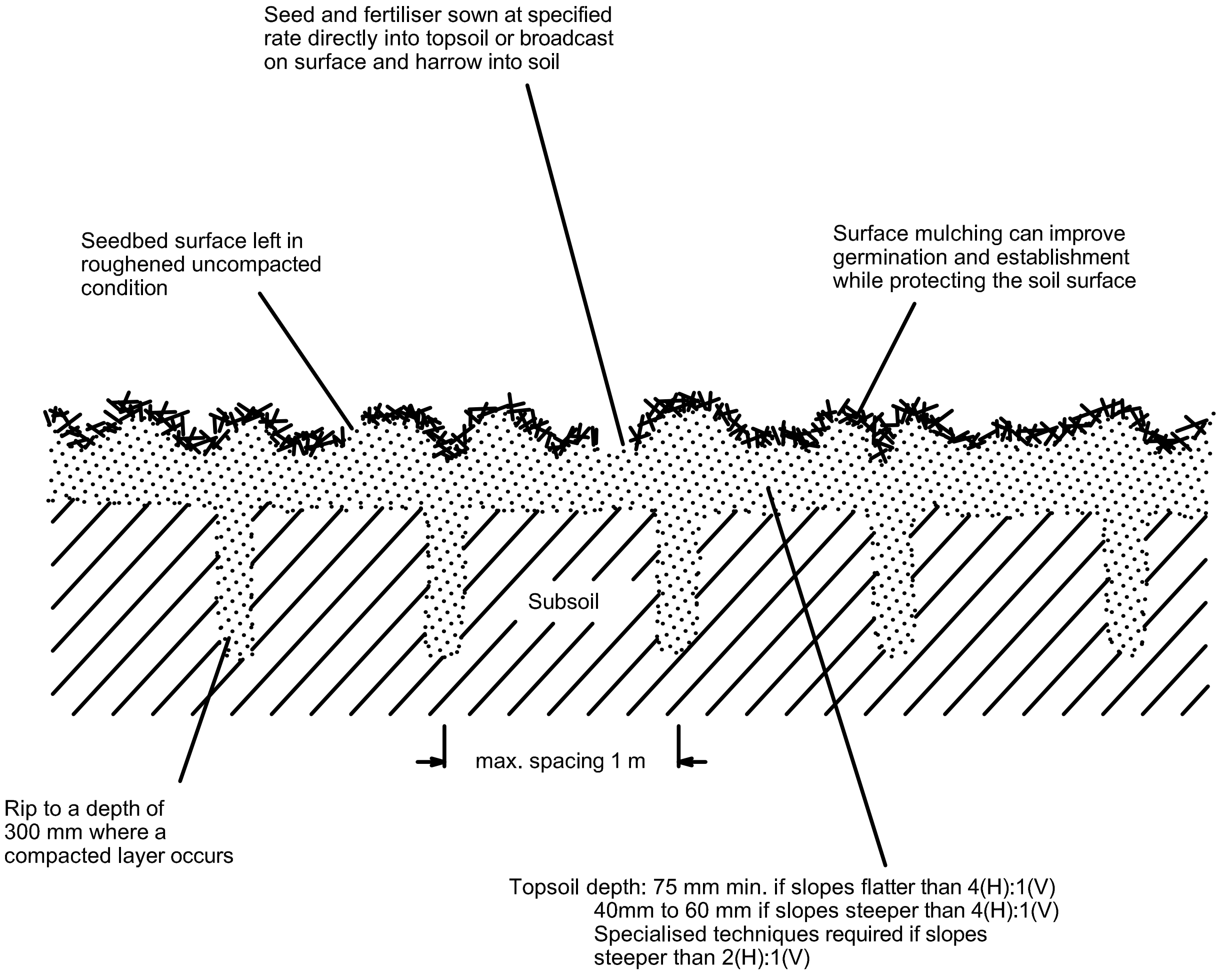
SD 6-13



Construction Notes

1. Strip the topsoil, level the site and compact the subgrade.
2. Cover the area with needle-punched geotextile.
3. Construct a 200 mm thick pad over the geotextile using road base or 30 mm aggregate.
4. Ensure the structure is at least 15 metres long or to building alignment and at least 3 metres wide.
5. Where a sediment fence joins onto the stabilised access, construct a hump in the stabilised access to divert water to the sediment fence

STABILISED SITE ACCESS SD 6-14



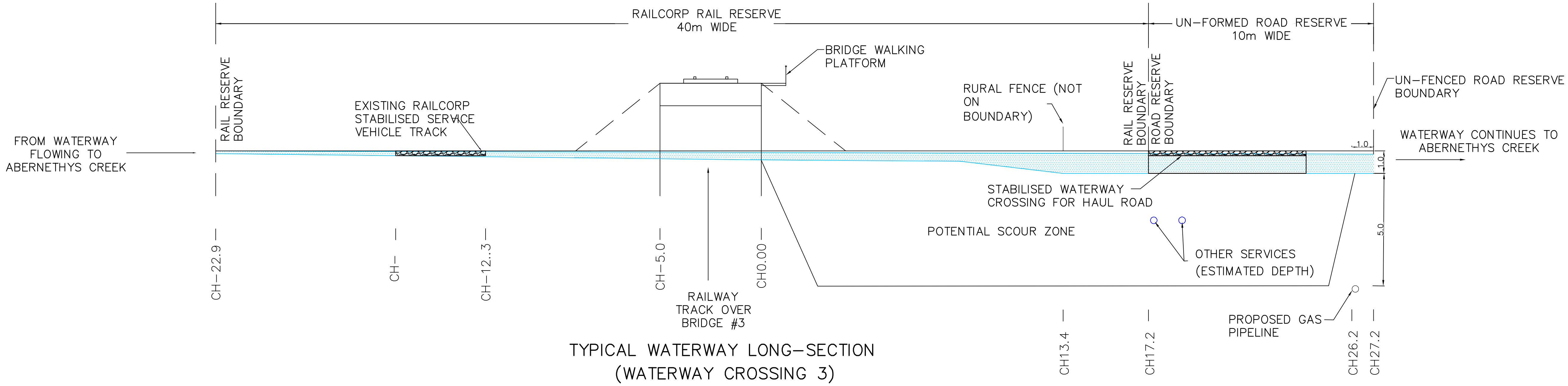
Construction Notes

1. Loosen compacted soil before sowing any seed. If necessary, rip the soil to a depth of 300 mm. Avoid rotary hoe cultivation.
2. Work the ground only as much as necessary to achieve the desired tilth and prepare a good seedbed.
3. Avoid cultivation in very wet or very dry conditions.
4. Cultivate on or close to the contour where possible, not up and down the slope.

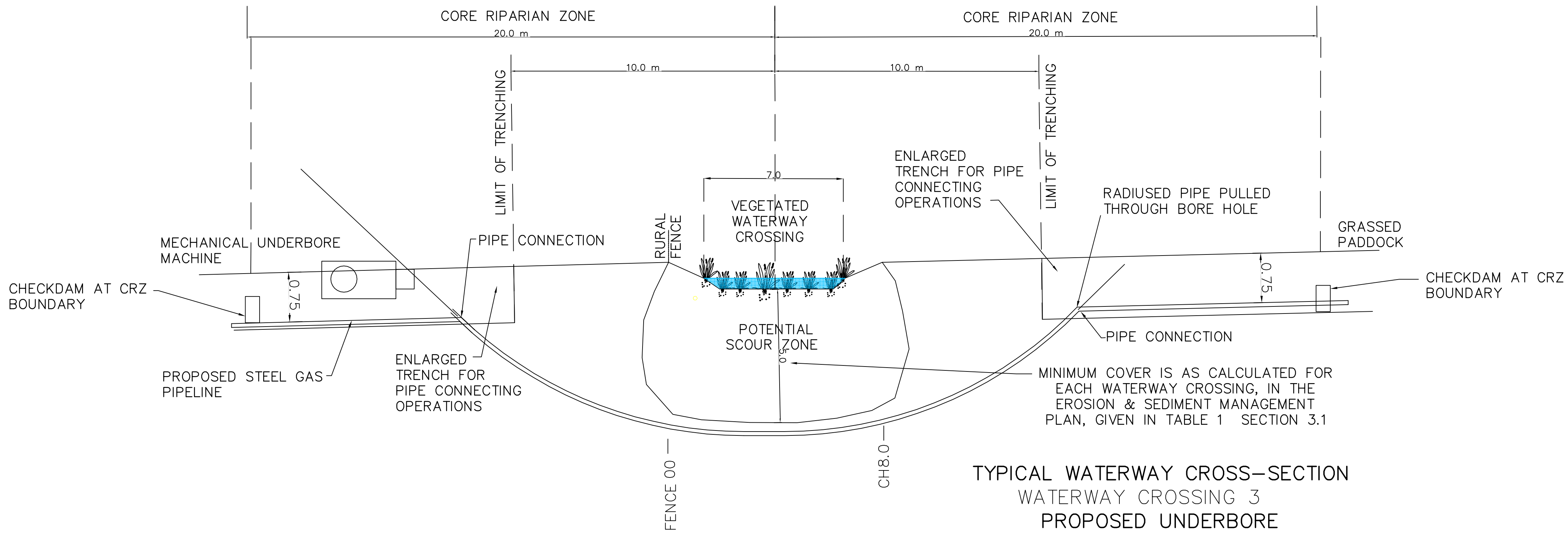
SEEDBED PREPARATION

SD 7-1

Appendix E – Figure 2: Cross Section of Waterway Crossing 3



TYPICAL WATERWAY LONG-SECTION
(WATERWAY CROSSING 3)



TYPICAL WATERWAY CROSS-SECTION
WATERWAY CROSSING 3
PROPOSED UNDERBORE

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0 10 20 30 40 50 100

scale: — 1:1000

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1:1000 @ A3	ORIGIN:
	DATE OF PLAN: October 2011

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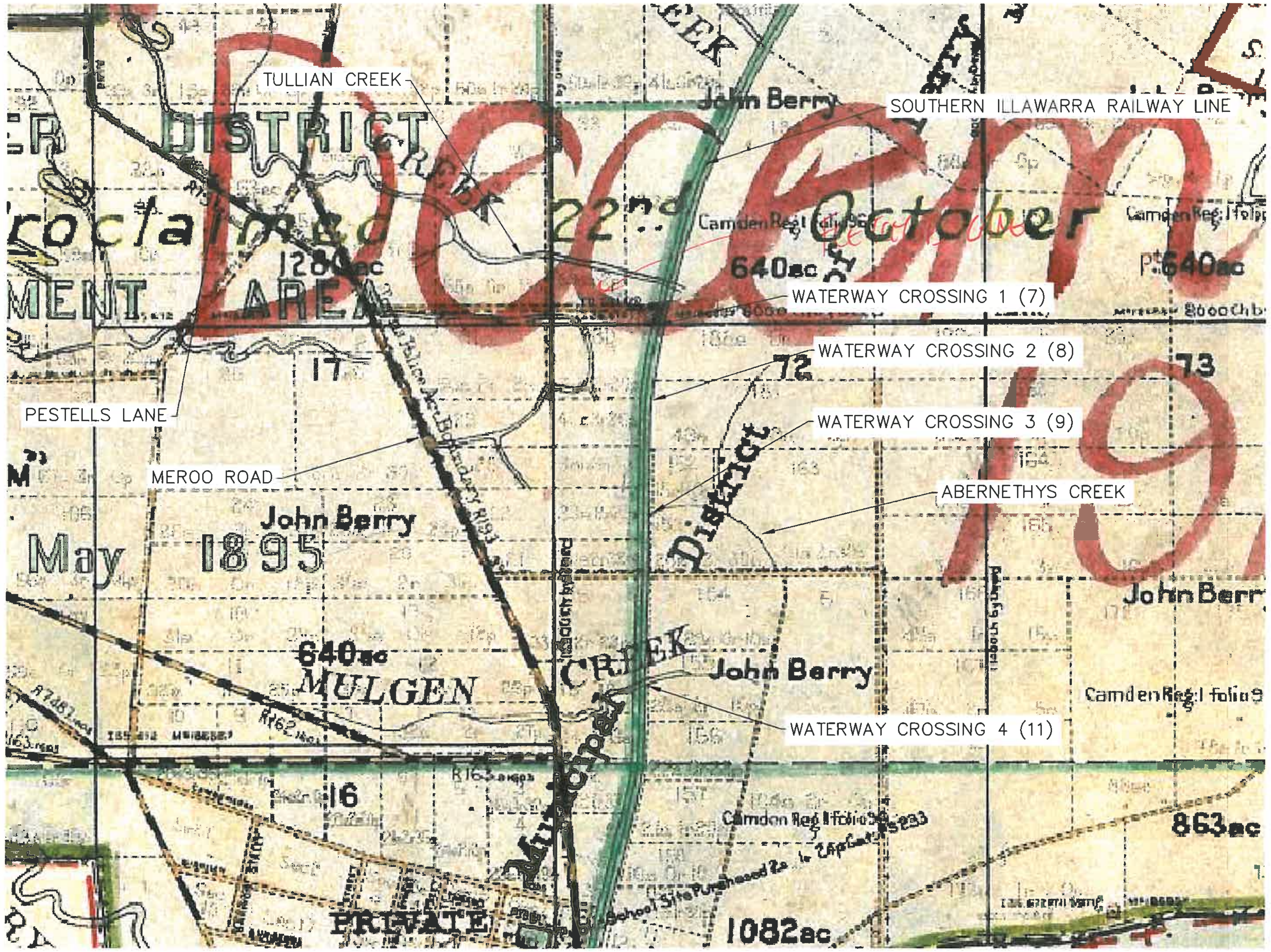
APPENDIX E: YPICAL SECTIONS – WATERWAY CROSSING 3 SHOWING UNDERBORE & SCOUR ZONES FOR PROPOSED GAS PIPELINE AT MEROO MEADOW AND BOMADERRY FOR SHOALHAVEN STARCHES

REF. No. 24710
sheet 1 of 1
REVISION 00

Appendix F: May 1895 Topographic Map Detail



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DATUM:
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DATE OF PLAN: FEB 2012

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APPENDIX F – may 1895 1:4000 topographic map for proposed gas pipeline project at Meroo Meadow and Bomaderry, NSW for Shoalhaven Starches

REF. No. 24710
sheet 1 of 1
REVISION 00

Appendix G: Coffey Environments Engineering Log – Excavation (Bore Holes CTP10, CTP12, CTP16 & CTP17)

coffey environments

Engineering Log - Excavation

Excavation No.	CTP10
Sheet	1 of 1
Office Job No.:	ENAUWOLL04006AA
Client:	MANILDRA GROUP
Principal:	
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541
Date started:	21.6.2011
Date completed:	21.6.2011
Logged by:	CA
Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282018 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142018 m	datum:	WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N				0.5			TOPSOIL; Sandy CLAY: Low to medium plasticity, pale yellow/brown, fine to medium grained sand, with some roots.	M	MD		TOPSOIL
						1.0		CL	Sandy CLAY: Medium plasticity, red/orange, with some silt, and a trace of roots and fine to coarse grained angular sandstone gravel.	<Wp	St		RESIDUAL
			Seepage			1.5 – 2.5		CL	Sandy Gravelly CLAY: Medium plasticity, orange/brown with some pale yellow/pale brown pockets and fine to medium grained highly weathered sandstone gravel.		H		EXTREMELY WEATHERED MATERIAL End on slow progress
						3.0			Test pit CTP10 terminated at 2.5m				

Sketch

method		support	notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation	penetration 1 2 3 4 — no resistance ranging to refusal	U_{63}	undisturbed sample 63mm diameter	moisture	S	soft
BH	backhoe bucket	water	D	disturbed sample	D dry	F	firm
B	bulldozer blade	water level on date shown	V	vane shear (kPa)	M moist	St	stiff
R	ripper	water inflow	Bs	bulk sample	W wet	VSt	very stiff
E	excavator	water outflow	E	environmental sample	Wp plastic limit	H	hard
			R	refusal	W_L liquid limit	Fb	friable
						VL	very loose
						L	loose
						MD	medium dense
						D	dense
						VD	very dense

coffey environments

Engineering Log - Excavation

		Excavation No.	CTP12
		Sheet	1 of 1
		Office Job No.:	ENAUWOLL04006AA
Client:	MANILDRA GROUP	Date started:	21.6.2011
Principal:		Date completed:	21.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282092 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142461 m	datum:	WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N							TOPSOIL; CLAY: High plasticity, brown, with some silt and roots.	>Wp	S		TOPSOIL
			►	ASS		0.5		CH	Sandy CLAY: High plasticity, brown, with some silt, and a trace of roots.			x	ALLUVIAL/ESTUARINE SOIL
				ASS		1.0							
				ASS		1.5		CH	Sandy CLAY: High plasticity, grey, fine grained sand, and some silt.		St	x x x	
				ASS		2.0							
						2.5							End on steady progress
									Test pit CTP12 terminated at 2.5m				
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure	S shoring N nil	U_{50} undisturbed sample 50mm diameter	based on unified classification system	VS very soft
X existing excavation	penetration 1 2 3 4	U_{63} undisturbed sample 63mm diameter	moisture	S soft
BH backhoe bucket	no resistance ranging to refusal	D disturbed sample	D dry	F firm
B bulldozer blade	water	V vane shear (kPa)	M moist	St stiff
R ripper	water level on date shown	Bs bulk sample	W wet	VSt very stiff
E excavator	water inflow	E environmental sample	Wp plastic limit	H hard
	water outflow	R refusal	W_L liquid limit	Fb friable
				VL very loose
				L loose
				MD medium dense
				D dense
				VD very dense

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COF .GDT 29.7.11

Form GEO 5.2 Issue 3 Rev.2

coffey environments

Engineering Log - Excavation

Excavation No.	CTP16
Sheet	1 of 1
Office Job No.:	ENAUWOLL04006AA
Date started:	22.6.2011
Date completed:	22.6.2011
Logged by:	CA
Checked by:	SM

Client: MANILDRA GROUP

Principal:

Project: CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT

Test pit location: PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541

equipment type and model: 5T EXCAVATOR | Pit Orientation: N-S | Easting: 282191 m | R.L. Surface: NOT MEASURED

excavation dimensions: 2m long 0.45m wide | Northing: 6142933 m | datum: WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N							TOPSOIL; CLAY: High plasticity, brown, with some roots.	<Wp	F		TOPSOIL
				ASS		0.5		CH	CLAY: High plasticity, grey with some iron stained orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	Wp	VSt	x	ALLUVIAL SOIL
				ASS		1.0							
				ASS		1.5							
				ASS		2.0		CH	Sandy CLAY: High plasticity, grey with orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	>Wp Saturated	St	x	
			►			2.5			Test pit CTP16 terminated at 2.5m				End on steady progress
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	S shoring N nil penetration 1 2 3 4 no resistance ranging to refusal water water level on date shown water inflow water outflow	U_{50} undisturbed sample 50mm diameter U_{63} undisturbed sample 63mm diameter D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	based on unified classification system moisture D dry M moist W wet Wp plastic limit W_L liquid limit	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense

Form GEO 5.2 Issue 3 Rev.2

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COF .DT 28.7.11

coffey environments

Engineering Log - Excavation

Excavation No. CTP17
Sheet 1 of 1
Office Job No.: ENAUWOLL04006AA

Client:	MANILDRA GROUP	Date started:	22.6.2011
Principal:		Date completed:	22.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:		Easting	282284 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing	6143258 m	datum:	WGS84 (Approx)

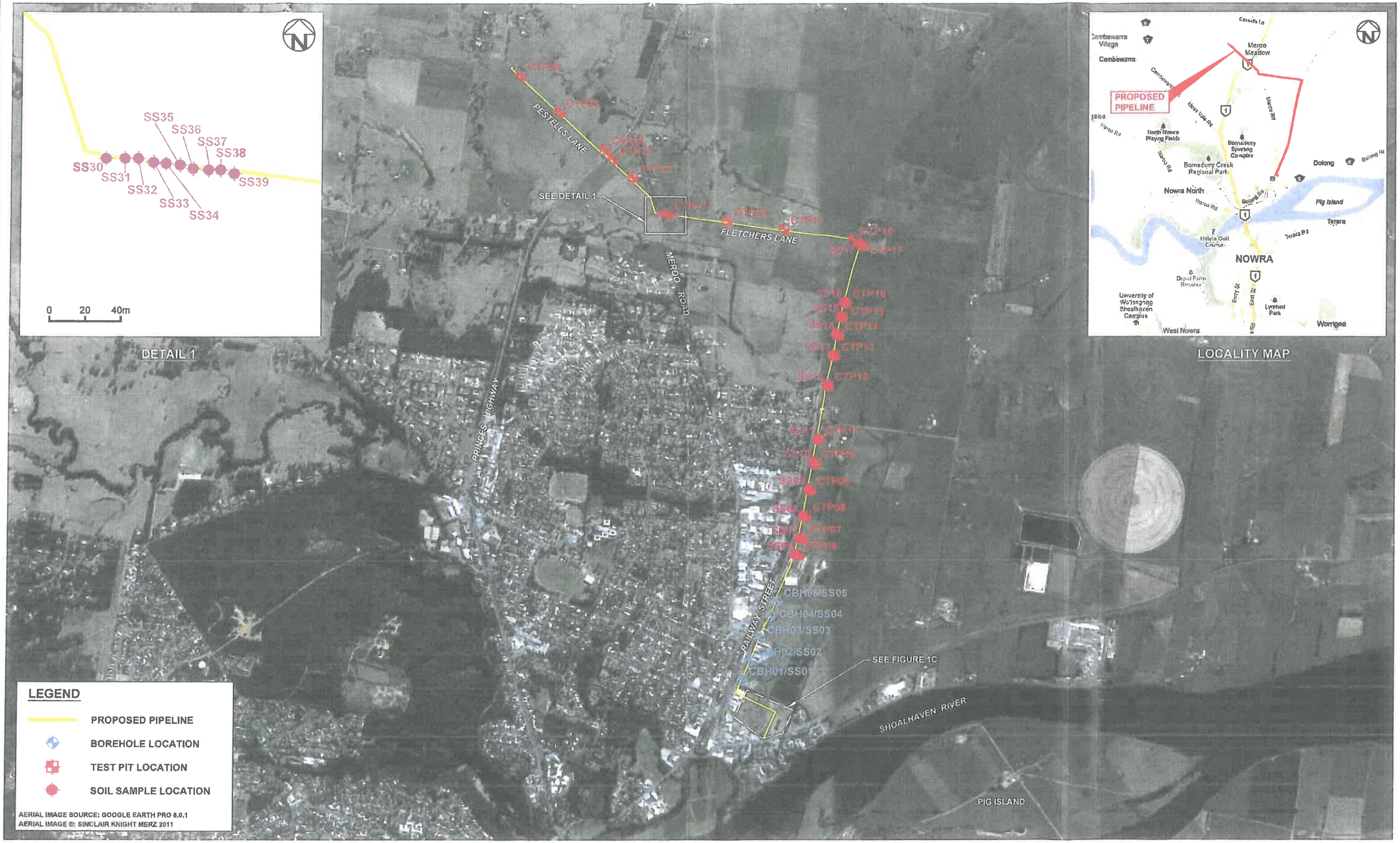
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa	structure and additional observations
E		N	NONE OBSERVED						TOPSOIL; CLAY: Medium plasticity, brown, with some fine grained roots.	Wp	F		TOPSOIL
								CH	CLAY: High plasticity, brown with some orange pockets, with a trace of fine grained sand, roots and fine to coarse grained gravel.	<Wp	VSt		ALLUVIAL SOIL
				ASS		0.5						x	
				ASS		1.0						x	
				ASS		1.5							
						2.0						x	
						2.5							End on steady progress
									Test pit CTP17 terminated at 2.5m				
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	S shoring N nil penetration 1 2 3 4 no resistance ranging to refusal water water level on date shown water inflow water outflow	U_{50} undisturbed sample 50mm diameter U_{63} undisturbed sample 63mm diameter D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	based on unified classification system moisture D dry M moist W wet Wp plastic limit W_L liquid limit	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COF DT 28.7.11

Form GEO 5.2 Issue 3 Rev.2



revision	description	drawn	approved	date

200 0 200 600 1000

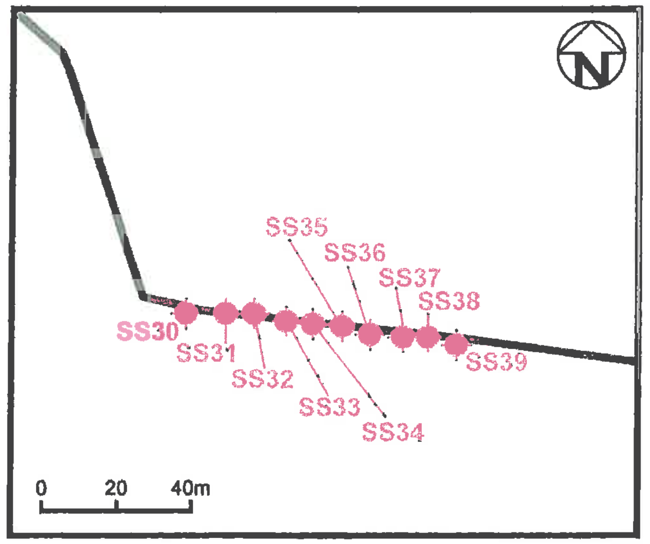
Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	28-07-11
scale	AS SHOWN
original size	A3

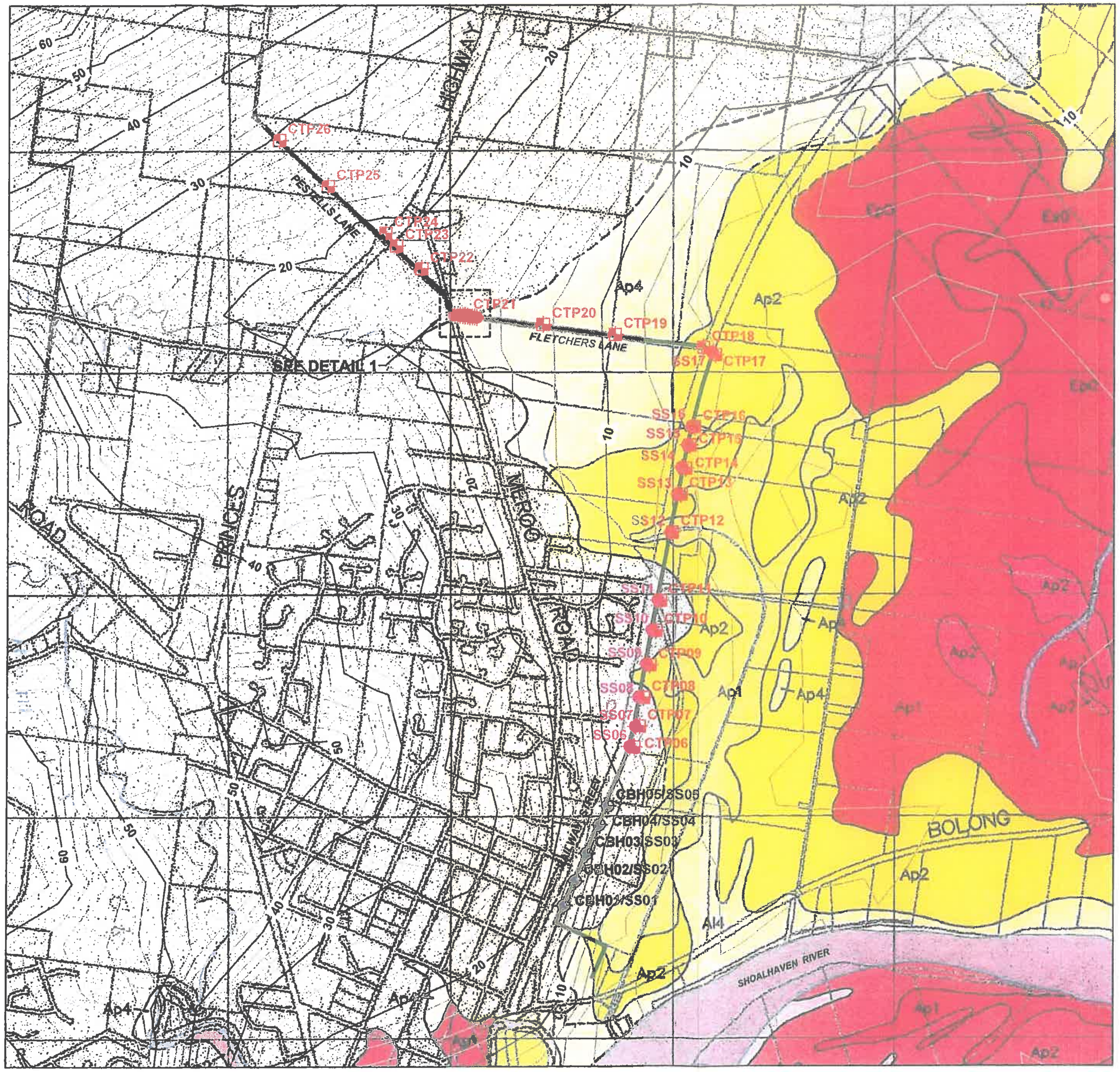
coffey environments
SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS
project no: ENAUWOLL04006AA-R01	figure no: FIGURE 1

Map Class Description		Depth to Acid Sulfate Soil Materials
HIGH PROBABILITY High probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.
		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
LOW PROBABILITY Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.
		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
NO KNOWN OCCURRENCE Acid sulfate soils are not known or expected to occur in these environments.		No known occurrences of acid sulfate soil materials.



DETAIL 1



LEGEND

- PROPOSED PIPELINE
- BOREHOLE LOCATION
- TEST PIT LOCATION
- SOIL SAMPLE LOCATION

REFERNCE: BURRIER/BERRY 1:25 000 ACID SOIL RISK MAP (1997) EDITION 2, PREPARED BY THE NSW DEPARTMENT OF LAND AND WATER CONSERVATION (DLWC)

revision	description	drawn	approved	date

200 0 200 600 1000

Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

coffey environments
SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH 1:25000 BURRIER/BERRY ASS RISK MAP
project no: ENAUWOLL04006AA-R01	figure no: FIGURE 2

Appendix H: Catchment Stormwater Runoff Calculations

CATCHMENT 1 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method   Q = FCIA

Total Area (A)	11.74 ha
Time of Concentration (mins)	20.20 mins
Rainfall Intensity (I)	102 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**2.33 m3/sec**

CATCHMENT 1 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method   Q = FCIA

Total Area (A)	11.74 ha
Time of Concentration (mins)	20.20 mins
Rainfall Intensity (I)	174 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**3.97 m3/sec**

CATCHMENT RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	545.40	ha
Time of Concentration (mins)	86.88	mins
Rainfall Intensity (I)	47	mm/hr
Runoff Coefficient (C)	0.60	
Factor (F)	0.00278	
DISCHARGE (Q)	**42.72**	**m3/sec**

CATCHMENT RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	545.40	ha
Time of Concentration (mins)	86.88	mins
Rainfall Intensity (I)	85	mm/hr
Runoff Coefficient (C)	0.60	
Factor (F)	0.00278	
DISCHARGE (Q)	**77.27**	**m3/sec**

CATCHMENT 3 RUNOFF CALCULATIONS
Shoalhaven City Council

Discharges for 1:5 ARI

Nowra
Rational Method Q = FCIA

Total Area (A)	896.50	ha
Time of Concentration (mins)	104.94	mins
Rainfall Intensity (I)	41	mm/hr
Runoff Coefficient (C)	0.70	
Factor (F)	0.00278	
DISCHARGE (Q)	**71.47**	**m3/sec**

CATCHMENT 3 RUNOFF CALCULATIONS
Shoalhaven City Council

Discharges for 1:100ARI

Nowra
Rational Method Q = FCIA

Total Area (A)	896.50	ha
Time of Concentration (mins)	104.94	mins
Rainfall Intensity (I)	76	mm/hr
Runoff Coefficient (C)	0.70	
Factor (F)	0.00278	
DISCHARGE (Q)	**132.48**	**m3/sec**

CATCHMENT 4 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	115.40 ha
Time of Concentration (mins)	48.15 mins
Rainfall Intensity (I)	66 mm/hr
Runoff Coefficient (C)	0.80
Factor (F)	0.00278
DISCHARGE (Q)	**16.93 m3/sec**

CATCHMENT 4 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	115.40 ha
Time of Concentration (mins)	48.15 mins
Rainfall Intensity (I)	117 mm/hr
Runoff Coefficient (C)	0.80
Factor (F)	0.00278
DISCHARGE (Q)	**30.00 m3/sec**

Appendix I: HY-8 Culvert Analysis Reports for Waterway Crossings 1, 2, 3 and 4, with Scour Depth Calculation Results

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 1

Headwater Elevation (m)	Total Discharge (cms)	Culvert 1A Discharge (cms)	Culvert 1B Discharge (cms)	Culvert 1C Discharge (cms)	Culvert 1D Discharge (cms)	Culvert 1E Discharge (cms)	Culvert 1F Discharge (cms)	Roadway Discharge (cms)	Iterations
0.43	2.33	0.39	0.39	0.39	0.39	0.39	0.39	0.00	16
0.44	2.49	0.42	0.42	0.42	0.42	0.42	0.42	0.00	3
0.46	2.66	0.44	0.44	0.44	0.44	0.44	0.44	0.00	3
0.48	2.82	0.47	0.47	0.47	0.47	0.47	0.47	0.00	3
0.50	2.99	0.50	0.50	0.50	0.50	0.50	0.50	0.00	3
0.52	3.15	0.52	0.52	0.52	0.52	0.52	0.52	0.00	3
0.53	3.31	0.55	0.55	0.55	0.55	0.55	0.55	0.00	3
0.55	3.48	0.58	0.58	0.58	0.58	0.58	0.58	0.00	3
0.57	3.64	0.61	0.61	0.61	0.61	0.61	0.61	0.00	2
0.58	3.81	0.63	0.63	0.63	0.63	0.63	0.63	0.00	2
0.60	3.96	0.66	0.66	0.66	0.66	0.66	0.66	0.00	2
2.00	13.88	2.31	2.31	2.31	2.31	2.31	2.31	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

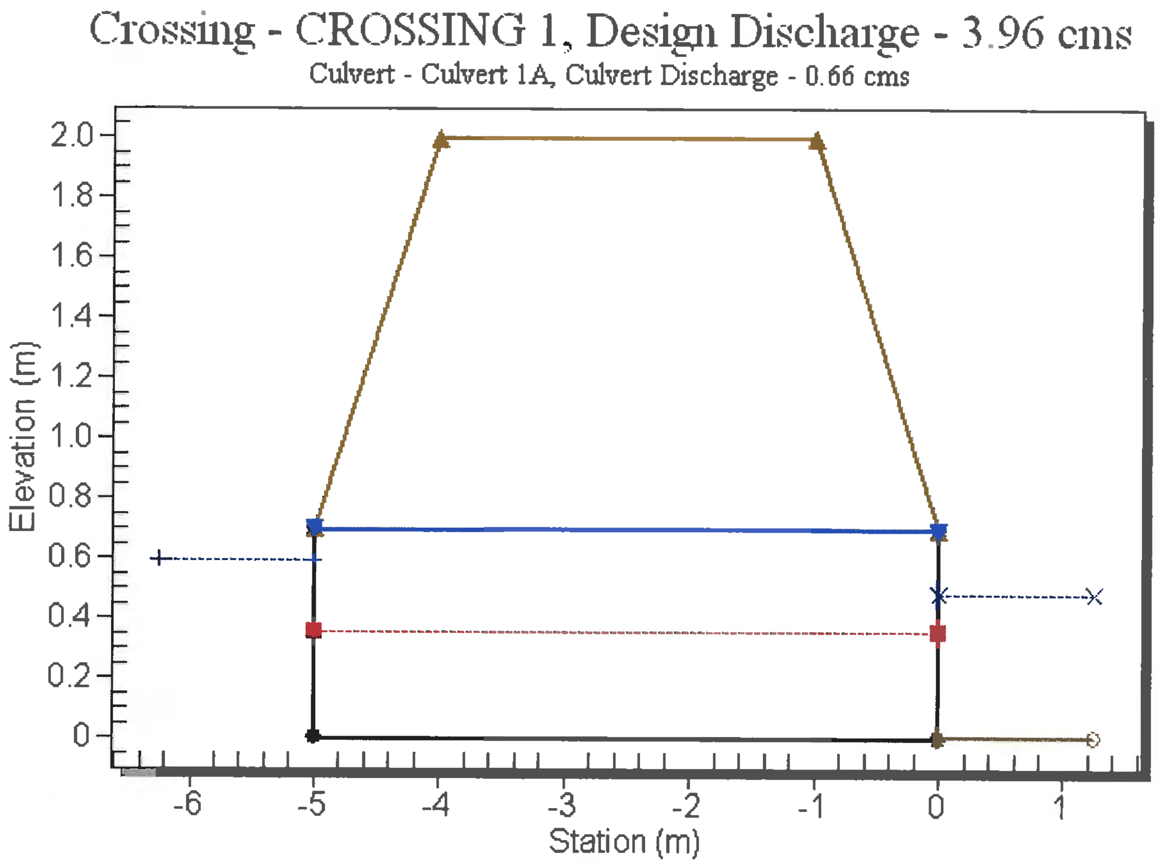
****

Inlet Elevation (invert): 0.00 m,   Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m,   Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1A



Site Data - Culvert 1A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1A

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 1B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

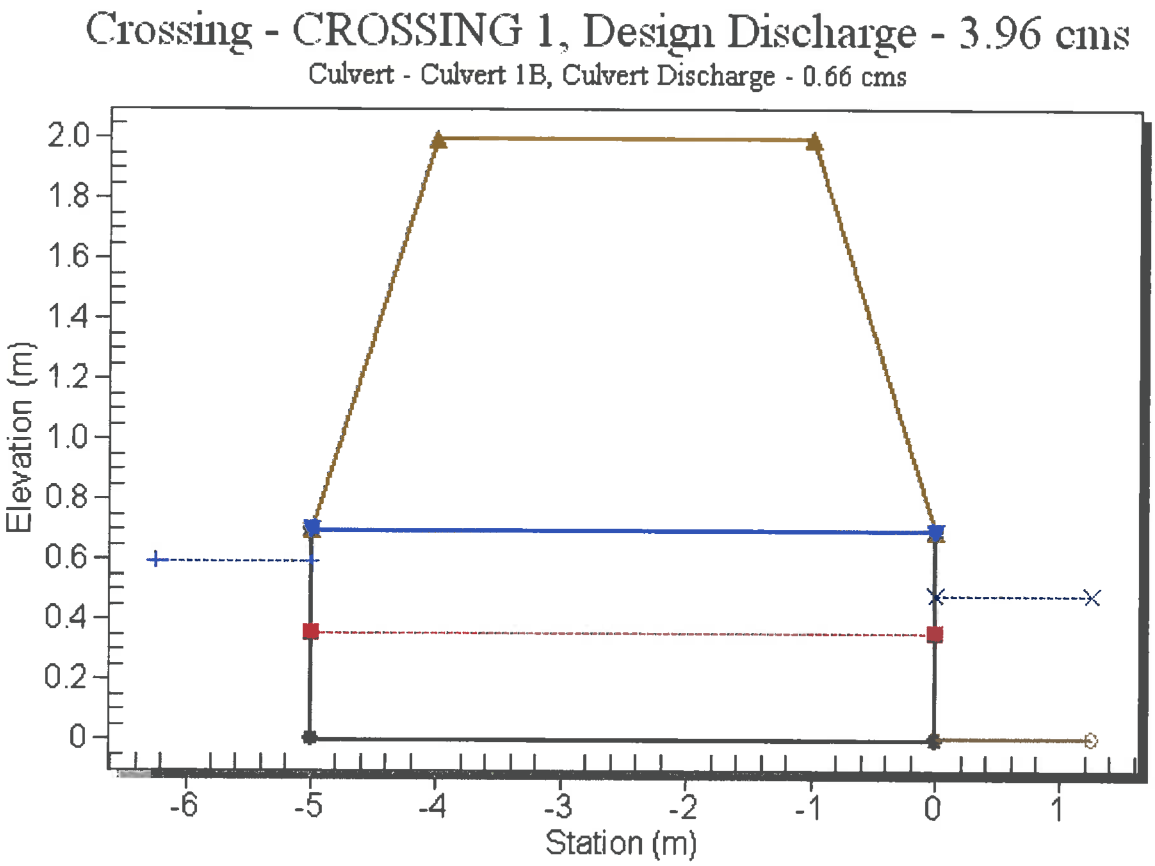
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1B



Site Data - Culvert 1B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1B

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 1C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

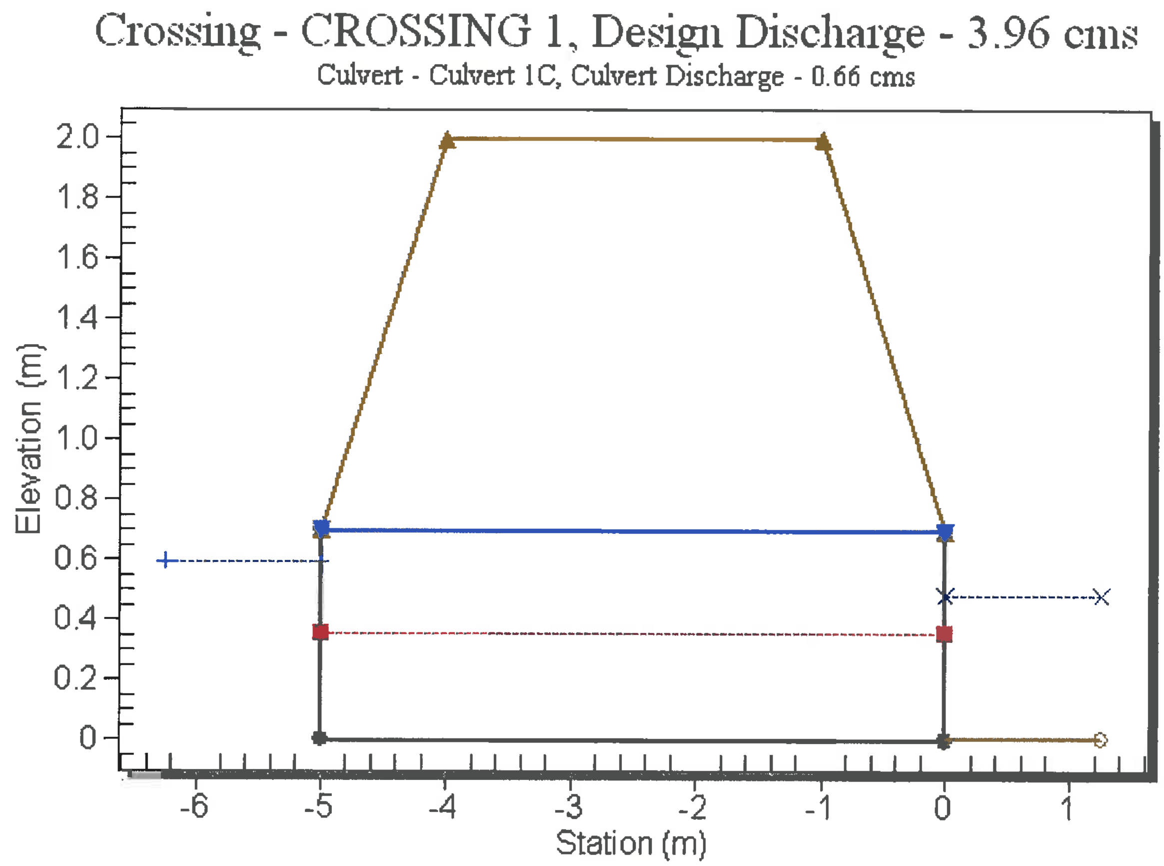
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1C



Site Data - Culvert 1C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1C

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Culvert Summary Table: Culvert 1D

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

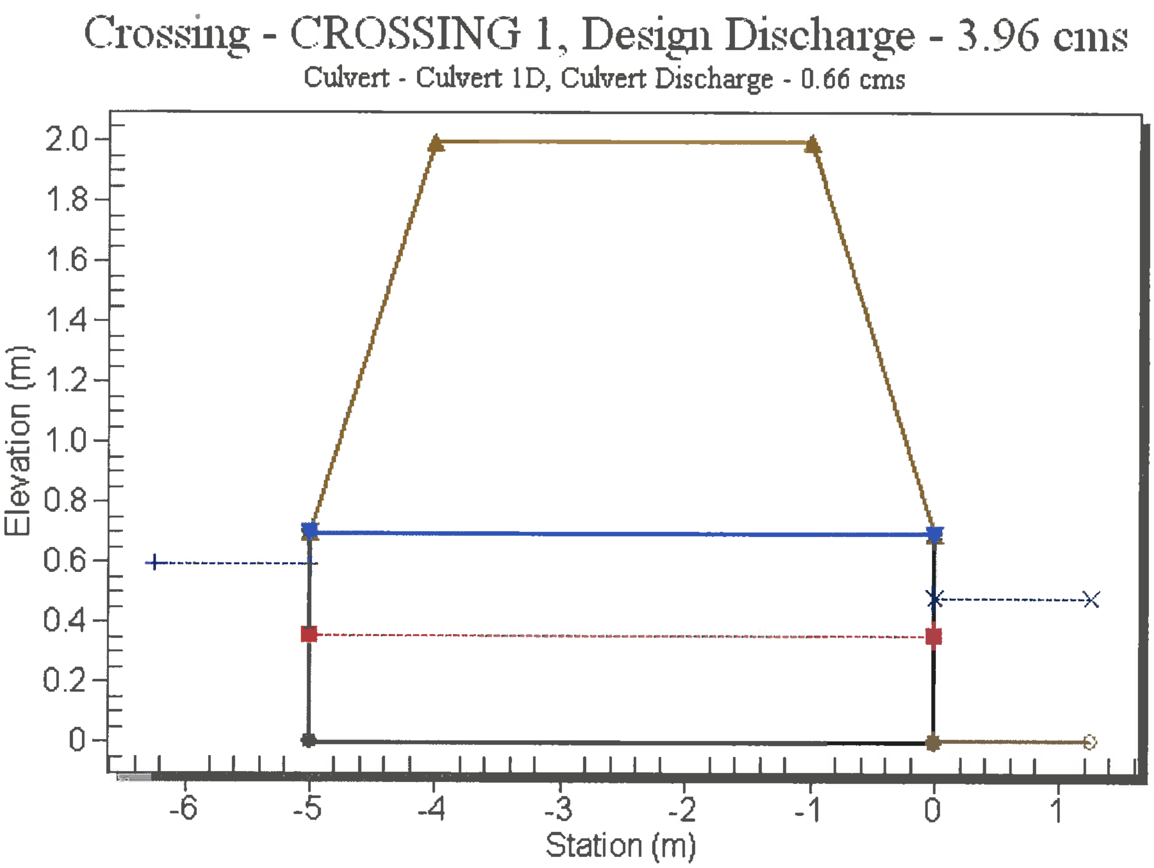
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1D



Site Data - Culvert 1D

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1D

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 6 - Culvert Summary Table: Culvert 1E

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

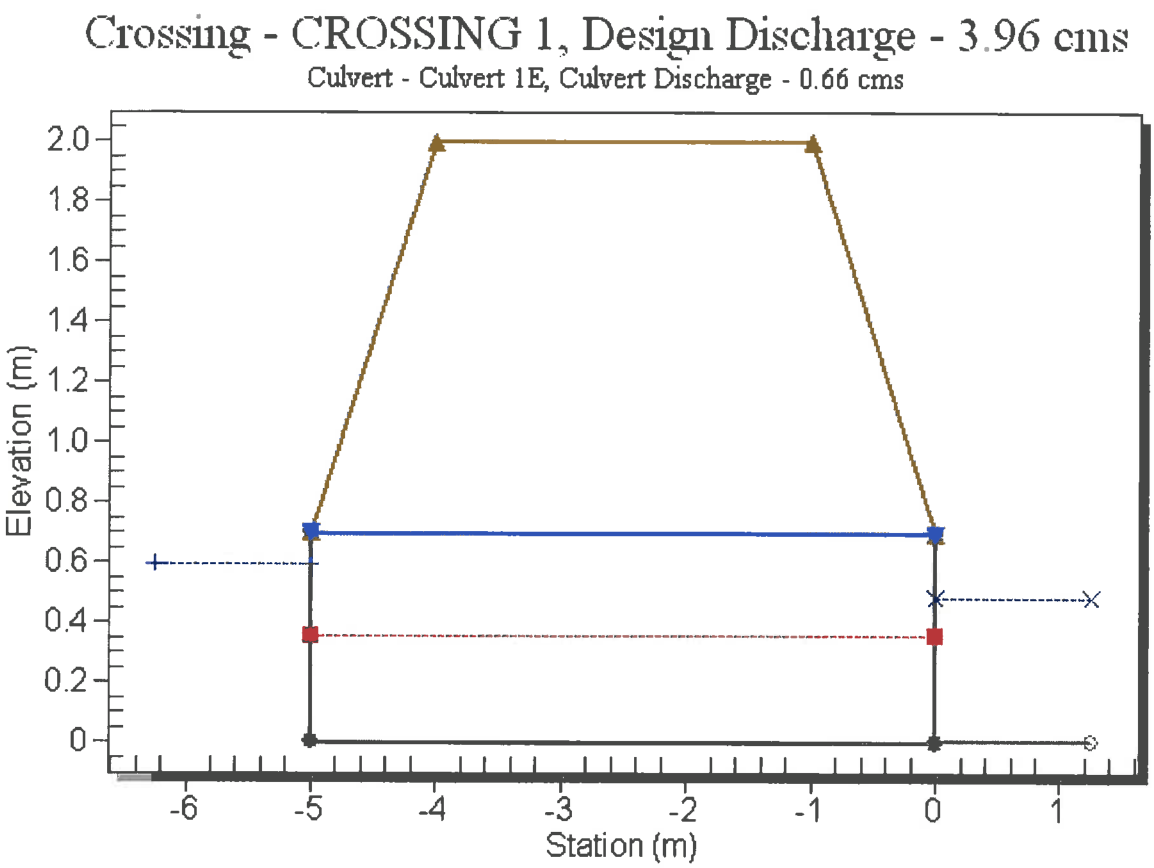
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1E



Site Data - Culvert 1E

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1E

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 7 - Culvert Summary Table: Culvert 1F

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

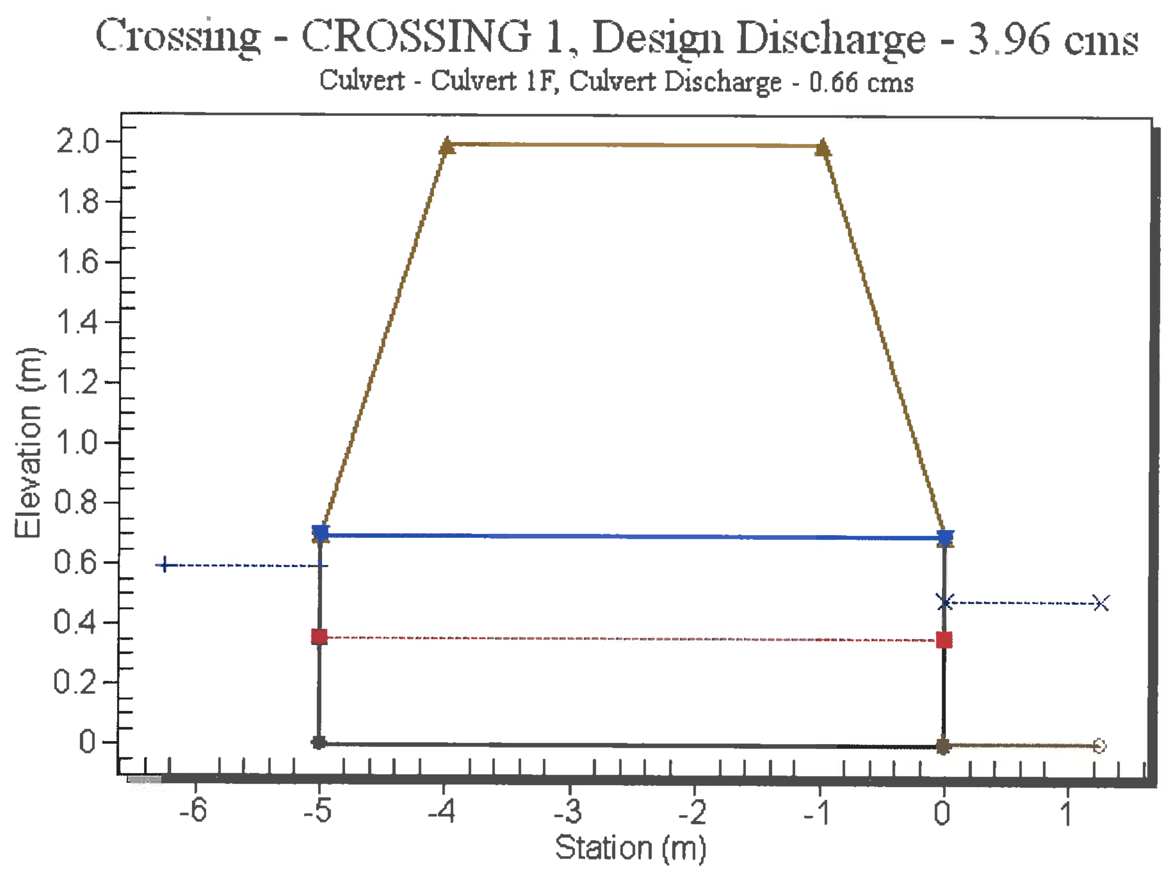
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1F



Site Data - Culvert 1F

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1F

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 8 - Downstream Channel Rating Curve (Crossing: CROSSING 1)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
2.33	0.36	0.36	1.14	34.97	0.65
2.49	0.37	0.37	1.17	36.39	0.65
2.66	0.39	0.39	1.20	37.77	0.65
2.82	0.40	0.40	1.22	39.10	0.66
2.99	0.41	0.41	1.24	40.41	0.66
3.15	0.43	0.43	1.27	41.68	0.66
3.31	0.44	0.44	1.29	42.92	0.67
3.48	0.45	0.45	1.31	44.14	0.67
3.64	0.46	0.46	1.33	45.33	0.67
3.81	0.47	0.47	1.35	46.50	0.67
3.96	0.49	0.49	1.37	47.57	0.68

Tailwater Channel Data - CROSSING 1

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 5.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 m

Crest Elevation: 2.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 1	
Culvert	Culvert 1A	
Flow	3.96	cms
Culvert Data		
Culvert Width (including multiple barrels)	1.0	m
Culvert Height	0.7	m
Outlet Depth	0.70	m
Outlet Velocity	0.94	m/s
Froude Number	0.36	
Tailwater Depth	0.49	m
Tailwater Velocity	1.37	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	100.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.161	kPa
Modified Shear Number	0.264	
Scour Hole Dimensions		
Length (LS)	3.768	m
Width (WS)	3.777	m
Depth (DS)	0.871	m
Volume (VS)	1.464	m^3
DS at 0.4(LS)	1.507	m
Tailwater Depth (TW)	0.485	m
Velocity with TW and WS	0.286	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 2

Headwater Elevation (m)	Total Discharge (cms)	Culvert 2A Discharge (cms)	Culvert 2B Discharge (cms)	Culvert 2C Discharge (cms)	Culvert 2D Discharge (cms)	Roadway Discharge (cms)	Iterations
1.69	42.00	7.86	13.11	13.11	7.86	0.00	32
1.73	45.50	8.05	13.41	13.41	8.05	2.52	9
1.75	49.00	8.13	13.55	13.55	8.13	5.57	6
1.77	52.50	8.20	13.67	13.67	8.20	8.68	5
1.78	56.00	8.27	13.78	13.78	8.27	11.87	5
1.80	59.50	8.33	13.88	13.88	8.33	15.03	4
1.81	63.00	8.35	13.94	13.94	8.35	18.38	4
1.83	66.50	8.20	13.69	13.69	8.20	22.68	4
1.84	70.00	8.04	13.43	13.43	8.04	27.01	4
1.86	73.50	7.88	13.17	13.17	7.88	31.36	4
1.87	76.00	7.77	12.98	12.98	7.77	34.48	4
1.70	42.23	7.92	13.20	13.20	7.92	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 2A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	7.86	1.69	1.687	1.488	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	8.05	1.73	1.730	1.559	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	8.13	1.75	1.750	1.615	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	8.20	1.77	1.768	1.668	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	8.27	1.78	1.783	1.719	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	8.33	1.80	1.797	1.768	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	8.35	1.81	1.802	1.811	4-FFf	1.000	0.926	1.000	1.199	2.783	2.577
66.50	8.20	1.83	1.765	1.827	4-FFf	1.000	0.915	1.000	1.237	2.732	2.626
70.00	8.04	1.84	1.728	1.843	4-FFf	1.000	0.903	1.000	1.275	2.680	2.672
73.50	7.88	1.86	1.692	1.857	4-FFf	1.000	0.891	1.000	1.311	2.628	2.718
76.00	7.77	1.87	1.666	1.868	4-FFf	1.000	0.883	1.000	1.337	2.590	2.749

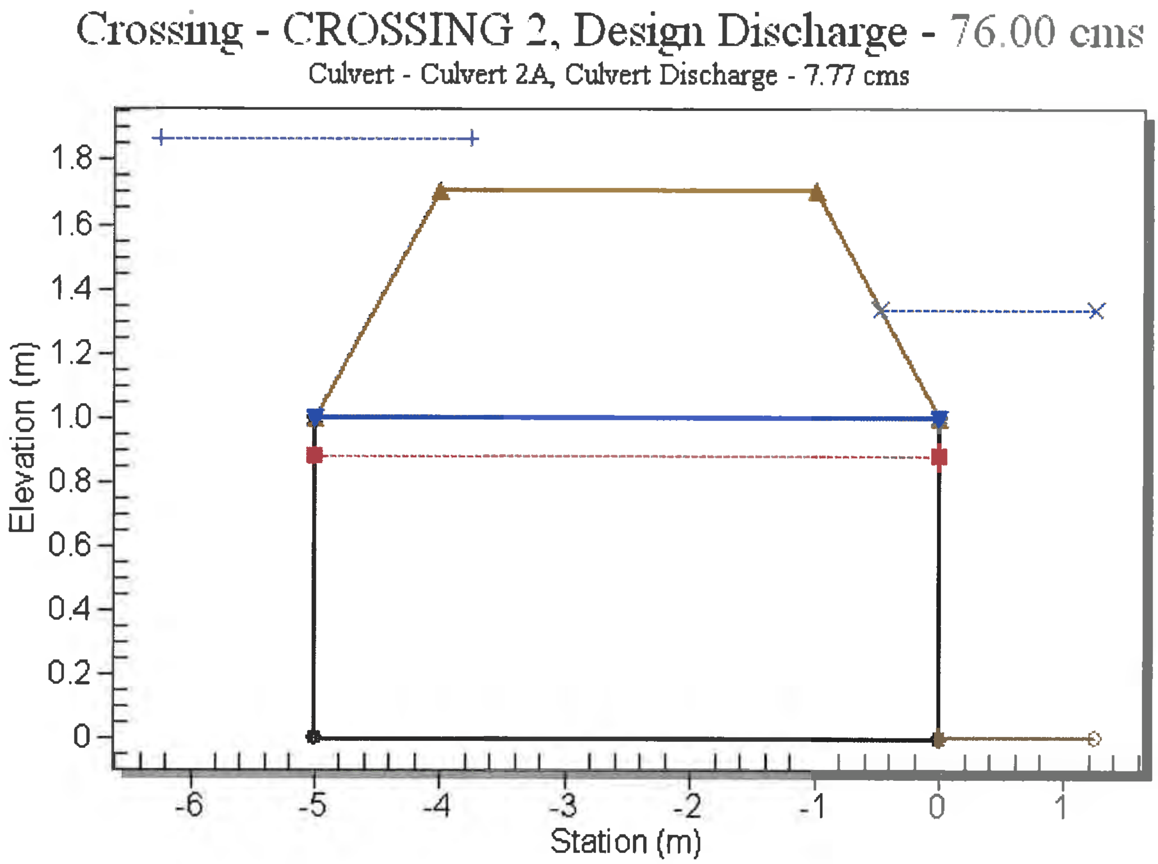
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2A



Site Data - Culvert 2A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2A

Barrel Shape: Concrete Box

Barrel Span: 3000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 2B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	13.11	1.69	1.687	1.486	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	13.41	1.73	1.730	1.556	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	13.55	1.75	1.750	1.613	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	13.67	1.77	1.768	1.666	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	13.78	1.78	1.783	1.717	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	13.88	1.80	1.797	1.765	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	13.94	1.81	1.807	1.811	4-FFf	1.000	0.927	1.000	1.199	2.789	2.577
66.50	13.69	1.83	1.770	1.827	4-FFf	1.000	0.916	1.000	1.237	2.738	2.626
70.00	13.43	1.84	1.733	1.843	4-FFf	1.000	0.904	1.000	1.275	2.686	2.672
73.50	13.17	1.86	1.696	1.857	4-FFf	1.000	0.893	1.000	1.311	2.634	2.718
76.00	12.98	1.87	1.670	1.868	4-FFf	1.000	0.884	1.000	1.337	2.596	2.749

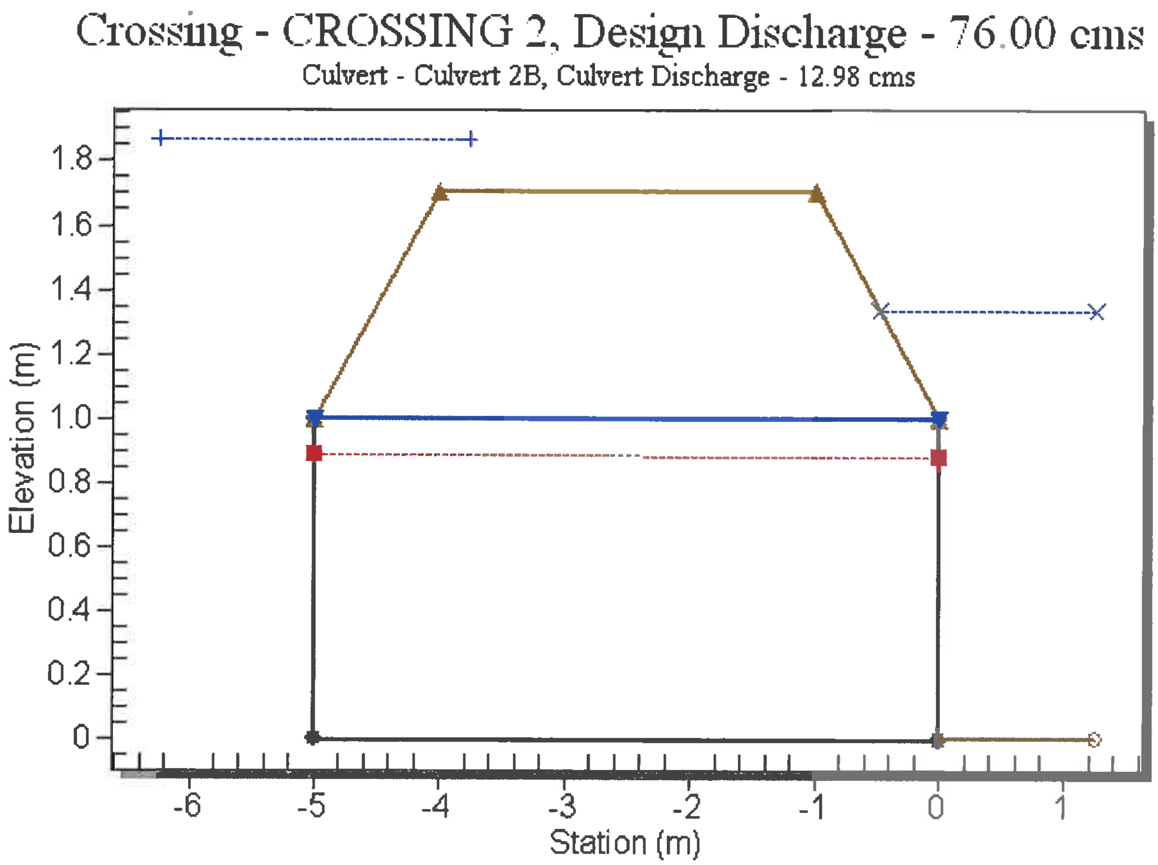
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2B



Site Data - Culvert 2B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2B

Barrel Shape: Concrete Box

Barrel Span: 5000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 2C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	13.11	1.69	1.687	1.486	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	13.41	1.73	1.730	1.556	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	13.55	1.75	1.750	1.613	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	13.67	1.77	1.768	1.666	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	13.78	1.78	1.783	1.717	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	13.88	1.80	1.797	1.765	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	13.94	1.81	1.807	1.811	4-FFf	1.000	0.927	1.000	1.199	2.789	2.577
66.50	13.69	1.83	1.770	1.827	4-FFf	1.000	0.916	1.000	1.237	2.738	2.626
70.00	13.43	1.84	1.733	1.843	4-FFf	1.000	0.904	1.000	1.275	2.686	2.672
73.50	13.17	1.86	1.696	1.857	4-FFf	1.000	0.893	1.000	1.311	2.634	2.718
76.00	12.98	1.87	1.670	1.868	4-FFf	1.000	0.884	1.000	1.337	2.596	2.749

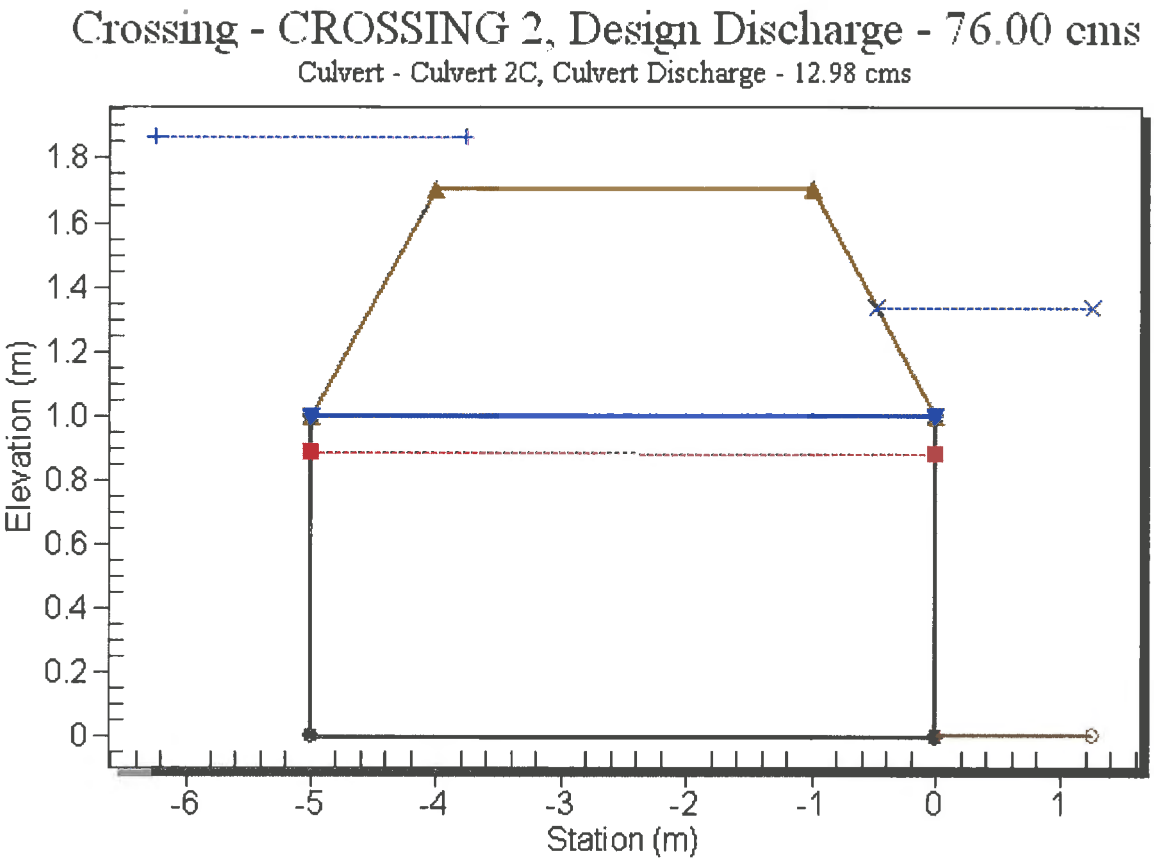
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2C



Site Data - Culvert 2C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2C

Barrel Shape: Concrete Box

Barrel Span: 5000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Culvert Summary Table: Culvert 2D

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	7.86	1.69	1.687	1.488	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	8.05	1.73	1.730	1.559	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	8.13	1.75	1.750	1.615	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	8.20	1.77	1.768	1.668	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	8.27	1.78	1.783	1.719	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	8.33	1.80	1.797	1.768	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	8.35	1.81	1.802	1.811	4-FFf	1.000	0.926	1.000	1.199	2.783	2.577
66.50	8.20	1.83	1.765	1.827	4-FFf	1.000	0.915	1.000	1.237	2.732	2.626
70.00	8.04	1.84	1.728	1.843	4-FFf	1.000	0.903	1.000	1.275	2.680	2.672
73.50	7.88	1.86	1.692	1.857	4-FFf	1.000	0.891	1.000	1.311	2.628	2.718
76.00	7.77	1.87	1.666	1.868	4-FFf	1.000	0.883	1.000	1.337	2.590	2.749

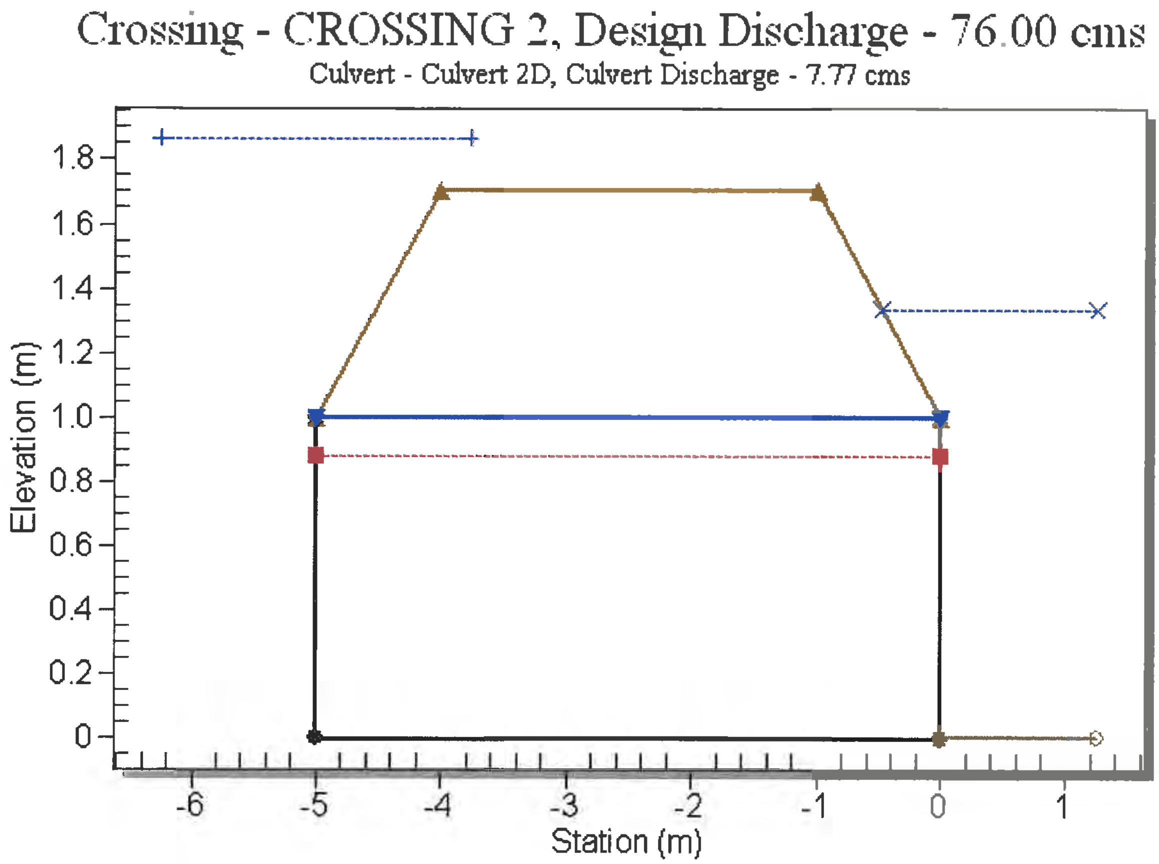
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2D



Site Data - Culvert 2D

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2D

Barrel Shape: Concrete Box

Barrel Span: 3000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: CROSSING 2)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
42.00	0.94	0.94	2.24	92.60	0.77
45.50	0.99	0.99	2.30	97.06	0.77
49.00	1.03	1.03	2.36	101.39	0.78
52.50	1.08	1.08	2.42	105.58	0.78
56.00	1.12	1.12	2.47	109.65	0.79
59.50	1.16	1.16	2.53	113.62	0.79
63.00	1.20	1.20	2.58	117.48	0.79
66.50	1.24	1.24	2.63	121.26	0.80
70.00	1.27	1.27	2.67	124.94	0.80
73.50	1.31	1.31	2.72	128.55	0.80
76.00	1.34	1.34	2.75	131.08	0.81

Tailwater Channel Data - CROSSING 2

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 18.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 2

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 m

Crest Elevation: 1.70 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 2	
Culvert	Culvert 2A	
Flow	76.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	3.0	m
Culvert Height	1.0	m
Outlet Depth	1.00	m
Outlet Velocity	2.59	m/s
Froude Number	0.83	
Tailwater Depth	1.34	m
Tailwater Velocity	2.75	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	200.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.309	kPa
Modified Shear Number	1.040	
Scour Hole Dimensions		
Length (LS)	12.258	m
Width (WS)	9.868	m
Depth (DS)	2.307	m
Volume (VS)	46.408	m^3
DS at 0.4(LS)	4.903	m
Tailwater Depth (TW)	1.337	m
Velocity with TW and WS	0.463	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 3

Headwater Elevation (m)	Total Discharge (cms)	Culvert 3A Discharge (cms)	Culvert 3B Discharge (cms)	Culvert 3C Discharge (cms)	Roadway Discharge (cms)	Iterations
2.14	71.47	23.83	23.83	23.83	0.00	4
2.30	77.57	25.87	25.87	25.87	0.00	4
2.45	83.67	27.90	27.90	27.90	0.00	4
2.61	89.77	29.93	29.93	29.93	0.00	4
2.76	95.87	31.96	31.96	31.96	0.00	4
2.92	101.98	33.98	33.98	33.98	0.00	10
3.03	108.08	34.73	34.73	34.73	3.82	11
3.06	114.18	33.69	33.69	33.69	12.97	6
3.09	120.28	32.49	32.49	32.49	22.66	5
3.12	126.38	31.22	31.22	31.22	32.66	5
3.14	132.00	29.98	29.98	29.98	41.90	4
3.00	109.23	36.41	36.41	36.41	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 3A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

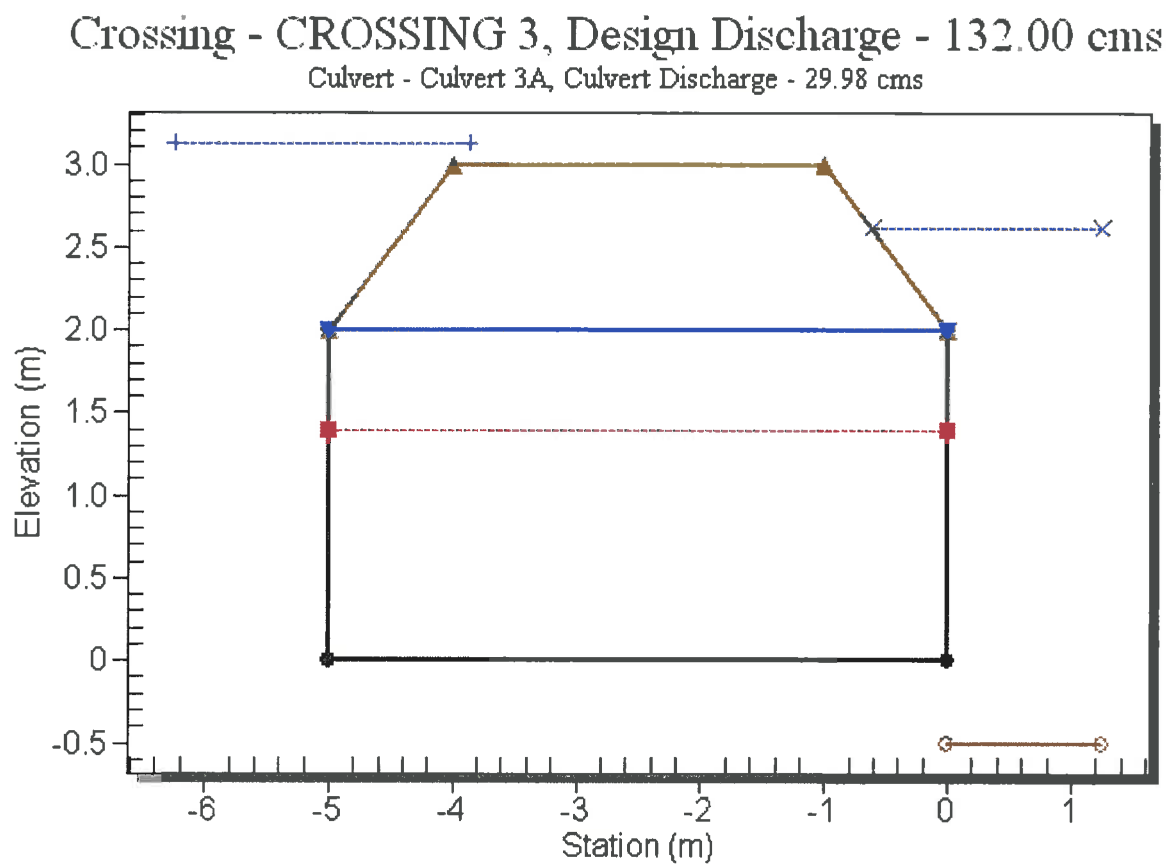
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3A



Site Data - Culvert 3A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3A

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 3B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

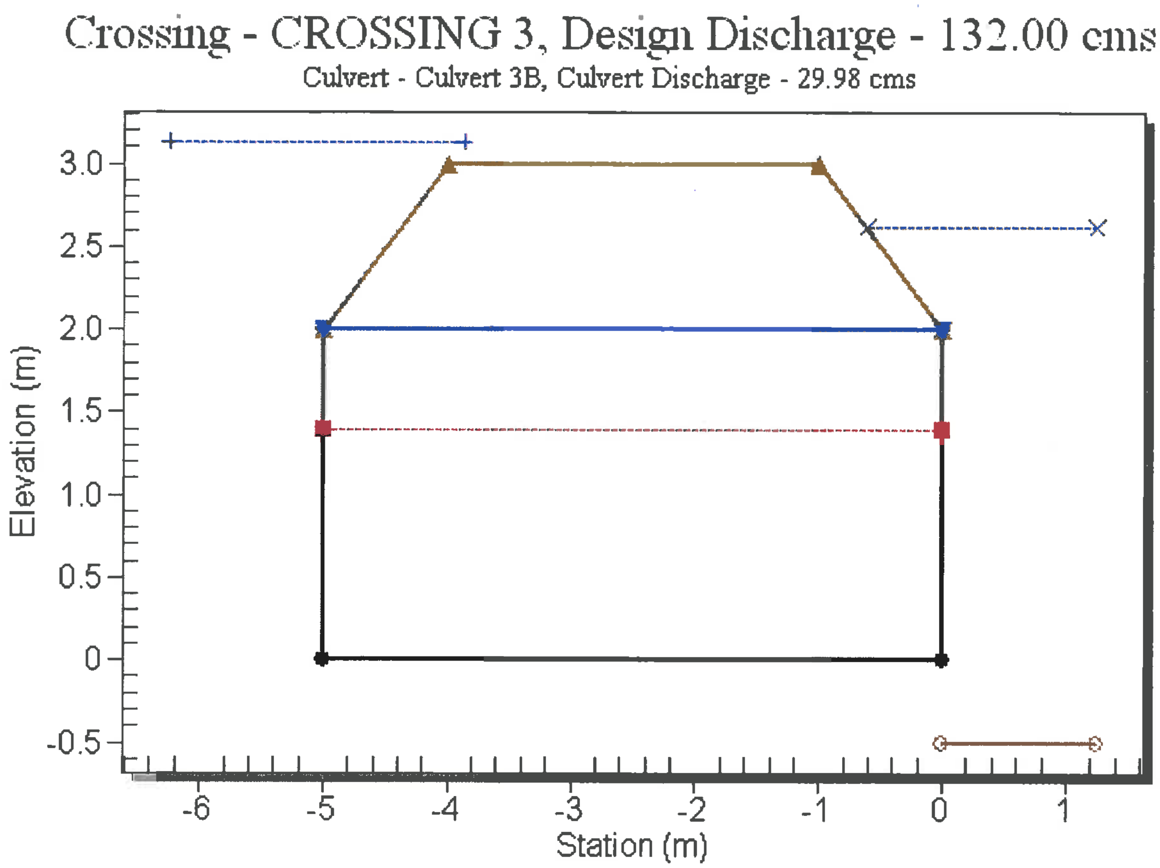
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3B



Site Data - Culvert 3B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3B

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 3C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

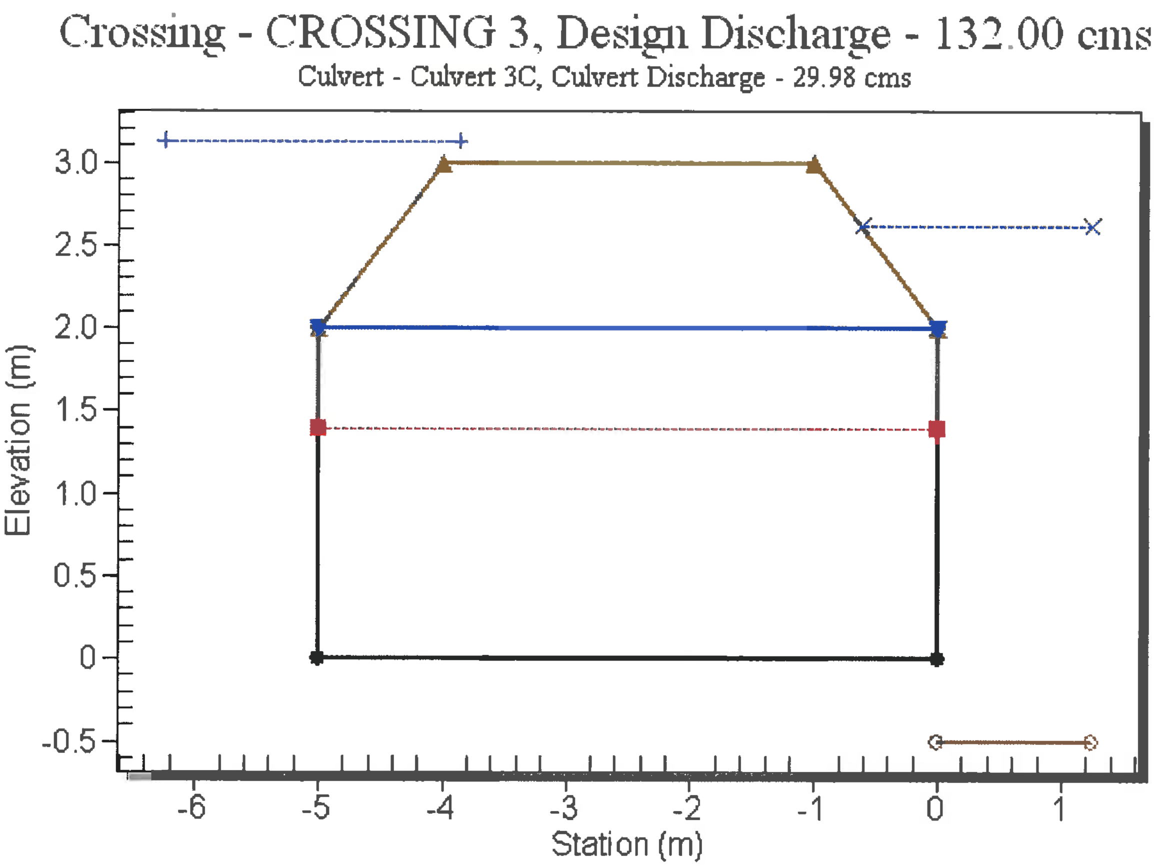
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3C



Site Data - Culvert 3C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3C

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Downstream Channel Rating Curve (Crossing: CROSSING 3)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
71.47	1.81	2.31	3.21	226.92	0.82
77.57	1.91	2.41	3.28	236.29	0.82
83.67	2.00	2.50	3.34	245.25	0.83
89.77	2.09	2.59	3.41	253.84	0.83
95.87	2.17	2.67	3.47	262.10	0.83
101.98	2.26	2.76	3.52	270.06	0.84
108.08	2.33	2.83	3.58	277.75	0.84
114.18	2.41	2.91	3.63	285.19	0.84
120.28	2.48	2.98	3.68	292.40	0.84
126.38	2.55	3.05	3.72	299.40	0.85
132.00	2.62	3.12	3.77	305.67	0.85

Tailwater Channel Data - CROSSING 3

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 5.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: -0.50 m

Roadway Data for Crossing: CROSSING 3

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 500.00 m

Crest Elevation: 3.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 3	
Culvert	Culvert 3A	
Flow	132.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	5.8	m
Culvert Height	2.0	m
Outlet Depth	2.00	m
Outlet Velocity	2.58	m/s
Froude Number	0.58	
Tailwater Depth	3.12	m
Tailwater Velocity	3.77	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	100.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.161	kPa
Modified Shear Number	1.988	
Scour Hole Dimensions		
Length (LS)	29.855	m
Width (WS)	21.665	m
Depth (DS)	5.099	m
Volume (VS)	644.857	m^3
DS at 0.4(LS)	11.942	m
Tailwater Depth (TW)	3.118	m
Velocity with TW and WS	0.345	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 4

Headwater Elevation (m)	Total Discharge (cms)	Culvert 4A Discharge (cms)	Culvert 4B Discharge (cms)	Roadway Discharge (cms)	Iterations
1.02	16.93	8.54	8.54	0.00	11
1.06	18.24	9.20	9.20	0.00	10
1.11	19.54	9.81	9.81	0.00	9
1.15	20.85	10.43	10.43	0.00	8
1.19	22.16	11.12	11.12	0.00	7
1.23	23.47	11.75	11.75	0.00	7
1.27	24.77	12.43	12.43	0.00	6
1.31	26.08	13.06	13.06	0.00	6
1.32	27.39	8.26	8.26	0.00	11
1.32	28.69	18.24	18.24	0.00	6
1.32	29.00	18.24	18.24	0.00	4
3.00	61.39	30.70	30.70	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 4A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
16.93	8.54	1.02	0.807	1.017	6-FFt	1.458	0.470	0.998	0.997	1.007	1.887
18.24	9.20	1.06	0.848	1.062	6-FFt	1.532	0.493	1.040	1.040	1.040	1.932
19.54	9.81	1.11	0.885	1.107	6-FFt	1.601	0.515	1.081	1.081	1.067	1.974
20.85	10.43	1.15	0.922	1.150	6-FFt	1.668	0.537	1.121	1.121	1.095	2.013
22.16	11.12	1.19	0.962	1.192	6-FFt	1.742	0.560	1.160	1.159	1.128	2.051
23.47	11.75	1.23	0.997	1.234	6-FFt	2.000	0.581	1.197	1.197	1.155	2.087
24.77	12.43	1.27	1.033	1.275	6-FFt	2.000	0.603	1.234	1.233	1.186	2.122
26.08	13.06	1.31	1.066	1.315	6-FFt	2.000	0.623	1.269	1.269	1.210	2.155
27.39	8.26	1.32	0.789	1.322	6-FFt	1.426	0.459	1.304	1.304	0.745	2.187
28.69	18.24	1.32	1.322	1.426	6-FFt	2.000	0.779	1.338	1.337	1.604	2.218
29.00	18.24	1.32	1.322	1.434	6-FFt	2.000	0.779	1.346	1.345	1.595	2.225

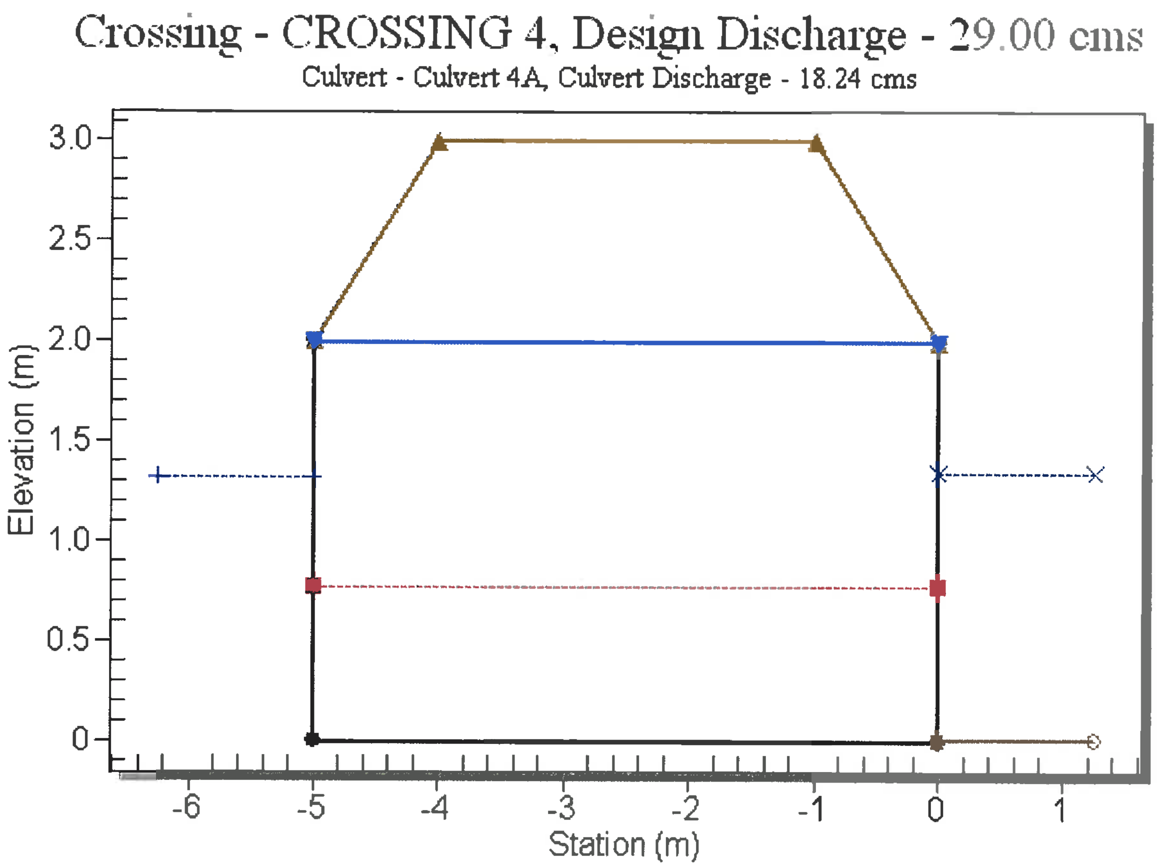
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 4A



Site Data - Culvert 4A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 4A

Barrel Shape: Concrete Box

Barrel Span: 8500.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 4B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
16.93	8.54	1.02	0.807	1.017	6-FFt	1.458	0.470	0.998	0.997	1.007	1.887
18.24	9.20	1.06	0.848	1.062	6-FFt	1.532	0.493	1.040	1.040	1.040	1.932
19.54	9.81	1.11	0.885	1.107	6-FFt	1.601	0.515	1.081	1.081	1.067	1.974
20.85	10.43	1.15	0.922	1.150	6-FFt	1.668	0.537	1.121	1.121	1.095	2.013
22.16	11.12	1.19	0.962	1.192	6-FFt	1.742	0.560	1.160	1.159	1.128	2.051
23.47	11.75	1.23	0.997	1.234	6-FFt	2.000	0.581	1.197	1.197	1.155	2.087
24.77	12.43	1.27	1.033	1.275	6-FFt	2.000	0.603	1.234	1.233	1.186	2.122
26.08	13.06	1.31	1.066	1.315	6-FFt	2.000	0.623	1.269	1.269	1.210	2.155
27.39	8.26	1.32	0.789	1.322	6-FFt	1.426	0.459	1.304	1.304	0.745	2.187
28.69	18.24	1.32	1.322	1.426	6-FFt	2.000	0.779	1.338	1.337	1.604	2.218
29.00	18.24	1.32	1.322	1.434	6-FFt	2.000	0.779	1.346	1.345	1.595	2.225

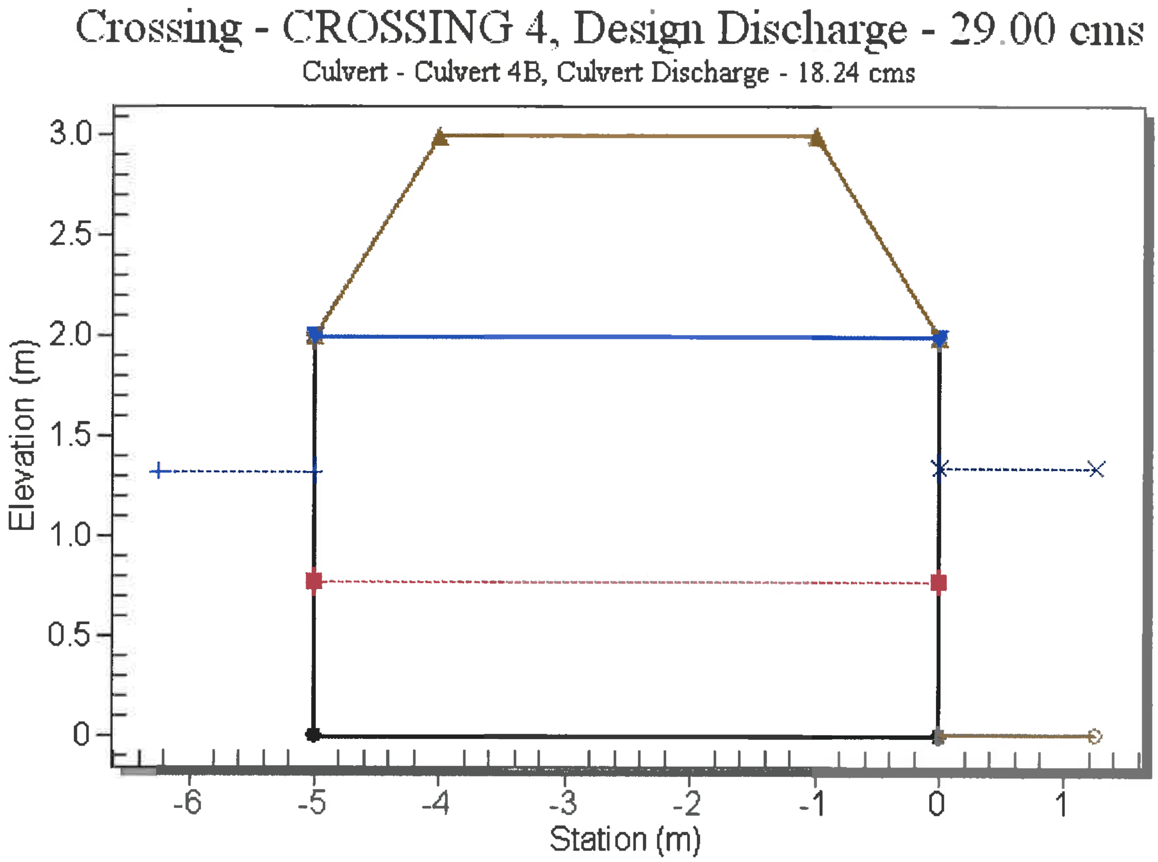
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 4B



Site Data - Culvert 4B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 4B

Barrel Shape: Concrete Box

Barrel Span: 8500.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Downstream Channel Rating Curve (Crossing: CROSSING 4)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
16.93	1.00	1.00	1.89	97.75	0.67
18.24	1.04	1.04	1.93	101.93	0.67
19.54	1.08	1.08	1.97	105.95	0.67
20.85	1.12	1.12	2.01	109.86	0.68
22.16	1.16	1.16	2.05	113.64	0.68
23.47	1.20	1.20	2.09	117.32	0.68
24.77	1.23	1.23	2.12	120.89	0.68
26.08	1.27	1.27	2.15	124.38	0.69
27.39	1.30	1.30	2.19	127.78	0.69
28.69	1.34	1.34	2.22	131.09	0.69
29.00	1.35	1.35	2.22	131.86	0.69

Tailwater Channel Data - CROSSING 4

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 7.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0450

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 4

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 330.00 m

Crest Elevation: 3.00 m

Roadway Surface: Paved

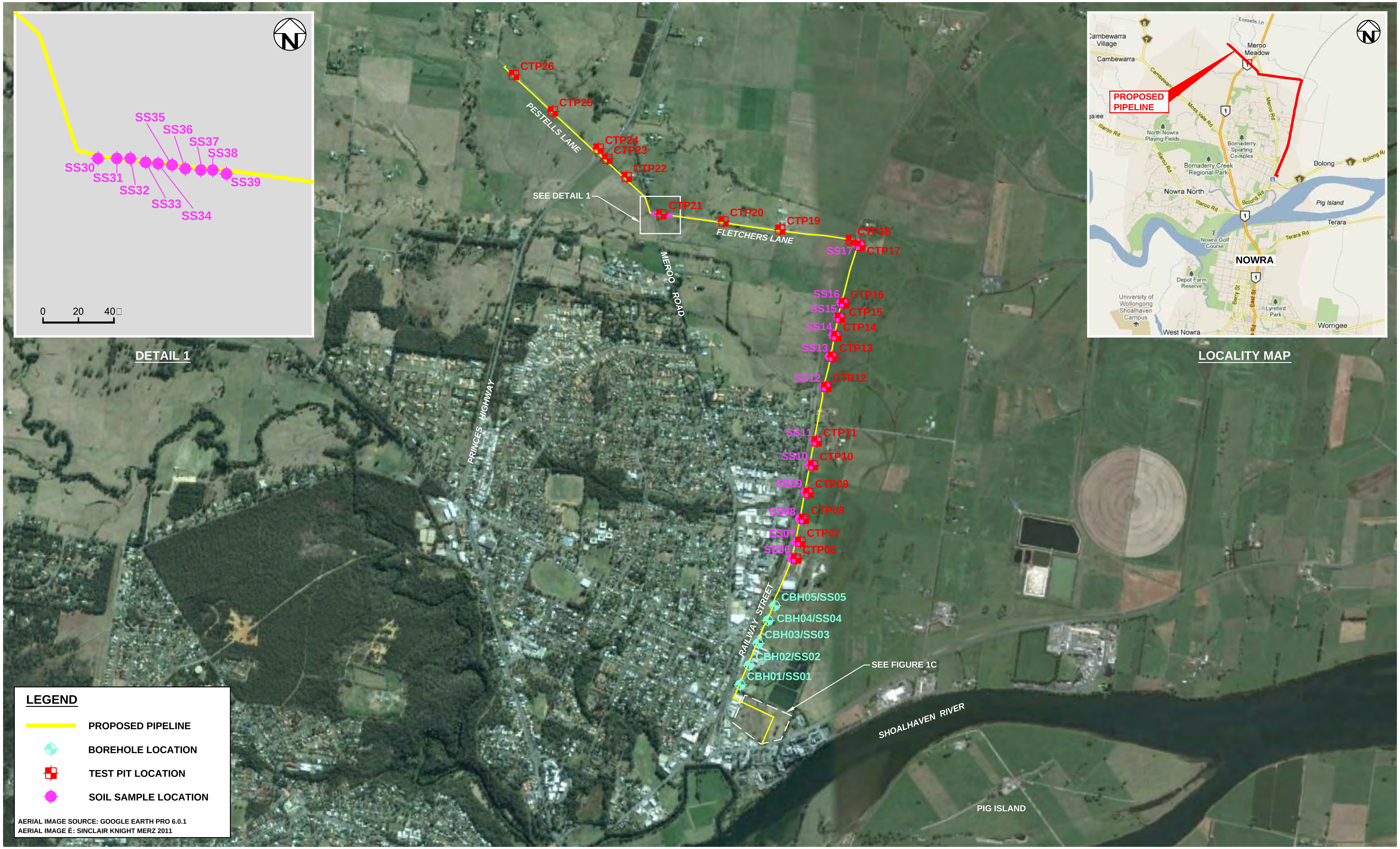
Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

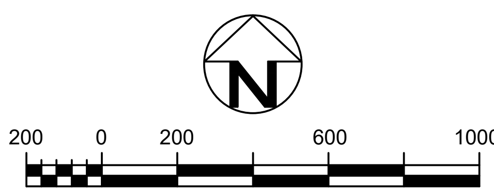
Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 4	
Culvert	Culvert 4A	
Flow	29.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	8.5	m
Culvert Height	2.0	m
Outlet Depth	1.35	m
Outlet Velocity	1.59	m/s
Froude Number	0.44	
Tailwater Depth	1.35	m
Tailwater Velocity	2.22	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	400.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.605	kPa
Modified Shear Number	0.201	
Scour Hole Dimensions		
Length (LS)	13.920	m
Width (WS)	14.573	m
Depth (DS)	3.352	m
Volume (VS)	74.992	m^3
DS at 0.4(LS)	5.568	m
Tailwater Depth (TW)	1.345	m
Velocity with TW and WS	0.785	m/s

GEOTECH



revision



Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

coffey

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS
project no:	ENAUWOLL04006AA-R01
figure no:	FIGURE 1

PLOT DATE: 28/25/2011 12:25 PM DWG FILE: F:\GEOTECHNICS\1.PROJECTS\OTHER OFFICE JOBS\WOLLONGONG\ENAUWOLL04006AA\FIGURES\ENAUWOLL04006AA_FIGURE 1A-B-C.DWG

revision	description	drawn	approved	date

100 0 100 300 500

Horizontal Scale (metres) 1:10 000

drawn	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

coffey

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS - SHEET 1 OF 2
project no:	ENAUWOLL04006AA-R01
figure no:	FIGURE 1A

revision	description	drawn	approved	date

100 0 100 300 500

Horizontal Scale (metres) 1:10 000

drawn	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

coffey

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS - SHEET 2 OF 2
project no:	ENAUWOLL04006AA-R01
figure no:	FIGURE 1B

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm		IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
			DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
	SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

(A 0.075 mm particle is about the smallest particle visible to the naked eye)

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.

Defect Discontinuity or break in the continuity of a substance or substances.

Mass Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbreviation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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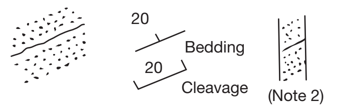
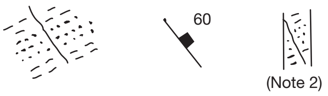
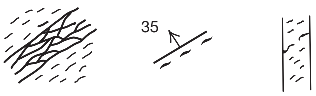
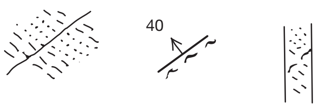
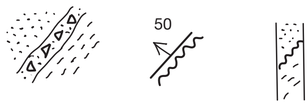
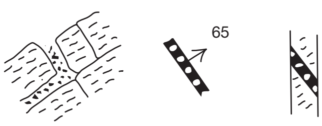
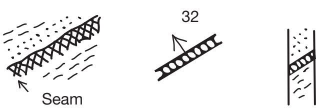
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram / Map Symbol / Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.	
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.	
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.	
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.	
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.	
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.	
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.	

DEFECT SHAPE

	TERMS
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

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Engineering Log - Excavation

Excavation No.	*CTP08*
Sheet	1 of 1
Office Job No.:	*ENAUWOLL04006AA*
Client:	*MANILDRA GROUP*
Date started:	*21.6.2011*
Principal:	
Date completed:	*21.6.2011*
Project:	*CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT*
Logged by:	*CA*
Test pit location:	*PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541*
Checked by:	*SM*

equipment type and model: 5T EXCAVATOR | Pit Orientation: N-S | Easting: 281965 m | R.L. Surface: NOT MEASURED

excavation dimensions: 1.5m long 0.45m wide | Northing: 6141716 m | datum: WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N							**TOPSOIL; Sandy CLAY/Clayey SAND:** Fine to medium grained, brown, with some roots.	M	MD		TOPSOIL
								CH	**Sandy CLAY:** High plasticity, pale brown/pale yellow, fine to medium grained sand, with some roots and silt.	Wp	F		ALLUVIAL SOIL
						0.5							
			►	ASS						>Wp			
						1.0		CL	**Sandy CLAY:** Medium plasticity, iron stained red/brown with grey pockets, fine to medium grained sand, with a trace of roots.	Wp	VSt	×	RESIDUAL SOIL
				ASS									
						1.5							
												×	
						2.0				<Wp	H		
						2.5							End on steady progress
									Test pit CTP08 terminated at 2.5m				
						3.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

drawn	RB		client:	MANILDRA GROUP PTY LTD	
approved	CA	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW	
date	19/07/2011				
scale	NTS		title:	PHOTO OF TEST PIT CTP08	
original size	A4		project no:	ENAUWOLL04006AA-AA	Photo Plate: 12

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Engineering Log - Excavation

Excavation No. **CTP09**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**21.6.2011**
Principal:		Date completed:	**21.6.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model: 5T EXCAVATOR   Pit Orientation: N-S   Easting: 281992 m   R.L. Surface: NOT MEASURED

excavation dimensions: 1.5m long 0.45m wide   Northing: 6141863 m   datum: WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N							**TOPSOIL; Sandy CLAY:** High plasticity, brown, fine to medium grained sand, with some roots.	>Wp	S		TOPSOIL
								CH	**CLAY:** High plasticity, dark grey/black, with some silt and fine grained sand, and a trace of roots.			×	ALLUVIAL/ESTUARINE SOIL? Slight SO_4 odour
						0.5							
				ASS									
			► (water inflow)										Test pit wall falling in under own weight at 0.6m
						1.0							
				ASS									
								CL	**CLAY:** Medium plasticity, pale yellow/pale brown, with some fine grained sand, and a trace of roots.				
						1.5							
				ASS				SC	**Clayey SAND:** Fine to medium grained, grey, with a trace of silt.	W	MD		
						2.0							
				ASS									
						2.5							End on steady progress
									Test pit CTP09 terminated at 2.5m				
						3.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client: **MANILDRA GROUP PTY LTD**
approved	CA		project: **ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	19/07/2011		
scale	NTS		title: **PHOTO OF TEST PIT CTP09**
original size	A4		project no: **ENAUWOLL04006AA-AA** Photo Plate: **13**

coffey environments

Engineering Log - Excavation

Excavation No. **CTP10**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**21.6.2011**
Principal:		Date completed:	**21.6.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282018 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142018 m	datum:	WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N				0.0–0.5			**TOPSOIL; Sandy CLAY:** Low to medium plasticity, pale yellow/brown, fine to medium grained sand, with some roots.	M	MD		TOPSOIL
						0.5–1.4		CL	**Sandy CLAY:** Medium plasticity, red/orange, with some silt, and a trace of roots and fine to coarse grained angular sandstone gravel.	<Wp	St	x (at ~1.0)	RESIDUAL
			Seepage (~2.2)			1.4–2.5		CL	**Sandy Gravelly CLAY:** Medium plasticity, orange/brown with some pale yellow/pale brown pockets and fine to medium grained highly weathered sandstone gravel.		H	x (at ~2.0)	EXTREMELY WEATHERED MATERIAL End on slow progress
						2.5			Test pit CTP10 terminated at 2.5m				

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0

Sketch

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation			U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4	no resistance ranging to refusal	D	disturbed sample		F	firm
B	bulldozer blade			V	vane shear (kPa)		St	stiff
R	ripper			Bs	bulk sample	**moisture**	VSt	very stiff
E	excavator			E	environmental sample	D dry	H	hard
		water		R	refusal	M moist	Fb	friable
		water level on date shown				W wet	VL	very loose
		water inflow				Wp plastic limit	L	loose
		water outflow				W_L liquid limit	MD	medium dense
							D	dense
							VD	very dense

drawn	**RB**	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	**MANILDRA GROUP PTY LTD**
approved	**CA**		project:	**ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	**19/07/2011**			
scale	**NTS**		title:	**PHOTO OF TEST PIT CTP10**
original size	**A4**		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **14**

coffey environments

Engineering Log - Excavation

Excavation No.	*CTP11*
Sheet	1 of 1
Office Job No.:	*ENAUWOLL04006AA*
Date started:	*21.6.2011*
Date completed:	*21.6.2011*
Logged by:	*CA*
Checked by:	*SM*

Client: ***MANILDRA GROUP***

Principal:

Project: ***CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT***

Test pit location: ***PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541***

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282038 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	1.5m long 0.45m wide			Northing:	6142154 m	datum:	WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED						**TOPSOIL; Sandy CLAY:** Low plasticity, brown, with some roots.	<Wp	F		TOPSOIL
						0.5		CL	**Sandy CLAY:** Medium plasticity, iron stained orange/brown, with some fine to coarse grained angular sandstone gravel, and a trace of roots.		VSt, H		RESIDUAL SOIL
						1.0, 1.5		CL	**Sandy CLAY:** Medium plasticity, orange/brown wtih grey pockets, and some fine to coarse grained angular sandstone gravel.				EXTREMELY WEATHERED MATERIAL
									SANDSTONE: Fine to medium grained, red/brown, low to medium strength.				HIGHLY WEATHERED SANDSTONE
						2.0, 2.5, 3.0			Test pit CTP11 terminated at 1.7m				End on very slow progress

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COFFEY.GDT 29.7.11

Form GEO 5.2 Issue 3 Rev.2

drawn	**RB**	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	**MANILDRA GROUP PTY LTD**
approved	**CA**		project:	**ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	**19/07/2011**			
scale	**NTS**		title:	**PHOTO OF TEST PIT CTP11**
original size	**A4**		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **15**

coffey environments

Engineering Log - Excavation

Excavation No. **CTP12**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**21.6.2011**
Principal:		Date completed:	**21.6.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282092 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142461 m	datum:	WGS84 (Approx)

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N							**TOPSOIL; CLAY:** High plasticity, brown, with some silt and roots.	>Wp	S		TOPSOIL
			►			0.5		CH	**Sandy CLAY:** High plasticity, brown, with some silt, and a trace of roots.				ALLUVIAL/ESTUARINE SOIL
				ASS								×100	
				ASS		1.0							
				ASS		1.5		CH	**Sandy CLAY:** High plasticity, grey, fine grained sand, and some silt.		St	×100 ×200 ×200	
				ASS		2.0							
						2.5			Test pit CTP12 terminated at 2.5m				End on steady progress
						3.0							

Sketch

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation			U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4	no resistance ranging to refusal	D	disturbed sample		F	firm
B	bulldozer blade			V	vane shear (kPa)	**moisture**	St	stiff
R	ripper			Bs	bulk sample	D dry	VSt	very stiff
E	excavator	**water**		E	environmental sample	M moist	H	hard
			water level on date shown	R	refusal	W wet	Fb	friable
			water inflow			Wp plastic limit	VL	very loose
			water outflow			W_L liquid limit	L	loose
							MD	medium dense
							D	dense
							VD	very dense

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COFFEY.GDT 29.7.11

Form GEO 5.2 Issue 3 Rev.2

Engineering Log - Excavation

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Excavation No.	*CTP13*
Sheet	1 of 1
Office Job No.:	*ENAUWOLL04006AA*
Date started:	*22.6.2011*
Date completed:	*22.6.2011*
Logged by:	*CA*
Checked by:	*SM*

Client: ***MANILDRA GROUP***

Principal:

Project: ***CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT***

Test pit location: ***PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541***

equipment type and model:	5T EXCAVATOR	Pit Orientation: N-S	Easting: 282129 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide		Northing: 6242631 m	datum:	WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N	NONE OBSERVED						**TOPSOIL; CLAY:** High plasticity, brown, with some roots and silt and a trace of fine grained sand.	Wp	VSt		TOPSOIL
				ASS		0.5							
				ASS		1.0		CH	**CLAY:** High plasticity, brown to grey with some iron stained orange/brown pockets, some silt, and a trace of roots.	<Wp/Wp			ALLUVIAL SOIL
				ASS		1.5							
				ASS		2.0							
						2.5							End on slow progress
									Test pit CTP13 terminated at 2.5m				
						3.0							

Sketch

method		support / penetration / water	notes, samples, tests		classification symbols and soil description / moisture	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation	penetration 1 2 3 4	U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	no resistance ranging to refusal	D	disturbed sample		F	firm
B	bulldozer blade	water	V	vane shear (kPa)		St	stiff
R	ripper	water level on date shown	Bs	bulk sample	moisture	VSt	very stiff
E	excavator	water inflow	E	environmental sample	D dry	H	hard
		water outflow	R	refusal	M moist	Fb	friable
					W wet	VL	very loose
					Wp plastic limit	L	loose
					W_L liquid limit	MD	medium dense
						D	dense
						VD	very dense

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	MANILDRA GROUP PTY LTD
approved	CA		project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW
date	19/07/2011			
scale	NTS		title:	PHOTO OF TEST PIT CTP13
original size	A4		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **17**

coffey environments

Engineering Log - Excavation

Excavation No. **CTP14**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**22.6.2011**
Principal:		Date completed:	**22.6.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282149 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142748 m	datum:	WGS84 (Approx)

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	NONE OBSERVED						**TOPSOIL; CLAY:** High plasticity, brown, with some silt and roots.	Wp	S		TOPSOIL
								CH	**CLAY:** High plasticity, brown with some orange pockets, and some silt, and a trace of roots.		VSt		ALLUVIAL SOIL
						0.5						X	
				ASS									
				ASS		1.0						X	
								CH	**CLAY:** High plasticity, orange/brown and grey, wtih some fine to medium grained sand and silt.	<Wp/Wp			
				ASS		1.5							
						2.0						X	
						2.5							End on steady progress
									Test pit CTP14 terminated at 2.5m				
						3.0							

Sketch

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation			U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4		D	disturbed sample		F	firm
B	bulldozer blade	no resistance ranging to refusal		V	vane shear (kPa)		St	stiff
R	ripper			Bs	bulk sample	**moisture**	VSt	very stiff
E	excavator			E	environmental sample	D dry	H	hard
		water		R	refusal	M moist	Fb	friable
		water level on date shown				W wet	VL	very loose
		water inflow				Wp plastic limit	L	loose
		water outflow				W_L liquid limit	MD	medium dense
							D	dense
							VD	very dense

drawn	**RB**	client:	**MANILDRA GROUP PTY LTD**
approved	**CA**	project:	**ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	**19/07/2011**		
scale	**NTS**	title:	**PHOTO OF TEST PIT CTP14**
original size	**A4**	project no: **ENAUWOLL04006AA-AA**	Photo Plate: **18**

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SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

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Engineering Log - Excavation

Excavation No. **CTP15**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	MANILDRA GROUP	Date started:	22.6.2011
Principal:		Date completed:	22.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282169 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142851 m	datum:	WGS84 (Approx)

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED						**TOPSOIL; CLAY:** High plasticity, black/dark grey, with some silt and roots, and a trace of fine grained sand.	<Wp	St		TOPSOIL
				ASS		0.5		CH	**CLAY:** High plasticity, grey with some iron stained orange/brown pockets, with a trace of roots, fine grained sand and fine to coarse grained angular gravel.	Wp	VSt		ALLUVIAL SOIL
				ASS		1.0				<Wp			
						1.5							
						2.0					H		
						2.5							End on slow progress
						3.0			Test pit CTP15 terminated at 2.5m				

Sketch

method		support		notes, samples, tests		classification symbols and soil description		consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system		VS	very soft
X	existing excavation	**penetration** 1 2 3 4		U_{63}	undisturbed sample 63mm diameter			S	soft
BH	backhoe bucket	no resistance ranging to refusal		D	disturbed sample			F	firm
B	bulldozer blade	**water**		V	vane shear (kPa)	**moisture**		St	stiff
R	ripper	water level on date shown		Bs	bulk sample	D	dry	VSt	very stiff
E	excavator	water inflow		E	environmental sample	M	moist	H	hard
		water outflow		R	refusal	W	wet	Fb	friable
						Wp	plastic limit	VL	very loose
						W_L	liquid limit	L	loose
								MD	medium dense
								D	dense
								VD	very dense

Form GEO 5.2 Issue 3 Rev.2

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COFFEY.GDT 29.7.11

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client: **MANILDRA GROUP PTY LTD**
approved	CA		project: **ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	19/07/2011		
scale	NTS		title: **PHOTO OF TEST PIT CTP15**
original size	A4		project no: **ENAUWOLL04006AA-AA** Photo Plate: **19**

coffey environments

Engineering Log - Excavation

Excavation No.	**CTP16**
Sheet	1 of 1
Office Job No.:	**ENAUWOLL04006AA**
Date started:	**22.6.2011**
Date completed:	**22.6.2011**
Logged by:	**CA**
Checked by:	**SM**

Client: **MANILDRA GROUP**

Principal:

Project: **CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**

Test pit location: **PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**

equipment type and model: 5T EXCAVATOR | Pit Orientation: N-S | Easting: 282191 m | R.L. Surface: NOT MEASURED

excavation dimensions: 2m long 0.45m wide | Northing: 6142933 m | datum: WGS84 (Approx)

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N				0.0			**TOPSOIL; CLAY:** High plasticity, brown, with some roots.	<Wp	F		TOPSOIL
						0.3		CH	**CLAY:** High plasticity, grey with some iron stained orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	Wp	VSt		ALLUVIAL SOIL
				ASS		0.6							
				ASS		1.1						× (1.0)	
				ASS		1.6							
						1.8		CH	**Sandy CLAY:** High plasticity, grey with orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	>Wp	St	× (2.0)	
				ASS		2.1							
			►			2.5			Test pit CTP16 terminated at 2.5m				End on steady progress
						3.0							

Sketch

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation	**penetration** 1 2 3 4	no resistance ranging to refusal	U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket			D	disturbed sample	**moisture**	F	firm
B	bulldozer blade	**water**		V	vane shear (kPa)	D dry	St	stiff
R	ripper		water level on date shown	Bs	bulk sample	M moist	VSt	very stiff
E	excavator		water inflow	E	environmental sample	W wet	H	hard
			water outflow	R	refusal	Wp plastic limit	Fb	friable
						W_L liquid limit	VL	very loose
							L	loose
							MD	medium dense
							D	dense
							VD	very dense

drawn	RB		client: MANILDRA GROUP PTY LTD
approved	CA	coffey environments	project: ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW
date	19/07/2011	SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	
scale	NTS		title: PHOTO OF TEST PIT CTP16
original size	A4		project no: **ENAUWOLL04006AA-AA** Photo Plate: **20**

coffey environments

Engineering Log - Excavation

Excavation No.	CTP17
Sheet	1 of 1
Office Job No.:	ENAUWOLL04006AA
Client:	MANILDRA GROUP
Principal:	
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541
Date started:	22.6.2011
Date completed:	22.6.2011
Logged by:	CA
Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:		Easting: 282284 m	R.L. Surface: NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing: 6143258 m	datum: WGS84 (Approx)

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED			0.0–0.3			**TOPSOL; CLAY:** Medium plasticity, brown, with some fine grained roots.	Wp	F		TOPSOIL
						0.3–2.5		CH	**CLAY:** High plasticity, brown with some orange pockets, with a trace of fine grained sand, roots and fine to coarse grained gravel.	<Wp	VSt	× (0.5), × (1.0), × (2.0)	ALLUVIAL SOIL
				ASS (0.6–0.7)									
				ASS (1.1–1.2)									
				ASS (1.6–1.7)									
						2.5							End on steady progress
						2.5–3.0			Test pit CTP17 terminated at 2.5m				

Sketch

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation			U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4		D	disturbed sample		F	firm
B	bulldozer blade	no resistance ranging to refusal		V	vane shear (kPa)	**moisture**	St	stiff
R	ripper			Bs	bulk sample	D dry	VSt	very stiff
E	excavator	**water**		E	environmental sample	M moist	H	hard
		water level on date shown		R	refusal	W wet	Fb	friable
		water inflow				Wp plastic limit	VL	very loose
		water outflow				W_L liquid limit	L	loose
							MD	medium dense
							D	dense
							VD	very dense

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	**MANILDRA GROUP PTY LTD**
approved	CA		project:	**ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	19/07/2011			
scale	NTS		title:	**PHOTO OF TEST PIT CTP17**
original size	A4		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **21**

coffey environments

Engineering Log - Excavation

Excavation No. **CTP18**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**4.5.2011**
Principal:		Date completed:	**4.5.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model:	7T CAT BACKHOE	Pit Orientation:	E-W	Easting:	282230 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6143289 m	datum:	WGS84 (Approx)

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED	E (~0.25)		0.0–0.3			**TOPSOIL; CLAY:** Medium plasticity, brown, with some roots and silt, with a trace of fine to medium grained sand and fine to coarse grained angular gravel.	<Wp	St		TOPSOIL
				ASS (~0.55)		0.3–1.4		CL	**CLAY:** Medium plasticity, brown/grey with some iron stained orange/brown pockets, wth some roots and fine to medium grained sand, and a trace of silt.	<Wp/Wp	VSt	×	ALLUVIAL SOIL
				ASS (~1.55), ASS (~2.05), ASS (~2.55)		1.4–2.6		CH	**CLAY:** High plasticity, iron stained orange/brown with grey pockets, some fine to medium grained sand, and a trace of fine to medium grained sub-angular ironstone gravel.	Wp	St/VSt	×	
						2.6			Test pit CTP18 terminated at 2.6m				CTP18 Terminated at 2.6m on steady progress

Sketch

method		support	notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation		U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	**penetration** 1 2 3 4	D	disturbed sample		F	firm
B	bulldozer blade	no resistance ranging to refusal	V	vane shear (kPa)	**moisture**	St	stiff
R	ripper		Bs	bulk sample	D dry	VSt	very stiff
E	excavator	**water**	E	environmental sample	M moist	H	hard
		water level on date shown	R	refusal	W wet	Fb	friable
		water inflow			Wp plastic limit	VL	very loose
		water outflow			W_L liquid limit	L	loose
						MD	medium dense
						D	dense
						VD	very dense

drawn	RB	coffey environments SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE	client:	**MANILDRA GROUP PTY LTD**
approved	CA		project:	**ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPELINE BOMADERRY NSW**
date	19/07/2011			
scale	NTS		title:	**PHOTO OF TEST PIT CTP18**
original size	A4		project no: **ENAUWOLL04006AA-AA**	Photo Plate: **22**

coffey environments

Engineering Log - Excavation

Excavation No. **CTP19**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	**MANILDRA GROUP**	Date started:	**4.5.2011**
Principal:		Date completed:	**4.5.2011**
Project:	**CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT**	Logged by:	**CA**
Test pit location:	**PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541**	Checked by:	**SM**

equipment type and model:	7T CAT BACKHOE	Pit Orientation:	E-W	Easting:	281832 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6143349 m	datum:	WGS84 (Approx)

excavation information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED	E					**TOPSOIL; Sandy CLAY:** Medium to high plasticity, brown, with some silt and roots, and a trace of fine grained gravel.	<Wp	St		TOPSOIL
				ASS		0.5		CH	**CLAY:** High plasticity, grey to dark grey mottled pale orange/pale brown, with some roots and fine to medium grained sand.	Wp			ALLUVIAL SOIL
				ASS		1.0						× ×	
				ASS		1.5		CH	**Sandy CLAY;** High plasticity, grey with orange/brown iron stained pockets, fine to medium grained sand, and some silt and roots.			×	
				ASS		2.0						×	
						2.5			Test pit CTP19 terminated at 2.5m				CTP19 Terminated at 2.5m on steady progress
						3.0							

Sketch

method		support		notes, samples, tests		classification symbols and soil description		consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system		VS	very soft
X	existing excavation	**penetration** 1 2 3 4	no resistance ranging to refusal	U_{63}	undisturbed sample 63mm diameter			S	soft
BH	backhoe bucket	**water**		D	disturbed sample	**moisture**		F	firm
B	bulldozer blade		water level on date shown	V	vane shear (kPa)	D	dry	St	stiff
R	ripper		water inflow	Bs	bulk sample	M	moist	VSt	very stiff
E	excavator		water outflow	E	environmental sample	W	wet	H	hard
				R	refusal	Wp	plastic limit	Fb	friable
						W_L	liquid limit	VL	very loose
								L	loose
								MD	medium dense
								D	dense
								VD	very dense

FRAC CALCS

CREEK 1 TO 4

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **DRAINAGE CHANNEL - FLOWING INTO TULLIAN CREEK** 7/02/2022 REV 0

CAVITY EXPANSION THEORY WAS USED TO DETERMINE MAX BORE HOLE PRESSURE

The model is developed to establish the maximum allowable pressure that can be applied to a given soil without hydrofacture occuring, expressed as follows

$$p_{max} = u + [\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Where

pMax is the max allowable mud pressure in bore hole in kPa

Ro	Initial Bore Radius (For Pilot Hole)	4.25 inch	0.05 m			
Rpmax	Radius of Plastic Zone		0.32 m	Borehole Size	0.10795	m
	Rmax Generally 3 times the bore hole size					

Soil Variables

$\varphi =$ Soil Friction Angle [°]		25.00 Deg		Worst case scenario value
$c =$ cohesion		2.00 kPa		Worst case scenario value
$\gamma =$ Unit weight of soil above the groundwater	15 kN	1529.05 kg/m3		Worst case scenario value
$\gamma' =$ Unit weight of soil below the groundwater		1529.05 kg/m3		
E = Youngs Modulus		10.00 Mpa		
v = Poissons Ratio		0.30		
G = Shear Modulus G = E / (2(1+v))		3.85 Mpa	3,846.15	kPa

Variables Dependent on Bore Geometry at	Under Creek Bed	Deepest Point - Bore Mid Point		Under Creek Bed
$h_s =$ Depth of the Bore below Ground Surface		2.90 m		
$h_w =$ Height of groundwater over the bore		0.00 m		
$u =$ Groundwater Pressure		0.00 kPa		
$\sigma' =$ Effective Stress $= \gamma \cdot (h_s - h_w) + \gamma'(h_w)$		4,434.25 kg/m2	43.50	kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **DRAINAGE CHANNEL - FLOWING INTO TULLIAN CREEK** 7/02/2022 REV 0

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 67.98552

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.75

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 182.96 kPa 26.53 psi

Variables Dependent on Bore Geometry at North of Bank Outside Creek Bank

h_s = Depth of the Bore below Ground Surface	2.47	m
h_w = Height of groundwater over the bore	0.00	m
u = Groundwater Pressure	0.00	kPa
σ' = Effective Stress = $\gamma\cdot(h_s - h_w) + \gamma'(h_w)$	3,776.76 kg/m2	37.05 kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 58.80964

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.77

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 158.73 kPa 23.02 psi

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **DRAINAGE CHANNEL - FLOWING INTO TULLIAN CREEK** 7/02/2022 REV 0

Variables Dependent on Bore Geometry at South of Bank Outside Creek Bank

h_s = Depth of the Bore below Ground Surface	2.47 m			
h_w = Height of groundwater over the bore	0.00 m			
u = Groundwater Pressure	0.00 kPa			
σ' = Effective Stress = $\gamma \cdot (h_s - h_w) + \gamma'(h_w)$		3,776.76 kg/m2	37.05 kPa	

sinQ 0.422618262
cosQ 0.906307787
tanQ 0.466307658
cotQ 2.144506921

$[\sigma_0' \cdot (1+\sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi]$ = 58.80964

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.77

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Borehole pressure to be less than this
158.73 kPa 23.02 psi

Check - Internal Pressure within Borehole

Annular Pressure (Pd) of Drill Fluid exerted by a mid sized HDD rig ranges from 10kPa to 52kPa for a 100 to 120m HDD

Hydrostatic pressure of the Drill Fluid is $P_{\text{drill fluid hydrostatic}} = h_{\text{drill fluid}} \times 9.81 \times \rho_{\text{drill fluid}}$

Where,

Height of drill fluid column $h_{\text{drill fluid}}$

Mud Weight $\rho_{\text{drill fluid}}$ = 1.20 kg/l

(mud weight of 1.20 kg/l used due to cuttings suspended in the hole)

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **DRAINAGE CHANNEL - FLOWING INTO TULLIAN CREEK** 7/02/2022 REV 0

Accordingly for various locations along the HDD path the internal pressures are as per below.

		Ph	Location of Drill Head	Expected Pd	Total Expected Internal Pressure
Pdrill fluid Hydrostatic					
	at 2.7m head (h)	31.78 kPa	1/3 into HDD	24 kPa	55.8 kPa
	at 2.9m head (h)	34.14 kPa	1/2 into HDD	31 kPa	65.1 kPa
	at 2.7m head (h)	31.78 kPa	2/3 into HDD	38 kPa	69.8 kPa

Comparing the internal pressures vs the soil bearing pressures at various points along the HDD it is clear that frac out is not probable

REFERENCES

Ariaratnam, Samuel T., Stauber, Richard M., Bell, J., Harbin, B., Cannon, F. (2003). "Predicting and Controlling Hydraulic Fracturing During Horizontal Directional Drilling" American Society of Civil Engineers Conference Proceedings Paper, New Pipeline Technologies, Security and Safety.

Bennett and Wallin, 2008. Step-By-Step Evaluation of Hydrofracture Risks for HDD Projects, Proceedings of 2008 No-Dig Conference, Dallas, Texas, April 27-May 2, 2008

Delft Geotechnics. (1997) A Report by Department of Foundations and Underground Engineering Prepared for O'Donnell Associates of Sugarland, TX.

Luger, H.J., and Hergarden, A.M. (1988) "Directional Drilling in Soft Soil: Influence of Mud Pressures", International Society of Trenchless Technology, No-Dig Conference.

Rowe, R.K. (2000). Geotechnical and Geoenvironmental Engineering Handbook. Kluwer Academic Publishing Group. The Netherlands. ISBN 0-7923-8613-2.

Staheli, K., Bennett, R.D., O'Donnell, H., Hurley, T., (1998). "Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling (HDD)", CPAR-GL-98-1, April 1998.

Terzaghi, K., and Peck, R. (1948) Soil Mechanics in Engineering Practice. John Wiley & Sons, Inc.

U.S. Army Corps of Engineers, (1990). "Engineering Manual, EM 1110-1-1904. Engineering and Design – Settlement Manual." 30 September 1990.

Xia, Hongwei (2009) Investigation of Maximum Mud Pressure Within Sand and Clay During Horizontal Directional Drilling, Ph.D. Thesis, Queen's University, Kingston, Ontario, Canada, January 2009.

Kimberlie, S, Christopher, P, Laura, W, 2010, " EFFECTIVENESS OF HYDROFACTURE PREDICTION FOR HDD DESIGN"

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **TRIBUTARY OF TULLIAN CREEK** 7/02/2022 REV 0

CAVITY EXPANSION THEORY WAS USED TO DETERMINE MAX BORE HOLE PRESSURE

The model is developed to establish the maximum allowable pressure that can be applied to a given soil without hydrofacture occuring, expressed as follows

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Where

pMax is the max allowable mud pressure in bore hole in kPa

Ro	Initial Bore Radius (For Pilot Hole)	4.25	inch	0.05	m			
Rpmax	Radius of Plastic Zone			0.32	m	Borehole Size	0.10795	m
	Rmax Generally 3 times the bore hole size							

Soil Variables

$\varphi =$ Soil Friction Angle [°]			25.00	Deg		Worst case scenario value
$c =$ cohesion			2.00	kPa		Worst case scenario value
$\gamma =$ Unit weight of soil above the groundwater	15	kN	1529.05	kg/m3		Worst case scenario value
$\gamma' =$ Unit weight of soil below the groundwater			1529.05	kg/m3		
E = Youngs Modulus			10.00	Mpa		
v = Poissons Ratio			0.30			
G = Shear Modulus G = E / (2(1+v))			3.85	Mpa	3,846.15	kPa

Variables Dependent on Bore Geometry at	Under Creek Bed	Deepest Point - Bore Mid Point				Under Creek Bed
$h_s =$ Depth of the Bore below Ground Surface		4.30	m			
$h_w =$ Height of groundwater over the bore		-1.80	m			
$u =$ Groundwater Pressure		17.66	kPa			
$\sigma' =$ Effective Stress $= \gamma\cdot(h_s - h_w) + \gamma'(h_w)$		6,574.92	kg/m2	64.50	kPa	

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **TRIBUTARY OF TULLIAN CREEK**

7/02/2022 REV 0

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 97.86051

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.70

$$p_{max} = u + [\sigma_0'\cdot(1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 277.54 kPa 40.24 psi

Variables Dependent on Bore Geometry at North of Bank - Ch 2713 Outside Creek Bank

h_s = Depth of the Bore below Ground Surface	3.25	m
h_w = Height of groundwater over the bore	0.00	m
u = Groundwater Pressure	0.00	kPa

σ' = Effective Stress = $\gamma\cdot(h_s - h_w) + \gamma'(h_w)$ 4,969.42 kg/m2 48.75 kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 75.45427

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.74

$$p_{max} = u + [\sigma_0'\cdot(1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 202.46 kPa 29.36 psi

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **TRIBUTARY OF TULLIAN CREEK** 7/02/2022 REV 0

Variables Dependent on Bore Geometry at **South of Bank - Ch 2798** Outside Creek Bank

$h_s =$ Depth of the Bore below Ground Surface 4.38 m

$h_w =$ Height of groundwater over the bore 0.00 m

$u =$ Groundwater Pressure 0.00 kPa

$\sigma' =$ Effective Stress $= \gamma \cdot (h_s - h_w) + \gamma'(h_w)$ 6,697.25 kg/m2 65.70 kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi]$ = 99.56765

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.70

$$p_{max} = u + [\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Borehole pressure to be less than this
264.20 kPa 38.31 psi

Check - Internal Pressure within Borehole

Annular Pressure (Pd) of Drill Fluid exerted by a mid sized HDD rig ranges from 10kPa to 100kPa for a 100 to 200m HDD

Hydrostatic pressure of the Drill Fluid is $P_{\text{drill fluid hydrostatic}} = h_{\text{drill fluid}} \times 9.81 \times \rho_{\text{drill fluid}}$

Where,

Height of drill fluid column $h_{\text{drill fluid}}$

Mud Weight $\rho_{\text{drill fluid}} = 1.20$ kg/l

(mud weight of 1.20 kg/l used due to cuttings suspended in the hole)

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **TRIBUTARY OF TULLIAN CREEK** 7/02/2022 REV 0

Accordingly for various locations along the HDD path the internal pressures are as per below.

		Ph	Location of Drill Head	Expected Pd	Total Expected Internal Pressure
Pdrill fluid Hydrostatic					
	at 3.25m head (h)	38.26 kPa	1/3 into HDD	39 kPa	77.3 kPa
	at 4.3m head (h)	52.97 kPa	1/2 into HDD	52 kPa	105.0 kPa
	at 4.38m head (h)	51.56 kPa	2/3 into HDD	78 kPa	129.6 kPa

Comparing the internal pressures vs the soil bearing pressures at various points along the HDD it is clear that frac out is not probable

REFERENCES

Ariaratnam, Samuel T., Stauber, Richard M., Bell, J., Harbin, B., Cannon, F. (2003). "Predicting and Controlling Hydraulic Fracturing During Horizontal Directional Drilling" American Society of Civil Engineers Conference Proceedings Paper, New Pipeline Technologies, Security and Safety.

Bennett and Wallin, 2008. Step-By-Step Evaluation of Hydrofracture Risks for HDD Projects, Proceedings of 2008 No-Dig Conference, Dallas, Texas, April 27-May 2, 2008

Delft Geotechnics. (1997) A Report by Department of Foundations and Underground Engineering Prepared for O'Donnell Associates of Sugarland, TX.

Luger, H.J., and Hergarden, A.M. (1988) "Directional Drilling in Soft Soil: Influence of Mud Pressures", International Society of Trenchless Technology, No-Dig Conference.

Rowe, R.K. (2000). Geotechnical and Geoenvironmental Engineering Handbook. Kluwer Academic Publishing Group. The Netherlands. ISBN 0-7923-8613-2.

Staheli, K., Bennett, R.D., O'Donnell, H., Hurley, T., (1998). "Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling (HDD)", CPAR-GL-98-1, April 1998.

Terzaghi, K., and Peck, R. (1948) Soil Mechanics in Engineering Practice. John Wiley & Sons, Inc.

U.S. Army Corps of Engineers, (1990). "Engineering Manual, EM 1110-1-1904. Engineering and Design – Settlement Manual." 30 September 1990.

Xia, Hongwei (2009) Investigation of Maximum Mud Pressure Within Sand and Clay During Horizontal Directional Drilling, Ph.D. Thesis, Queen's University, Kingston, Ontario, Canada, January 2009.

Kimberlie, S, Christopher, P, Laura, W, 2010, " EFFECTIVENESS OF HYDROFACTURE PREDICTION FOR HDD DESIGN"

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **ABERNETHYS CREEK** 7/02/2022 REV 0

CAVITY EXPANSION THEORY WAS USED TO DETERMINE MAX BORE HOLE PRESSURE

The model is developed to establish the maximum allowable pressure that can be applied to a given soil without hydrofacture occuring, expressed as follows

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Where

pMax is the max allowable mud pressure in bore hole in kPa

Ro	Initial Bore Radius (For Pilot Hole)	4.25 inch	0.05 m			
Rpmax	Radius of Plastic Zone		0.32 m	Borehole Size	0.10795 m	
	Rmax Generally 3 times the bore hole size					

Soil Variables

$\varphi =$ Soil Friction Angle [°]		25.00 Deg		Worst case scenario value
$c =$ cohesion		2.00 kPa		Worst case scenario value
$\gamma =$ Unit weight of soil above the groundwater	15 kN	1529.05 kg/m3		Worst case scenario value
$\gamma' =$ Unit weight of soil below the groundwater		1529.05 kg/m3		
E = Youngs Modulus		10.00 Mpa		
v = Poissons Ratio		0.30		
G = Shear Modulus G = E / (2(1+v))		3.85 Mpa	3,846.15	kPa

Variables Dependent on Bore Geometry at

	Under Creek Bed	Deepest Point - Bore Mid Point		Under Creek Bed
$h_s =$ Depth of the Bore below Ground Surface		7.11 m		
$h_w =$ Height of groundwater over the bore		-6.61 m		
$u =$ Groundwater Pressure		64.84 kPa		
$\sigma' =$ Effective Stress $= \gamma\cdot(h_s - h_w) + \gamma'(h_w)$		10,871.56 kg/m2	106.65	kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **ABERNETHYS CREEK** 7/02/2022 REV 0

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 157.8239

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.60

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 471.29 kPa 68.34 psi

Variables Dependent on Bore Geometry at North of Bank - Ch 3207 Outside Creek Bank

h_s = Depth of the Bore below Ground Surface	6.90	m
h_w = Height of groundwater over the bore	-4.90	m
u = Groundwater Pressure	48.07	kPa
σ' = Effective Stress = $\gamma\cdot(h_s - h_w) + \gamma'(h_w)$	10,550.46 kg/m2	103.50 kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 153.3426

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.61

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 443.89 kPa 64.36 psi

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **ABERNETHYS CREEK** 7/02/2022 REV 0

Variables Dependent on Bore Geometry at **South of Bank - Ch 3271** Outside Creek Bank

h_s = Depth of the Bore below Ground Surface	6.12	m		
h_w = Height of groundwater over the bore	-4.12	m		
u = Groundwater Pressure	40.42	kPa		
σ' = Effective Stress = $\gamma \cdot (h_s - h_w) + \gamma'(h_w)$	9,357.80	kg/m2	91.80	kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi]$ = 136.698

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.63

$$p_{max} = u + [\sigma_0' \cdot (1 + \sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Borehole pressure to be less than this
396.32 kPa 57.47 psi

Check - Internal Pressure within Borehole

Annular Pressure (Pd) of Drill Fluid exerted by a mid sized HDD rig ranges from 10kPa to 100kPa for a 100 to 200m HDD

Hydrostatic pressure of the Drill Fluid is $P_{\text{drill fluid hydrostatic}} = h_{\text{drill fluid}} \times 9.81 \times \rho_{\text{drill fluid}}$

Where,

Height of drill fluid column $h_{\text{drill fluid}}$

Mud Weight $\rho_{\text{drill fluid}}$ = 1.20 kg/l

(mud weight of 1.20 kg/l used due to cuttings suspended in the hole)

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **ABERNETHYS CREEK** 7/02/2022 REV 0

Accordingly for various locations along the HDD path the internal pressures are as per below.

		Ph	Location of Drill Head	Expected Pd	Total Expected Internal Pressure
Pdrill fluid Hydrostatic					
	at 6.9m head (h)	81.23 kPa	1/3 into HDD	39 kPa	120.2 kPa
	at 7.11m head (h)	83.70 kPa	1/2 into HDD	52 kPa	135.7 kPa
	at 6.12m head (h)	72.04 kPa	2/3 into HDD	78 kPa	150.0 kPa

Comparing the internal pressures vs the soil bearing pressures at various points along the HDD it is clear that frac out is not probable

REFERENCES

Ariaratnam, Samuel T., Stauber, Richard M., Bell, J., Harbin, B., Cannon, F. (2003). "Predicting and Controlling Hydraulic Fracturing During Horizontal Directional Drilling" American Society of Civil Engineers Conference Proceedings Paper, New Pipeline Technologies, Security and Safety.

Bennett and Wallin, 2008. Step-By-Step Evaluation of Hydrofracture Risks for HDD Projects, Proceedings of 2008 No-Dig Conference, Dallas, Texas, April 27-May 2, 2008

Delft Geotechnics. (1997) A Report by Department of Foundations and Underground Engineering Prepared for O'Donnell Associates of Sugarland, TX.

Luger, H.J., and Hergarden, A.M. (1988) "Directional Drilling in Soft Soil: Influence of Mud Pressures", International Society of Trenchless Technology, No-Dig Conference.

Rowe, R.K. (2000). Geotechnical and Geoenvironmental Engineering Handbook. Kluwer Academic Publishing Group. The Netherlands. ISBN 0-7923-8613-2.

Staheli, K., Bennett, R.D., O'Donnell, H., Hurley, T., (1998). "Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling (HDD)", CPAR-GL-98-1, April 1998.

Terzaghi, K., and Peck, R. (1948) Soil Mechanics in Engineering Practice. John Wiley & Sons, Inc.

U.S. Army Corps of Engineers, (1990). "Engineering Manual, EM 1110-1-1904. Engineering and Design – Settlement Manual." 30 September 1990.

Xia, Hongwei (2009) Investigation of Maximum Mud Pressure Within Sand and Clay During Horizontal Directional Drilling, Ph.D. Thesis, Queen's University, Kingston, Ontario, Canada, January 2009.

Kimberlie, S, Christopher, P, Laura, W, 2010, " EFFECTIVENESS OF HYDROFACTURE PREDICTION FOR HDD DESIGN"

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **MULGEN CREEK** 7/02/2022 REV 0

CAVITY EXPANSION THEORY WAS USED TO DETERMINE MAX BORE HOLE PRESSURE

The model is developed to establish the maximum allowable pressure that can be applied to a given soil without hydrofacture occuring, expressed as follows

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]\cdot\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Where

pMax is the max allowable mud pressure in bore hole in kPa

Ro	Initial Bore Radius (For Pilot Hole)	4.25	inch	0.05	m		
Rpmax	Radius of Plastic Zone			0.32	m	Borehole Size	0.10795 m
	Rmax Generally 3 times the bore hole size						

Soil Variables

$\varphi =$ Soil Friction Angle [°]			25.00	Deg		Worst case scenario value
$c =$ cohesion			2.00	kPa		Worst case scenario value
$\gamma =$ Unit weight of soil above the groundwater	15	kN	1529.05	kg/m3		Worst case scenario value
$\gamma' =$ Unit weight of soil below the groundwater			1529.05	kg/m3		
E = Youngs Modulus			10.00	Mpa		
v = Poissons Ratio			0.30			
G = Shear Modulus G = E / (2(1+v))			3.85	Mpa	3,846.15	kPa

Variables Dependent on Bore Geometry at	Under Creek Bed	Deepest Point - Bore Mid Point				Under Creek Bed
$h_s =$ Depth of the Bore below Ground Surface		5.40	m			
$h_w =$ Height of groundwater over the bore		-4.40	m			
$u =$ Groundwater Pressure		43.16	kPa			
$\sigma' =$ Effective Stress $= \gamma\cdot(h_s - h_w) + \gamma'(h_w)$		8,256.88	kg/m2	81.00	kPa	

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **MULGEN CREEK** 7/02/2022 REV 0

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 121.3337

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.66

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 361.58 kPa 52.43 psi

Variables Dependent on Bore Geometry at North of Bank - Ch 3826 Outside Creek Bank

h_s = Depth of the Bore below Ground Surface	3.75	m
h_w = Height of groundwater over the bore	-1.00	m
u = Groundwater Pressure	9.81	kPa
σ' = Effective Stress = $\gamma\cdot(h_s - h_w) + \gamma'(h_w)$	5,733.94 kg/m2	56.25 kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi]$ = 86.12391

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)$ = 0.03

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.72

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c\cdot\cos\varphi + c\cdot\cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0'\cdot\sin\varphi + c\cdot\cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c\cdot\cot\varphi \quad [1]$$

Borehole pressure to be less than this
= 239.81 kPa 34.77 psi

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

NATIONAL AUSTRALIAN PIPELINES PTY. LTD.

HDD NAME **MULGEN CREEK**

7/02/2022 REV 0

Variables Dependent on Bore Geometry at South of Bank - Ch 3993 Outside Creek Bank

h_s = Depth of the Bore below Ground Surface 4.53 m

h_w = Height of groundwater over the bore -1.00 m

u = Groundwater Pressure 9.81 kPa

$\sigma' = \text{Effective Stress} = \gamma \cdot (h_s - h_w) + \gamma'(h_w)$ 6,926.61 kg/m2 67.95 kPa

sinQ	0.422618262
cosQ	0.906307787
tanQ	0.466307658
cotQ	2.144506921

$[\sigma_0' \cdot (1+\sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi]$ = 102.7685

$\frac{-\sin\varphi}{1+\sin\varphi}$ = -0.2971

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)$ = 0.04

$\left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}}$ = 2.69

$$p_{max} = u + [\sigma_0' \cdot (1+\sin\varphi) + c \cdot \cos\varphi + c \cdot \cot\varphi] \cdot \left(\left(\frac{R_0}{R_{pmax}}\right)^2 + \frac{\sigma_0' \cdot \sin\varphi + c \cdot \cos\varphi}{G}\right)^{\frac{-\sin\varphi}{1+\sin\varphi}} - c \cdot \cot\varphi \quad [1]$$

Borehole pressure to be less than this
282.07 kPa 40.90 psi

Check - Internal Pressure within Borehole

Annular Pressure (Pd) of Drill Fluid exerted by a mid sized HDD rig ranges from 10kPa to 100kPa for a 100 to 200m HDD

Hydrostatic pressure of the Drill Fluid is $P_{\text{drill fluid hydrostatic}} = h_{\text{drill fluid}} \times 9.81 \times \rho_{\text{drill fluid}}$

Where,

Height of drill fluid column $h_{\text{drill fluid}}$

Mud Weight $\rho_{\text{drill fluid}}$ = 1.20 kg/l

(mud weight of 1.20 kg/l used due to cuttings suspended in the hole)

Natural Gas Pipeline and Pressure Reduction Station
FRAC OUT ANALYSIS

HDD NAME **MULGEN CREEK** 7/02/2022 REV 0

Accordingly for various locations along the HDD path the internal pressures are as per below.

		Ph	Location of Drill Head	Expected Pd	Total Expected Internal Pressure
Pdrill fluid Hydrostatic					
	at 3.75m head (h)	44.15 kPa	1/3 into HDD	39 kPa	83.1 kPa
	at 5.4m head (h)	63.57 kPa	1/2 into HDD	52 kPa	115.6 kPa
	at 4.53m head (h)	53.33 kPa	3/4 into HDD	91 kPa	144.3 kPa

Comparing the internal pressures vs the soil bearing pressures at various points along the HDD it is clear that frac out is not probable

REFERENCES

Ariaratnam, Samuel T., Stauber, Richard M., Bell, J., Harbin, B., Cannon, F. (2003). "Predicting and Controlling Hydraulic Fracturing During Horizontal Directional Drilling" American Society of Civil Engineers Conference Proceedings Paper, New Pipeline Technologies, Security and Safety.

Bennett and Wallin, 2008. Step-By-Step Evaluation of Hydrofracture Risks for HDD Projects, Proceedings of 2008 No-Dig Conference, Dallas, Texas, April 27-May 2, 2008

Delft Geotechnics. (1997) A Report by Department of Foundations and Underground Engineering Prepared for O'Donnell Associates of Sugarland, TX.

Luger, H.J., and Hergarden, A.M. (1988) "Directional Drilling in Soft Soil: Influence of Mud Pressures", International Society of Trenchless Technology, No-Dig Conference.

Rowe, R.K. (2000). Geotechnical and Geoenvironmental Engineering Handbook. Kluwer Academic Publishing Group. The Netherlands. ISBN 0-7923-8613-2.

Staheli, K., Bennett, R.D., O'Donnell, H., Hurley, T., (1998). "Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling (HDD)", CPAR-GL-98-1, April 1998.

Terzaghi, K., and Peck, R. (1948) Soil Mechanics in Engineering Practice. John Wiley & Sons, Inc.

U.S. Army Corps of Engineers, (1990). "Engineering Manual, EM 1110-1-1904. Engineering and Design – Settlement Manual." 30 September 1990.

Xia, Hongwei (2009) Investigation of Maximum Mud Pressure Within Sand and Clay During Horizontal Directional Drilling, Ph.D. Thesis, Queen's University, Kingston, Ontario, Canada, January 2009.

Kimberlie, S, Christopher, P, Laura, W, 2010, " EFFECTIVENESS OF HYDROFACTURE PREDICTION FOR HDD DESIGN"

HEAD

TRACKING

TOOL

DigiTrak

Falcon F5®

Directional Drilling Guidance System

- Wideband technology evaluates hundreds of frequencies for the best possible performance around active interference
- Ultra-low frequency options for battling passive interference on the jobsite
- Scan for interference, select optimum frequencies, and pair transmitter at the jobsite
- Switch between paired bands mid-bore
- Full Scale Sensitive Pitch provides 0.1% resolution through ±99.9% slope for precision grade work
- Max Mode filters noise to boost weak data signals and stabilize depth readings
- Standard warranty for 19- and 15-inch transmitters is 3 years/500 hours

Falcon F5 Is Now *Passive Aggressive*

The ability to choose the right transmitter frequency is more important than power in overcoming the effect of active interference. In October of 2015, DCI introduced Falcon technology, a significant new approach to overcoming active interference on HDD jobsites. DCI now introduces a new approach to addressing the problem of passive interference: sub-kilohertz frequencies. Falcon F5 with Sub-k Rebar capability allows a locating specialist to scan the jobsite and select the best frequency in the ultra-low frequency range of 0.33–0.75 kHz to combat passive interference.

Falcon Innovation Continues

Falcon is the HDD industry's only walkover guidance system able to specifically address both active and passive interference. Transmitter frequencies below 1 kHz are proven most effective for jobsites where passive interference is a problem. In addition, the new Falcon F5 receiver supports Full Scale Sensitive Pitch (FSSP) for 0.1% resolution through ±99.9% slope for precision grade work.

The Falcon F5 receiver offers the industry's first fully integrated GPS capability using the DigiTrak iGPS module. Snap on the iGPS module and it automatically powers on to receive and record satellite GPS data.

Use the free LWD Mobile app to view the progress of the bore and overlay the iGPS locate points on your smart device.

The Falcon F5 Wideband Transmitter

A Falcon F5 transmitter provides versatility in all types of active interference at frequencies of 4.5–45 kHz. The Falcon F5 wideband design vastly outperforms single-frequency transmitters of past generations. It also comes standard with fluid pressure measurement. No other guidance system allows an operator to scan for active interference and then pair optimized frequencies to a transmitter at every jobsite. This provides substantial cost savings and increases pilot bore productivity.

The Falcon F5 Sub-k Rebar Transmitter

The newest entrant into the Falcon F5 wideband transmitter lineup is the Sub-k Rebar transmitter. It uses frequencies below 1 kHz and provides frequency selection options from 0.33–0.75 kHz. This frequency range is ideal for addressing project scenarios that exhibit passive interference. Whether sidewalk, roadway, or runway, the Sub-k outperforms other options above 1 kHz. These transmitters include fluid pressure measurement as a standard feature.

Wideband Sub-k Rebar

Falcon Frequency Optimizer

DigiTrak FALCON F5® Guidance System

	DigiTrak Sub-kHz			The other guys	DigiTrak Wideband								
Band Number	0.3	0.5	0.7		7	11	16	20	25	29	34	38	43
Range in kHz	.33 – .40	.40 – .58	.58 – .75	1.5 – 4.0	4.5 – 9.0	9.0 – 13.5	13.5 – 18	18 – 22.5	22.5 – 27	27 – 31.5	31.5 – 36	36 – 40.5	40.5 – 45

Ease of Use

Falcon F5 raises the bar on walkover locating system capability and ease of use. Our customers have always relied on the Falcon F5's color, icon-driven screen for easy menu navigation. *Ball-in-the-Box* has never been more powerful and still provides a real-time status of the bore in progress. Minimize downtime caused by alternative products that claim to get the job done but often fall short. Keep your project on DigiTrak and maximize your productivity.

3 Year/500 Hour Warranty

Register your new Falcon 19- or 15-inch transmitter within 90 days for an enhanced warranty of 3 years or 500 hours, whichever occurs first. Ask your dealer about an extended warranty option that provides 5 year/750 hour coverage.

Transmitter Specifications

See the separate Falcon F5 Transmitter Specification Sheet for details on the six different 19-, 15-, and 8-inch wideband options for active interference and Sub-k Rebar options for combating passive interference. Falcon F5 also supports our popular DucTrak transmitters.

Receiver Specifications

Product ID	FF5
Model number	FAR5
Receiving frequencies	0.33–45.0 kHz
Telemetry channels[1]	4
Telemetry range[2]	defined by remote display
Power source	Lithium-ion battery pack
Battery life	8–12 hrs
Functions	Menu-driven
Controls	Trigger and toggle switches
Graphic display	Full-color LCD
Audio output	Beeper
Accuracy	±5%
Voltage, current	14.4 VDC nominal, 390 mA max
Operating temperature	-20–60° C
Dimensions	27.94 x 13.97 x 38.1 cm
Weight (with battery)	3.9 kg

Aurora Touchscreen Display Specifications

Product ID and model number	AF8, AF10
Power source - cabled	10–28 VDC
Current	1.75, 2.1 A maximum
Controls	21.3, 26.4 cm touchscreen
Graphic display	LCD
Audio output	Speaker
Telemetry channels[1]	4
Telemetry range[2]	500 m
Operating temperature	-20–60° C
Dimensions[3]	24.9 x 16.8 x 8.1, 29.2 x 23.7 x 5.8 cm
Weight	1.9, 2.9 kg

[1] Local telemetry frequencies and power levels available at www.DigiTrak.com.
[2] Telemetry range can be increased with an optional external receiving antenna.
[3] Dimensions do not include external mounting hardware.

PRE-COM

RISK

ASSESSMENT

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
		ENTER ASSESSMENT DATA				Procedural Mitigation, Codes of Practice, Australian Standards, Training and Induction Programmes, Physical Mitigation	ENTER ASSESSMENT DATA				
Horizontal Directional Drilling	Stakeholder impact - injuries and supply/service disruption	3	4	12	High	• Establish Exclusion zone and signage to isolate drill area • Fencing HDD excavation to ensure restricted access • Warning signage • Hazard lights • SWMS for HDD • Entry and exit pits safe distance from access • Traffic Management, if required • Review Drilling and HDD management plan in conjunction with Shoalhaven Starches	2	3	6	Low	Y
	Handling/Bulk Storage/transporting hazardous or dangerous goods - spills, contamination, skin irritation and burns	3	4	12	High	• Ensuring containers labelled and sealed • Register of Dangerous Goods, MSDS in Site Office • Appropriate lift location • Appropriate equipment for handling/transfer • Correct PPE to be worn in accordance with Shoalhaven Starches and NAP induction as well as MSDS requirements • Spill kits in site yard and on refuelling vehicle • MSDS on file and upto date • Employee trained and competent. • Induction. • Shoalhaven Starches Audits • Licensed operator to carry bulk dangerous goods. • All transport done In accordance with EPA guidelines	2	3	6	Low	Y
	Entanglement occurs during drilling - Unauthorised personnel to work area Automated Actions, Pinch points from rod loading and jaw clamps - Soft tissue injuries	3	4	12	High	• Exclusion zone around drill identified • Authorised Persons Only Signage. • Visitor sign on Log. • Obtain Work permit • SWMS for HDD • Machinery guarding • Trained competent operators verified for employees / subcontractors • No loose clothing allowed • Isolation & tag out protocols for maintenance	2	4	8	Moderate	Y
	Noise emitted from drilling plant - OH&S issues	5	3	15	High	• All plant to be risk assessed and have scheduled maintenance / servicing • Selection of equipment to provide noise attenuation • Appropriate PPE • Job rotation to reduce exposure limit (Where required)	2	2	4	Negligible	Y
	Impact with an existing services - injuries	3	4	12	High	• Approved Boring Procedure and HDD Management Plan in conjunction with NAP and Shoalhaven Starches requirements • Tracking of the bore during drilling • Exposure of services where possible, with spotter when borer is in proximity. • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipelines • DBYD and service register to be developed to ascertain risk of impact to services	2	4	8	Moderate	Y
	Drilling Failure - major supply/service issues	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan.	2	4	8	Moderate	Y

CONSTRUCTION ACTIVITY	HAZARD / RISK DESCRIPTION Possible Initiating Events	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		MITIGATION / CONTROLS TO BE IMPLEMENTED Additional Mitigation Measures to reduce risks are listed in red	LIKELIHOOD	CONSEQUENCE	RISK RATING Technical Risk Rating (L x C)		ALARP YES / NO?
						• Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline • Emergency response plan (Frac out management plan)					
	Frac out occurring impacting roadways / environment	3	5	15	High	• Approved Boring Procedures, Fluid Management Plan • Using an experienced drilling contractor • SWMS for HDD • Conduct proving holes prior to commencement for head selection - Geotech Analysis • NAP permit to work procedure for conducting bore • Selection of HDD bore profile during design, with safety margin from underground services and adequate margin from existing pipeline / impact to road • Emergency response plan (Frac out management plan)	2	4	8	Moderate	Y

SWMS

Jelmac Industries Pty Ltd
2 Jeanette Maree Court
Kilsyth VIC 3137
Phone: 0417 351 908
ABN: 60 165 118 972

Jelmac Industries Pty Ltd
SWMS
Safe Work Method Statement

THIS FORM IS TO IDENTIFY TASK / SITE HAZARDS AND TO MINIMISE THE RISKS TO PERSONS AND/OR DAMAGE TO PROPERTY.					
Project:	National Australia Pipelines				
Site Address:	Creek Crossing				
Site Muster Point:		**Start Date:**		**Supervisor**	Brad Boote
Specific Task:	Directional Drilling & Vacuum Truck	**Finish Date:**		**Phone:**	0417351908
Plant & Equipment:	Directional Drill, Vacuum Truck, Support Vehicle. Hand tools.				
Hazardous Materials:					
Personal Protective Equipment Required:	Uniform; Footwear ☑; Hi Visibility ☑; Hard Hat ☑; Eyewear ☑; Fall Arrest ☐; Gloves ☑; Hearing ☑; Dust Mask ☑; First Aid ☑				
Managers Approval:	Brad Boote	**Signed:**		**Date:**	20-01-2022

CONSEQUENCES	POSSIBLE COURSES OF ACTION	LIKELIHOOD	MINOR (1)	SERIOUS (2)	SEVERE (3)	MAJOR (4)	CATASTROPHIC (5)
MINOR	First Aid, No Medical Treatment required. Spillages, leaks or other escapes, which occur and are contained. Supervisor to report and monitor.	(A)...ALMOST CERTAIN Will likely occur once or more every couple of years. Expected to or occurs regularly.	Medium	High	High	Extreme	Extreme
SERIOUS	Lost time injury/medical treatment required. Spillages or leakages, which have migrated offsite. Supervisor to report and manage by routine procedures. Immediate reparative/first aid action required.	(B)...LIKELY Will likely occur once or more in 10 years.	Low	Medium	High	High	Extreme
SEVERE	Single permanent or partial disability. Discharge of any substance from site, which has the potential to harm the environment. Supervisor to report and manage by specific monitoring plan or procedures. Stop work, immediate reparative/first aid action required.	(C)...POSSIBLE Could occur but not probable. Has not occurred at Jelmac.	Low	Low	Medium	High	High
MAJOR	Total permanent disability. Actual material harm to the environment on or off site with short-term effects and reparable by remedial action. Supervisor to report and allocate responsibility to appropriate senior manager. Stop work, immediate attention needed urgently.	(D)...UNLIKELY Not expected to occur. Has not occurred at Jelmac but has occurred within the industry in Australia.	Negligible	Low	Low	Medium	High
CATASTROPHIC	Multiple fatalities or total permanent disability. Actual material harm to the environment on or offsite with long term or irreparable effects. Supervisor to report and notify appropriate senior manager to manage via detailed control plan. Stop work, quarantine site, supervisor to contact relevant emergency services.	(E)...RARE May occur in exceptional circumstances. Has occurred in known history in the industry.	Negligible	Negligible	Low	Low	Medium

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

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Standards & Requirements	Occupation Health & Safety (OHS) Act 2004, Occupation Health & Safety (OHS) Regulations 2007,	FSR1: Temporary works, excavations and underground and overhead services FSR 02: Plant Equipment NAP Ground Penetration Permit	NAE PTW Certificates of Competency TM Plan

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Safety Management	Lack of safe work practices places workers, public and wildlife at risk.	**A**	**5**	**E**	All Jelmac Directional Drilling staff members are issued upon acceptance of employment a Safety Folder containing all occupational health and safety procedures. Staff members are expected to refer to and follow these procedures to ensure safe work practices. Staff and emergency contact details are provided at the rear of the folder. Site-specific forms SWMS and JSA are available.	**E**	**3**	**L**	Management/ Supervisors/ All Personnel
	First Aid	Lack of sufficient first aid can significantly increase injury.	**C**	**3**	**M**	All vehicles are equipped with a Standard Workplace First Aid Kit. Injury is to be assessed and medical assistance sought if required. Follow Emergency Procedures if required and consult Emergency Contact Details if necessary.	**C**	**2**	**L**	Management/ Supervisors/ All Personnel
	Environmental Management	Wildlife, significant vegetation, noxious weeds, waste, hazardous chemicals and materials.	**C**	**3**	**M**	Identify Environmental Management procedure. Inspect, identify and assess risks. Ensure compliance with local, state or EPA guidelines. Ensure safe removal or avoidance of any wildlife and or vegetation. Ensure wash down of plant and machinery to avoid transfer of any noxious weeds. If asbestos is encountered, stop works immediately and contact engineer or supervisor. Control of Drill slurry , erect silt controls at Bore entry & exit, Remove excess via Vac unit for disposal to EPA accredited site	**E**	**1**	**N**	Management/ Supervisors/ All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Emergency Preparedness	Fire, explosion, flood, bush fire, bomb threats.	**E**	**5**	**M**	Plant and LV Inductions need to be completed. Identify Emergency Procedures procedure. Assess location and impending weather conditions and forecast. All trucks and plant are equipped with fire extinguishers, which are all current with tags as per legislative requirements. Ensure any hoses are clearly labelled and accessible, ensure work areas suitable, secure and clear, avoid creating fire hazards and consider evacuation plans. Identify Emergency Contact Details form. Ensure all staff are identified and accounted for in the event of an emergency.	**E**	**3**	**L**	Management/ Supervisors/ All Personnel
	Weather	Exposure to UV radiation, extreme weather conditions (Extreme heat, Rain, Storms), Visibility.	**C**	**2**	**L**	Identify and assess impending weather conditions and forecast. Use sunscreen, hats/protective brims, long sleeve shirts, and neck flaps. Reassess site and work conditions in extreme weather conditions or poor visibility. Source extra equipment; modify safe work practices or hours of work as necessary.	**E**	**2**	**N**	Management/ Supervisors/ All Personnel
	PPE (Personal Protective Equipment)	Inappropriate or inadequate personal protective equipment can result in injury, overexposure to elements and lack of identification to the public or co-workers.	**C**	**2**	**L**	Issue of appropriate personal protective equipment prior to works or as required per task – long sleeves and trousers to be worn at all times. All staff must wear high visibility clothing and/or vests and approved safety boots wherever applicable. Hard hats and safety glasses are issued at employment and are to be worn at all times. Sunscreen is available to all staff at all times. Staff members are expected to return worn/damaged items to management for replacement.	**E**	**2**	**N**	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Drive to or from site and site access	Vehicular and Pedestrian Traffic. Collisions with other vehicles. Collisions with static structures. Collisions with pedestrians.	A	5	E	Driver must be appropriately licenced for the class of vehicle being driven/operated. Driver must abide all road rules. Driver must ensure vehicle is fit for task, road worthy, registered and must complete a Daily Plant Checklist prior to use. All personnel are to be made aware of the "Safe Entry and Exit of Worksite" procedure and be pre-started prior to entering site.	B	5	E	Driver
	Establish correct location	Time Wastage / economic loss.	B	1	L	Correct documentation and plans, effective communication. Refer to engineers construction pack,	E	1	N	Site Supervisor
	Traffic Management	Struck By Traffic Pedestrian Interface Non Compliance	B	3	H	No works within 7 metres of road without Traffic Management in place. Must have a spotter/observer to monitor pedestrian traffic and any site movement. Pedestrians to be escorted around works where required. Ensure a No Go Zone around Directional Drill and points of drill head entry and exit by placement of Temporary fencing for full perimeter of work zones to ensure public and personnel safety. Works in shared user path, access to be maintained at all times. Beware of pedestrians and implement exclusion zone. Refer to vehicle access plan	E	2	N	Site Supervisor / All Personnel
	Manual Handling	Physical Injury	C	2	L	Determine position, size and weight of object. Consider use of mechanical aids or extra personnel for task. Ensure appropriate personal protective equipment is worn. Adopt good posture and movement technique. Two persons required to reposition temporary timber stairs for batter access. Report any injuries or near miss and always consider any relevant improvements.	D	1	N	Site Supervisor / All Personnel

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Using hand tools	Manual Handling, condition and maintenance, incorrect usage, risk of injury, use as a weapon.	C	2	L	Ensure manual handling advice and techniques are employed. Consider and ensure you are using the appropriate tool for the task. Ensure tools are inspected and maintained, replace if damaged. Ensure all tools are accounted for and secure.	E	2	N	Site Supervisor / All Personnel
	Working with chemicals	Spillage, Explosion, Inhalation, Absorption & Ingestion	D	3	L	All chemicals to be used in conjunction with appropriate SDS, which are attached to the back of the SWMS. Ensure compliance with EPA guidelines. Ensure suitable storage and transport. SDS available at hand. Ensure user competency, adequate signage, and chemical spill / clean-up kits available, personal protective equipment available. Identify Emergency Contact Details.	E	3	L	Site Supervisor / All Personnel
	Presence of existing services	Striking of services	B	4	H	Identify and assess location. NAP Ground Penetration Permit Action Dial Before You Dig information. Identify asset owners. Pothole, hand expose and sight all high-risk services outside of rail corridor on each side of the proposed alignment in order to ascertain inverts and alignments of assets in the design vicinity so the bore design can be considered in relation to existing assets. Modify route and or employ safe work practices to avoid disturbance or damages to at risk services.	E	3	L	Management/ Site Supervisor

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Ref	DESCRIPTION OF TASK	HAZARDS	PRE-RISK LEVEL			SAFE WORK METHOD RISK TREATMENT OPTIONS & ACTIONS	RESIDUAL RISK			RESPONSIBLE
			L	C	R		L	C	R	
	Plant, machinery and equipment	Compliance/ Failure	D	2	L	All plant and equipment to be site inspected. Ensure all plant and equipment is inspected and cleared for use. Pre-start equipment checks, Regular service and maintenance checks and records.	E	1	N	All Personnel
		Movement of vehicles and machinery	B	4	H	Ensure machinery is equipped with suitable warning and hazard identifying devices (e.g. signs, lights, and alarms) and appropriately maintained. All operators hold appropriate license/s, to be VOC'd and comply with plant manufacturers operating guidelines. Ensure site awareness and security is maintained prior to operation. Exclusion zone of 5m to be maintained from drill head when operational.	D	4	M	All Personnel
		Spillage of diesel fuel and/or oil and lubricants	D	2	L	Refuelling to occur at properly designated area e.g. service station or depot refuelling area. Vehicle to carry Spills Kit to absorb any accidental leakage.	D	1	N	All Personnel
		Presence of existing overhead services	C	3	M	Identify any overhead services and ensure safe working distance from service is maintained.	E	3	L	All Personnel
	Unloading and Set Up Of Machinery.	Unloading plant from truck	C	3	M	Assess area for potential hazards i.e. uneven ground, overhead obstacles, safe deployment of ramps. No standing or climbing on the back of trucks without handrails.	E	1	N	All Personnel
		Overhead obstacles	C	3	M	Move to safer location.	E	1	N	All Personnel
		Ramps	C	2	L	Ensure appropriate ramps are installed and maintained.	E	2	N	All Personnel

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			L	C	R		L	C	R	
	Boring.	Machine Failure	C	1	L	Pre-start equipment checks, regular service and maintenance checks and records.	E	1	N	All Personnel
		Slipping from batter	C	5	H	No walking on batter. Access only using the stairs provided.	E	2	N	All Personnel
		Excess Drill Mud	C	1	L	Use vacuum truck to remove sludge during the drilling process. Dispose of excess Drilling slurry to an EPA accredited facility	D	1	N	All Personnel
		Frac out	C	1	L	Stop and assess immediate risk and secure if necessary. Use Vac Truck to remove sludge. Erect Silt Controls Prevent any flows to Drainage system, inclusive of Ground water. All clean up via vac unit	D	1	N	All Personnel
		Pipe pull back	C	3	M	Ensure effective communication with drill rig operator. Monitor Mud flows as annular space is filled, Removing excess via vac unit for disposal to an EPA facility.	E	3	L	All Personnel
	Site Reinstatement	Open excavations / Open pits	C	3	M	Backfill or secure. Ensure all lids are replaced or open pits secured.	E	2	N	All Personnel
		Trip Hazards	C	2	L	Remove.	E	1	N	All Personnel
		Heavy equipment, tools, products	C	2	L	Correct manual handling techniques.	D	1	N	All Personnel

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EMPLOYEE SIGN OFF

I have read and understood all tasks, hazards and control measures described within this document and agree to comply with the controls prescribed herein.

No.	Name of Employee	Date	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			

Note: Do not sign this document if you do not understand or agree, or do not intend to comply with the controls prescribed herein.

SHOALHAVEN STARCHES PTY LTD
NATURAL GAS PIPELINE AND PRESSURE REDUCTION STATIONS –
SHOALHAVEN STARCHES BOMADERRY

Temporary Track Construction Across Creek – TP GAS PIPELINE – MOD 1

Work Method Statement

Document No.		NAP-SS-WMS-03		
Revision:	**Date:**	**Prepared**	**Checked**	**Approved**
Rev A	7/02/22	Mukesh Bhatia	Ajay Kesavan	Martin Moran

TABLE OF CONTENTS

APPENDIX

- Erosion and Sediment Control Plan

1.1 INTRODUCTION

The purpose of this method statement is to provide specific instruction for the following work scope to ensure the works are adequately planned and delivered in accordance with Construction Specifications.

1.2 SCOPE

The scope of work applicable to this method statement is associated with

A) The construction of temporary access tracks across creeks/waterways to gain access to both sides of the creek as part of the Shoalhaven Starches – Natural Gas Pipeline and Pressure Reduction Stations Project.

Access tracks are required to be constructed across the following creeks/waterways there is also a requirement to install the gas pipeline under the creeks/waterways

1. Drainage Channel – Flowing onto Tullian Creek – Image 1
2. Tributary of Tullian Creek – Image 2
3. Abernethys Creek – Image 3
4. Mulgen Creek – Image 4

1.3 ABREVIATIONS AND DEFINITIONS

ALARP	As Low As Reasonable Practical
Checklist	A document that records or defines the actions that must be undertaken for a given task.
CEMP	Construction Environmental Management Plan
DBYD	Dial Before You Dig 1100
Hazard	Any operation or task that places personnel or equipment at risk to death, injury and or damage
JSEA	Job Safety Environmental Analysis
NCR	Non-Conformance Report
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
ROW	Right of Way
NAP	National Australia Pipeline Pty Ltd
Supervisor	The responsible person who oversees, or directs control of works being undertaken during the construction of the pipeline

1.4 REFERENCES

1. Project Approval (MP10_018 MOD1) SHOALHAVEN STARCHES GAS PIPELINE PROJECT - INCREASE IN PIPELINE DIAMETER AND ASSOCIATED WORKS.
2. Shoalhaven Starches Natural Gas Pipeline IFC drawings
3. Shoalhaven Starches Natural Gas Pipeline Construction Environmental Management Plan (CEMP)
4. Shoalhaven Starches Natural Gas Pipeline Construction Safety Management Plan (CSMP)
5. ESCP – APA Ref 24710

1.5 PERMITS

The following approvals/permits need to be in place before commencement of site works.

1. Development Application Approval - Minister for Planning and Infrastructure has approved the Development Application 10_0108-Mod-1 on 21 January 2022.'
2. NRAR Creek/Waterway Crossing Approval
3. DPIE Approval

2.0 RESPONSIBILITIES

The Project Management Team – Project Manager, Engineer, Construction Supervisor and HSE Officer – shall ensure that all project staff are adequately skilled to perform their assigned tasks and are aware of their obligations and responsibilities with regards to OH&S, Environmental Management, Quality Assurance, Industrial Relations and Administrative Functions.

The Crew Supervisor shall be responsible for the coordination of the personnel, equipment, and materials to complete the works in accordance with the relevant specifications.

2.1 JOB DESCRIPTIONS

All site personnel will have a formal job description. Detailed job descriptions for personnel have been developed and approved by the Project Manager. Please refer to the Project Execution Plan for detailed job descriptions.

To ensure that the Project is managed in accordance with the requirements of the Project and that of the contract the following key personnel have the following responsibilities.

3.0 HAZARD IDENTIFICATION AND RISK MANAGEMENT

The NAP shall, so far as reasonably practicable, ensure that any manager or supervisor is provided with such information, instruction, and training as are necessary to ensure that each employee under their management or supervision is, while at work, so far as is reasonably practicable, safe from injury and risks to health.

All personnel must be committed to achieving a safe working environment and strive to fulfill the objectives of the Project Health, Safety and Environment policy with compliance to the Safety Management Plan and the Environmental Management Plan.

3.1 MANAGEMENT CONTROLS

3.1.1 Risk Assessment

A full project risk assessment has been undertaken and the mitigation measures identified in this have been incorporated into this Work Method Statement. A JSEA will be produced by carrying out a risk assessment on this Work Method Statement and incorporating input from work crews. Each Crew member will be required to review this JSEA.

3.1.2 JSEA

The base JSEA shall be developed with input from the Project Manager, Construction Manager and HSE Advisor. The JSEA shall be reviewed and added to, as required by each crew, utilizing their experience in conducting the task. All crew personnel are to review and sign onto the JSEA before work begins.

3.1.3 Pre-Start

Supervisors shall ensure that meetings are held prior to starting each shift, and/or whenever the work scope changes. The meetings should:

- Review the state of the works as left by the previous shift
- The target progress for the current shift
- The means of achieving the target progress
- The state of works required at the end of the shift
- Any additional safety hazards (changing conditions as work progresses)
- Any environmental hazards

3.1.4 Tool Box Meeting

Tool box meetings shall be held at regular intervals. The tool box meetings will be used to relay information such as hazard alerts between crews and make all crews aware of larger issues and general hazards.

4.0 LOCATION OF WATERWAYS

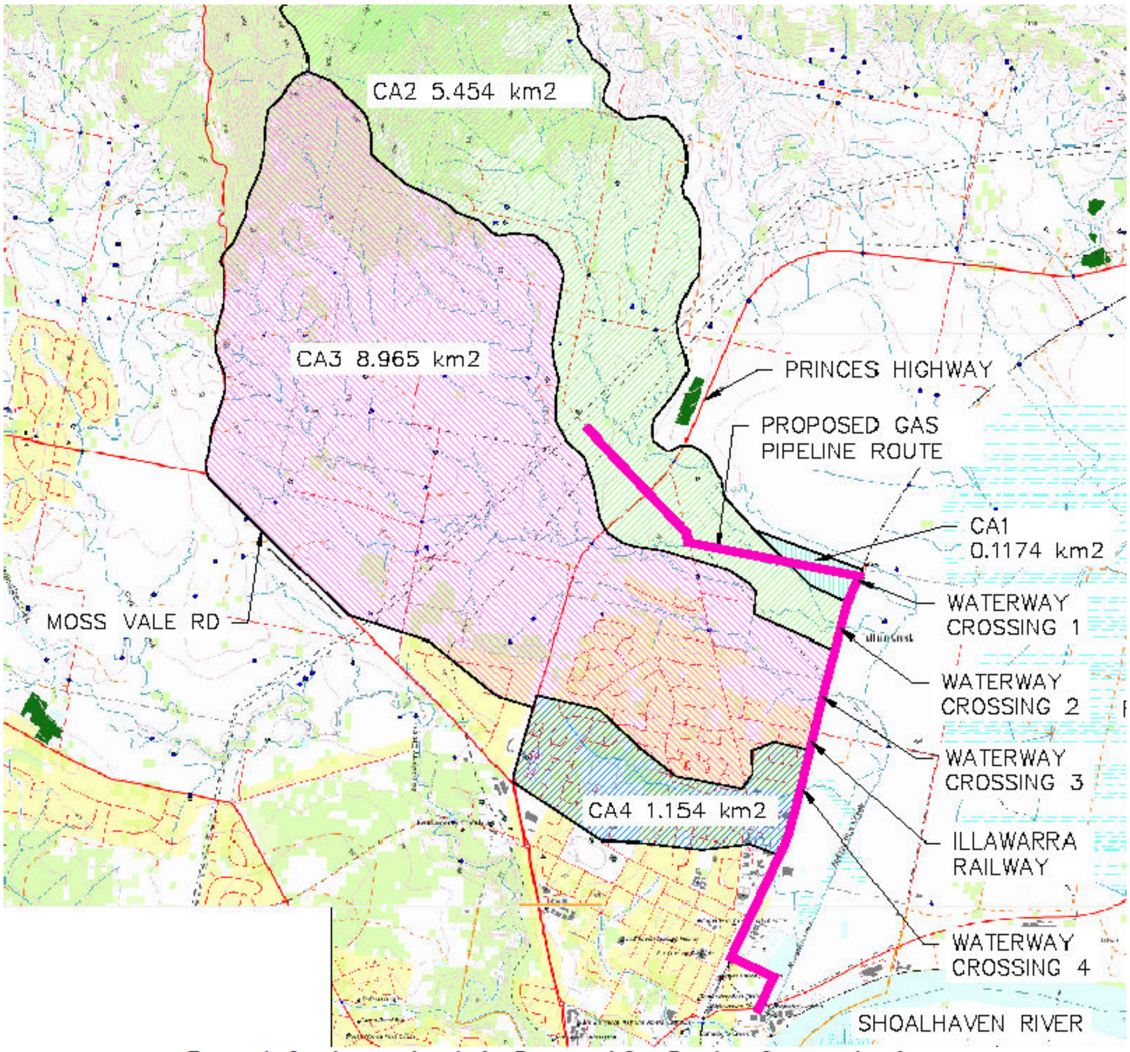


Figure 1: Catchment details for Proposed Gas Pipeline Geomorphic Assessment

Vegetation within the waterways and riparian zones were found to be common between the four waterway crossings. Remnant vegetation adjacent the proposed gas pipeline route on the Shoalhaven floodplain is from forested or saline wetlands, which would have been removed to make way for the railway reserve, train track and agriculture (dairy farming).

Overall condition of existing riparian vegetation was poor with low structural and floristic diversity, significant weed infestation, and exposed soils observed along stream banks. The main vegetation type found in riparian zones was kikuyu grass with sporadic plantings of native trees and shrubs, mainly at low lying areas downstream on the floodplain. Waterway vegetation consists mainly of aquatic weeds and reed beds that have grown through the grass lined waterways. Extensive weed infestations were identified along all the proposed waterway crossings.

Majority of the vegetation being disturbed is Kikuyu grass.

4.1 DRAINAGE CHANNEL – FLOWING ONTO TULLIAN CREEK

A small drainage channel, at the outlet of the first culvert immediately downstream of Fletchers Lane, flowing onto the floodplain and eventually into the Tullian Creek

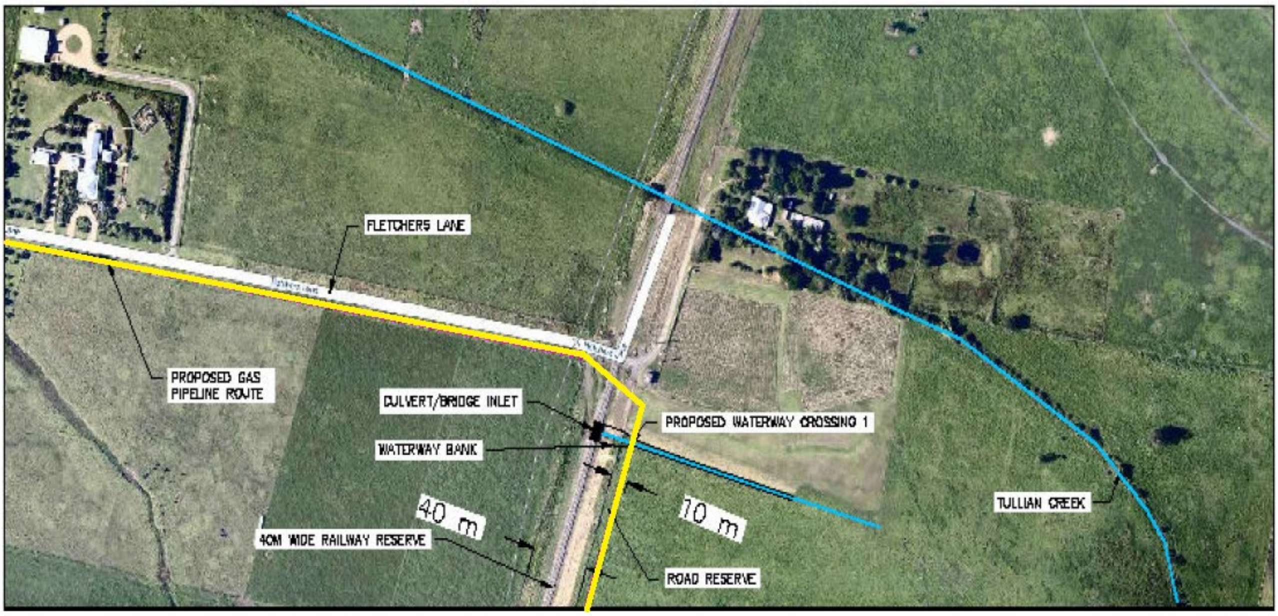


Image 1: Plan view of waterway crossing 1

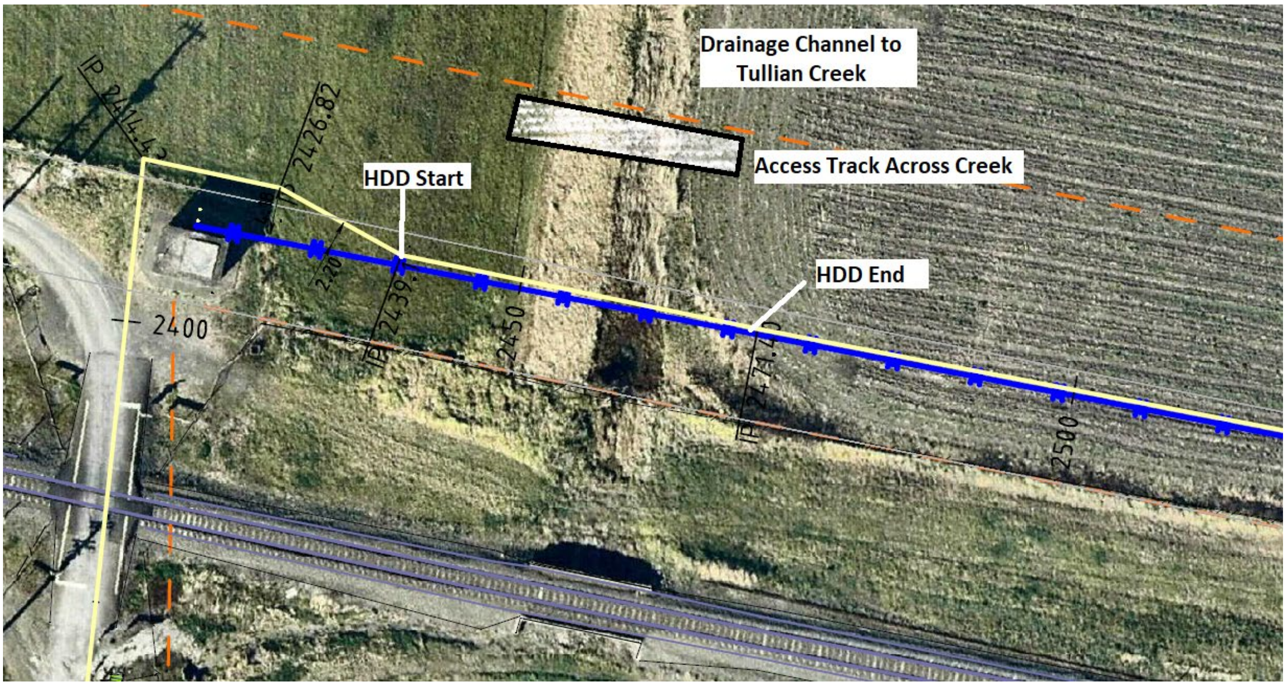


Image 1.1 – Plan view with Access Track Location

4.2 TRIBUTARY OF TULLIAN CREEK

A small tributary waterway of Tullian Creek, flowing through the 2nd main bridge/culvert south of Fletchers lane.

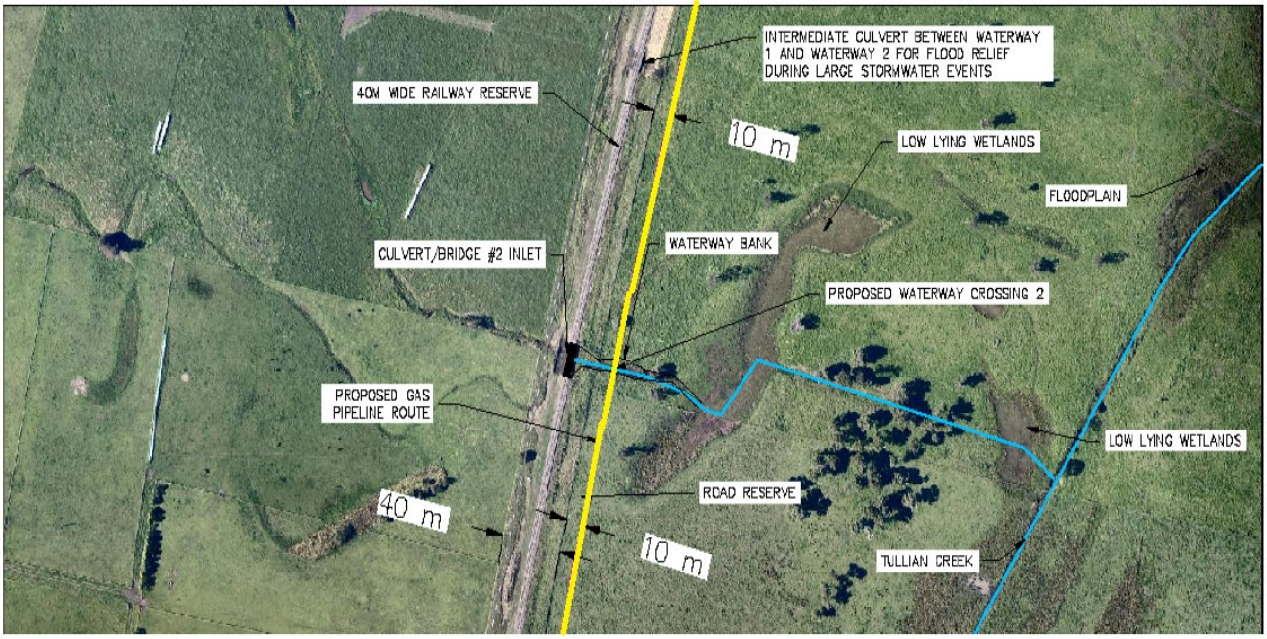


Image 2: Plan view of waterway crossing 2.

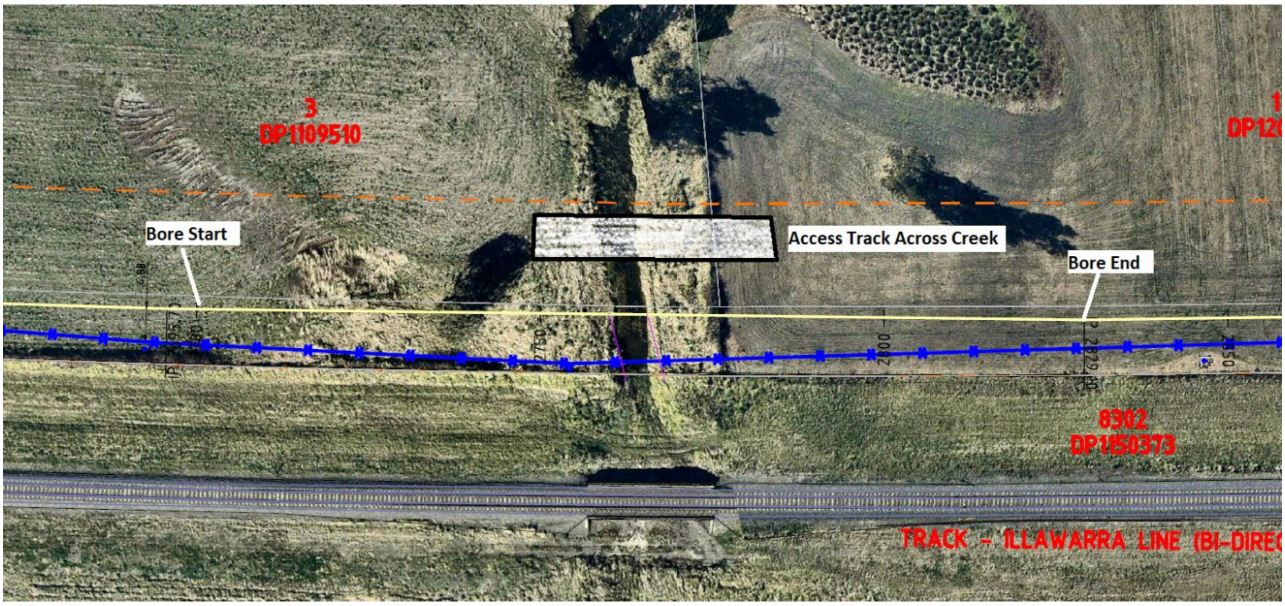


Image 2.1 – Plan view with Access Track Location

4.3 ABERNETHYS CREEK

Approx 200m north of Edwards Avenue

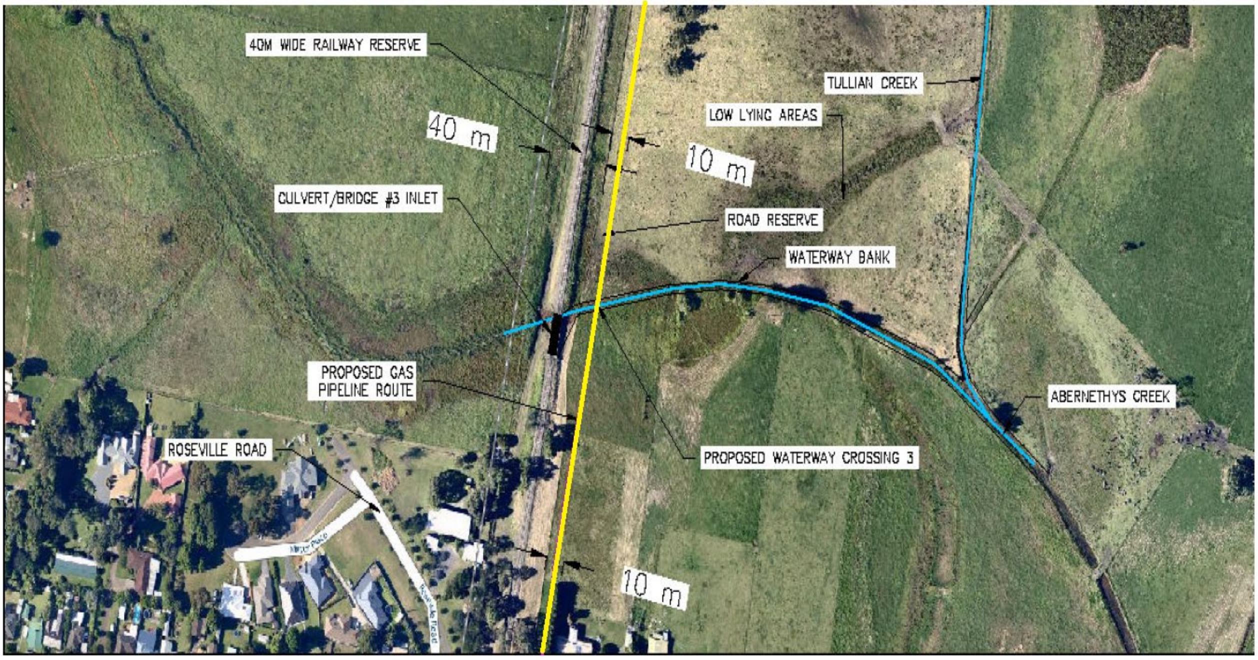


Image 3: Plan view of waterway crossing 3

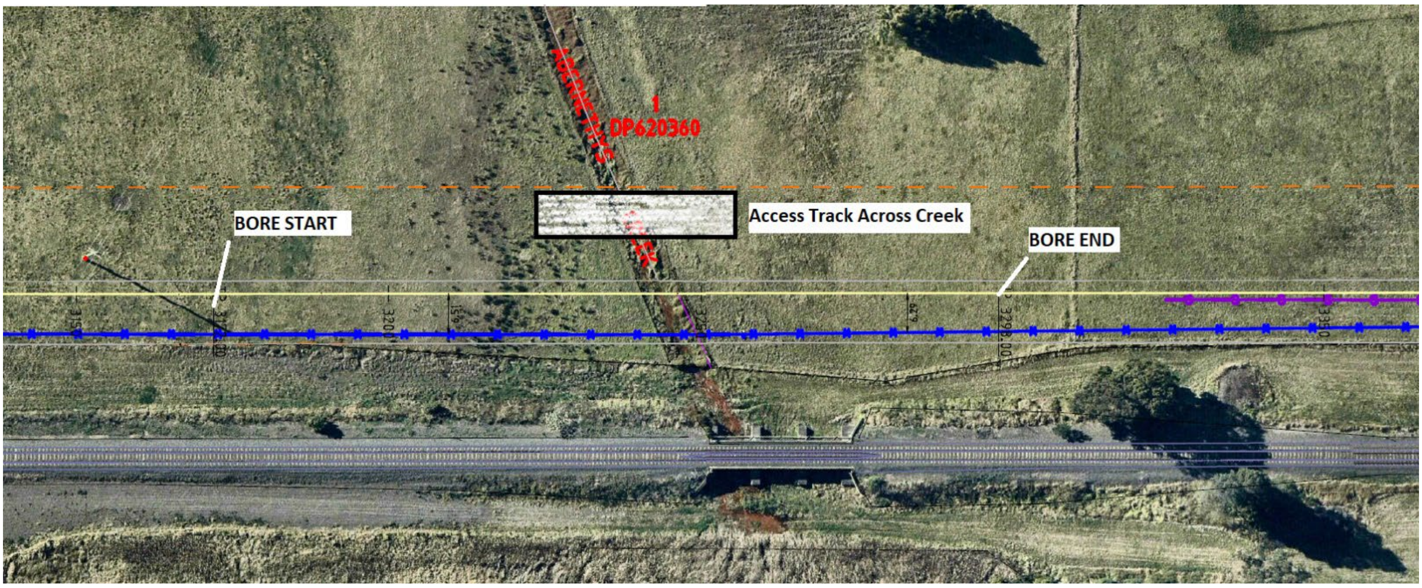


Image 3.1 – Plan view with Access Track Location

4.4 MULGEN CREEK

Approx 400m south of Edwards Avenue

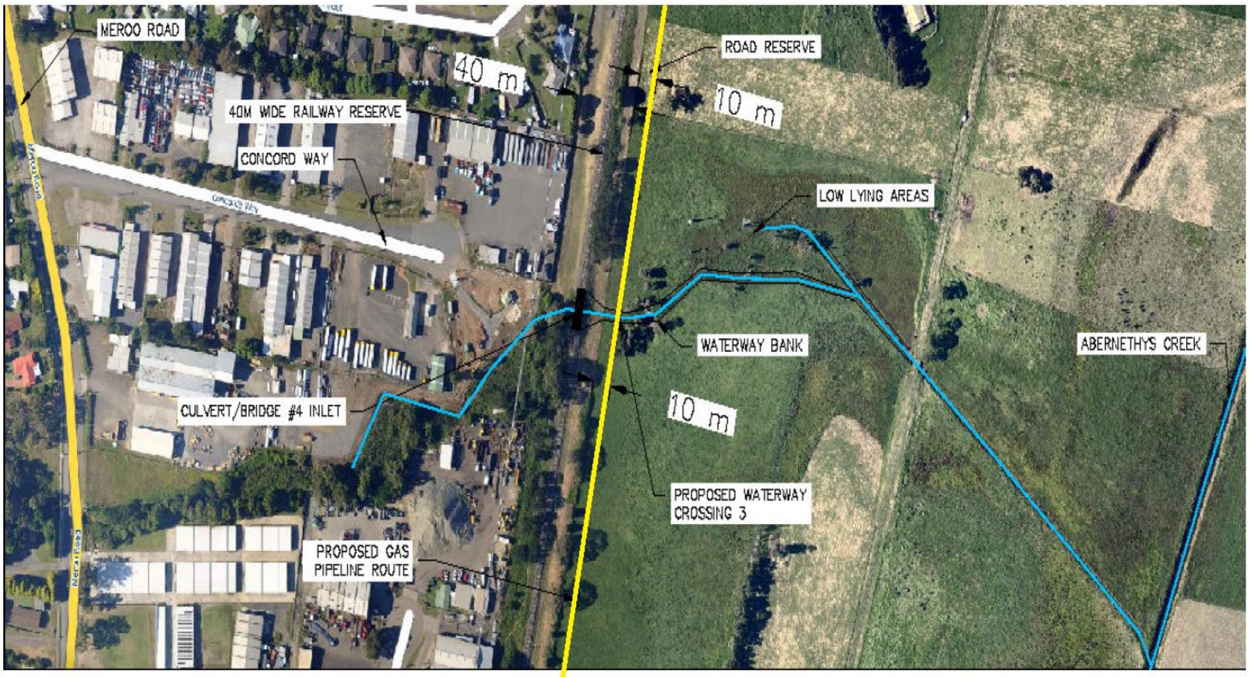


Image 4: Plan view of waterway crossing 4

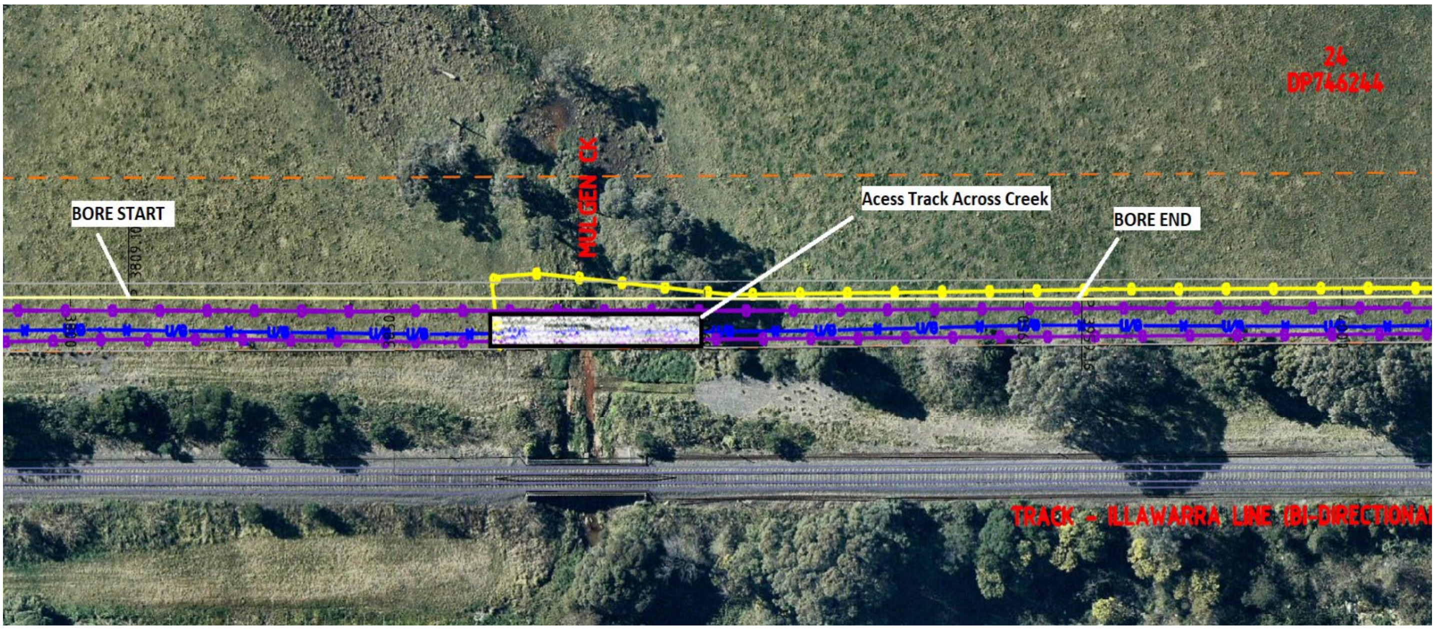


Image 4.1 – Plan view with Access Track Location

5.0 ACCESS TRACK CONSTRUCTION METHODOLOGY

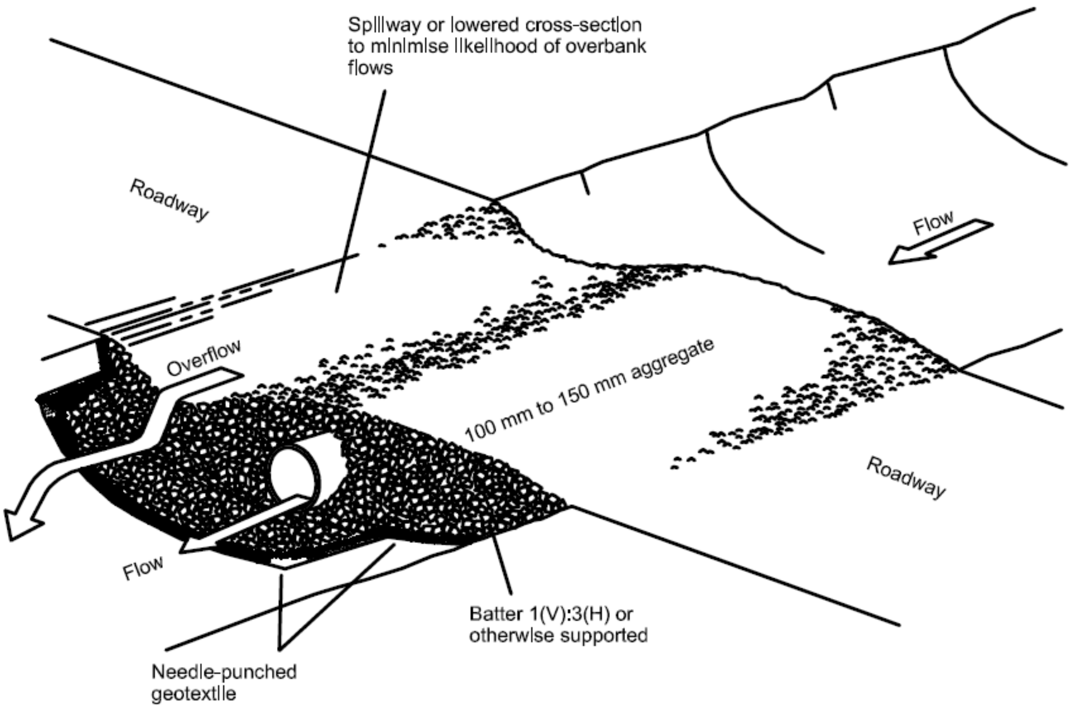
5.1 PLANT/RESOURCES

The plant and equipment required for completing the water crossing is as per below.

Excavator 21 ton, & bucket
Excavator 25 ton, & bucket
Loader
Utes
Tipper Truck
Water pump 2” or 3”
Spill kits, Silt Fencing, Steel Plates
Flume Pipe
Rock Beaching

5.2 CONSTRUCTION OF ACCESS TRACK ACROSS CREEK

An access track will be constructed across the creek as shown below



The construction steps will be as per below

- Complete a dilapidation survey of the site
- Place a geotextile layer across the creek
- Place a single or dual flume pipe parallel to the creek to ensure sufficient flow
- Supply and install rock beaching (100mm to 150mm aggregate rock) over the flume pipe as per the above design
- Extend the rock beaching past the inlet and outlet of the flume pipe to allow less than 3(H) : 1(V) slope
- Ensure flume pipe extends beyond toe of fill embankments
- Install a lower section to act as an emergency spillway
- Crossover will be inspected after every rain event.

5.3 REINSTATEMENT POST WORKS

- The access track and flume pipe constructed will be removed post pipeline construction works.
- All rock will be disposed offsite
- Flume pipe will be removed
- Geo-matting placed will be removed
- Original bank contours to be re-established
- The topsoil below the geo-matting will be aerated
- Kikuyu grass seeds will be spread across the disturbed topsoil
- Jute matting or bio-degradable fabric will be placed over the disturbed topsoil across the waterway bed/banks and pinned down.
- The rehabilitated works will be monitored regulator for signs of erosion during the DLP period.

APPENDIX

- Extract of Erosion and Sediment Control Plan

EROSION AND SEDIMENT CONTROL PLAN

EROSION & SEDIMENT CONTROL

MANAGEMENT PLAN

---

for the

PROPOSED

SHOALHAVEN STARCHES PTY LTD

GAS PIPELINE

at

Meroo Meadow & Bomaderry, NSW

allen, price & associates
land and development consultants

APA Ref: 24710

DATE: February 2012

Table of Contents

List of Figures

Table of Revisions

Rev	Date	Details
00	06/02/12	For client review
01	13/02/12	Final Report for Client

Report prepared by:

Date: 13 February 2012

Adam Urszulak

MEng (Civil Engineering), BTech (Marine Engineering)

1 Introduction

The Shoalhaven Starches expansion project was approved in 2009 by the Minister of Planning and includes general expansion of the factory to increase ethanol production output, and a proposed gas fired co-generation plant to supply electricity and steam to the factory. To allow competively priced gas supplies to be sourced and to meet any increased energy demand, the company proposes to construct and operate their own gas pipeline. This report examines the management of erosion and sediment control for the proposed Shoalhaven Starches gas pipeline.

A new natural gas main, to be privately owned and operated by Shoalhaven Starches, is proposed to enable the company to source competitively priced gas supplies for its manufacturing operations and contribute to the preservation of the environment by increasing the efficiency of the factory including through a proposed co-generation power plant. Natural gas is currently obtained from via an ActewAGL owned gas pipeline connected to the Eastern Gas Main. The Shoalhaven Starches factory currently sources energy from a combination of coal, natural gas, diesel and electricity. ??

Construction will impact the environment to varying degrees along the proposed 5.5km route. A number of alternative routes for the proposed gas main were assessed by Shoalhaven Starches through a number of consultants including Allen, Price and Associates. This was done to determine the route most likely to minimise possible impacts to the environment. The route described in this report was assessed to have the lowest possibility of environmental impact, especially on sensitive areas which include; local wetlands, waterways, agricultural pasture, road & rail reserves, and Council infrastructure.

The proposed gas main route begins at an existing connection to the Eastern Gas Line (EGL) at Pestells Lane, Meroo Meadow. It will be built mainly in road reserves along the proposed route, through to a proposed gas pressure reduction station on land privately owned by Shoalhaven Starches, on the northern side of Bolong Road at Bomaderry. From this point, the gas main will continue under Bolong Road to the opposite side and into another property owned by Shoalhaven Starches, and will then be distributed for use within the factory.

1.1 Aim & Scope

The aim of this report is to broadly address erosion and sediment control issues outlined in the Director General's requirements, under the heading of Soil and Water, for the Shoalhaven Starches Project (MP 10_0108), issued on 8th November 2010. The specific requirements include providing;

- "specific reference to erosion and sedimentation management during construction".
- "detailed information describing how water bodies or water courses would be traversed and proposed measures to avoid or minimise any predicted impacts".

The Director General's Requirements are addressed in this report in accordance with the guidelines, principles and recommended standards for managing erosion and sediment control, outlined in Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition (The Blue Book), and Volume 2A- Installation of Services. These are comprehensive erosion and sediment control guides used throughout NSW, and will be referred to frequently throughout this report.

This report provides information for project administrators and managers to gain a better understanding of the erosion and sediment control issues and requirements specifically for the proposed Shoalhaven Starches gas pipeline project. Information is general in nature and does not take place of an erosion and sediment control plan (ESCP), which is required to be produced prior to construction. This report gives guidance for the future completion of the ESCP.

The main aims of erosion and sediment control (ESC) for this project are;

- Protect disturbed areas from the eroding action of stormwater runoff.
- Prevent sediment from disturbed soils entering into waterways and stormwater systems by providing filtration to remove sediment from stormwater..
- Divert clean stormwater runoff that would naturally flow through the proposed construction areas, preventing it from becoming polluted by sediment from soils that have been disturbed during excavation.
- Aid in rehabilitating disturbed soils, riparian zones and waterways.

Traffic control measures are required at certain sections along the proposed route during construction. This report does not take into consideration the need for traffic control, which may impact on the installation and maintenance of erosion and sediment controls outlined. The traffic management plan (TMP) is to take into consideration ESC where required.

Erosion and sediment controls will impact on public and privates services and infrastructure adjacent to the proposed gas pipeline. Impacts to infrastructure are not assessed in this report. A separate report has been written for this purpose by Allen, Price and Associates, titled 'Infrastructure Impacts Report'.

2 Erosion and Sediment Control Management

Effective project development through efficient process management is a significant factor of ecological sustainable development. Erosion and sediment control is a legislated requirement of all work sites, therefore effective management principals is an essential part of the project development process for developing adequate erosion and sediment control on linear service installation projects. This ensures environmental protection.

The following topics are briefly discussed in this section;

- erosion and sediment (E & S) control legislation.
- project planning methods for erosion and sediment control.
- general (E & S) control principals used on service installation projects.

2.1 Legislation

The legislation relating to erosion and sediment control of service installation projects fall under the development assessment framework and provisions of the Environmental Planning and Assessment Act 1979. These include;

- Protection of the Environment Operations Act 1997.
- Rivers and Foreshores Improvement Act 1948.
- Fisheries Management Act 1984.

Other Acts that may require consideration based on the route of the proposed gas pipeline include;

- National Parks and Wildlife Act 2003
- Native Vegetation Act 2003
- Roads Act 1993
- Soil conservation Act 1938
- Threatened Species Conservation Act 1995
- Water Management Act 2000

The first three pieces of Legislation will now be briefly summarized.

2.1.1 Protection of the Environment Operations Act 1997

The Environment Protection Authority (EPA) regulates; any activity listed in schedule 1 of the Protection of the Environment Act 1997 (POEO Act), state or public authority activities, and other activities where a license regulating water pollution is issued. Any other activity, under this Act, falls under the regulatory authority of the local Council.

Water pollution is prohibited under this Act unless it is in accordance with the provision of an ‘environment protection license, as issued under this Act.

The Shoalhaven Starches gas pipeline route crosses minor waterways that eventually lead into major waterways.

2.1.2 Water Management Act 2000 and Controlled Activities

The NSW Office of Water administers the Water Management Act 2000 and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity. under the Water Management Act 2000, a controlled activity means:

- the erection of a building or the carrying out of a work (within the meaning of the *Environmental Planning and Assessment Act 1979*), or
- the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or
- the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or
- the carrying out of any other activity that affects the quantity or flow of water in a water source.

Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 m of the highest bank of the river, lake or estuary.

Laying of gas pipes in or across watercourses and adjoining waterfront land constitutes a controlled activity under the Water Management Act 2000. The Shoalhaven Starches gas main crosses a number of minor waterways. As the proposed gas pipeline comprises a ‘major project’ pursuant to the provisions of Part 3A of the EP&A Act, controlled activity approval is not required pursuant to Section 75U of this act.

2.1.3 Fisheries Management Act 1994

Activities relating to the installation of services that involve dredging or reclamation of waterways have the potential to block the passage of fish and harm marine vegetation, and therefore require a permit, to be issued under this Act by the Department of Primary Industries (DPI). As outlined above the proposed gas pipeline comprises a 'major project' pursuant to the provisions of Part 3A of the EP&A Act, approvals required pursuant to Sections 201, 205 and 209 of the Fisheries Management Act are not required pursuant to Section 75U of the EP&A Act

2.2 Project Planning for Erosion and Sediment Control

Volume 2A of Landcoms Managing Urban Stormwater-Soil and Construction indicates that effective management of erosion and sediment control on linear service installation projects requires systematically addressing the following five main planning activities;

- Developing systems for documentation and communication.
- Assessing constraints and opportunities.
- Preparing an ESCP.
- Restoring and remediating sites.
- Other planning considerations.

2.3 General Soil and Water Management Principals for Service Installation Projects

There are seven general principles of effective soil and water management for land disturbance associated with urban development, according to section 1.5 of Landcoms Managing Urban Stormwater; Soils and Construction, Volume 2A. These broadly apply to the planning, design and construction of most service installation projects. They provide the framework for the application of more specific erosion and sediment controls required on for the proposed gas main project. The seven general principals include;

1. Assess soil and water implications of a project at the planning stage.
2. Plan for erosion and sediment control and assess site constraints during the design phase and before any earthworks begin.
3. Minimise the area of soil disturbed and exposed to erosion.
4. Conserve topsoil for later site rehabilitation/regeneration.
5. Control water flows from the top and through the project area – divert up-slope 'clean' water away from disturbed areas and ensure concentrated flows are below erosive levels.
6. Rehabilitate disturbed lands quickly.
7. Maintain erosion and control measures appropriately

2.4 Developing Systems for Documentation and Communication.

The project principal will be responsible for ensuring all personnel working on the project are made aware of their individual responsibilities for proper environmental management and care. The systems that facilitate this require planning, implementation and control, and make up the Environmental Management System (EMS). The principal and/or contractor(s) are required to develop an EMS, which is presented as part of a Construction Environmental Management Plan (CEMP).[1]

The CEMP outlines environmental objectives and targets, and describes how the contractor(s) will manage and control the environmental aspects of the project to meet these. It must interface with all other plans, describe the overall project management system, and expand on the environmental section of the project business plan.[1]

The CEMP is an active document which is revised and updated as construction progresses. It provides all relevant site personnel, including superintendeant, construction managers, foreman and subcontractors, practical and up to date information on all environmental aspects of the project.

The following key components should be the minimum included in the CEMP, as they identify the aims, actions and outcomes required to meet the project's environmental objectives;

- Description of the principal or contractor's environmental management system.
- CEMP objectives and targets.
- Risk Assessment.
- Constraints.
- Roles, responsibilities and contact details.
- Environmental controls.
- Monitoring and Compliance. [1]

Regular audits or compliance inspections are to be made by the principal or their representative to ensure compliance with environmental conditions specified in the CEMP. This includes ensuring rapid project completion incentives do not promote environmentally harmful practices.[1]

The CEMP should also ensure the contractor's EMS conforms to;

- AS/NZS ISO 14001:2004. Environmental Management Systems – Requirements and guidance for use.

- NSW Construction Policy Steering Committee Environmental management systems guidelines, 1998.[1]

2.5 Assessing constraints and opportunities.

This report was written based on a site assessment of the proposed gas pipeline route. Consideration was given to providing adequate control of erosion and sedimentation with minimum expenditure, and identifying constraints and opportunities. These are explored in more detail in relation to the proposed gas pipeline route.

The proposed gas pipeline route, shown in Figure 1 (Appendix A), was selected based on desktop studies, field work and consultation with Shoalhaven Starches Pty Ltd, Cowmann Stoddart, URS Australia Pty Ltd, Allen, Price and Associates and Shoalhaven City Council. The aim was to avoid environmentally sensitive areas. An area of sensitivity was found along the route. It is shown as a black hatch in Figure 1 (Appendix A), which shows the sensitive coastal location through Bomaderry.

Section 3.3.2 of -Volume 2A gives a list of site characteristics and constraints that were generally considered during the site investigation. The following site characteristics and constraints were investigated during the site inspection along the proposed route;

- Existing exposed areas and likely areas of soil disturbance
- Existing vegetation
- Site topography
- Location of potential drainage lines and waterways.
- Landscape constraints including flood hazard, water logging and rock outcrops.
- Acid sulphate contaminated soils
- Opportunity to repair previous or existing areas of land degradation
- Disposal of surplus excavated material.
- Susceptibility to tunnel erosion

Soil constraints such as erodibility, erosion hazard, dispersibility, salinity, fertility or expansive and reactive soil types were not assessed in this report. These need to be determined during detailed design of the E&SC plan.

Since much of the route is located over land with negligible grade, minimal land degradation was observed. Areas along the banks of waterways where the proposed gas main will cross were found to be susceptible to erosion and degradation. There are no areas along the route that were found to require stabilisation due to past erosion and sediment control issues.

The majority of vegetation along the route is grass and weed found within the road reserves. Native trees were found in all road reserves along the route. Some of these will require removal to facilitate pipeline construction.

The proposed route is mainly flat with a 'gentle' slope to the south east, toward Abernethys Creek and the Shoalhaven River. Some areas are steeper along the route, although generally short in length. These areas require greater erosion and sediment control. Further details are provided in section 3 of this report.

There are a number of waterways and drainage lines that can be used to facilitate erosion and sediment control. These are shown on APA drawing 24710-04 (Appendix C).

Based on information obtained from Shoalhaven City Council, there are minimal areas where acid sulphate soils will pose a problem. The area is classed to have a low probability of acid sulphate soils.

Tunnel erosion may pose a problem on the steeper sections along the route, which are adjacent to a number of waterways. These areas will need further investigation during detailed design. Trench stops and bulk heads may need to be used to stop erosion and damage to the gas pipe or other related issues from occurring.

No areas were observed that could take surplus excavated materials since the majority of the route is within road reserves or adjacent to prime agricultural land.
Erosion and sediment control measures chosen need to minimise adverse impacts to existing vegetation and local wildlife. The passage of native animals through the site shall be allowed and the effect of erosion and sediment controls on native vegetation be considered when selecting controls.
The proposed route was originally selected to minimize disturbance to wildlife and sensitive environmental areas. Correct selection and placement of erosion and sediment controls will minimize impacts to the environment.

Opportunity exists for minor route alteration during detailed design. This aim would be to avoid specific areas along the route that constrain the construction of the proposed gas pipeline, and save time and money by reducing the amount of erosion and sediment control required. These areas are shown in Appendix C, on APA drawing 24710-04, indicated by the words 'Minor route Alteration?".

2.6 Erosion and Sediment Control Management Procedures

The following list describes general erosion and sediment control procedures, to be incorporated into the CEMP of the Shoalhaven Starches gas pipeline project;

- All works are to be carried out in accordance with Landcoms Managing Urban Strormwater; Soils and Construction Volume 1, 4th Edition, March 2004 & Volume 2A.
- The contractor shall take all reasonable measures to minimise the effects of dust emissions from the site including the spreading of mulch in areas where construction has been completed.
- All topsoil from the construction areas is to be stripped and stockpiled. Stockpiles are to be located outside areas of concentrated stormwater runoff and are required to be grass seeded or mulched if they are to remain for longer than fourteen (14) days.
- The movement of machinery over the site should be limited to the construction areas to avoid disturbance to existing vegetated areas. No-go areas are to be marked off prior to commencement of works. Machinery should be inspected prior to exiting construction area to ensure excess mud and debris is not tracked onto roadways. During and on completion of the workday contractors should inspect to insure the roadways adjacent to the project site are free of excess mud/debris and clean if necessary.
- Areas of the site that are disturbed by construction works are to be topsoiled, seeded and fertilised immediately after construction works in the particular area have finished and not left till the end of the overall construction.
- Construction areas shall not be left in an open and disturbed state for more than fourteen (14) days. Areas expected to be left open for periods longer than this are to be seeded.
- Filter fences are to be removed only after all disturbed areas have established a good grass covering, minimum 70%.
- Any existing bare or disturbed areas of the site not affected by the construction works are to be topsoiled, seeded and fertilised as soon as practicable after each phase of work.
- Sediment & erosion control structures are to be maintained on a daily basis during construction and on a minimum of weekly basis during the six month liability period (or as required

depending upon weather conditions). All material removed from the traps is to be spread and grass seeded or disposed of, off site in an approved manner.

- All imported fill is assumed to be a material other than dispersive clay. All fill material is to be tested for dispersability prior to placement on the site and if found to be dispersive the superintendent is to be notified prior to placement of any fill for advice on treatment of dispersive soils.
- Sediment fence/filter can be used as E & S control around stockpiles, adjacent to the main trench, around areas where underboring of waterways will occur and be installed around the perimeter of wetlands, and should be installed at all drainage structures receiving stormwater runoff from excavated areas. Filter/sediment fences are to be constructed from an approved filter material and erected in accordance with the manufacturer's instructions.
- Swales and table drains along the route should have staked straw bale or socked mesh dams installed on road reserve shoulders that receive runoff stormwater runoff from excavated soils.
- Waste generated by the construction process should be collected and retained on site in appropriate containers and be removed offsite to a licensed landfill when appropriate
- Washing out of concrete truck chutes should occur at specific locations pre-determined prior to construction. Bermed pits with a large enough volume to take multiple pours should be excavated for this purpose. Material from the pits shall be disposed of and the pits regraded when all concrete work is complete.
- Materials that may be brought on site for construction of the proposed gas main include:
    - Aggregate of various sizes for trench backfill, bedding, and other applications.
    - Pipe and associated fittings.
    - Wood in various forms for staking, marking alignment and forming for concrete work.
    - Paint for marking alignments and the location of various utilities.
    - Where possible materials should be placed above ground on pallets or alternative.

3 Site Specific Erosion & Sediment Control Management

This section of the report provides a general assessment of the erosion and sedimentation controls required at specific locations along the proposed gas pipeline route. Recommended control measures are based on a site assessment conducted by staff of Allen, Price and Associates, and recommendations from Volume 2A of Managing Urban Stormwater – Soils and Construction - Installation of services, available from the Environment Protection Authority.

The road and rail reserves that the proposed gas pipeline will lay in are used as headings in this section of the report. The reserves were systematically assessed, with greater attention given to locations within road reserves that contain a waterway crossing. This is due to the potential for increased erosion and sediment control issues at these locations, when compared to the majority of the route which is over land that is mostly flat.

3.1 Route

A site assessment was undertaken by staff of Allen, Price and Associates to better understand the erosion and sediment issues caused by the proposed pipeline construction. The full length of the route was inspected and photographed so that the site was well identified for the purpose of writing this report.

The proposed Shoalhaven Starches gas main route is through two rural areas; Meroo Meadow and Bomaderry, approximately 7km and 5km respectively north of the Nowra Township in NSW. It will be constructed mainly through the following road reserves, which include the positions as given in Figure 1 (Appendix A);

- Pestells Lane (from 1 to 4).
- Princes Highway (3).
- Meroo Road (4).
- Fletchers Lane (from 5 to 6).
- An un-named road reserve adjacent to the railway reserve (from 7 to 13).
- Edwards Lane (10).
- Railway Street (from 13 to 15).
- Bolong Road (15).

The route is described in more detail below:

- Begin at tie-in station of the existing ActewAGL gas pipeline to the Eastern Gas Pipeline, on Pestells Lane. This is the proposed location for the Shoalhaven Starches gas pipeline meter and valve block arrangement (1).
- Continue south east along the southern road shoulder of Pestells Lane (2).
- Continue through the Princes Highway intersection, into the east shoulder of the Princes Highway road reserve (3).
- Continue south-east along the unformed section of Pestells Lane (3).
- Continue through the Pestells Lane/Meroo Rd intersection, to the east shoulder of Meroo Road (4).
- Change direction and continue south - south east along Meroo Road (4).
- Continue through the intersection of Meroo Road/Fletchers Lane, to the south shoulder of Fletchers Lane (4).
- Change direction and continue east along Fletchers Lane (5).
- Change direction at the intersection between Fletchers Lane and Railcorps rail reserve, and continue south for approximately 50m, just beyond the large culvert under the railway track (6).
- Change direction within the rail reserve and continue south east under the track ballast to the eastern side of the rail reserve. Continue through to the un-named road reserve adjacent to the rail reserve (7).
- Change direction and continue south through the un-named road reserve, parallel to the railway reserve (7).
- Cross waterway (8) (9).
- Continue south, through Edwards Ave intersection, back into the un-named road reserve adjacent to the railway reserve (10).
- Cross waterway (11).
- Continue south along the un-named road reserve into the east shoulder of the un-sealed section of Railway Street (12).
- Continue south along Railway St, transitioning from the un-sealed section to the sealed section of Railway Street into the east side road reserve (13).
- Continue past the intersection between Railway Street and Cambewarra Road (14).
- Continue along the east shoulder of Railway Street past the Cambewarra Road intersection until Lot 16 DP572583 on Railway St is reached (15).
- Change direction toward the east and follow the open channel drain along the north boundary of Lot 16 DP572583

- Change direction toward the south at a point that provides a 100m buffer between the proposed gas main and Abernethys creek. This is the approximate boundary of a sensitive coastal area, shown hatched in black criss-cross in Figure 1 (Appendix A) (15).
- Continue parallel along the 100m buffer boundary, until reaching the position of the proposed gas pressure reduction station on lot 16 DP572583 (15).
- Exit the pressure reduction station and continue south along the 100m buffer boundary (15).
- Cross Bolong Road into Manildra Factory Land (15).

3.2 Trenching

There are differing requirements for erosion and sediment control depending on whether the proposed trench runs across grade, down grade or obliquely. The gradient of the land is also an important factor. Much of the proposed gas main route is flat with exceptions at waterway crossings, Edwards Avenue and Railway Street. General erosion and sediment control techniques useful for these areas can be observed in Figures 2 and 3 of Appendix D

Across grade:

- Heaped soil from trench to be placed on up-hill side to form an earth bank

Down grade:

- Measures to be taken to filter sediment laden water downstream.
- Sediment fences can be used at the majority of steep sections on the proposed site to catch silt.
- Earth banks can be used across backfilled sections of the trench to slow moving water down and direct it out away from trench.
- Trench stops may be required on slopes that grade down to waterway crossings.

Obliquely:

- Heaped soil from trench to be placed on up-hill side to form an earth bank.
- Steep grades may require trench stops.

See section 6 of the DECCs Managing Urban Stormwater-Soils and Construction, Volume 2A, for further details.

3.3 Soil and Stockpile Management

Stockpiles will be required along the proposed route to store materials, excavated soil and top soil. The minimum depth of pipeline cover is 0.75m giving a total trench depth of approximately 1m. Minimum width of trench is 0.6m. Therefore the calculated volume of soil to be excavated per meter length of pipe is $0.6m^3$. The required depth of cover is greater at waterway crossings. There is to be no trenching of waterway crossings, hence the volume of soil removed at these points along the route is reduced in comparison to trenched areas.

The most suitable location for stockpiles would most likely be over the backfilled trench of the previously completed stage or on the opposite side of the road reserve within the verge or footpath area. The stockpile size and spread needs to be limited to allow machinery to pass, and also to reduce the mass sitting above the newly installed gas main and other existing services.

Erosion and sediment control will consist of sediment fence and straw bale filters on the low side of the stockpile. Dust emissions need to be minimized. Due to the relatively short construction period required during staged construction, stockpiles would most likely not be in place for more than a one week, although it may be possible to utilize one stockpile location for consecutive stages of construction, increasing the time that disturbed soils are exposed.

Section 4.3 of the Blue Book contains further information on stockpile construction. A typical stockpile detail is available in Appendix D (SD4-1).

3.4 Road Reserves

A number of road reserves will be impacted by construction of the proposed gas pipeline. This section assesses each systematically and addresses general erosion and sediment controls required.

A small portion of Railcorps land (20-50m) will be used for the proposed gas main, located at position 7 in Figure 1 (Appendix A). The track in the reserve is active with passenger and freight trains passing through each day to the nearby Bomaderry Railway Station and Manildra Factory. Manildra's private rail reserve will also require underboring, adjacent to Bolong Road.

Under each road reserve heading in this section, the areas in the given road reserve requiring erosion and sediment control, and the proposed erosion and sediment control have a unique identification number from 1 to 51, that corresponds to with the same number used in APA drawing 24710-04 (Appendix C) to show the position being discussed. For example, area 1 corresponds to the proposed valve and meter station on Pestells Lane, with a sediment fence and straw bale filter proposed as the possible control measure, as shown below. In APA drawing 24710-04 (Appendix C), this is shown as "E

& S (1):" followed by a blue book identification number, for example "SD6-7, SD6-8, SD6-14", corresponding to the construction guide in the Blue Book for the recommended control.

3.4.1 Pestells Lane

The proposed gas pipe line begins on Pestells Lane as shown at position 1 in Figure 1 (Appendix A). This location corresponds to sheet 2 and 3 of APA drawing 24710-04 (Appendix C) in Appendix C.

The majority of the gas main route in Pestells Lane will be open trenched. Staged construction of the pipeline along Pestells Lane is recommended to allow adequate room for storage of topsoil and material stockpiles within the road reserve, behind the section of pipe being trenched.

The exit out of the proposed valve/metering block, across Pestells Lane into south side verge could be underbored to minimize disturbance to the road and reduce erosion and sediment controls required.

Erosion and sediment control

Areas requiring erosion and sediment control;

1. Proposed and existing valve/metering station
2. Table drain along boundary of road and southern shoulder of Pestells Lane.
3. Cattle yard gravel access driveway on the south side of Pestells Lane.
4. Culvert and table drains at south west corner of Princes Highway.

Proposed erosion and sediment control;

1) Sediment fence and Straw bale filter.
2) Sediment fence.
3) Sediment fence and Straw bale filter.
4) Sediment fence and Straw bale filter.

3.4.2 Princes Highway

The proposed gas pipeline will cross the Princes Highway at position 5 in Figure 1 (Appendix A). This location corresponds to sheet 4 of APA drawing 24710-04 (Appendix C) in Appendix C.

To mitigate impacts to the road surface and pavement, the crossing of the Princes Highway shall be by underbore. A stabilised access and storage facility approximately 20m x 40m will be required in the south west side of the road reserve for underbore operations.

Erosion and sediment control

The following areas will require erosion and sediment control;

5. Large culvert and headwalls passing stormwater under the highway.
6. Table drain on the south side of the intersection, flowing parallel to the Princes Highway and feeding into and out of the culvert inlet and outlet.
7. Table drain on south side of Pestells Lane where proposed gas main approaches the intersection.
8. Soil and construction material stockpiles to possibly be located on south west shoulder of Princes Highway road reserve.
9. Marsh area at culvert outlet on east side of Princes Highway road reserve.

Proposed erosion and sediment control for the given areas include;

5) Sediment fence and straw bale filter.
6) Sediment fence and straw bale filter as check dams.
7) Straw bale or rock check dams in table drain to prevent sediment flowing along table drains.
8) Sediment fence around base of stockpiles.
9) Sediment fence around perimeter of reed bed/marsh. Temporary culvert to outlet into table drain on Pestells Lane

3.4.3 Pestells Lane (Unformed Section)

The un-formed section of Pestells Lane intersects the Princes Highway and Meroo Road, as shown at position 4 in Figure 1 (Appendix A). This location corresponds to sheet 5 of APA drawing 24710-04 (Appendix C).

The unformed section of Pestells Lane on the east side of the Princes Highway is relatively flat. It contains a table drain on the north side.

Waterway Crossings

There is no waterway crossing through the unformed section of Pestells Lane.

Erosion and sediment control

The following areas require erosion and sediment control;

10. Table drain parallel to boundary on northern side of road reserve.
11. Soil and construction material stockpiles.

Proposed erosion and sediment control for the given areas include;

10. Straw bale or rock check dam to be laid inside table drain.
11. Sediment fence around soil and material stockpiles.

3.4.4 Meroo Road

The proposed gas main will cross Meroo Road at position 4 in Figure 1 (Appendix A). This location corresponds to sheet 5 of APA drawing 24710-04 (Appendix C). Associated photographs shown on this sheet are found in Appendix B.

An underbore would be the best option for crossing Meroo Road in order to minimize damage to the road and prevent associated traffic control issues. A stabilised site will be required for machinery, the most likely position being the west side of the intersection in the un-formed portion of Pestells Lane, where the underbore will be made.

Erosion and sediment control

The following areas will require erosion and sediment control;

12. Table drains and culvert downstream of proposed underbore inlet, on west side of Meroo Road.
13. Table drain downstream of proposed underbore outlet, on east side of Meroo Road.
14. Culvert entrance on east side of Meroo Road, at intersection with Fletchers Lane.
15. Soil and construction material stockpiles.

Proposed erosion and sediment control for the given areas include;

12. Straw bale filter laid across table drains and surrounding culvert headwall.
13. Straw bale filter laid across table drain. Ensure excavated material laid on high side of trench.
14. Straw bale and Sediment fence filter at entrance of culvert
15. Sediment fence around soil and material stockpiles.

3.4.5 Fletchers Lane

Fletchers Lane extends from position 4 to position 7, and intersects Meroo Road at position 4, as shown in Figure 1 (Appendix A).This location corresponds to sheets 5, 6, 7 and 8 of APA drawing 24710-04 (Appendix C) in Appendix C.

A large culvert takes water from the west side of Meroo Road, and outlets at the south west side of the Fletchers Lane and Meroo Road intersection, which leads to an open channel drain. An underbore crossing of Fletchers Lane would limit the excavation in that area, lessening the chance of sediment and erosion.

A stabilised site will be required for machinery, the most likely position being the north side of the intersection in the verge of Fletchers Lane, where the underbore will be made.

Erosion and sediment

The following areas will require erosion and sediment control;

16. Position of proposed Fletchers Lane underbore.
17. Large culvert inlet and outlet, fed by table drain on Meroo Road's west side shoulder.
18. Diversion drains situated on the south side of Fletchers Lane that leads into the open channel drain.
19. Culverts under Fletchers Lane.
20. Table drain in Fletchers Lane south side road shoulder.
21. Soil and construction material stockpiles.

Proposed erosion and sediment control for these areas include;

16. Sediment fence or straw bales along edge of bitumen on inlet side of underbore construction area and straw bale sediment filters in table drain on north side road shoulder.
17. Sediment fence and straw bale filters in table drains and at inlet of culvert.
18. Divert stormwater runoff in the south side table drain via a geo-textile lined swale adjacent to road, to prevent stormwater flowing through diversion drains.
19. Straw bale filter at ends of diversion drains.
20. Straw bale filter in table drain at inlet to culverts.
21. Sediment fence around soil and material stockpiles.

3.4.6 Railcorp land and un-named road reserve

The intersection of Railcorps land and the un-named road reserve adjacent, with Fletchers Lane, is located at position 7 in Figure 1 (Appendix A). This location corresponds to sheet 8, 9, 10, 11, 12 and 13 of APA drawing 24710-04 (Appendix C) in Appendix C.

Erosion and sediment control

The following areas require the erosion and sediment control;

22. Table drain parallel to train track for approx 50m on west side of rail reserve.

23. Stabilised site access for underbore of train tracks.
24. Stockpiles for topsoil and materials.
25. Large culvert under train tracks.
26. Waterway crossing through intermittent creek that flows onto flood prone land, and into the Tullian Creek, at position 7 in Figure 1 (Appendix A).
27. Large swale on the south side of Fletchers Lane that flows into Tullian Creek at position 8 in Figure 1 (Appendix A).
28. Abernethys Creek at position 9 in Figure 1 (Appendix A).
29. Mulgen Creek at position 11 in Figure 1 (Appendix A).
30. Steep land sloping downgrade toward waterway crossing at position 9 and 11 in Figure 1 (Appendix A).

Proposed erosion and sediment control for these areas include;

22. Sediment fence along and straw bale filters laid across table drain.
23. Compacted rock, sediment fence, straw bale filters, temporary culvert/pipe.
24. Stockpiles will require sediment fence around base.
25. Straw bale filter and sediment fence at culvert inlet and outlet.
26. Mechanical underbore, sediment fence, trench stop.
27. Mechanical underbore, sediment fence, trench stop.
28. Mechanical underbore, sediment fence, trench stop.
29. Mechanical underbore, sediment fence, trench stop.
30. Check dams and trench stops along steep section of trench toward Edwards Avenue and area along route between Edwards Avenue and Railway Street.

3.4.7 Edwards Avenue Intersection

Edwards Avenue intersects the un-named road reserve at position 10, as shown in Figure 1 (Appendix A).This location corresponds to sheet 11 of APA drawing 24710-04 (Appendix C).

The proposed gas main is to be routed perpendicularly through Edwards Ave, which sits on the northern side of a small hill, in an east-west direction. Significant Erosion and sediment controls, especially along the trench will be needed to prevent erosion and pollution of the roadway, stormwater runoff and nearby creeks. An underbore crossing will be required at this point to minimize erosion and sediment control issues and prevent traffic management problems. A stabilised work site will be required either side of Edwards Ave for the underbore machine.

Erosion and sediment

The following areas of the Edwards Ave require erosion and sediment control;

31. Stabilised access for underbore machinery and access to un-named road reserve.
32. Table drains on north and south side of road reserve.
33. Trench on south side of Edwards Avenue.

Proposed erosion and sediment control for the given areas along Fletchers Lane include;

31. Compacted rock, sediment fence, straw bale filters, temporary culvert/pipe.
32. Sediment fence along and straw bale filters laid across table drain.
33. Trench stop or collar. Stop trench 3m before road reserve boundary.

3.4.8 Railway Street and Lot 16 DP1121337

Railway Street continues on from the un-named road reserve and runs parallel to the train tracks on Railcorps land. Railway Street begins at position 12, as shown in Figure 1 (Appendix A).This location corresponds to sheet 13, 14 and 15 of APA drawing 24710-04 (Appendix C).

Greater attention to erosion and sediment control is required here due to it being;

- Mainly Bitumen sealed with numerous traffic movements, and pedestrians
- Connected to the Shoalhaven Councils urban stormwater system through kerb & gutter, pits and pipes which lead to the Shoalhaven River.
- Numerous services and concrete or gravel driveways
- Open view of proposed works to the public.

There is limited room to store materials and excavated soil on Railway Street. A more suitable location would be the large vacant lot 16 DP1121337 where the proposed gas pipeline is to lay. A haul road is required to construct the proposed pipeline in this location, the material and topsoil stockpiles could be positioned in proximity to the proposed route.

Erosion and sediment

The following areas of the Railway St will require erosion and sediment control;

34. East side boundary of Railway Street.
35. Outlet of culvert.
36. Table drain.

37. Underbore of driveways.
38. Trench through east side of un-formed section of Railway Street.
39. Trench through east side of sealed section along Railway Street.
40. Kerb and Gutter.
41. Stormwater pits.
42. Large culvert and open drain through lot 16 DP1121337.
43. Haul road through Lot 16 DP 1121337

Proposed erosion and sediment control for the given areas include;

34. Provide temporary geo-textile lined table drain and sediment fence.
35. Sediment fence and straw bale filter over and around headwall of culvert outlet.
36. Straw bale check dams in table drain.
37. Sediment fence on boundary of property and along kerb and gutter.
38. Excavated material placed on high side of trench with temporary geo-textile lined table drain provided, and drained to table drain further behind stage being completed.
39. If excavated material to be stored in road reserve, enclose in sediment fence.
40. Gravel mesh check dams laid inside kerb and gutter.
41. Straw bale and gravel mesh filters placed around pit inlet.
42. Sediment fence, strawbale filter check dams
43. Stabilised site, sediment fence, strawbale filters, temporary geo-textile lined table drain

3.4.9 Bolong Road

Bolong Road is located at position 15 in Figure 1 (Appendix A). This location corresponds to sheet 16 of APA drawing 24710-04 (Appendix C).

The proposed crossing of the Shoalhaven Starches gas main at Bolong Road will require an underbore of Manildra's privately owned railway reserve, will continue under Bolong Road, and exit into the Shoalhaven Starches Interim Packing Plant. There is no possibility of open trenching due to the volume of traffic on Bolong Road and the number of services underground.

Erosion and sediment

The following areas will require erosion and sediment control;

44. Right of way (haul road) along route.
45. Proposed gas pressure reducing station.

46. Boundary of sensitive environmental area buffer zone.
47. Underbore location at railway pedestrian crossing.
48. Underbore outlet at Interim Packing Plant.
49. Culverts and headwalls.
50. Topsoil and material stockpiles.
51. Downstream gutter inlet pits
52. Stormwater pit
53. Shoalhaven Starches Railway reserve

Proposed erosion and sediment control for the given areas include;

42. Stabilised site access.
43. Stabilised site access, sediment fence and straw bale filter
44. Sediment fence.
45. Sediment fence and straw bale check dams in table drain.
46. Sediment fence and straw bale check dams in table drain.
47. Sediment fence and straw bale filters.
48. Sediment fence and straw bale filters.
49. Mesh and gravel filters.
50. Sediment fence or strawbale inlet filters.
51. Sediment fence.

3.5 Waterway Crossings

Four waterway crossings have been identified, in accordance with the Director General's requirements. These are located at positions 7, 8, 9 and 11 along the route as shown in Figure 1 (Appendix A). The water ways to be crossed include;

1. A small drainage channel, at the outlet of the first culvert/bridge immediately downstream of Fletchers Lane, flowing onto the floodplain and eventually into the Tullian Creek (position 7)

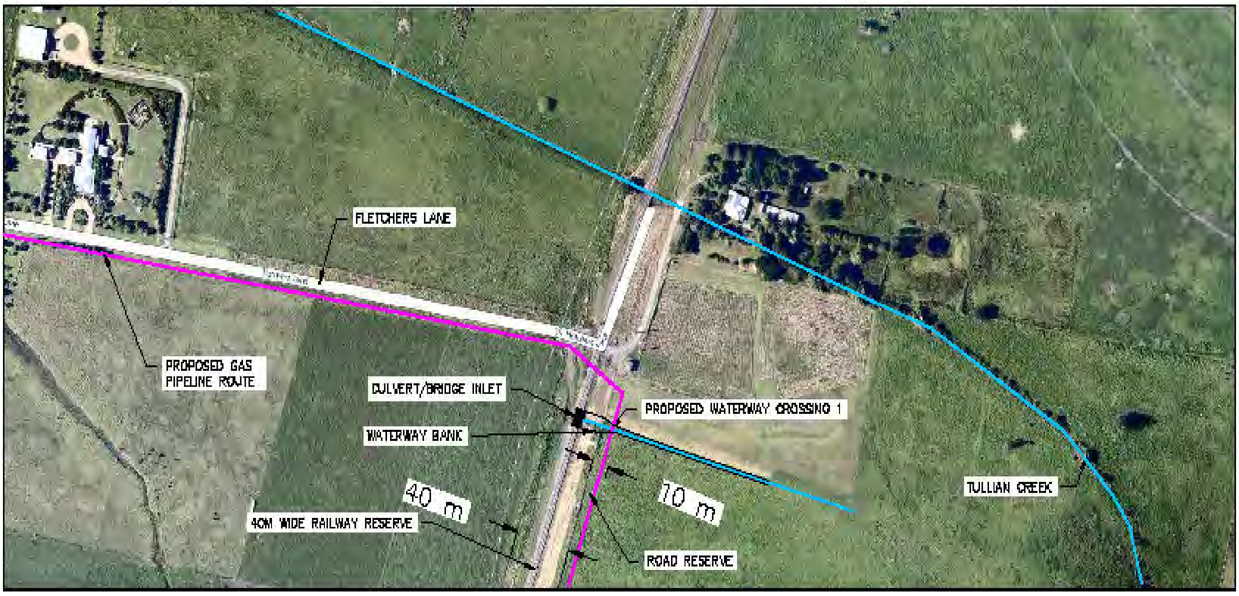


Image 1: Plan view of waterway crossing 1

2. A small tributary waterway of Tullian Creek, flowing through the 2nd main railway bridge/culvert south of Fletchers Lane. An intermediate culvert with no waterway is located between waterway 1 and waterway 2 (position 8)

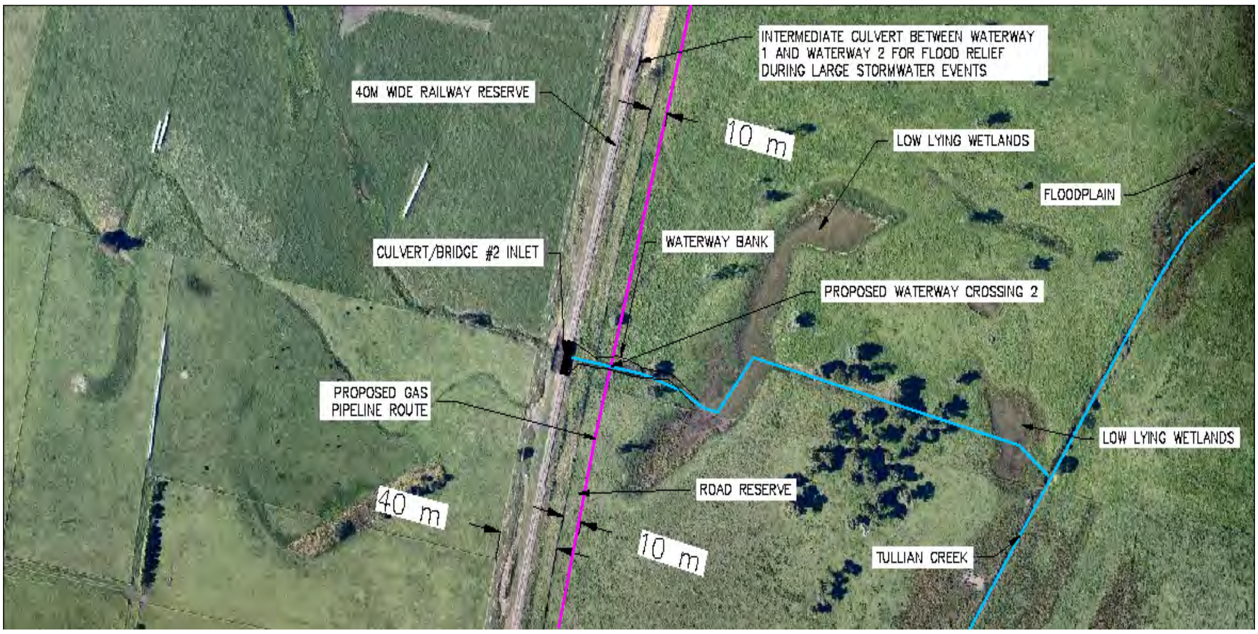


Image 2: Plan view of waterway crossing 2.

3. Abernethys Creek (position 9). Culvert/bridge #3 is located just upstream of the crossing point in the railway reserve.

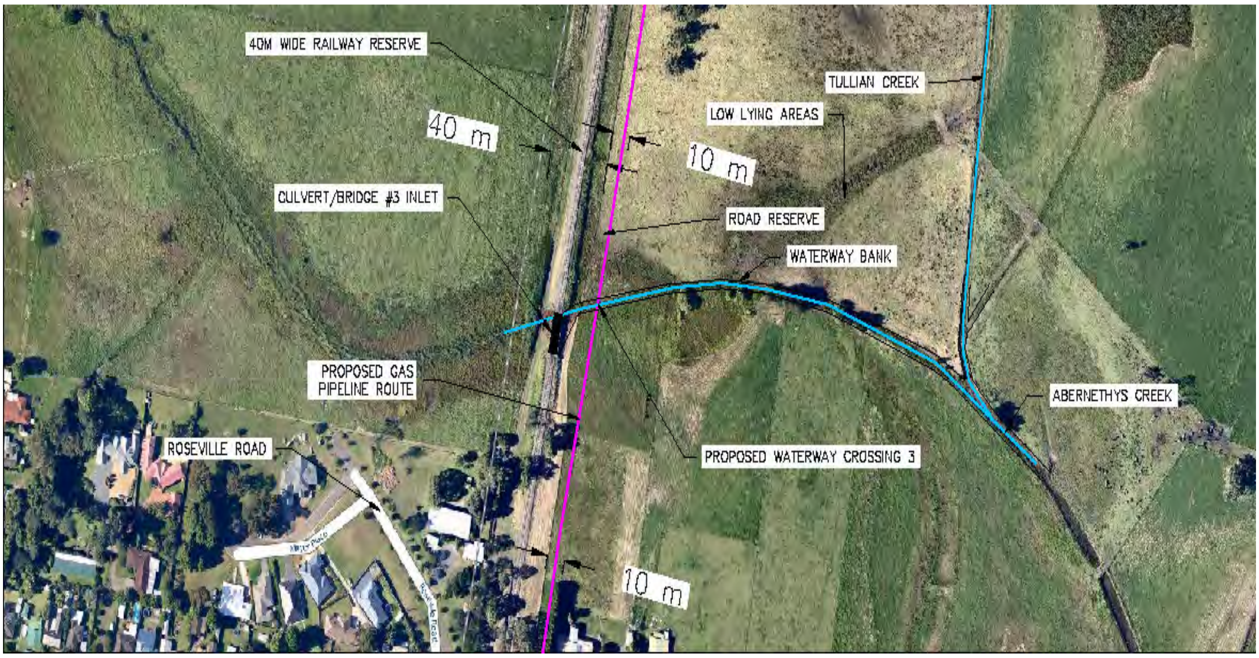


Image 3: Plan view of waterway crossing 3

4. Mulgen Creek (position 11). Culvert/bridge #4 is located just upstream of the crossing point in the railway reserve.

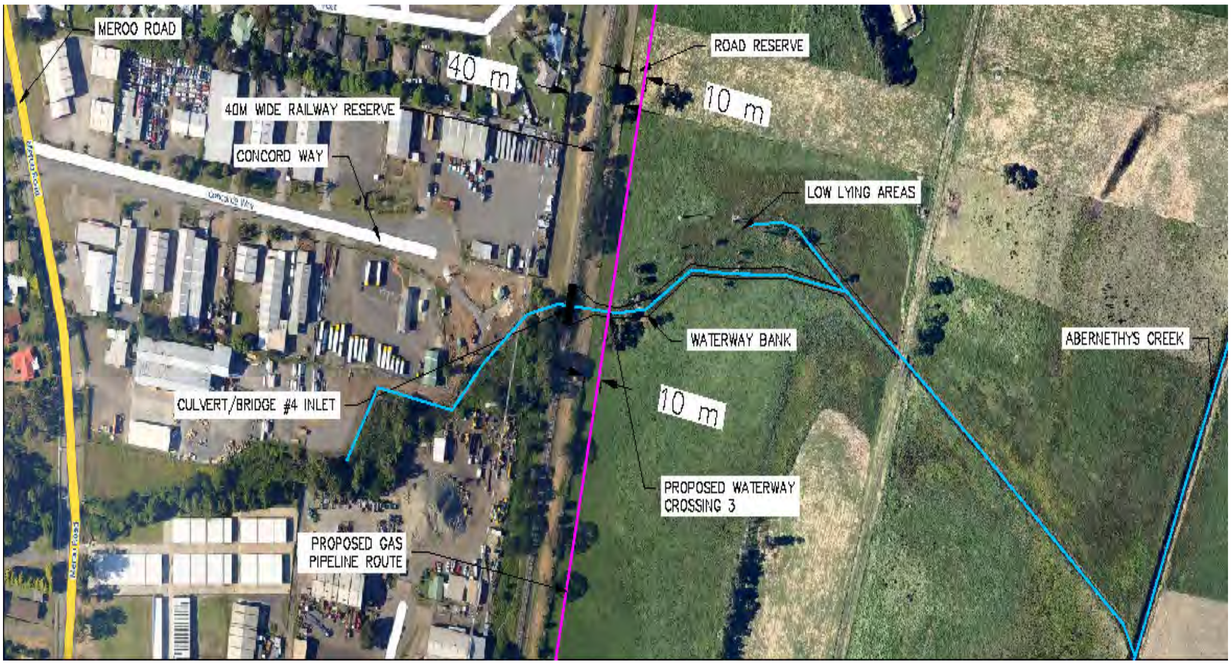


Image 4: Plan view of waterway crossing 4

The proposed waterway crossings are also shown in detail in APA drawing 24710-04 sheets 1 – 16 (Appendix C) with references given to photographs in Appendix B, taken at the waterway crossing sites. Typical long and cross sections of waterway 3 is available in Appendix E.

The immediate area surrounding waterways (Riparian zones) are susceptible to erosion and sedimentation due to the increased possibility of flowing water in these areas. The four waterways are minor and flow intermittently throughout the year, depending on the size of the storm event affecting the associated catchment. Erosion and sediment control management for waterway crossings will depend on the weather preceding, during and after proposed construction period. The ESCP should provide alternative controls based on weather forecasts and size of storm events expected.

Waterway crossings shall not be made by open trenching. All waterways shall be crossed by mechanical underbore, to mitigate impacts on waterways and surrounding riparian zones. Open trenching shall be stopped at the boundary of the core riparian zone waterway and trench stops put in place until a suitable waterway crossing has been made. The width and boundaries of waterway riparian zone are addressed in the geomorphic assessment that follows this section of the report.

Waterways will require temporary vehicle crossings for stabilised machinery access over the 5 m – 7 m wide right-of-way to be built within un-formed road reserves. Significant erosion and sedimentation is possible at waterway crossings and adequate control measures are needed to mitigate impacts to soils, vegetation and waterway geomorphic condition. Detail SD5-1 in Appendix D shows a typical construction method for a temporary waterway vehicle crossing.

Stabilised work sites approximately 20m x 40m are to be positioned at either side of waterway crossings for underbore machinery to be positioned to lay pipe under the bed of the waterways. Stabilised work sites are also require at other locations along the proposed route where underboring is required and other machinery will be best positioned during non-work periods. Stabilised work sites are to be built only when required as staged construction of the pipeline progresses along the route. Rehabilitation is to begin immediately when trenches and waterway crossings are backfilled and completed, respectively.

The proposed gas pipeline is to be buried under waterway beds with a minimum depth of cover from the bed to the top of pipe equal to 2.0m minimum. This value will increase if scour is an issue at the waterway crossing.

There is potential for fluvial geomorphic impacts on the proposed gas pipeline at waterway crossings. Changes may occur to the waterway characteristics, especially from the scouring action of flowing water at the outlet of the culverts and bridges immediately upstream of the proposed waterway crossings. A geomorphic assessment was made of the waterway crossings and associated core riparian zones to assess this potential..

To mitigate impacts on the pipeline due to fluvial geomorphic changes, the effect of scour on the waterway crossing was determined and the scour depth at each waterway crossing calculated to determine the depth of cover required under each waterway bed being crossed.

3.6 Fluvial Geomorphic Assessment

To assist in the environmental assessment procedure and to ensure on-going stability of the creeks being crossed by the proposed pipeline, a geomorphic assessment of the four proposed waterway crossings was made, in order of the waterways as identified in figure 1 (Appendix A), from location 7 to 11, by a photographic study obtained from site inspections and desktop study.

Over time, the shape, size and behavior of active waterways change, which increases the potential for significant impacts to the proposed gas pipeline at the waterway crossing points. This section of the report assesses the degree of impact that is likely to occur to the pipeline at the waterway crossings.

The objectives of the geomorphic assessment are;

- determine current geomorphic condition of the waterways and their associated riparian zones.
- determine geomorphic history of the proposed waterway crossings.
- determine future geomorphic effects on the waterways and impacts on the pipeline at the waterway crossings.
- provide machinery and construction site setbacks from waterways.
- Provide recommendations to mitigate potential geomorphic impacts to the pipeline, and to mitigate impacts of construction on riparian zone and bank stability.

To meet the objectives, the following aims were addressed:

- Site inspections of waterways and riparian zones.
- Determine waterway categories for riparian zone distance classification of waterway crossings.

- Modelling to determine characteristic behaviour of waterways and floodplain due to stormwater runoff.
- Determine culvert and bridge flood outlet velocities
- Calculate depth of scour at outlet of culverts and bridges
- Outline pipeline construction impacts to the waterway and riparian zones and mitigation measures.

Site Setting

Four proposed waterway crossings are to be made, between Fletchers Lane and Railway Street, on the northern bank of the Shoalhaven River, and Lower Shoalhaven River Floodplain, within the 10m wide unformed road reserve directly adjacent the Illawarra Railway Reserve and Railway track. These are located along the proposed route as shown in Figure 1 of Appendix A, with each waterway crossing location numbered 7, 8, 9 and 11.

Figure 1 below shows the boundaries of four catchments (CA1 to CA4) that flow into local waterways, and more specifically into the culverts and bridges at proposed pipeline waterway crossings. The catchments are bounded by Cambewarra Road, Moss Vale Road, Tourist Road and Cambewarra Lookout Road. Stormwater runoff flows into tributaries over Cambewarra Mountain, into the Tullian and Abernethys Creeks and eventually onto the Lower Shoalhaven River Floodplain. Appendix H contains catchment peak flow rate calculations.

An elevated railway track formed fill and capped with blue metal ballast approx 2-3m above the natural surface level, is located centrally in a 40m wide rail reserve running in a north-south direction, on the Lower Shoalhaven River Floodplain.

Flood water from Abernethys Creek and Tullian Creek are prevented from building up behind the elevated railway track by a number of concrete box culverts and steel bridges. The proposed gas pipeline route runs parallel to the railway line, within the un-named road reserve positioned directly downstream of the track on the Lower Shoalhaven River floodplain.

See APA plan 24710 sheets 1-16 for further details and Appendix B for photographs taken of the proposed route

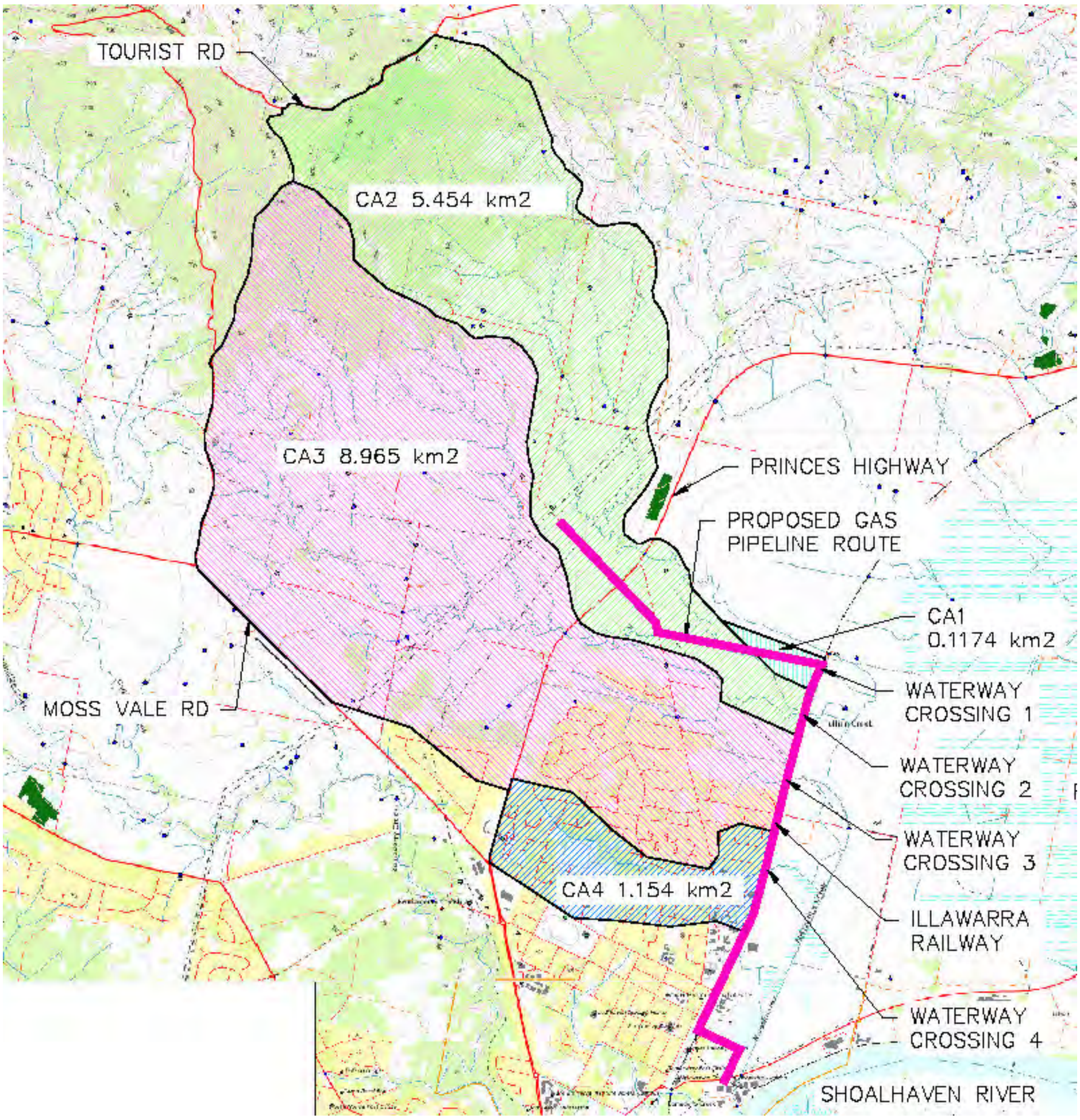


Figure 1: Catchment details for Proposed Gas Pipeline Geomorphic Assessment

3.7 Photographic Study of Waterway Crossings

3.7.1 Waterway Crossing 1

Figure 2: Culvert /Bridge #1 upstream of waterway crossing, and South of Fletchers Lane.

Figure 3: Looking South along the proposed pipeline route at waterway crossing 1, in the un-named road reserve between Fletchers Lane and Edwards Ave.

Figure 4: Looking downstream of waterway crossing 1, notice the reducing waterway cross section.

Figure 5: Looking upstream of waterway crossing 1, toward proposed crossing location and culvert/bridge

Figure 6: Waterway 1 vegetation at proposed crossing point

Figure 7: Looking downstream of waterway 1, toward floodplain and Tullian Creek (trees in background delineate creek)

Figure 8: Low lying wet area at intermediate culvert between waterway 1 and waterway 2

Figure 9: Intermediate Culvert at low lying area between waterway crossing 1 and waterway crossing 2

Figure 10: Looking South along proposed pipeline route, toward waterway crossing 1, whilst standing at the intermediate culvert outlet, with in the un-named road reserve.

3.7.2 Waterway Crossing 2

Figure 11: Culvert #2 and downstream reach of waterway crossing 2

Figure 12: Heavy weed infestation at boundary of road and rail reserves, at outlet of culvert/bridge #2

Figure 13: Looking south along proposed route in the road reserve at waterway crossing 2.

Figure 14: Bank Instability and Erosion at waterway crossing 2.

Figure 15: Looking east toward low lying area downstream of waterway crossing 2

Figure 16: Looking north toward waterway crossing 1, showing riffle zone and secondary waterway at waterway crossing 2

Figure 17: Riffle zone between main waterway 2 and secondary waterway 2, looking east toward floodplain

Figure 18: Water main infrastructure within road reserve, between waterway crossing 1 and waterway crossing 2

Figure 19: Wild life and vegetation at low lying area on the floodplain downstream of waterway 2

Figure 20: Wildlife and vegetation in riffle zone downstream of waterway 2 crossing

Figure 21: Merge of waterway 2 into low lying area and floodplain downstream of culvert/bridge #2

3.7.3 Waterway Crossing 3

Figure 22: Looking north toward culvert/ bridge #3 and proposed waterway crossing 3 at Abernethys Creek

Figure 23: Looking east toward floodplain and Abernethys Creek, downstream of waterway crossing 3.

Figure 24: Railway Bridge #3 showing main flow path of Abernethys creek with waterway 3 flowing under one cell

Figure 25: Heavy weed infestation at waterway crossing 3, looking upstream.

Figure 26: Vegetation in downstream reach, looking east toward floodplain

Figure 27: Looking south toward Edwards Avenue, at waterway crossing 3

Figure 28: Looking south toward steep section leading down to waterway 3.

3.7.4 Waterway Crossing 4

Figure 29: Looking south along proposed gas pipeline route, on crest of hill before relatively steep down grade to waterway crossing 4, along un-named road reserve.

Figure 30: Looking south down un-named road reserve, toward waterway crossing 4

Figure 31: Large bridge #4 just upstream of waterway crossing 4.

Figure 32: Heavy weed infestation at waterway 4 crossing

Figure 33: Existing stabilised vehicle crossing over waterway 4, immediately upstream of proposed pipeline crossing point

Figure 34: Looking South along un-named road reserve at proposed waterway crossing 4, with vegetation types shown

Figure 35: Waterway crossing 4, showing terrestrial and aquatic vegetation.

Figure 36: Floodplain and downstream reach of waterway crossing 4

Figure 37: Looking East over floodplain (northern bank of Shoalhaven River), downstream of waterway crossing 4

Figure 38: Low lying area downstream of waterway crossing 4

3.7.5 Waterway History

Changes to the waterways seem to have occurred only recently from European settlement in the area. An early Parish map obtained from the Department of Lands was proclaimed on the 31st of May 1895, (Appendix F) and discontinued in December 1916. From this it can be seen that the waterways are approximately in the same locations as they can be seen today.

Information obtained from the NSW Office of Environment and Heritage shows the single track, Illawarra Railway continued from Kiama Station and terminated at Bomaderry Station on the 2nd of June 1893.

It would seem that the culverts and bridges located just upstream of the waterway crossings were built for natural waterways that existed prior to construction of the elevated railway.

The configuration of the waterways, upstream of the railway line was observed to have changed based on the differences noticed between the latest 1:4000 topographic map of the area (Appendix F) and a 1:4000 topographic map dated 31st of May 1895 (Appendix J). It is most likely that natural waterways leading into low lying areas were extended as modified drainage channels and continued through to the Tullian and Abernethys Creeks.

Although these findings show that the waterways being crossed by the gas pipeline have changed slightly over the last 116 years, it is unlikely that significant changes will occur at the waterway crossing positions due to upstream varying conditions. Most of the areas immediately upstream of the waterway crossings are stable due to being occupied and utilized for farming or residential housing. The culverts and bridges at these positions are fixed and are likely to remain fixed points of impact for the lifespan of the pipeline.

3.7.1 Soil and Land

Meroo Meadow and Bomaderry are situated adjacent to and partly on the Lower Shoalhaven River floodplain. Main soils types in this area originate from Permian siltstone and shales of the Berry Formation, and Gerringong Volcanics (mainly west of the Princes Hwy), with quaternary river alluvium in the Shoalhaven floodplain (mainly east of the Princes Hwy).

Soils are typical of the area and do not require special treatment during excavation, except where acid sulphate soils are disturbed. The main component of significance in these soils is iron sulphide, which reacts with the atmosphere to form sulphuric acid. Erosion and excavation provides the means by which

the iron sulphide is uncovered or disturbed and therefore exposed to the atmosphere. The area surrounding Meroo Meadow and Bomaderry contains small wetland areas prone to flooding with a low probability of disturbing acid sulphate soils along the proposed gas main route. These areas are shown in the Shoalhaven LEP and should be identified in the ESCP, with appropriate treatment procedures developed.

Rainfall erosivity factor (R) for soils in the region is approximately 4250 mm/ha.hr.yr, as shown on Map 11: Rainfall Erosivity of the Wollongong 1:250,000 topographic Sheet, obtained from Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition, March 2004. The soils are described as having 'low permeability and low wet bearing strength, High run-on; localized shallow soils with localized rock outcrop'[(1)].

The proposed route follows a path mainly over 'prime agricultural land'. The current Shoalhaven Local Environmental Plan (1985) states that land classified as 1, 2 or 3 under the Department of Primary Industry's land classification system is regarded as 'prime crop and pasture' land. The proposed route is situated mainly through class 2 classified areas. Even though the proposed route is through prime agricultural land, it is located over existing formed and unformed road reserves, and a small portion of the railway reserve.

The longitudinal and transverse grade of the proposed route is generally flat, with gentle fall predominately toward the south-east. A number of areas along the route are relatively steep both longitudinally and transversely (greater than 1:4). Fortunately the longitudinal grades of waterways at proposed crossings are relatively flat and grade back toward the north and north-west. These positions are located generally at the Edwards Ave intersection, and along the un-named road reserve and Railway Street, adjacent to the train track.

The waterway cross sections at crossing points are trapezoidal, with flat bottomed beds. The longitudinal grade of the waterway beds at proposed crossings points are 0.4%, 0.5%, 0.5% and 0.8% respectively. Gradients were determined from 1:4000 topographic map contours.

The transverse gradient of land at the crossings is flat along the un-named road reserve, except for the land to the south of proposed waterway crossing at position 9, which falls relatively steeply back toward

the waterway from Edwards Avenue. The waterway crossing at position 11 is situated in a gully, with two steep sections either side grading back toward the waterway.

The potential for sedimentation and erosion issues is greatest at the steeper locations of the proposed gas pipeline route, especially adjacent to waterways, table drains, culverts and the Shoalhaven City Council stormwater system.

3.8 Waterway and Riparian Zone Assessment

Riparian lands are transition zones between terrestrial and aquatic environments. Section 5.2 of the Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1 Fourth Edition (Blue Book) describes three broad categories for riparian land. These include;
Category 1 – Environmental Corridor
Category 2 – Terrestrial and Aquatic habitat
Category 3 – Bank stability and water quality

Depending on the category, different management regimes apply to each. Site investigation, and study of the draft Shoalhaven LEP has determined that the riparian zones of the waterways at the crossing locations, as given in Figure 1 Appendix A, are categorised as follows;

- Waterway crossing 1 : Category 3
- Waterway crossing 2 : Category 3
- Waterway crossing 3 : Category 2
- Waterway crossing 4 : Category 2

Although waterway crossings 1 and 2 could be classed as category 2, since they have the potential to allow animals to cross over from one side of the floodplain to the other side, the waterways are greatly modified and located mainly on grazed agricultural land.

Waterway classification is used to identify minimum riparian corridor widths along waterways. Category 2 – Terrestrial and Aquatic Habitat classification aims to provide for a viable and robust node or reach of riparian habitat (both aquatic and terrestrial), with minimum CRZ width of 20m (measure from top of bank) along both sides of the watercourse with a 10m vegetated buffer zone either side.
The aim of maintenance and restoration of Category 2 waterways is to maintain native riparian vegetations, water quality, bank stability and provide suitable native animal habitats.

Due to the nature of these category 2 waterways, at the crossing locations with cattle grazing within the 20m wide CRZ over both banks, and the lack of existing diversified vegetation, the 10m wide vegetation buffer is not considered necessary.

Waterways classified as Category 3 require minimisation of sediment and nutrient transfer to provide bank stability, water quality and native vegetation protection. These are generally achieved where possible by emulating a naturally functioning stream, providing terrestrial and aquatic vegetated habitat refuges, using pipes and other engineering devices as a last resort and treating stormwater runoff before discharging to riparian zones or waterway.

The two Category 3 waterways are highly modified from natural conditions with a lack of diversified native vegetation. Cattle grazes within the 10m wide core riparian zones on either bank.

See Appendix E for further Details

3.8.1 Sea Level Rise

Shoalhaven City Council has commissioned revised flood modeling of the Lower Shoalhaven River Floodplain to assess the impacts on climate change induced sea level rise on flood levels. The information that follows was obtained from their recently made available climate change assessment report titled ‘Lower Shoalhaven River Floodplain Management Study and Plan – Climate Change Assessment (CCA).

Based on the following information using the 1% AEP flood event for comparison, during the proposed gas pipeline’s minimum service design life of 30 years the amount of flood level rise at the proposed development site due to sea level rise is insignificant. The possible increase in flood levels across the proposed gas main site due to sea level rise is comparatively small with respect to current flood levels during the 1% AEP flood event (0.36% max). Due to this, erosion and sediment control during construction of the proposed gas pipeline will not be affected by sea level rise, nor will there be need to tailor erosion and sediment control to compensate for sea level rise.

The proposed development is located approximately 12 to 15 km from the entrance of the Shoalhaven River. The proposed position of the gas main corresponds to cells 8 & 14 of Figure 1 in the CCA report. Referring to Figure 3 of the CCA report, by 2050 the anticipated benchmark 400mm rise in sea level will possibly cause a corresponding maximum 10 mm flood level rise during the 1%AEP flood event. By

2100 the increase to the flood level during the 1%AEP flood event across the site from an anticipated 900mm rise in sea level will be approximately 20mm.

Figure 46 of the Lower Shoalhaven River Flood Study (April 1990) shows the peak flood level during the 1% AEP flood event to be approximately 5.6m AHD. Comparing Figure 1 of the CCA report which shows the existing 1% AEP flood extent, to figures 2 and 4, the anticipated 1% AEP flood event in the years 2050 and 2100 respectively show there is no significant change to the flood extent across the proposed gas pipeline site.

Referring to figure 3 of the CCA report, the flood hazard category in the year 2050 over the area where the proposed gas pipeline will be situated remains consistent with the existing flood hazard category of 'High Hazard Flood Storage' as shown in figure 2 of the 'Lower Shoalhaven River Floodplain Risk Management Plan'.

Since over half of the proposed gas main will be situated in High Hazard flood storage area on the Shoalhaven River flood plane, an assessment of sea level rise on the proposed gas pipeline was made. It was found that there will be insignificant impacts to the gas pipeline, with respect to erosion and sediment control.

NSW Government Policy on Sea Level Rise

The NSW Department of Planning has issued a policy statement entitled "NSW Sea Level Rise Policy Statement" October 2009 which outlines the NSW Government's attitude towards the impacts of sea level rise on regional planning and new development.

The policy states the following:

The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100, with the two benchmarks allowing for consideration of sea level rise over different timeframes. The benchmarks were established by considering the most credible national and international projections of sea level rise and take into consideration the uncertainty associated with sea level rise projections. The Government will continue to monitor sea level rise observations and projections and will periodically review these planning benchmarks, with the next review likely to coincide with the release of the fifth IPCC report, due in 2014.

and

The sea level rise planning benchmarks will support consistent consideration of the influence of sea level rise on any coastal hazards and flooding risks that may influence a development or redevelopment site. The benchmarks are not intended to be used to preclude development of land that is projected to be affected by sea level rise. The goal is to ensure that such development recognises and can appropriately accommodate the projected impacts of sea level rise on coastal hazards and flooding over time, through appropriate site planning, design and development control.

Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments

The NSW Department of Environment, Climate Change and Water has issued a report entitled "*Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments",* August 2010.

The report adopts the planning benchmarks of the *NSW Government Policy on Sea level Rise* and provides guidance as to how to apply sea level rise benchmarks to flood risk assessments which are undertaken for flood affected areas.

The Guide states the following:

This guide applies to areas where projected sea level rise is likely to have a discernable impact on predicted flood levels. This includes the NSW Coastal Zone and areas in the vicinity of lower coastal waterways, including rivers, creeks, estuaries and ICOLLs. In particular, this is likely to apply if the land is:

- *likely to be inundated if water levels were 1.0 m above the upper limit of the current tidal range, generally defined by mean high water springs*
- *likely to be inundated if water levels were 1.0 m above the current flood planning level*
- *within 1.5 m of the maximum historic height of the entrance berm or the upper limit for management intervention identified in entrance management plans for any ocean entrance to the waterway which controls flooding (this commonly applies to ICOLLs)*
- *below 4 m AHD.*

The Guide also states:

Where a flood investigation has been prepared, the modeling can be updated to include sea level rise projections or a conservative assumption can be made about sea level rise impacts. Where the site is below 4 m AHD, an appropriate conservative assumption to estimate the 1-in-100 year ARI flood level is to add the sea level rise benchmarks to the 1-in-100 year ARI flood level relevant to the site.

3.8.2 Soil Analysis

Soil data was obtained from a borehole log report prepared by Coffey Environments on the 21-06-2011. Boreholes 17, 16, 12 and 10 correspond to waterway crossing locations 7, 8, 9 and 11 respectively and are available in Appendix G.

In general, the soils at proposed waterway crossings were fine grained, cohesive, highly plastic, clays and sandy clays, with shear saturated shear strengths between 100 and 400 kPa.

A soil sieve analysis for grain size was not made.

3.8.3 Vegetation

Vegetation within the waterways and riparian zones were found to be common between the four waterway crossings. Remnant vegetation adjacent the proposed gas pipeline route on the Shoalhaven floodplain is most likely from forested or saline wetlands, which would have been removed to make way for the railway reserve, train track and agriculture (dairy farming).

Overall condition of existing riparian vegetation was poor with low structural and floristic diversity, significant weed infestation, and exposed soils observed along stream banks.

The main vegetation type found in riparian zones was kikuyu grass with sporadic plantings of native trees and shrubs, mainly at low lying areas downstream on the floodplain.

Waterway vegetation consists mainly of aquatic weeds and reed beds that have grown through the grass lined waterways.

Extensive weed infestations were identified along all of the proposed waterway crossings, which included a number of noxious weeds, listed under class 4 and 5 of the Shoalhaven Local Government Area.

Lantana and blackberry was found at number of locations along the un-named road reserve and waterway crossings. It is recommended that these be removed during work site and haul road preparation to improve overall ecosystem health and allow the re-establishment of native species.

Lantana can be removed by cutting and mulching back into the ground. This method will provide some soil protection following weed removal to reduce both erosion and further weed infestation.

A vegetation management plan (VMP) is generally required to ensure riparian areas are managed appropriately and in accordance with strategic objectives. The VMP outlines management zones and establish guidelines for riparian management, focusing on the required actions to carry out the above recommendations. In addition, the VMP also incorporates site specific measures relating to personnel access, weed management, incident management, ASS, surface drainage and erosion controls.

For the Shoalhaven Starches gas pipeline project, a VMP is not considered necessary due to the proposed route being mainly in road reserves with little to no native vegetation along the route being disturbed. The majority of vegetation being disturbed is Kikuyu grass, which can be replaced by seeding or turfing.

To counteract the lack of a VMP, the ESCP should go into greater detail than normal regarding rehabilitation of disturbed vegetation, making every effort to ensure that disturbed areas are rehabilitated to existing conditions. Areas along the proposed route with native vegetation, such as waterways and road verges that contain shrubs and trees, should be identified in the ESCP and details given of how removed native vegetation will be replaced.

3.9 Erosion and Scour

Fluvial scour and bank erosion was observed at all waterway crossing locations. The majority of scour and erosion has occurred between the proposed waterway crossings and the culvert or bridge in the railway reserve immediately upstream of the crossing points. Limited erosion and scour has occurred downstream of the waterway crossings.

Outlets of culverts and bridges are known areas of significant scour and erosion. The waterway crossings were modelled to estimate the maximum scour depth due to a 1 in 100 year flood event. This is to determine the minimum depth of cover required to mitigate scour impacts on the gas pipeline under the waterway crossings. It should be noted that over time, a balance is reached at scour holes, where the depth remains constant and does not keep on growing, unless a significant morphologic change occurs to the waterway. Eroded sediment is transported from upstream and gets deposited at the scour hole. The 1 in 100 year storm event was chosen since it is used by Shoalhaven Starches for their planning policies.

3.9.1 Scour Depth

There is potential for a buried pipeline to be uncovered at waterway crossings. The minimum depth of burial, or soil cover over the pipeline is stipulated so that damage is prevented to the pipeline. Once buried, the pipeline is to remain in its covered state unless specifically removed.

Determining an adequate amount of cover over a pipeline that crosses under the bed of a waterway requires consideration of the effect of scour caused by the flooding characteristics of the waterway and the floodplain immediately in the vicinity of the crossings. As water flows through a waterway or over a surface, scour or erosion of the surface will occur when conditions are suitable. This is generally dependant on the characteristics of the waterway; materials used to construct the waterway; flow velocity and soil type.

Information from site inspections and desktop studies was used with HY-8 software form the United States Department of Transportation – Federal Highway Administration, to determine the scour potential and minimum depth of cover required between the beds of each waterway crossing. This software is based on the document, ‘Hydraulic Design of Energy Dissipaters for Culverts and Channels’, Publication No. FHWA-NHI-06-086 July 2006 Hydraulic Engineering Circular No. 14 Third Edition which is also used as a reference manual for the Australian Rainfall and Runoff Manual.

This report presents preliminary scour depth modelling results obtained from a simplified deterministic analysis. Sstatistical variance of the storm events, sediment transport, flow rates etc is not considered. Modelling was determined to be feasible, without the need for detailed survey data of the flood plain and waterways, by obtaining relative measurements of bridges and culverts, waterways, railway track and ballast, and undertaking a desktop study to obtain interpolated data from existing topographic maps and soil test results.

It is recommended that probabilistic modelling of scour depth be undertaken as part of the detailed design of the gas pipeline, and results compared with those presented in this report.

The most significant form of scour occurring at the waterway crossings is localised scour at the outlet of bridge/culverts, due to the large catchment coupled with the size of the bridge/culverts, and constriction of the waterways as they flow under the railway track, increasing the velocity through the opening. Peak flow rate calculations for catchments are available in Appendix H

The following assumptions were made for scour depth modelling presented in this report;

- All culverts are 5m wide.
- There is zero fall through bridge/culverts.
- Railway deck above bridge/culvert is level.
- Mannings is constant for banks and channels.
- Waterway cross sections are trapezoidal and level
- Culvert invert is at the same level as the waterway invert.
- Sub-catchments do not join together during large stormwater events.

A sensitivity analysis was made on important waterway variables including longitudinal waterway gradient, waterway bank and channel Mannings numbers, soil Plasticity Index and saturated shear stress. It was found that the most significant variables to affect scour depth are soil Plasticity Index and saturated soil shear stress.

HY-8 recommends an Atterberg limits test to determine the plasticity index (PI) by using the procedure outlined in ASTM D423-36. This test was not done as part of Coffey Environments Soil Analysis Report. The report does give descriptions of the plasticity of the soil. For all waterway crossings the soils were of

medium to high plasticity'. HY-8 requires an input between the limits of 5-15 for the Plasticity Index, which corresponds to medium and high plasticity soils.

It is also recommended to obtain Saturated Shear Stress values from a test done in accordance with ASTM D211-66-76. The Coffey Environments soil analysis report shows a pocket petrometer test being done, with values of shear stress ranging from approximately 50kPa to 400kPa along the route. This is an equivalent test to the recommended HY-8 test, ASTM D211-66-76.

A sensitivity test of the Plasticity Index (PI) and Saturated Shear Stress (SSS) with respect to scour depth was made between PI values of 10 and 15, and SSS values from +50 and -50 kPa from values given in the Coffey Environments Bore hole log report. The results of the sensitivity analysis showed that incrementing the HY-8 plasticity Index from 10 to the upper limit of 15 caused the modelled scour depth to increase by approximately 200mm, (5.7%). By altering the SSS results, a 180mm (5.5%) change in scour depth resulted. This can be considered insignificant as a factor of safety will need to be considered which will result in the depth of covers increasing well beyond these values.

Scour depth results are available in Appendix I. A summary table of each waterway crossing is provided in the following section, including calculated scour depth.

3.10 Geomorphic Assessment Conclusions and Recommendations

- Changes to waterway morphology is limited with no major changes to waterways observed in 116 year period.
- Minor morphological changes are occurring at outlets of bridges/culverts under railway tracks, just upstream of proposed waterway crossings.
- The major cause of morphological change is erosion occurring at proposed waterway crossings, from localised fluvial scour at outlet of culvert/bridges.
- Velocity of flow over proposed waterway crossings is above 2.0m/s, at three of the four waterway crossings, meaning there is a very high chance of scour occurring at these locations.
- The lack of healthy, diverse and continuous riparian vegetation along the bank of each waterway within the unnamed road reserve is contributing to bank erosion and instability.
- It is likely that revegetation works within the riparian zone will prevent bank recession continuing due to fluvial scour during small stormwater events.

- Protecting the toe and banks of waterway crossings along the width of the road reserve, increasing groundcover and promoting binding root growth as close to the toe of the bank as possible may be adequate to resist scour.
- The Core Riparian Zones of all waterways at their proposed crossings are highly degraded due to weed infestation, large flows and velocities, and the lack of an appropriate cattle grazing setback. It is recommended that waterway crossings 1 and 2 be classified as Category 3, and waterway crossings 3 and 4 be classified as Category 2, as per the draft Shoalhaven LEP, and section 5.2 of Landcoms Blue Book;
- Category 3 waterways have no CRZ width requirements, whilst Category 2 waterways require a 40m wide CRZ over the waterways with 10m wide vegetation buffer zone either side of the CRZ.
- Table 1 below shows scour depths and expected length of scour hole in meters downstream of culvert/bridge outlet. It can be seen that the calculated scour depths may not be reached at the pipeline crossing, especially if the proposed crossing points are at the outer boundary of the un-named road reserve. Since there is approximately 15m of railway reserve between the culvert/bridge and the common boundary between railway reserve and road reserve, it is estimated that greatest amount of scour will occur mainly within the railway reserve, and possibly decrease in depth as it approaches the waterway crossings.
- From the scour depth results, the minimum pipeline depth of cover at waterway crossing 3 will need to be increased from the minimum 2.0m, to a minimum of 5.1m. The minimum 2m depth of cover under the waterway beds at waterway crossings 1, 2, and 4 should be satisfactory.
- Further variance based modelling of scour at the waterway crossings is required, during detailed design, to take into consideration statistical variance of scour depth variables. The estimated scour hole lengths show that the calculated scour depths may be reached at waterway crossings 2 and 4. See Appendix E for further Detail

Table 1: Summary of Waterway Crossings and Scour Results

Water-way	*Waterway cross-section*			*Long-Grade*	*1%AEP Flow Rate*	*Soil Shear Strength*	*Culvert Outlet Velocity*	*Scour Depth*	*Scour Hole length*
	Depth (m)	*Bed Width (m)*	*Bank Widths (m)*	*%*	*(m^3/s)*	*(kPa)*	*(m/s)*	*(m)*	*From Culvert outlet (m)*
1	0.5	5.0	1	0.3	2.84	100	1.20	0.9	4
2	1.5	6.5	2	0.5	64.4	200	3.06	2.3	12
3	1.0	7.0	1	0.5	132	100	3.72	5.1	30
4	0.8	5.0	1	0.8	30.0	400	2.72	3.4	14

3.11 Site Rehabilitation, Maintenance and Monitoring

Continual site remediation and restoration is required during the proposed pipeline construction process. Progressive re-vegetation, removal of temporary erosion & sediment control measures, and site stabilization requires detailed planning.

Rehabilitation, maintenance and monitoring of the pipeline route shall be established as part of the ESCP. The photographic evidence presented in this report can be used to aid rehabilitation of disturbed sites, back to pre-existing conditions shown in the photos.

A vegetation management plan (VMP) should not be required from a qualified Landscape Architect shall due to the lack of diversified vegetation found along the proposed route and waterway crossings. To ensure adequate rehabilitation of each waterway's CRZ, vegetation rehabilitation and maintenance should be included as part of the ESCP, with all native trees and shrubs along the proposed route identified, and all native trees requiring removal to facilitate pipeline construction identified on the plan. For those areas requiring removal of native species, the ESCP should outline replacement species and their proposed location.

Top soils removed for trenching and work site preparation shall be stockpiled and reutilised over backfilled trenches and at rehabilitated work sites. If required, a top soil mix shall be prepared and approved by a qualified Landscape architect if further topsoil is required for adequate site rehabilitation.

Vehicle waterway crossings are to remain in place for the full rehabilitation period. Once rehabilitation has been established, vehicle crossings shall be removed and the waterways filled and regarded to match upstream and downstream conditions. Jute mesh is to be laid and secured over disturbed waterway crossing locations and the area re-vegetated through the jute mesh. If heavy flows are expected through re-vegetated waterways before adequate vegetation is established to protect the waterway, a temporary bypass around the disturbed waterway may be required, which is to be installed in accordance with the blue book.

Staged construction provides favorable conditions for re-vegetation. Progressive re-vegetation aims to minimize the area of disturbance during construction. Works should be staged and each stage stabilised immediately on completion of trench backfilling, or on removal of stockpiles placed over previously backfilled trenches. Since the majority of disturbed soils are within agricultural land (pasture), the

predominant vegetation affected is grass (kikuyu). The most immediately effective method of stabilization is to seed the disturbed area. More information regarding re-vegetation and site stabilization is available in Volume 1, section 7 of the Blue Book.

Maintenance and monitoring of erosion and sediment controls and rehabilitated areas is required on a periodic basis, to ensure the effectiveness of any mitigation measures implemented during and following the completion of the construction phase. Erosion and sediment controls are to remain in place after site works are officially completed, for a period not less than 6 months, or until 75% of the site has been adequately rehabilitated. This is to be decided by the superintendant of the project. The following table gives Monitoring requirements, frequency of monitoring and the person responsible for monitoring and maintenance;

Table 2: Rehabilitation Monitoring Requirements

Monitoring Requirement	Frequency	Responsibility
Erosion & Sediment Control Inspections	Weekly during construction and rehabilitation periods, and immediately after any storm event	Project Environmental Officer
Inspection of Waterways	Fortnightly until completion of entire project	Project Environmental Officer
Inspection of Vegetation	As per Vegetation Management Plan	Landscape Architect
Photographic Evidence (Riparian Zones and Waterways)	Fortnightly	Project Environmental Officer

4 Conclusion

Shoalhaven Starches have proposed to construct a 5.5km coated mild steel gas main to enable competitively priced gas to be sourced for the manufacturing operations at Bomaderry including a proposed gas co-generation plant,. The proposed pipeline will also provide for any future expansion at the Bomaderry site.

This report was written to address erosion and sediment control issues outlined under the heading of Soil and Water in the Director General's Requirements, Shoalhaven Starches Project (MP 10_0108), dated 8th November 2010, as part of the development application process.

Details of legislative requirements, project planning principles, documentation requirements, assessment of constraints and opportunities, site restoration and remediation, and general erosion and sediment control management procedures have been provided in this report.

Erosion and sediment control of linear service projects, such as the Shoalhaven Starches gas main, is legislated in NSW. The legislation relating to erosion and sediment control of service installation projects fall under the development assessment framework and provisions of the Environmental Planning and Assessment Act 1979 which include; Protection of the Environment Operations Act 1997, Water Management Act 2000, and the Fisheries Management Act 1984. Other legislation may affect the project which is listed in section 2.1.

Effective management of erosion and sediment control on linear service installation projects requires addressing planning activities which include developing systems for documentation and communication, assessing constraints and opportunities, preparing an ESCP, restoring and remediating sites and other planning considerations.

The project principal is responsible for ensuring all personnel are made aware of responsibilities for proper environmental management and care. The is achieved through the Environmental Management System (EMS).The principal and/or contractor(s) are required to develop an EMS, which is presented as part of the developers construction environmental management plan (CEMP). The CEMP is an active document, constantly being updated that; outlines environmental objectives and targets, describes how to manage and control the environmental aspects of the project, interfaces with all other plans, describes the overall project management system, and expands on the environmental section of the project business plan.

The CEMP should include the following to identify the aims, actions and outcomes required to meet the project's environmental objectives;

- Description of the principal's or contractor's environmental management system.
- CEMP objectives and targets.
- Risk Assessment.
- Constraints.
- Roles, responsibilities and contact details.
- Environmental controls.
- Monitoring and Compliance. [1]

Stabilised haul roads and machinery storage and stockpile sites are required along the route. These constrain pipeline construction. They require large surface areas to be disturbed and their position is critical for the efficient construction of the gas pipeline. Their location should be planed during the detailed erosion and sediment control plan construction stage. Stabilised work sites will be required at all waterway crossings, with adequate erosion and sediment controls put in place as per the Blue Book.

Since the majority of the proposed gas main route is over flat land, the use of simple erosion and sediment controls can be used. This includes sediment fence and straw bale filters which can be made to form almost any shape or follow any contour, and will divert and filter stormwater runoff. Geo-textile material placed to form temporary table drains can be used to divert water around work sites, and can be reused during later stages of the project.

Steeper sections along the route will also incorporate the same simple controls although additional controls will be required to adequately control runoff. This will depend on the steepness of the trench and how the contours grade around it. On steep sections along the route, check dams, trench stops and bulkheads placed within the trench will stop transportation of sediment and water toward the waterways. Trenches shall be stopped and a check dam installed at the boundary of all CRZs, before reaching the waterways. Appropriate waterway crossing techniques as described in Chapter 2 of this report, which were obtained from Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1 , 4th Edition are to be used.

It is recommended that where possible, excavated soil is placed adjacent to the proposed main trench on the upstream side, so that stormwater runoff will push the soil back into the trench and not into any adjacent waterways. The mound can be used as a diversion drain by placing geo-textile material at the base of the stockpiles.

Location of waterway crossings was discussed. The recommended method of pipeline waterway crossing is by underbore as it will minimize the disturbance to the waterway and surrounding areas, and reduce the re-vegetation and stabilization stages. Trenching across waterways shall not occur.

Staged construction of the proposed gas main is recommended and should be planned for as it not only benefits re-vegetation and re-stabilisation of disturbed areas, it enables efficient management of topsoil, and material stockpiles along the route.

A geomorphic assessment of the four proposed pipeline waterway crossings determined that the waterways had not changed significantly over a 116 year period, and would not likely change during the lifespan of the gas pipeline.

Waterway crossings lacked adequate riparian zones, with cattle allowed to graze right up to the bank of waterways, contributing to the lack of diverse vegetation, and outbreak of weed varieties. Waterways were also choked with aquatic weeds. An adequate core riparian zone should be established at all waterway crossings, in accordance with the Blue Book, as a Category 2 – Terrestrial and Aquatic habitat, to increase bank stability thereby reducing the erosion potential at the site.

An assessment of scour at the waterway crossings was made with HY-8 modeling software. It was found that velocities through the culverts and bridges just upstream of the crossings were high enough to cause scour at the crossing points along the route. The minimum 2.0m depth of cover needs to be increased to take scour into consideration, in accordance with the scour depths calculated and presented under the Heading of Geomorphic Assessment Conclusions and Recommendations.

A rehabilitation, maintenance and monitoring program is to be established prior to construction, utilizing a vegetation management plan to ensure the environment along the route is returned to the same if not better condition it was in before construction commenced. Erosion and sediment controls will need to be maintained for a minimum period of 6 months, and regular site visits also made to monitor the condition of the erosion and sediment controls and determine when the site has stabilised.

5 Recommendations

Based on the site investigation conducted by Allen, Price and Associates, the Shoalhaven Starches gas pipeline project is achievable with the installation and maintenance off simple erosion and sediment controls during construction. To move the project forward with regards to erosion and sediment control of the proposed project, the following recommendations are made ;

- Determine the exact route that the proposed gas pipeline will follow.
- Begin development of the Environmental Management System, and the Construction Environmental Management Plan.

- Prepare Erosion and Sediment Control Plan for the site.
- Prepare Vegetation Management Plan.
- Obtain detailed survey of the entire site, including upstream and downstream floodplain and waterways, and areas beyond the road reserves where sediment laden waters may be carried.
- Undertake variance based modelling to determine scour depth at waterway crossings.
- Ensure all erosion and sediment control requirements will be met by becoming familiar with the legislative requirements relating to Erosion and sediment management of linear service projects.
- Notify land owners along the proposed route of any erosion and sediment controls that require construction on their property. Obtain written permission.
- Discuss requirements with Shoalhaven City Council.

Allen, Price & Associates

13 February 2012

6 References

1. *2008, Managing Urban Stormwater-Soils and Construction, Volume 2A-Installation of Services*, Department of Environment and Climate Change, Sydney, NSW.
2. *2004, Managing Urban Stormwater-Soils and Construction, Volume 1- 4th Edition*, Landcom, Sydney, NSW
3. Coffey Environments (2011). *Engineering Log – Borehole CBH100, CBH103 and CBH104*. Additional
4. Cowman Stoddart (2007). Preliminary *Environmental Assessment Report, Proposed Ethanol Production Upgrade*. Prepared for Shoalhaven Starches, Bomaderry, NSW.
5. DLWC (2000). *Soil and Landscape Issues in Environmental Impact Assessment, Technical Report*
6. DNR (2008). *Water legislation and policies: NSW Government Natural Resource*.
7. http://naturalresources.nsw.gov.au/water/wma2000.shtml, accessed 15 March 2008.
8. DIPNR (2004). *Riparian Corridor Management Study Guidelines*. Former Dept. of Water
9. DWE (2008a). *Guidelines for Controlled Activities: Riparian Corridors*. Water Management Act 2000. NSW Dept. of Water and Energy.
10. DWE (2008b). *Guidelines for Controlled Activities: Vegetation Management Plans*. Water Management, Act 2000. NSW Dept. of Water and Energy.
11. Weeds Australia, (n.d.). *Weed Identification, Kikuyu grass Pennisetum clandestinum*.
12. http://www.weeds.org.au/cgi-bin/weedident.cgi?tpl=plant.tpl&ibra=all&card=E27, accessed 10 Jan 2012

Appendix A – Figure 1

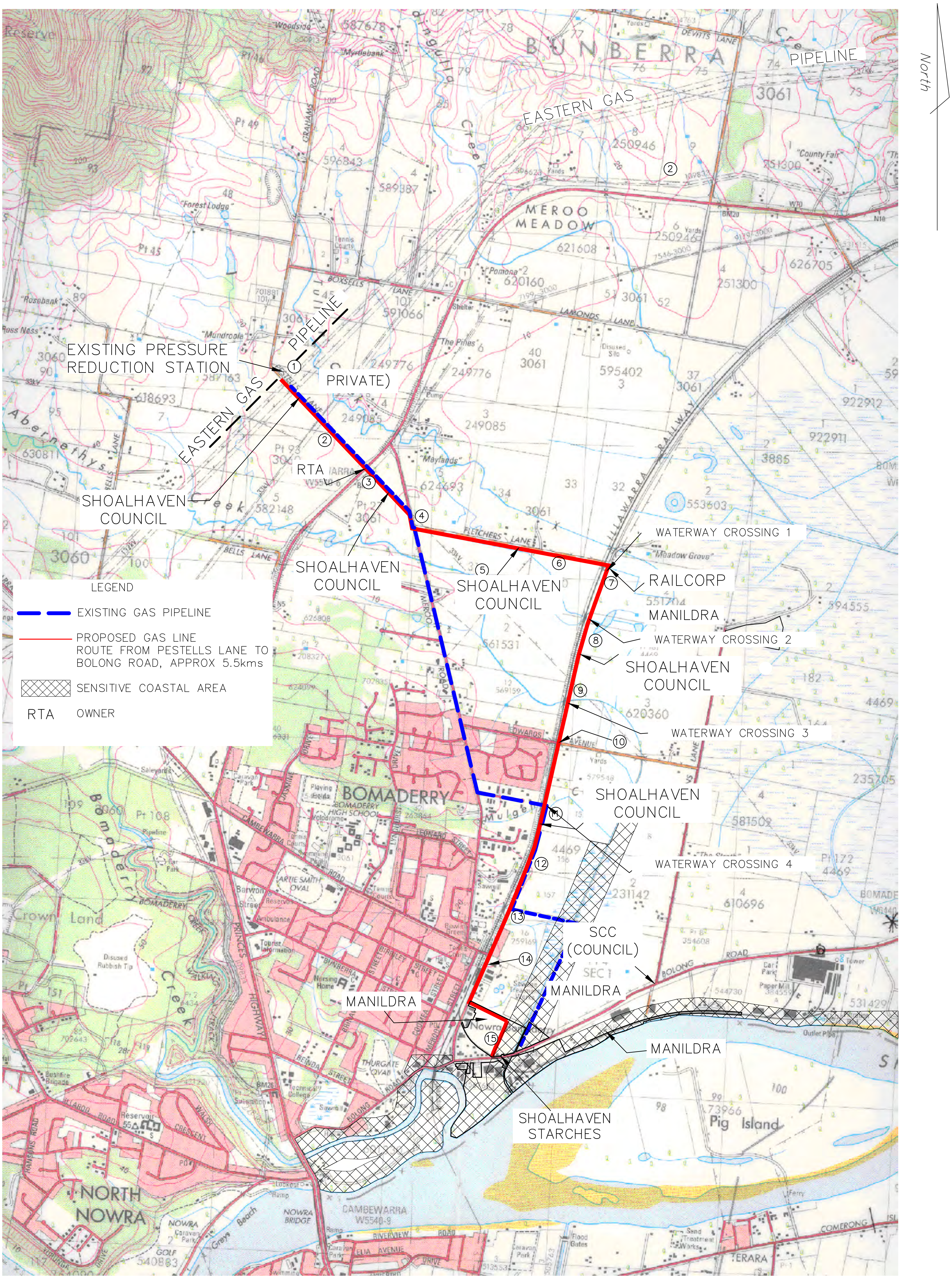


FIGURE 1

0 250 500 750 1000

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FIGURE SHOWING, PROPERTY OWNERS & WATERWAY CROSSINGS ALONG THE PROPOSED GAS LINE ROUTE, FROM EXISTING EASTERN GAS LINE TO SHOALHAVEN STARCHES BOLONG ROAD FACTORY

Rev: 01

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A3 SIZE
RATIO 1:22,000 DATE 18-8-11 REF: 24710-04a

Appendix B – Photographic Investigation of Proposed Route

Appendix B

Photo 1- Eastern Gas Pipeline tie-in point at Pestells Lane (valve and meter station)

Photo 2 Eastern Gas Pipeline tie-in point for existing ActewAGL gas pipeline at Pestells Lane

APPENDIX B: Photographs of Shoalhaven Starches proposed gas pipeline route at Meroo Meadow and Bomaderry, NSW.
Prepared by Allen, Price & Associates, Nowra, NSW. (02)44216544.
Project Ref. 24710

Photo 3-Pestells Lane verge (south side)

Photo 4-Cattle Loading Station and driveway on Pestells Lane

Photo 5- Existing ActewAGL gas main marker adjacent rural fence at Princes Highway Intersection

Photo 6- Proposed gas main route across Princes Highway

Photo 7- Table drain and culvert on Princes Highway intersection with Pestells Lane

Photo 8- Unformed section of Pestells Lane

Photo 9- Looking down embankment of Princess Highway, along existing gas pipe route

Photo 10- Un-formed Pestells Lane

Photo 11-Intersection of Pestells Lane with Meroo Road

Photo 12-Table drain along Meroo Road


Photo 13- Culvert headwall (bottom right) on Meroo Road and Fletchers lane intersection


Photo 14-Fletchers Lane intersection with Meroo Road

Photo 15-Possible stabilised machinery access and storage area on Fletchers lane intersection

Photo 16- Culvert Headwall and drain leading in Paddock

Photo 17-Open channel drain through paddock on south side of Fletchers Lane

Photo 18- Example of tail-out drains on south side of Fletchers Lane, leading into Open channel drain

Photo 19- Middle of Fletchers Lane

Photo 20-End of Fletchers Lane toward Railcorp railway reserve

Photo 21- Ramp crossing over train tracks at intersection of Fletchers lane and un-named road reserve

Photo 22-Large culvert in Railcorp railway reserve, beyond proposed railway track under-bore location

Photo 23- Gates to Railcorp railway reserve and un-named road reserve

Photo 24a- First waterway crossing, approximately 50m south of ramp over train tracks at end of Fletchers Lane

Photo 24b- First waterway crossing, showing culvert under railway tracks

Photo 24c- First waterway crossing, showing boundary between road reserve and Railcorp rail reserve

Photo 25a-Culvert between first and second waterway crossings for low lying area in rail reserve, adjacent to road reserve

Photo 25b-Vegetation within rail reserve at between first and second waterway crossings

Photo 26a-Low lying area at outlet of second waterway crossing, adjacent to Railcorp rail reserve

Photo 26b-Second waterway crossing, adjacent to Railcorp rail reserve

Photo 26c-Low lying area on approach of proposed gas main toward second waterway crossing

Photo 27a-Scour valve in un-named road reserve adjacent to third proposed waterway crossing, north of Edwards Avenue

Photo 27b-Third proposed waterway crossing, looking north along proposed gas main alignment

Photo 27c- Large railway bridge/culvert at third proposed waterway crossing

Photo 27d- Overhead view of third proposed waterway crossing

Photo 28- Looking north from third waterway crossing, along proposed gas main route

Photo 29- Water main marker at steep approach to Edwards Avenue, in un-named road reserve

Photo 30- Looking north along proposed gas main route in un-named road reserve, toward water main marker

Photo 31- Edwards Avenue crossing point on north side

Photo 32- South side Edwards Avenue crossing in un-named road reserve

Photo 33- Water main infrastructure in un-named road reserve

Photo 34- At gate on crest in un-named road reserve, looking south down into gully to the south of Edwards Ave

Photo 35a- Fourth waterway crossing, looking north, along proposed gas main route

Photo 35a- Approach to fourth waterway crossing, looking north

Photo 35b- Fourth waterway crossing

Photo 35c- Looking along stabilised vehicle track that crosses waterway number three

Photo 36- ActewAGL existing gas main marker on boundary of un-named road reserve, looking south along proposed gas pipeline alignment

Photo 37- Rural fence and gate at end of un-named road reserve and beginning of Railway Street

Photo 38- un-formed section of Railway Street, looking at ActewAGL existing gas main testing station

Photo 39- Railway Street

Photo 40- Water main infrastructure in Railway Street road reserve

Photo 41-Sewer rising main manhole and vent pipe

Photo 42- Water main infrastructure in Railway Street road reserve

Photo 43-Water main, power pole and existing gas main infrastructure in Railway Street

Photo 44- Beginning of sealed section of Railway Street

Photo 45- Stormwater headwall and culvert in Railway Street

Photo 46a- Scour valve shown with Large pipe culvert in background leading into drainage system under Railway Street

Photo 46b- Large pipe culvert in rail reserve on west side of Railway Street

Photo 46c- Small headwall for pipe culvert under Railway Street, taking stormwater from large pipe culvert shown in previous photo.

Photo 47- East side Railway Street road reserve-

Photo 48- West side Railway Street road reserve showing water main marker

Photo 49- Railway Street

Photo 50- Looking at Cambewarra Road intersection with Railway Street

Photo 51- Infrastructure at intersection between Cambewarra Road and Railway Street, on west side road reserve

Photo 52- Example of Railway Street Infrastructure in west side of road reserve


Photo 53a- Stormwater infrastructure in rail reserve on west side of Railway Street


Photo 53b- Stormwater infrastructure under road reserve beginning on west side of Railway Street, leading into pit on east, shown in following photo 53c

Photo 53c- Stormwater pit on east side of Railway Street

Photo 54- Open channel drain through lot 1 DP825808 Railway Street, taking water from pit shown in previous Photo.

Photo 55- Headwall and culvert under Railway Street, at direction change of proposed gas main

Photo 56- Sewer pipe through open channel drain in lot 1 DP825808

Photo 57- Culvert and support for sewer pipe accross open channel drain in lot 1 DP825808

Photo 58-Open channel drain in Lot 1 DP 825808

Photo 59- Sewer man hole in open drain along north boundary of Lot1 DP 825808

Photo 60- North boundary of Lot1 DP825808

Photo 61-Proposed gas main route in Shoalhaven Starches property lot 1 DP 825808

Photo 62- Looking toward Shoalhaven Starches Factory (Manildra), along existing sewer rising main alignment

Photo 63- Proposed gas main route through Shoalhaven Starches paddock, looking toward interim packing plant

Photo 64- Sewer pump station on Shoalhaven Starches land, with location of proposed gas main route and pressure reduction station in background

Photo 65- Civil works at most likely position of proposed gas main crossing of Bolong Road

Photo 66 - Bolong Road showing infrastructure in vicinity of proposed gas main crossing

Photo 67-Bolong Road showing infrastructure in vicinity of proposed gas main crossing

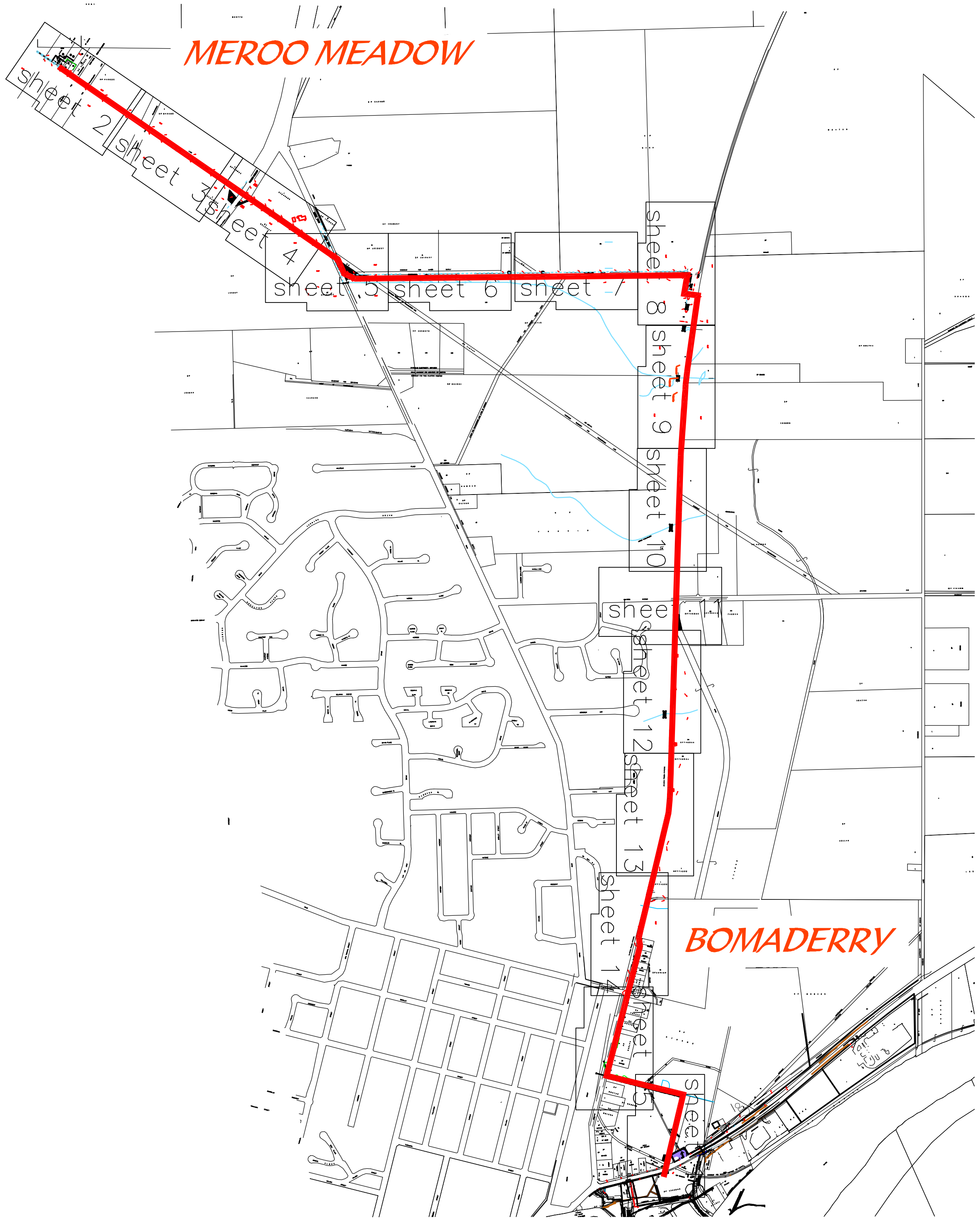
Photo 68- Shoalhaven Starches interim packing plant on south side of Bolong Road

Appendix C – APA Drawing 24710-04 Sheets 1 to 16

SHOALHAVEN STARCHES PROPOSED GAS PIPELINE

AT MEROO MEADOW AND BOMADERRY, NSW

APPENDIX C



This drawing complements two reports written by Allen, Price and Associates for the proposed Shoalhaven Starches gas pipeline project. To better understand the content of this drawing, the reports titled, 'Impacts on Infrastructure Report' and 'Erosion and Sediment Control Management Plan' should be read prior. This drawing is located in Appendix C of both reports.

Items shown on these sheets have not been located by detailed survey. They are indicatively shown based on field observation and measurement, and information given by service and infrastructure owners and operators.

LEGEND

1 2 DP 595402 — EXISTING BOUNDARY FENCE (SCC CADASTRE)

EXISTING RURAL FENCE

EXISTING GAS MAIN

PROPOSED GAS MAIN

GAS — EASTERN GAS LINE

E — EXISTING OVERHEAD ELECTRICAL POWER SERVICE

W — EXISTING WATER MAIN

S — EXISTING SEWER MAIN

SRM — EXISTING SEWER RISING MAIN

T — EXISTING UNDERGROUND TELSTRA LINE

EXISTING TAIL–OUT OR TABLE DRAIN

EXISTING CREEK OR SWALE DRAIN LESS THAN 5m WIDE

EXISTING TREE SHOWING APPROX. DRIP LINE

PP — POWER POLE (SCC INFRASTRUCTURE)

TP — TELEGRAPH POLE (RAIL INFRASTRUCTURE)

EXISTING BRIDGE

EXISTING CULVERT

AV — EXISTING AIR VALVE FOR WATER MAIN

SV — EXISTING STOP VALVE FOR WATER MAIN

SCV — SCOUR VALVE

RAILWAY TRACK

LAND SLOPE

TEMPORARY STABILISED SITE AND ACCESS FOR MACHINERY STORAGE AND UNDERBORE OPERATIONS

REVISION	BY	DATE

RATIO: 1:20000 on A3	DATUM:
	ORIGIN:
	DATE OF PLAN: AUGUST 2011

allen, price & associates
land and development consultants
75 plunkett street, nowra, nsw. 2541
phone:(02) 4421 6544 fax:(02) 4422 1821
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Plan for 'Infrastructure Impacts' and 'Erosion and Sediment Control Management' Reports for the proposed Shoalhaven Starches Gas Pipeline project at Meroo Meadow and Bomaderry, NSW

REF. No. 24710–04
sheet 1 of 16
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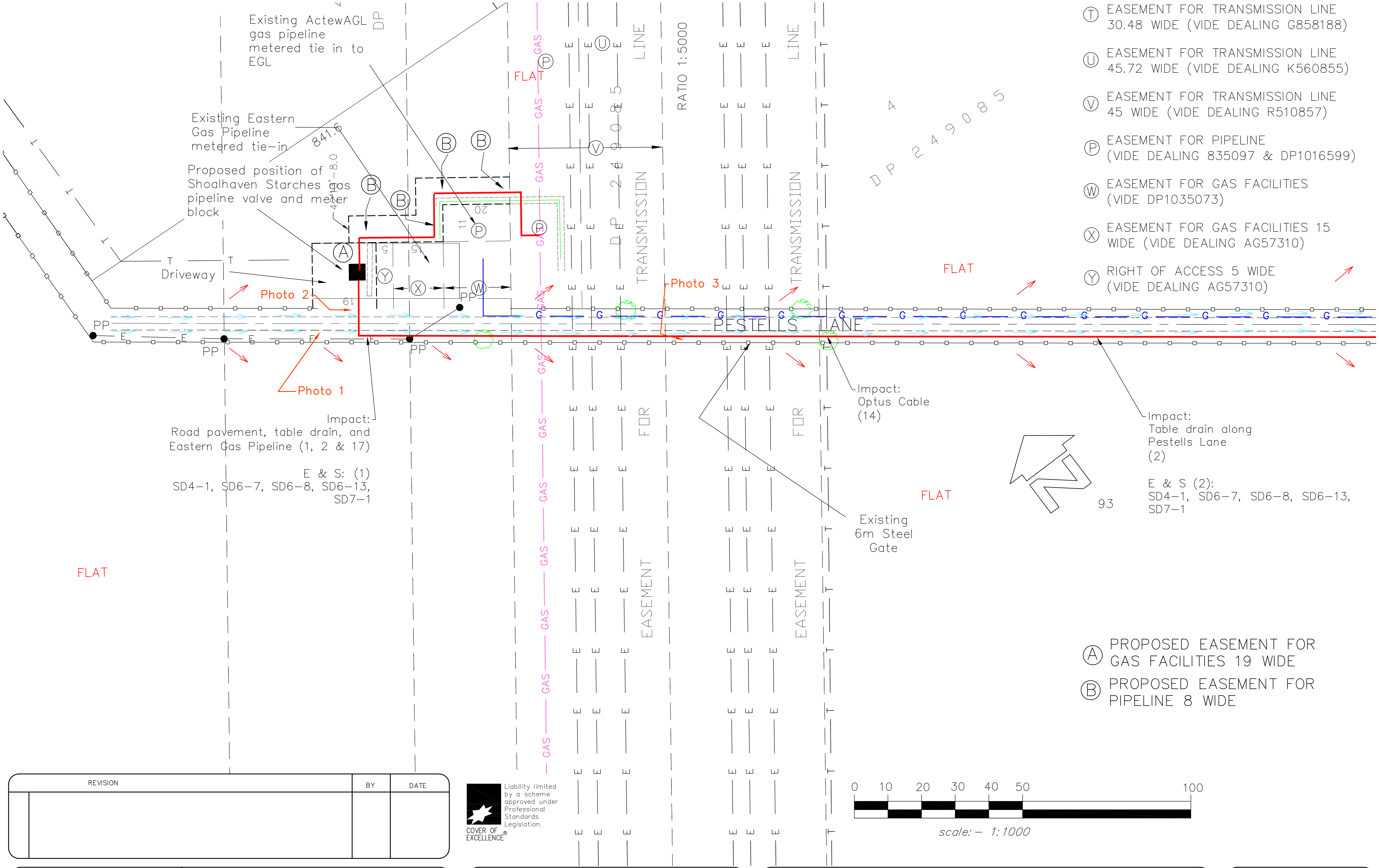

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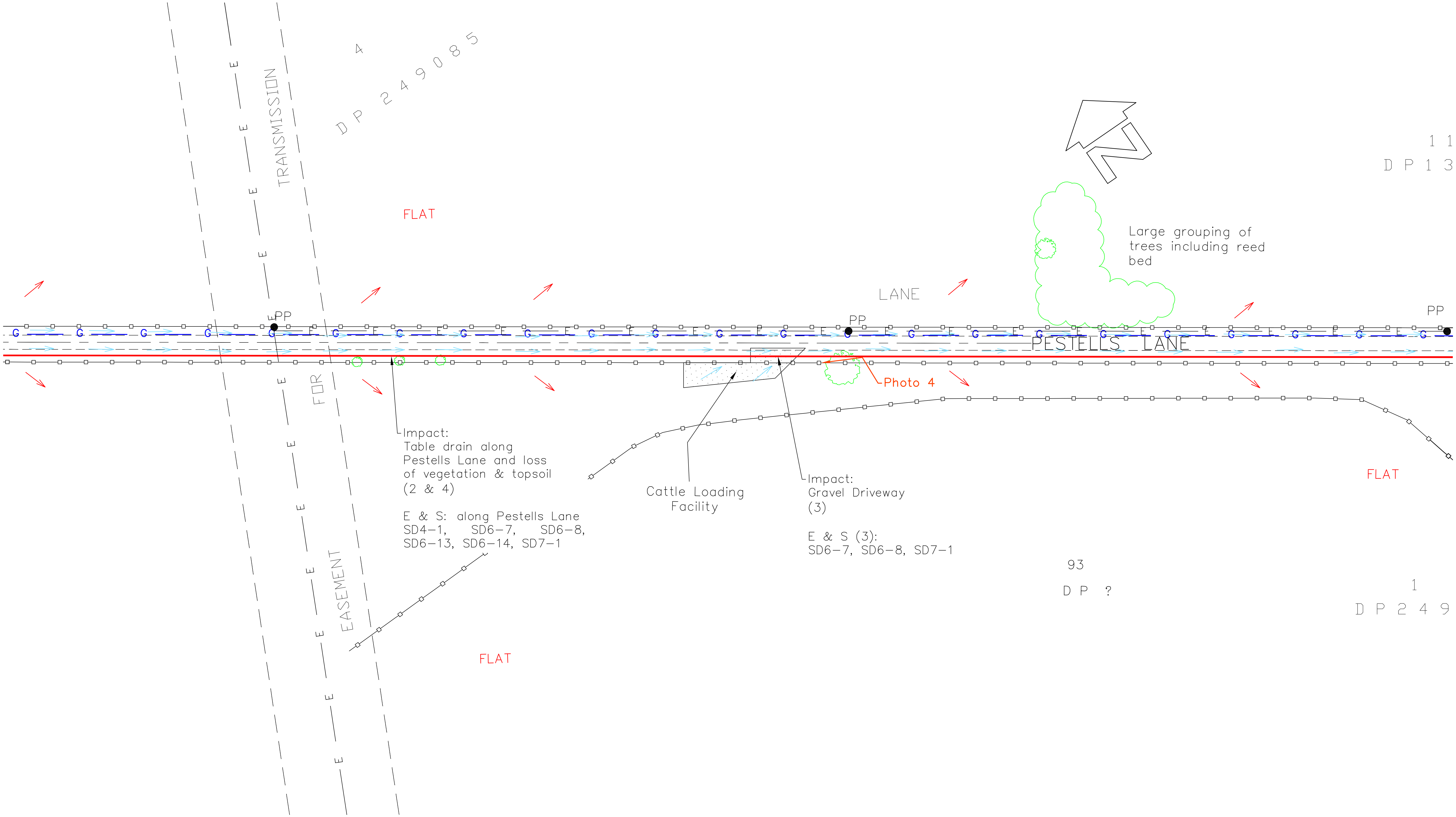

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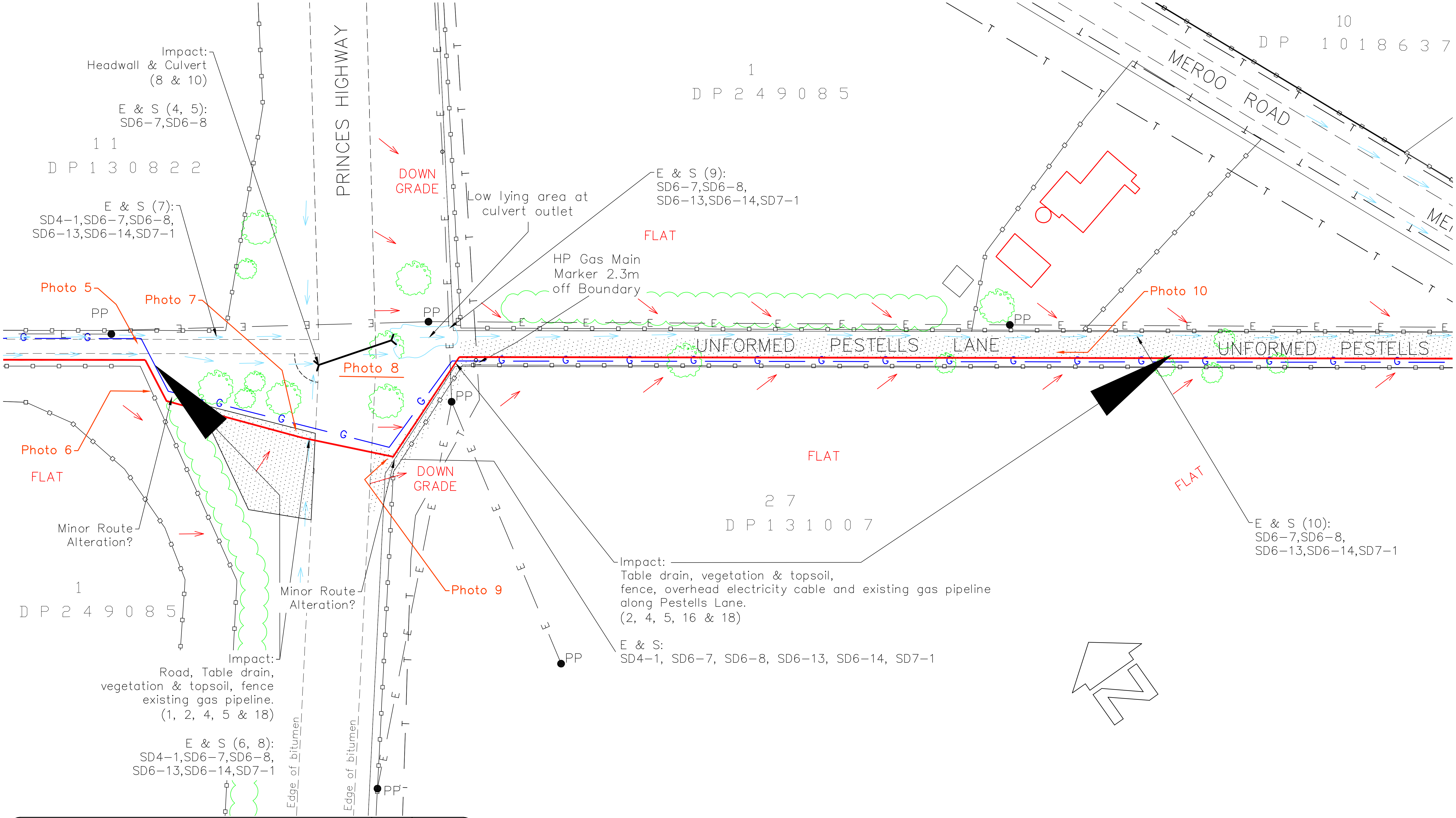

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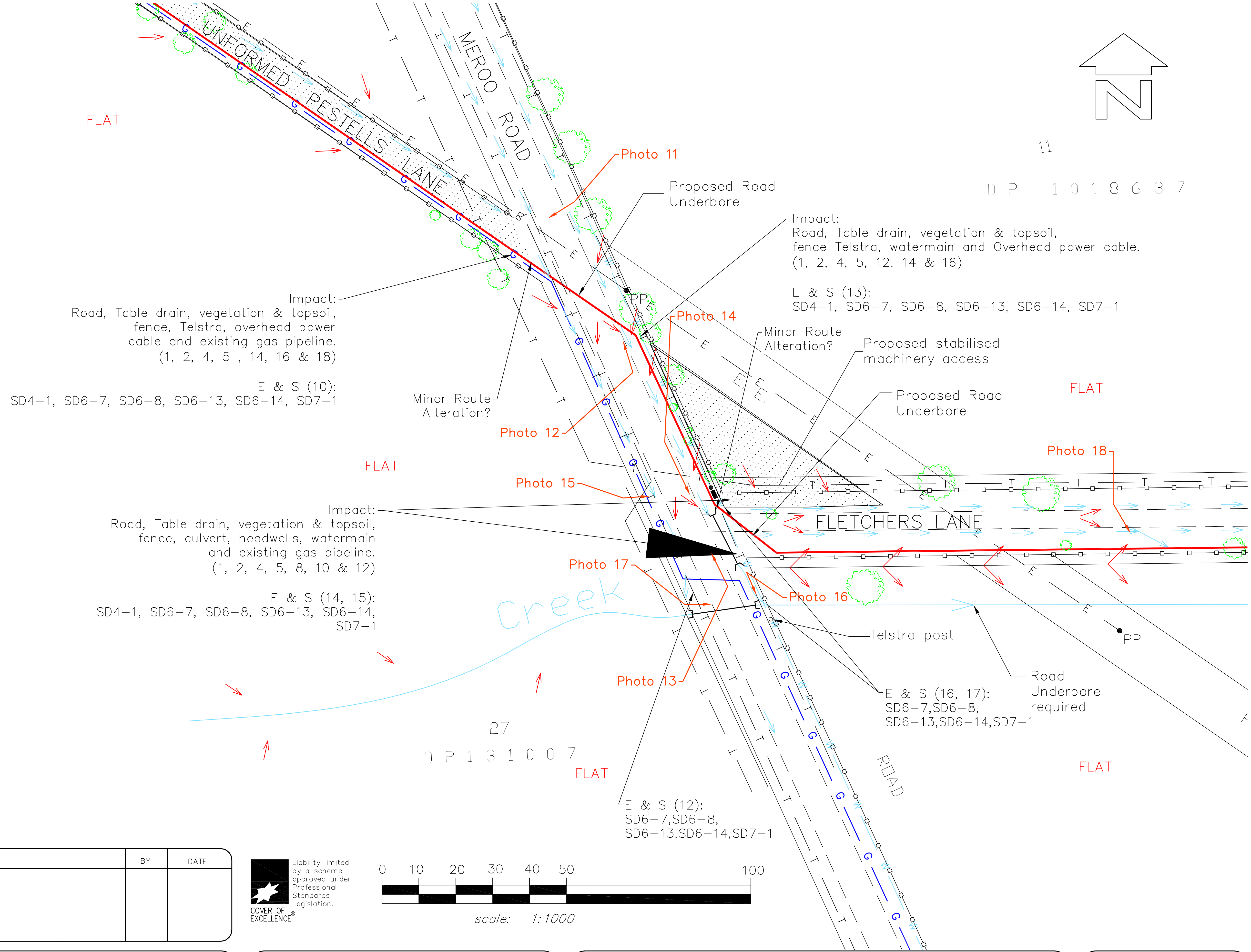

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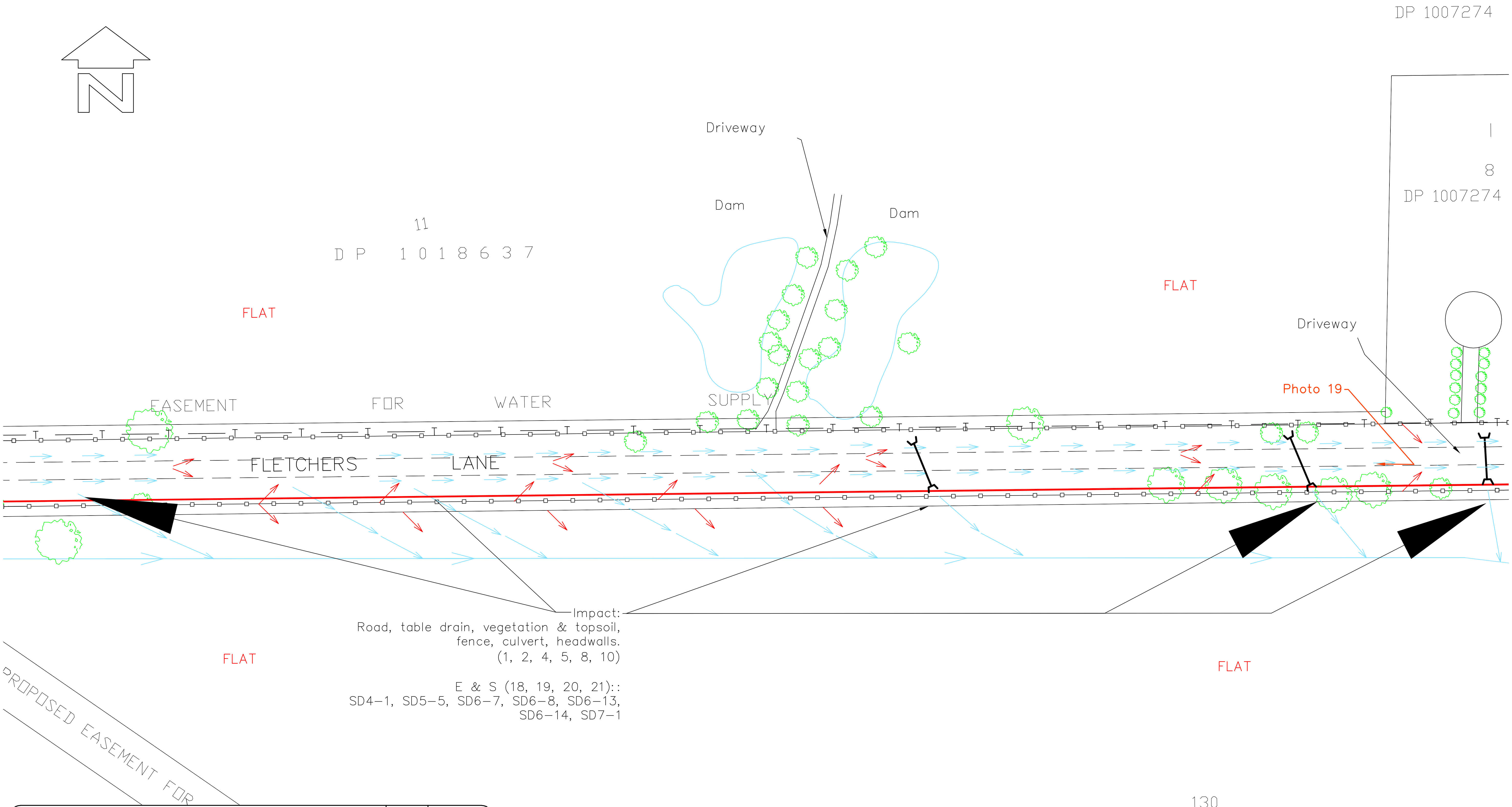

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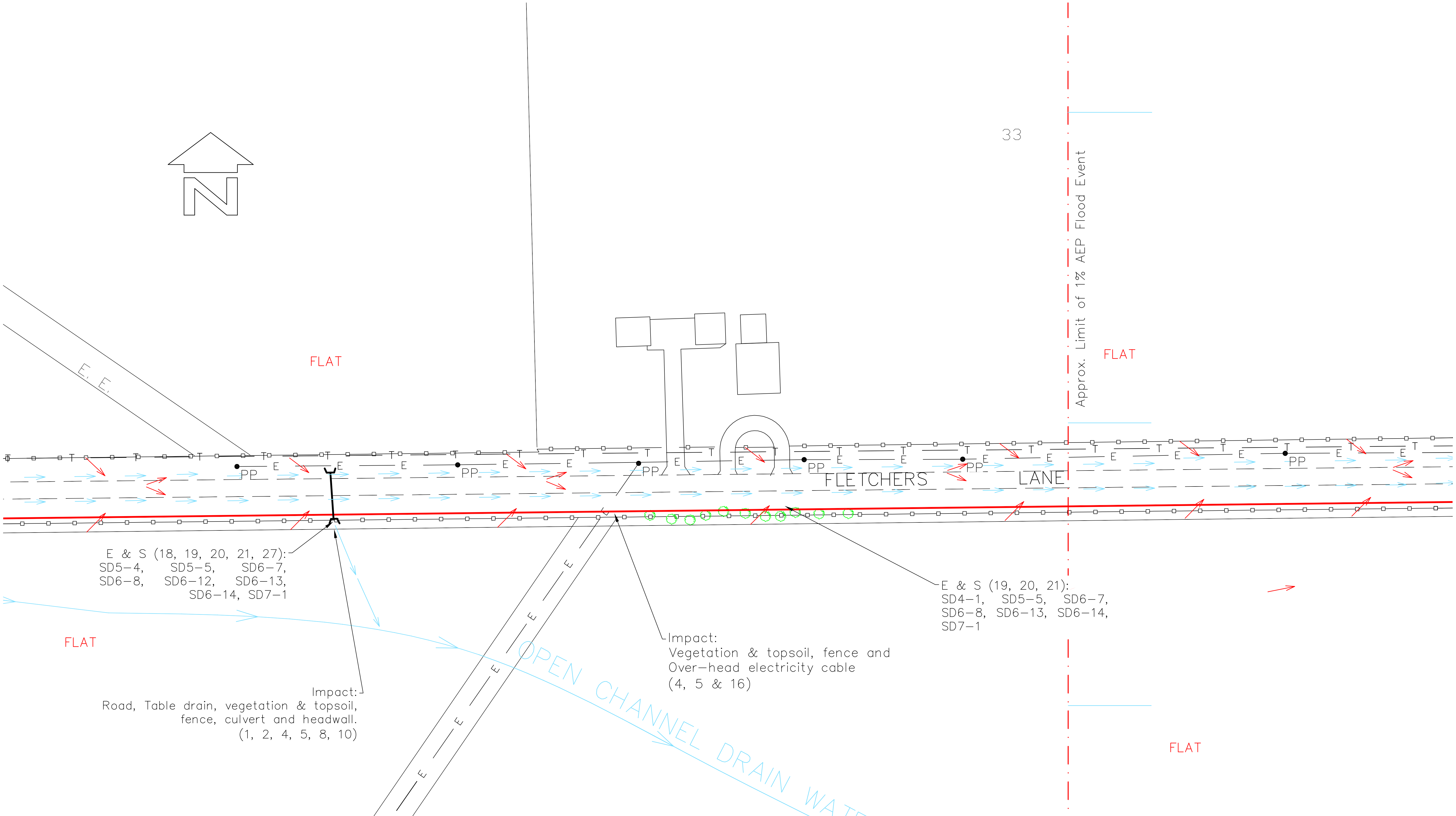

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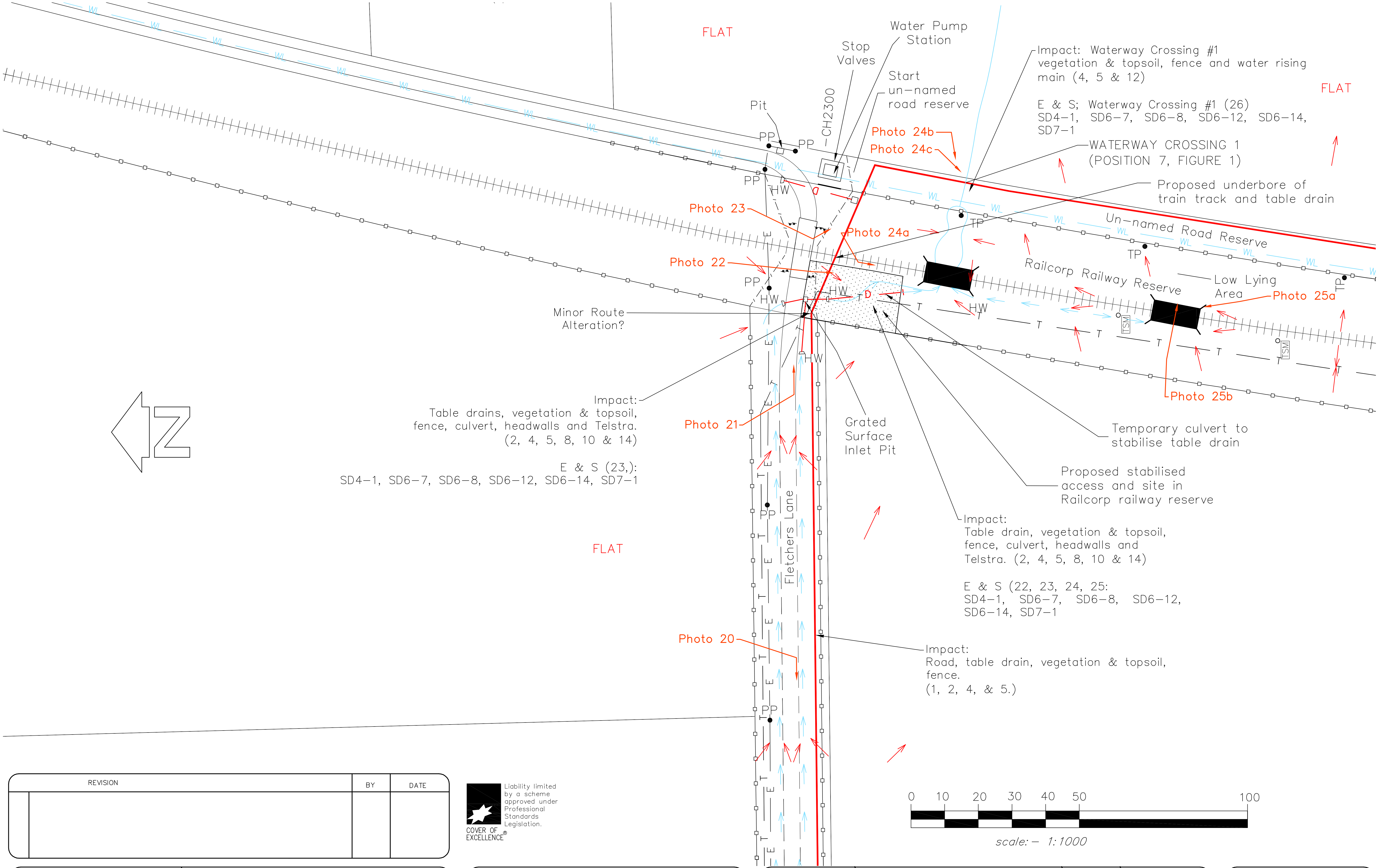

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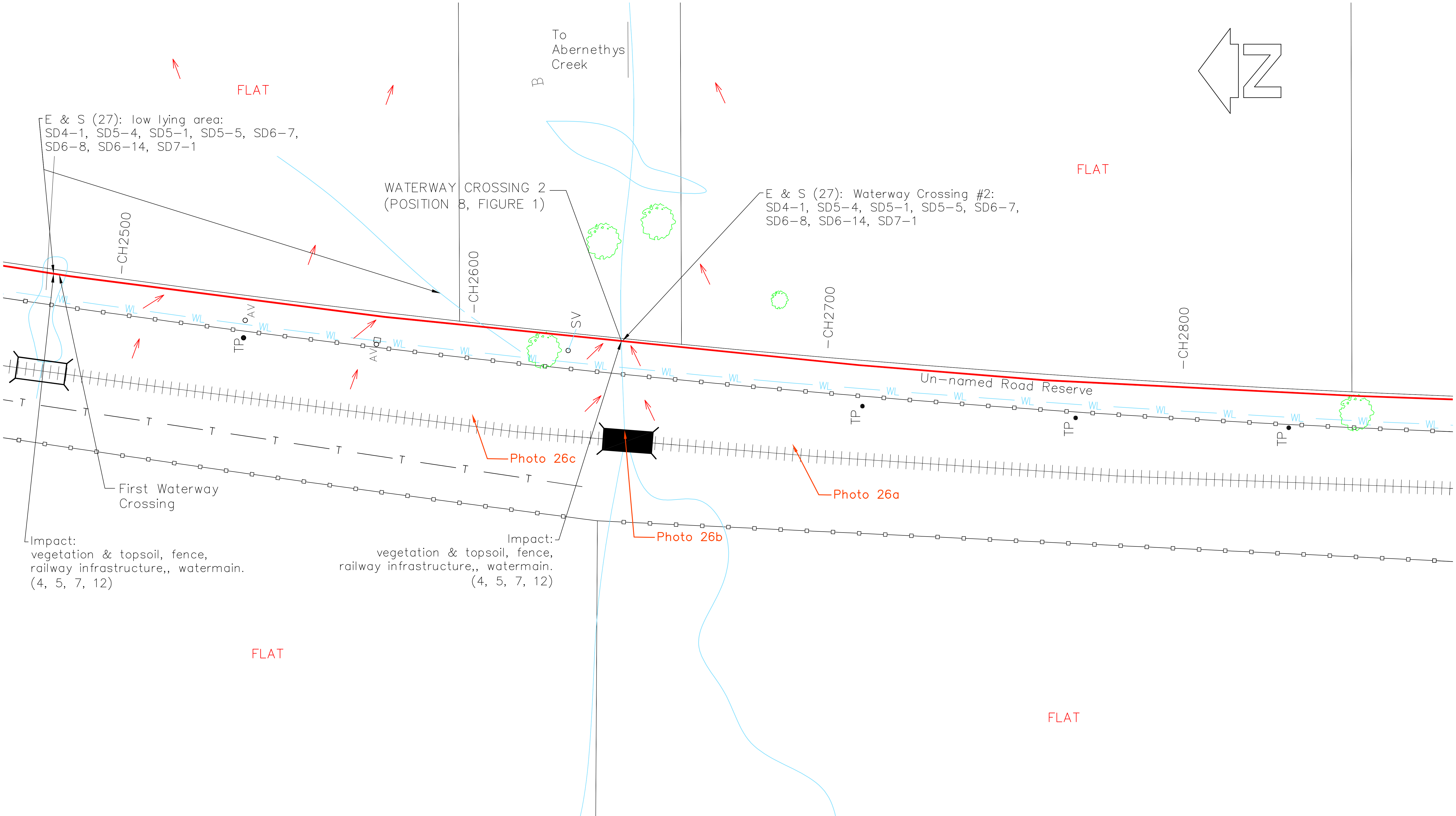

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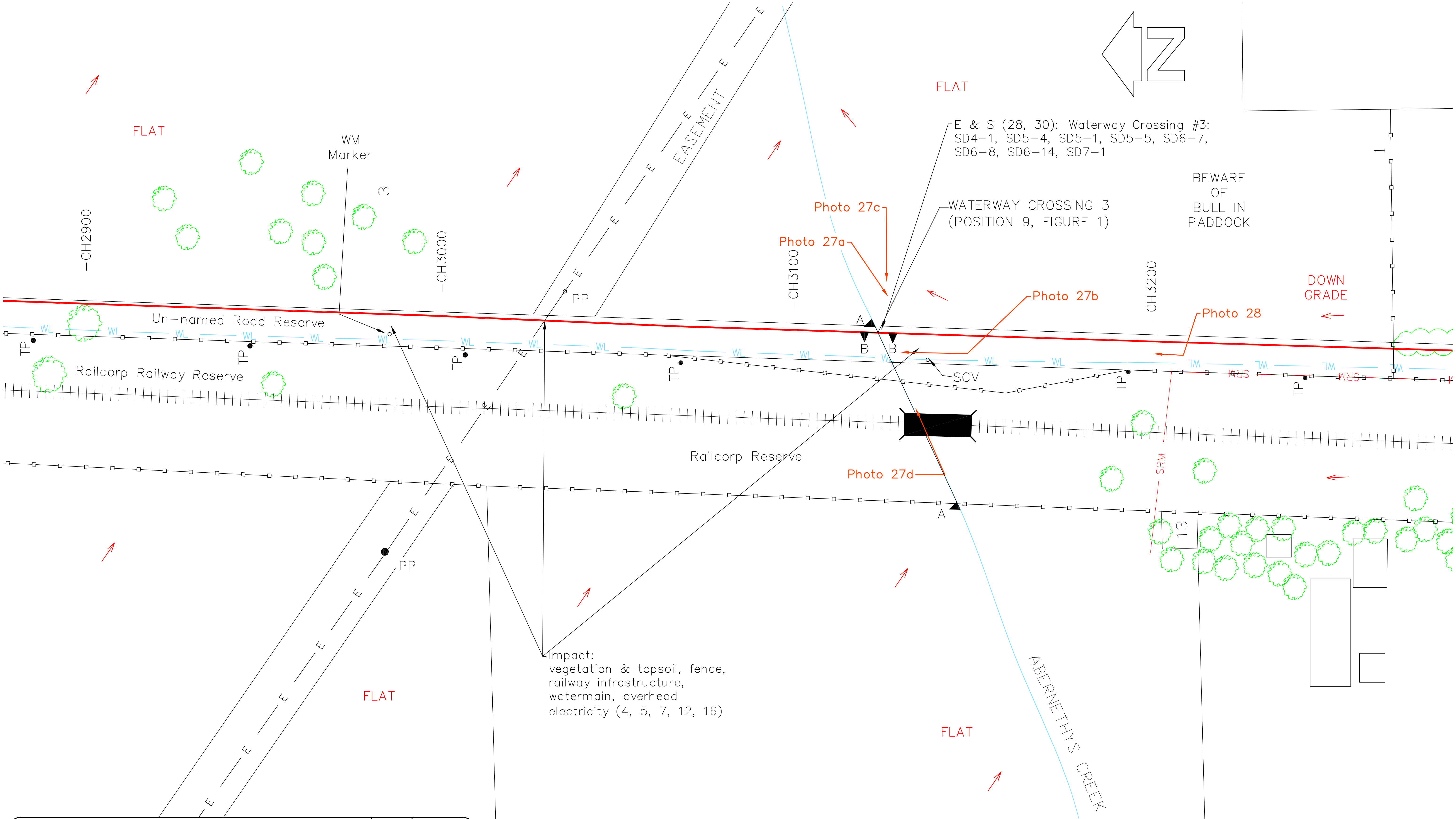

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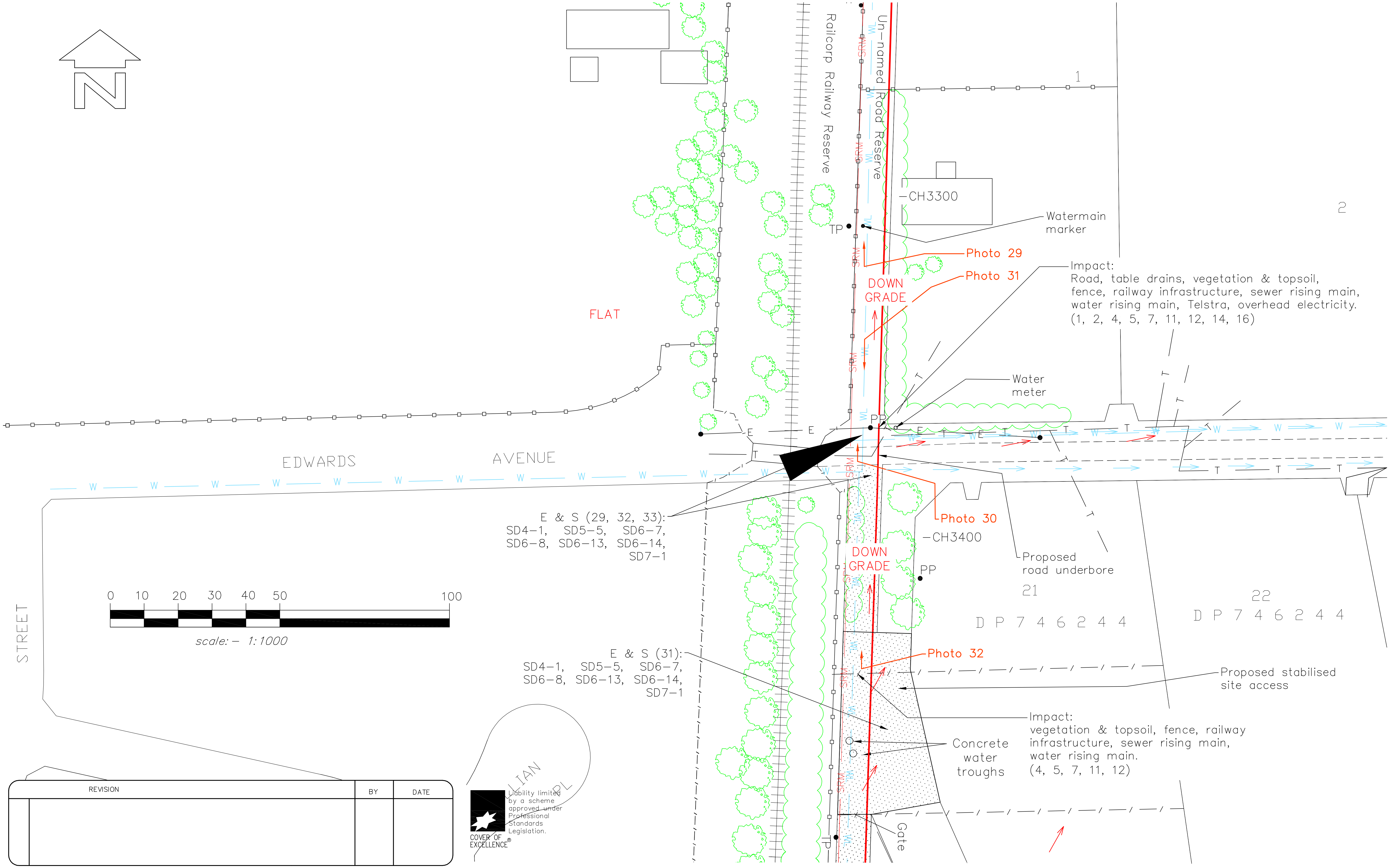

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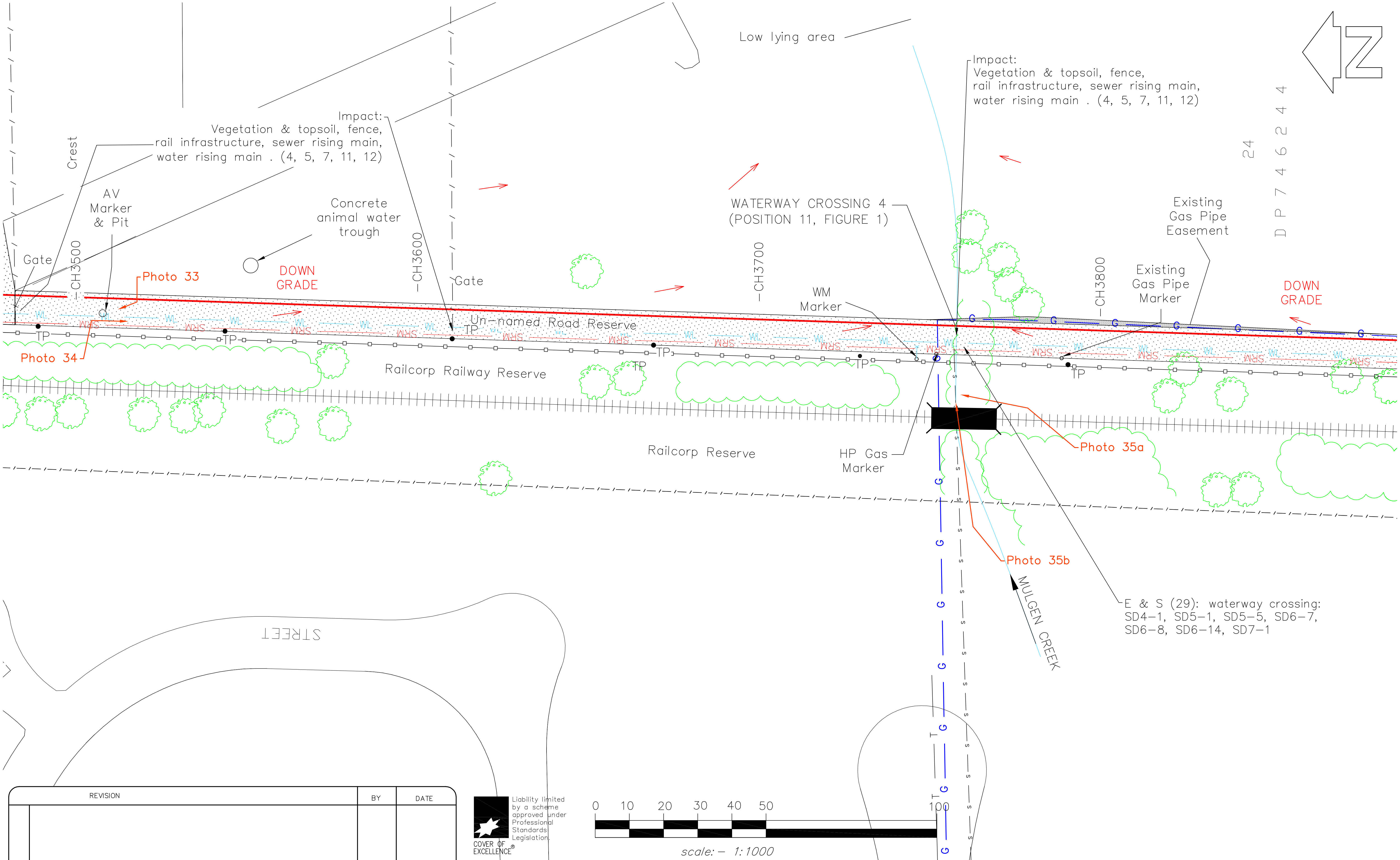

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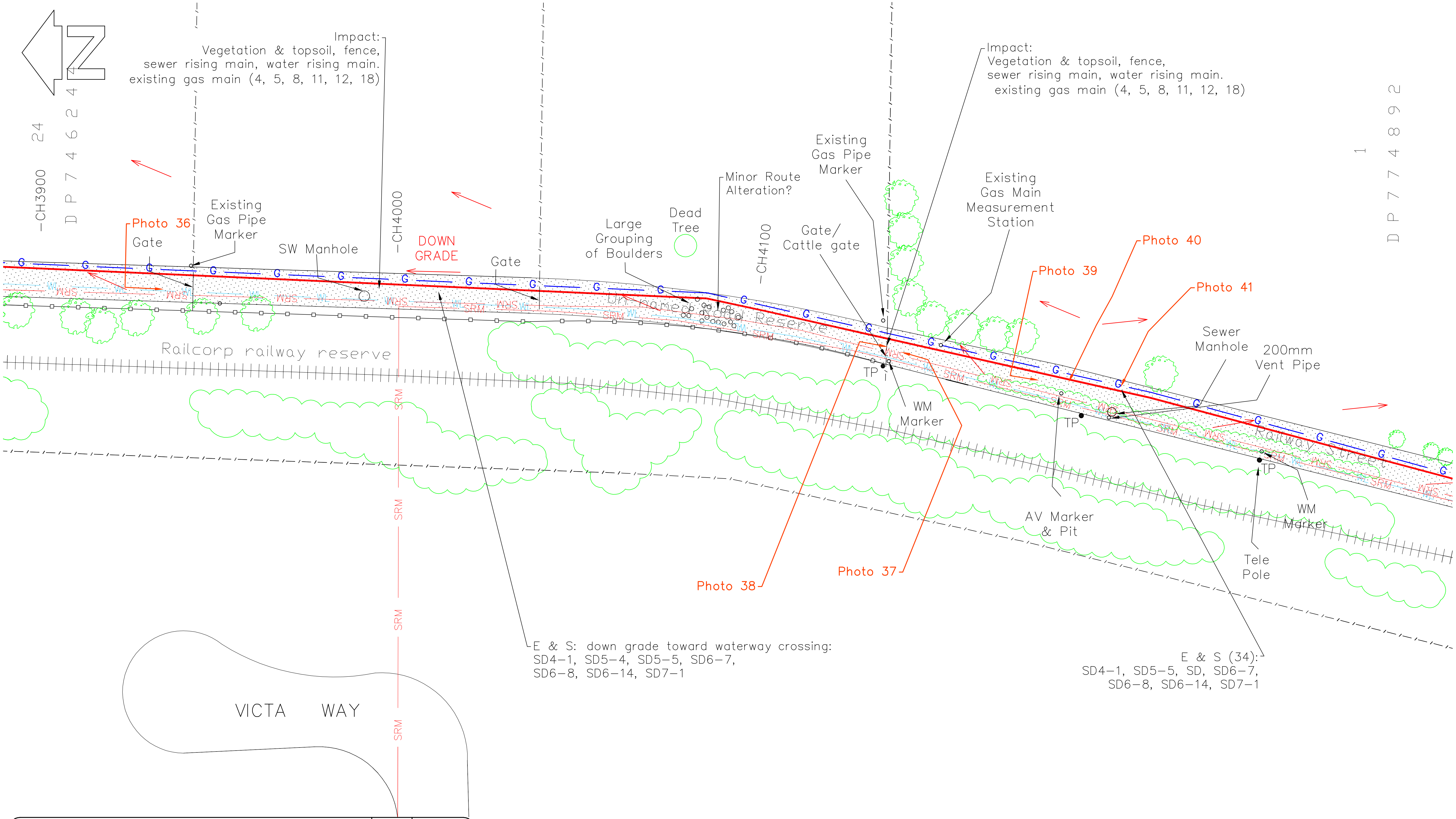

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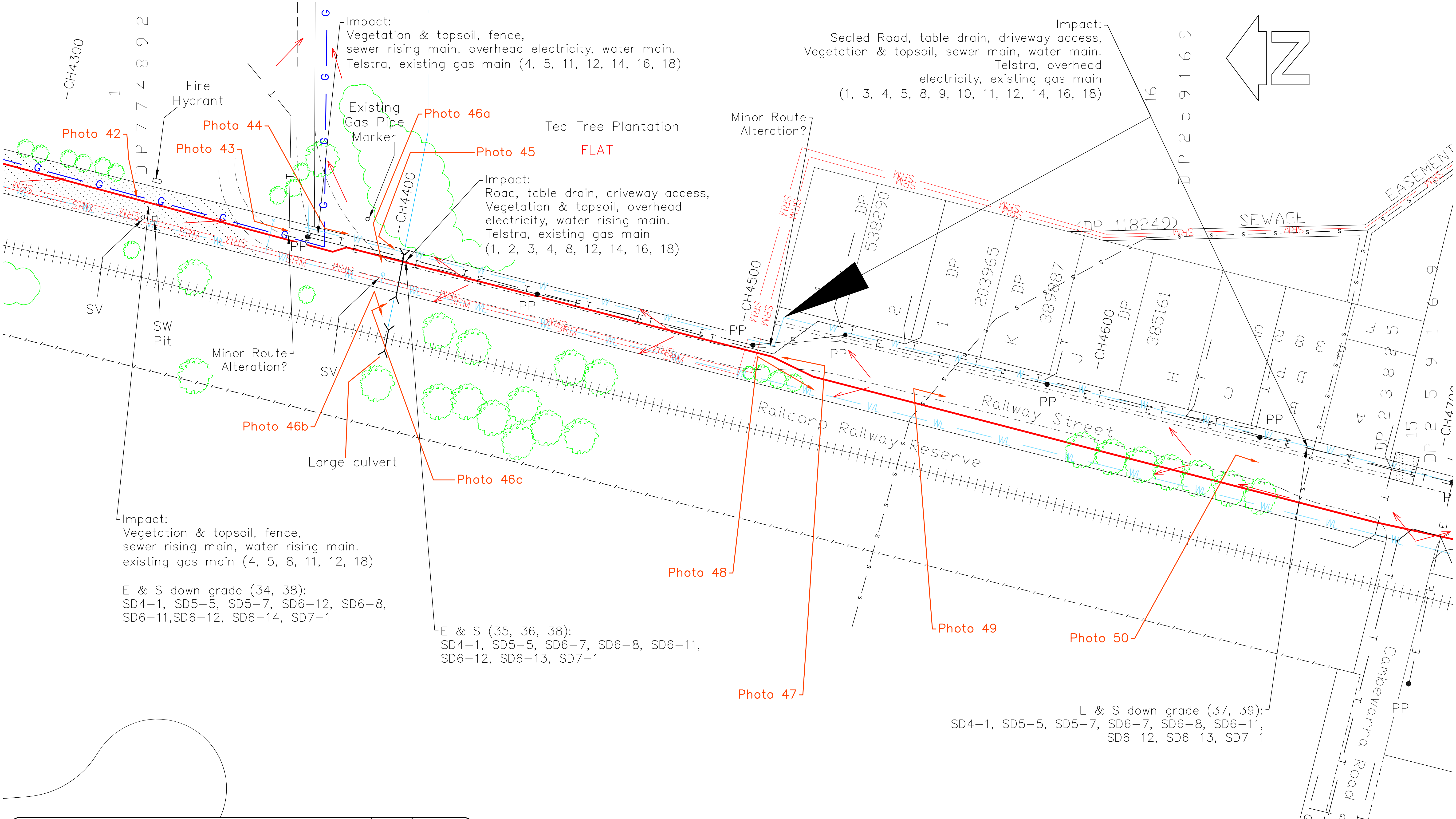

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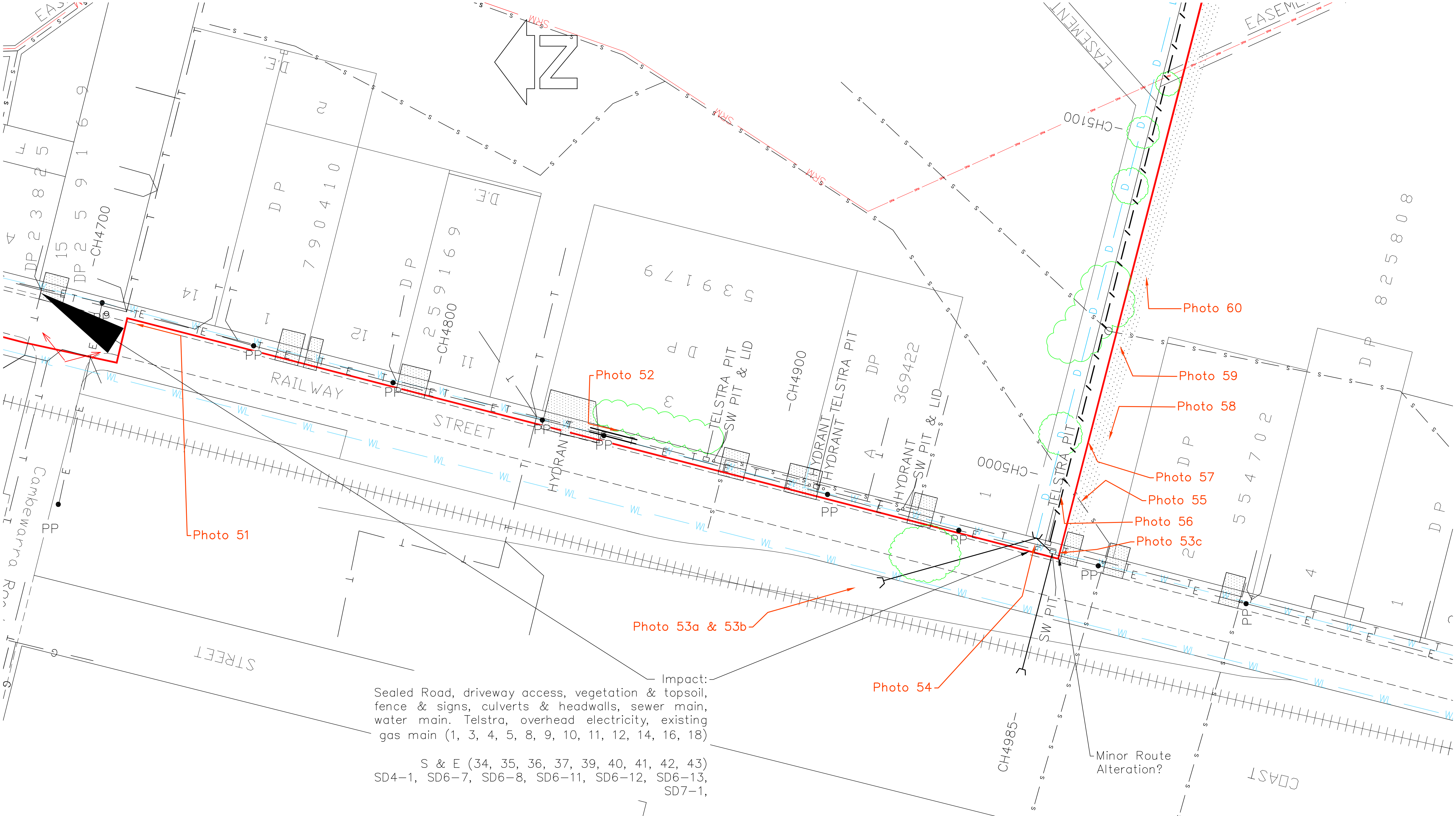

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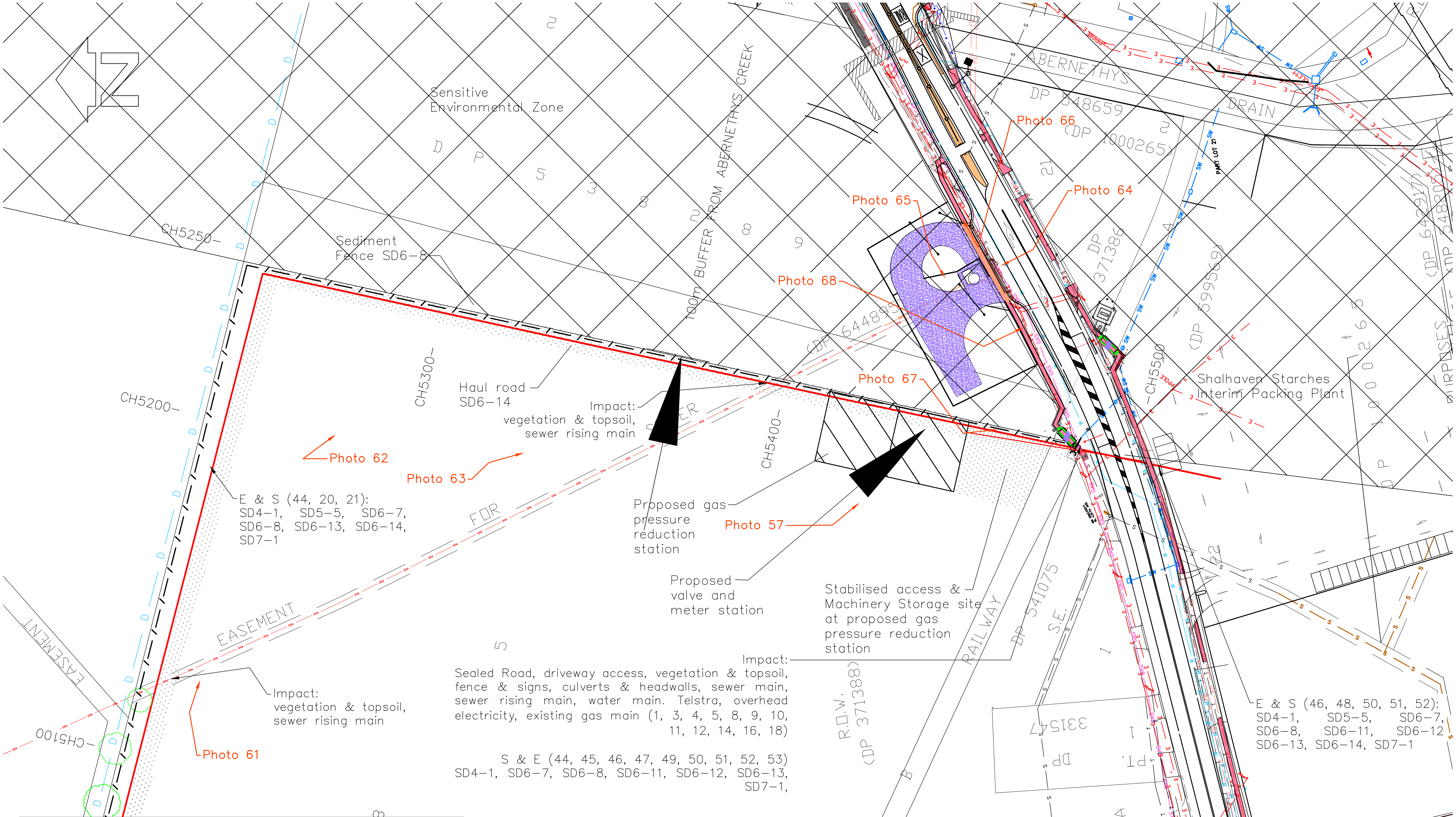

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Appendix D – Erosion and Sediment Control Figures

Appendix D:

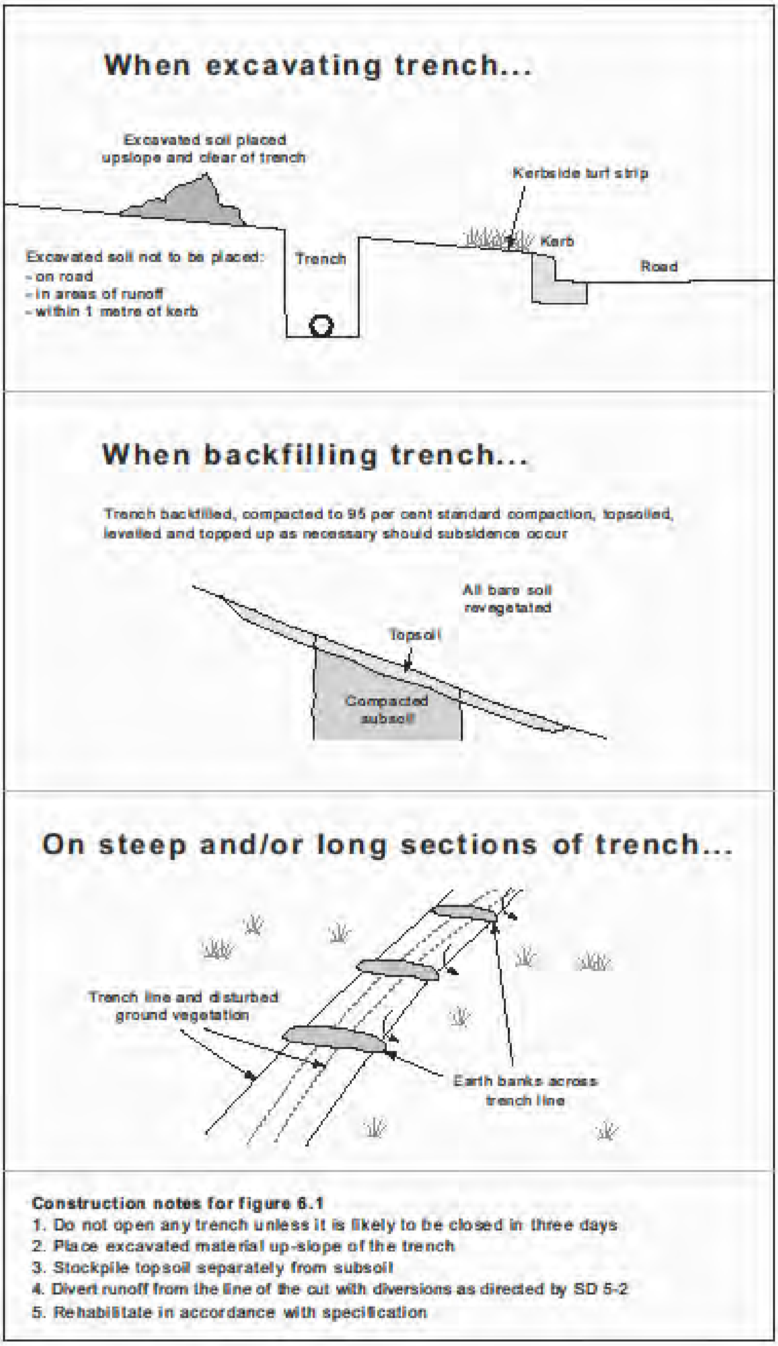


Figure 2: Erosion and sediment control details for trench construction on steep sites

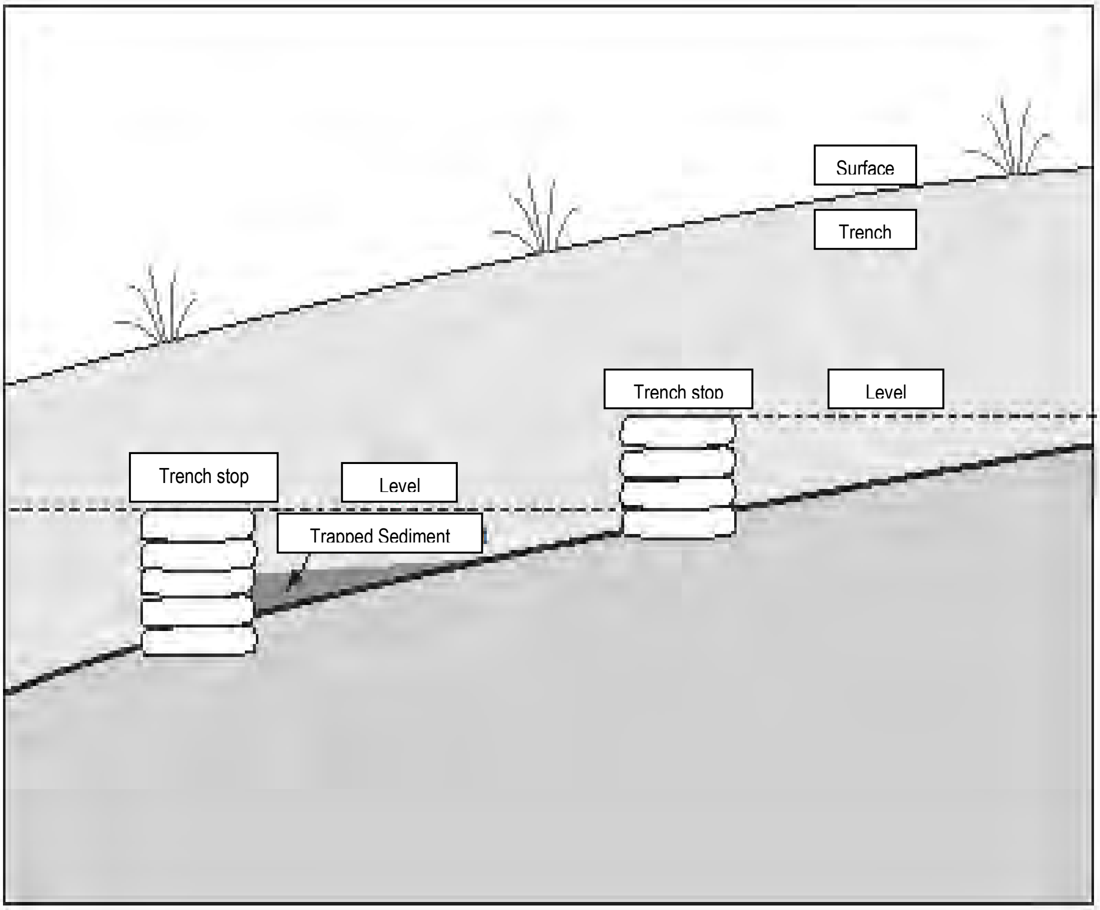
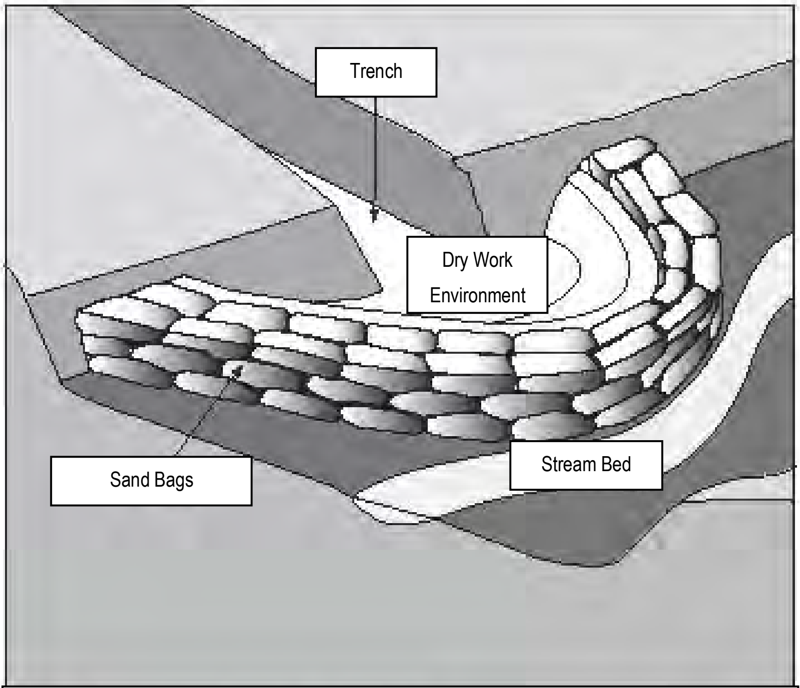
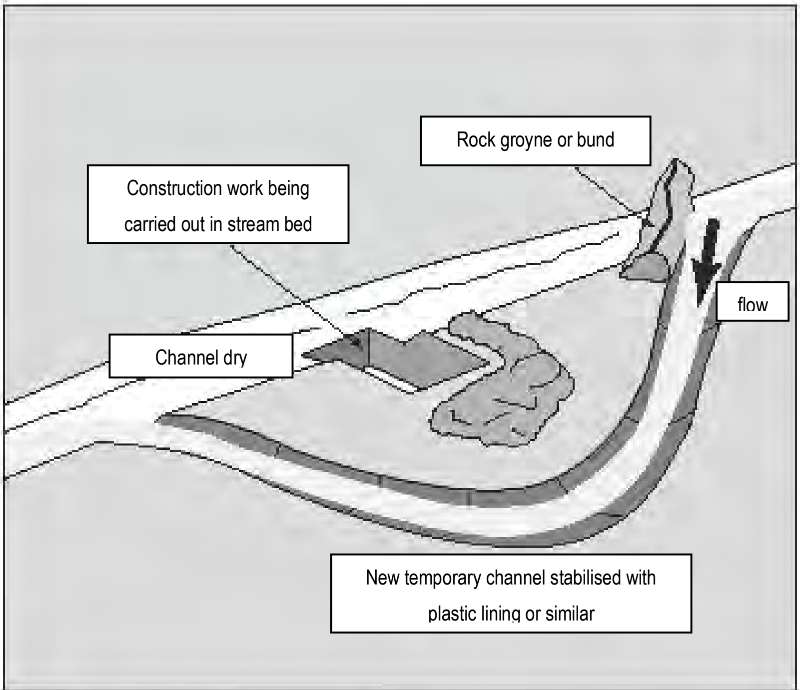


Figure 3: Typical trench stop detail for steep grades

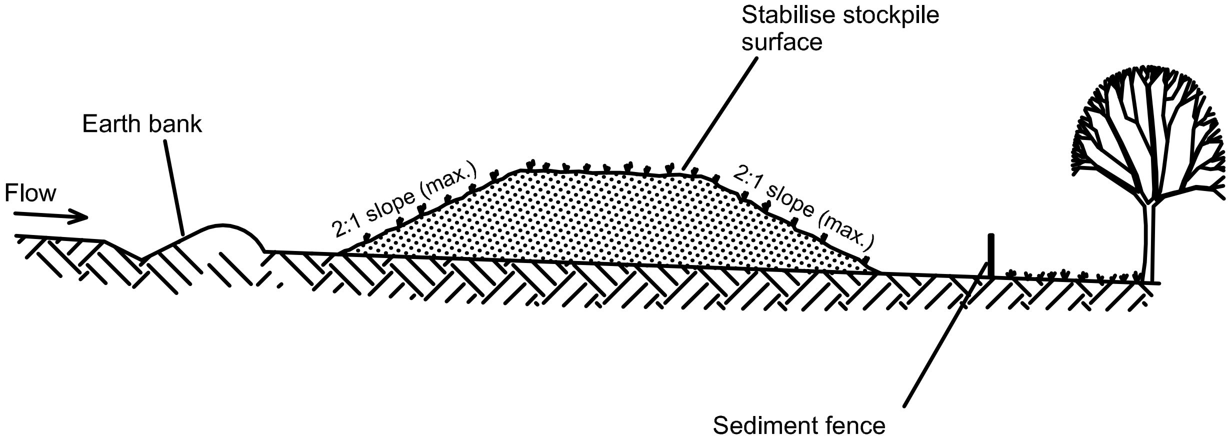


Option 1 – Stream diversion located within stream bed



Option 2 – Stream diversion via a new excavated channel

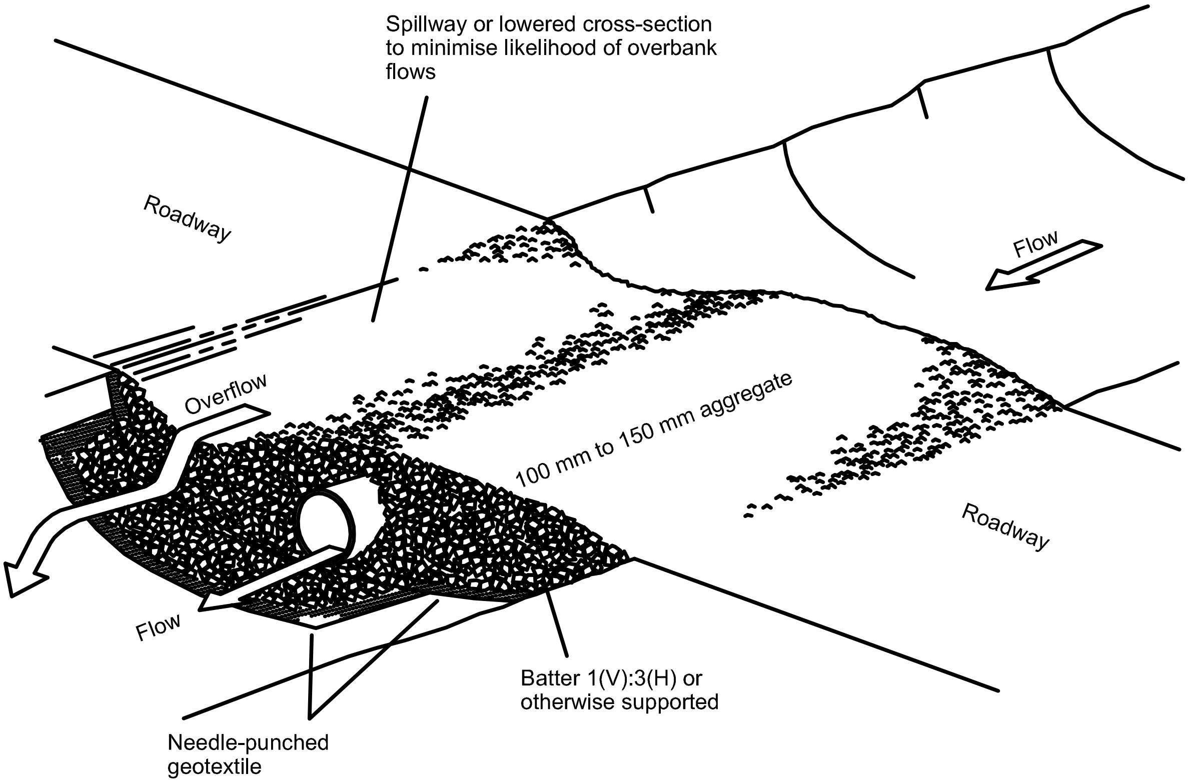
Figure 4: Typical options for waterway crossings



Construction Notes

1. Place stockpiles more than 2 (preferably 5) metres from existing vegetation, concentrated water flow, roads and hazard areas.
2. Construct on the contour as low, flat, elongated mounds.
3. Where there is sufficient area, topsoil stockpiles shall be less than 2 metres in height.
4. Where they are to be in place for more than 10 days, stabilise following the approved ESCP or SWMP to reduce the C-factor to less than 0.10.
5. Construct earth banks (Standard Drawing 5-5) on the upslope side to divert water around stockpiles and sediment fences (Standard Drawing 6-8) 1 to 2 metres downslope.

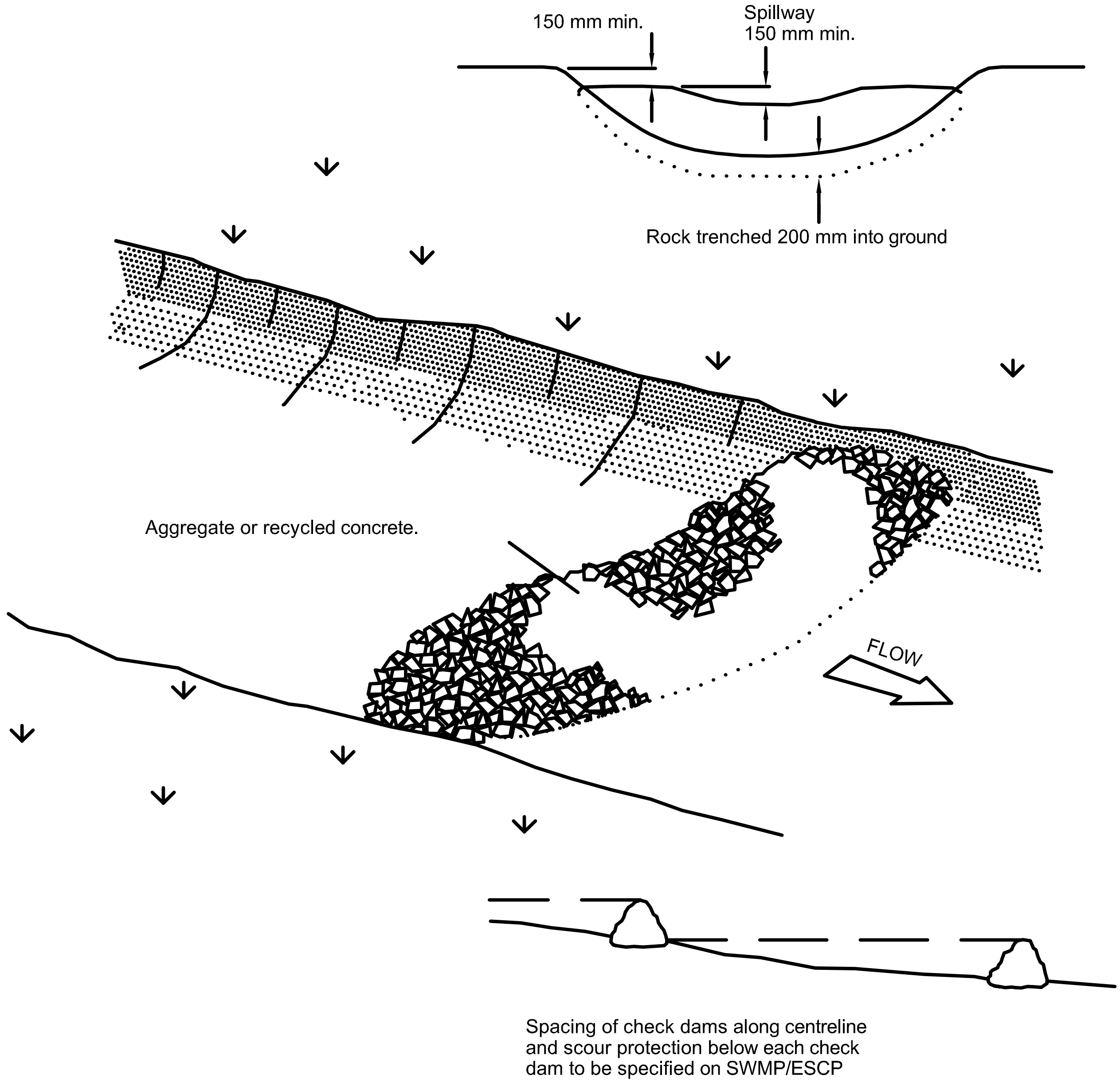
STOCKPILES SD 4-1



Construction Notes

1. Prohibit all traffic until the access way is constructed.
2. Strip any topsoil and place a needle-punched textile over the base of the crossing.
3. Place clean, rigid, non polluting aggregate or gravel in the 100 mm to 150 mm size class over the fabric to a minimum depth of 200 mm.
4. Provide a 3-metre wide carriageway with sufficient length of culvert pipe to allow less than a 3(H): 1 (V) slope on side batters.
5. Install a lower section to act as an emergency spillway in greater than design storm events.
6. Ensure that culvert outlets extend beyond the toe of fill embankments.

TEMPORARY WATERWAY CROSSING SD 5-1

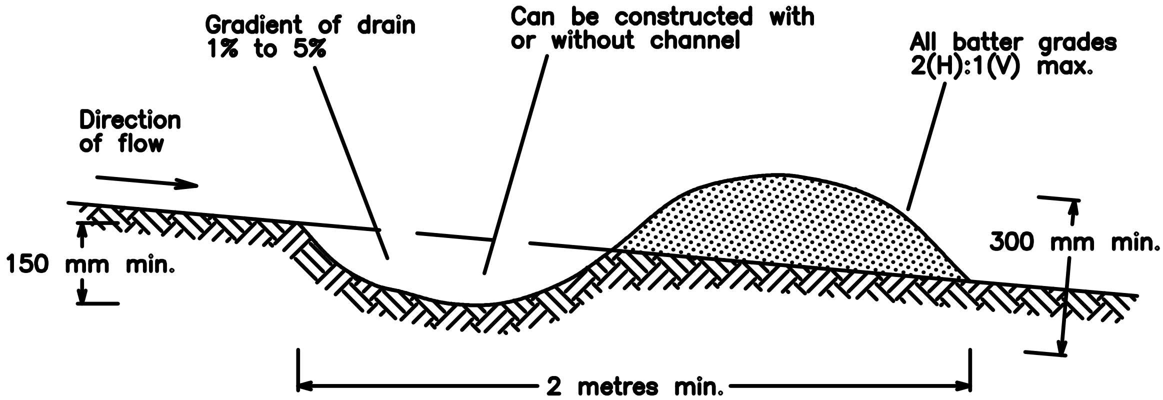


Construction Notes

1. Check dams can be built with various materials, including rocks, logs, sandbags and straw bales. The maintenance program should ensure their integrity is retained, especially where constructed with straw bales. In the case of bales, this might require their replacement each two to four months.
2. Trench the check dam 200 mm into the ground across its whole width. Where rock is used, fill the trenches to at least 100 mm above the ground surface to reduce the risk of undercutting.
3. Normally, their maximum height should not exceed 600 mm above the gully floor. The centre should act as a spillway, being at least 150 mm lower than the outer edges.
4. Space the dams so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM

SD 5-4



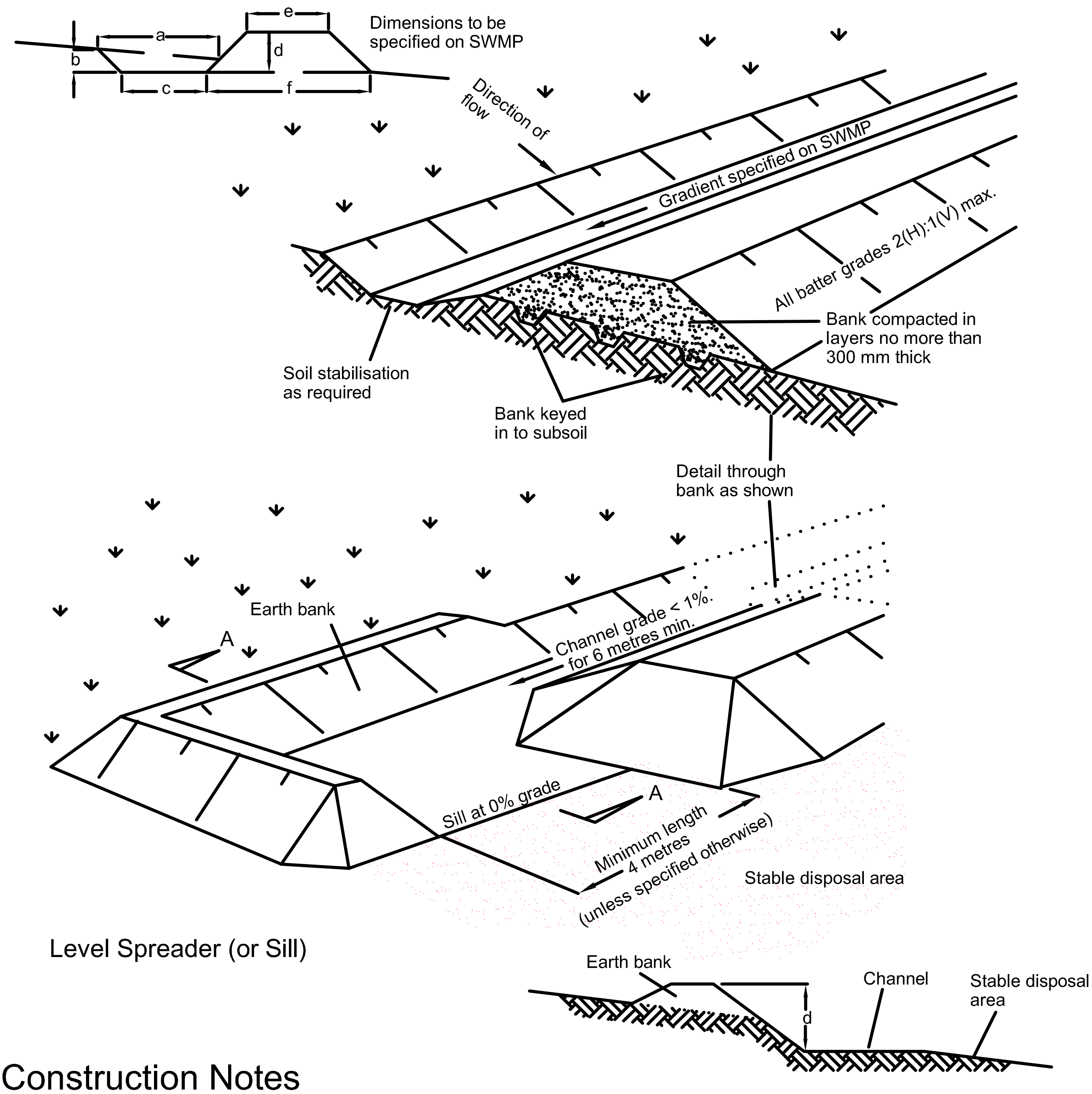
NOTE: Only to be used as temporary bank
where maximum upslope length is 80 metres.

Construction Notes

1. Build with gradients between 1 percent and 5 percent.
2. Avoid removing trees and shrubs if possible - work around them.

3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V shaped.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction.

EARTH BANK (LOW FLOW) SD 5-5



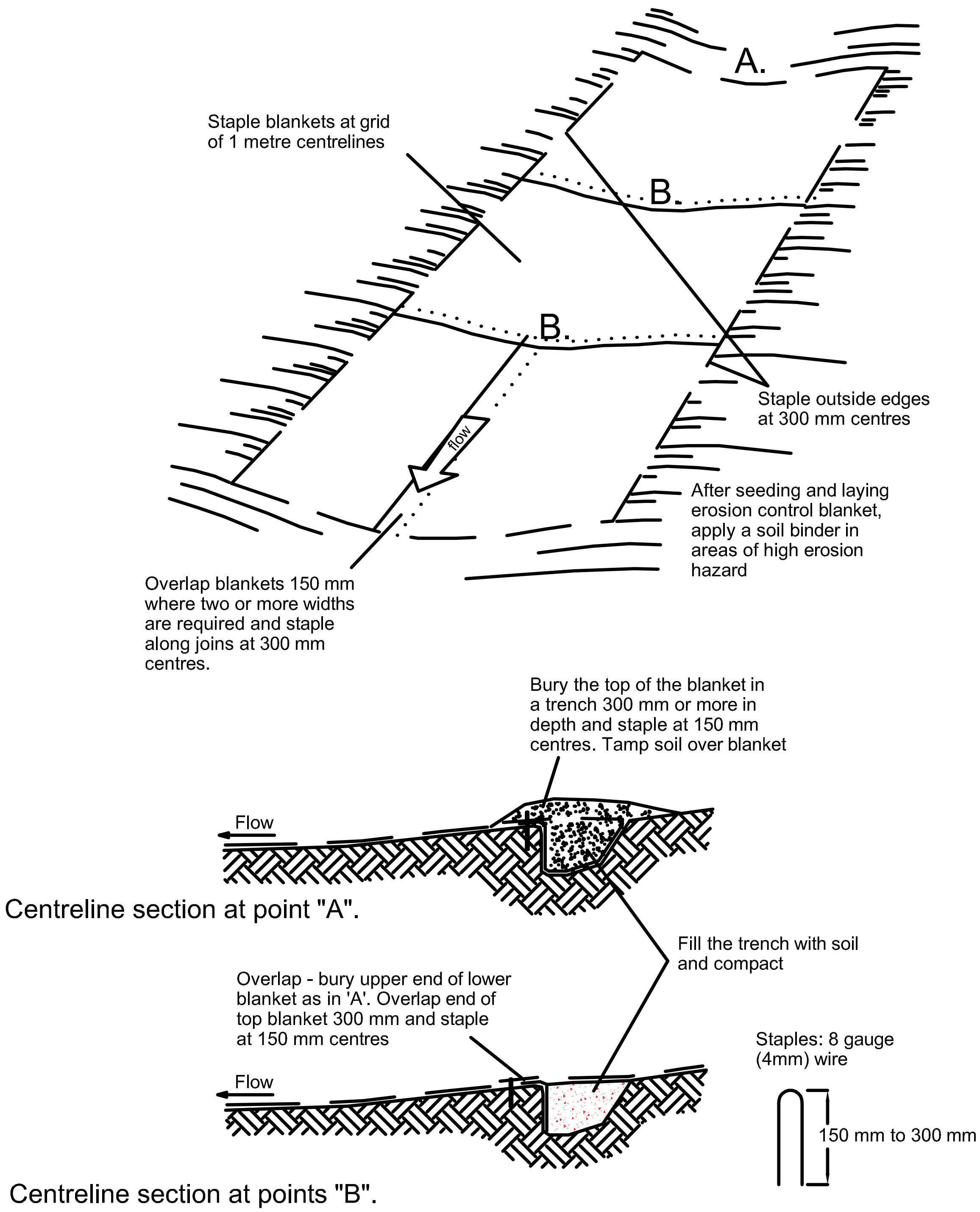
Level Spreader (or Sill)

Section AA

Construction Notes

1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V-shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

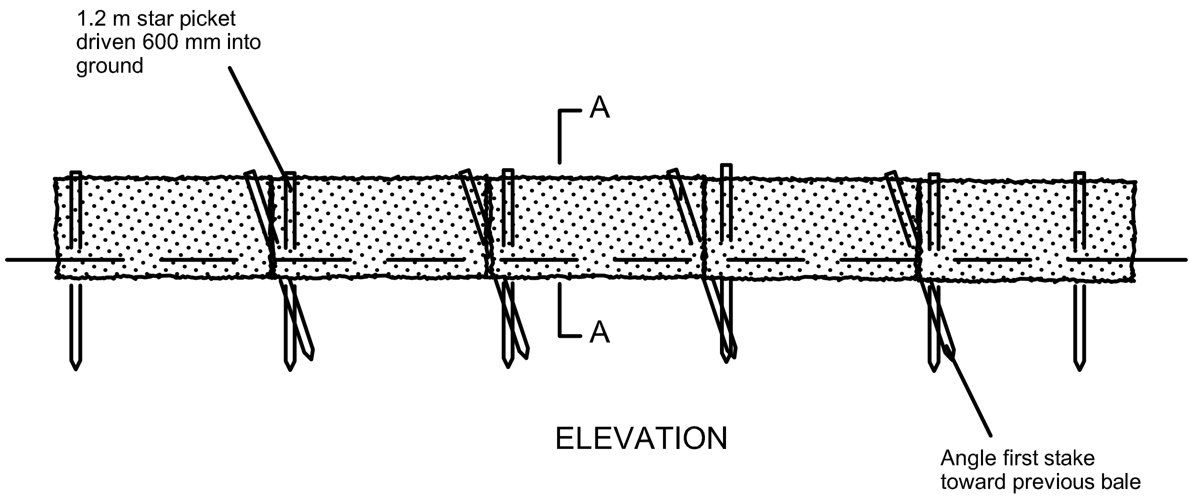
EARTH BANK (HIGH FLOWS) SD 5-6



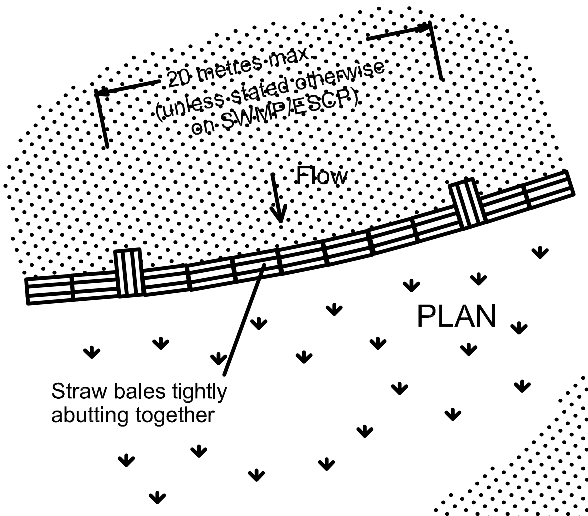
Construction Notes

1. Remove any rocks, clods, sticks or grass from the surface before laying matting
2. Ensure that topsoil is at least 75 mm deep.
3. Complete fertilising and seeding before laying the matting.
4. Ensure fabric will be continuously in contact with the soil by grading the surface carefully first.
5. Lay the fabric in "shingle-fashion", with the end of each upstream roll overlapping those downstream. Ensure each roll is anchored properly at its upslope end (Standard Drawing 5-7b).
6. Ensure that the full width of flow in the channel is covered by the matting up to the design storm event, usually in the 10-year ARI time of concentration storm event.
7. Divert water from the structure until vegetation is stabilised properly.

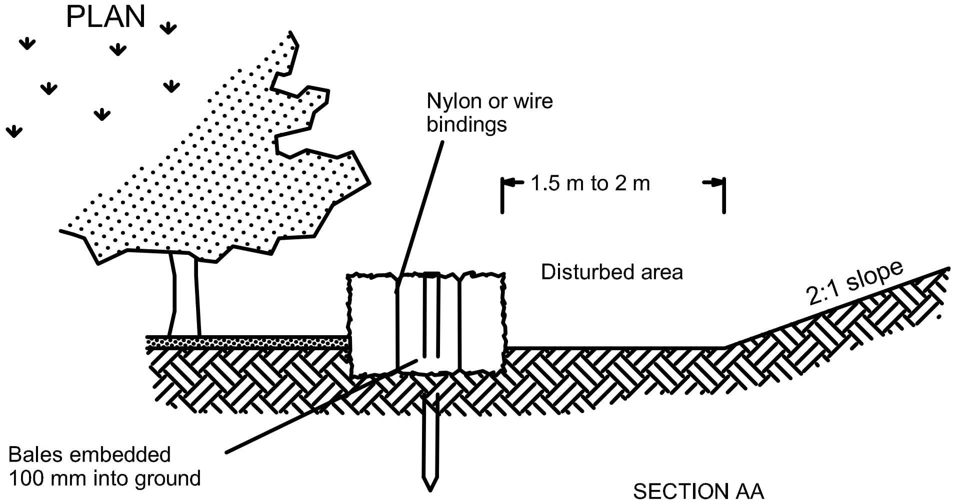
RECP : CONCENTRATED FLOW SD 5-7



ELEVATION



PLAN



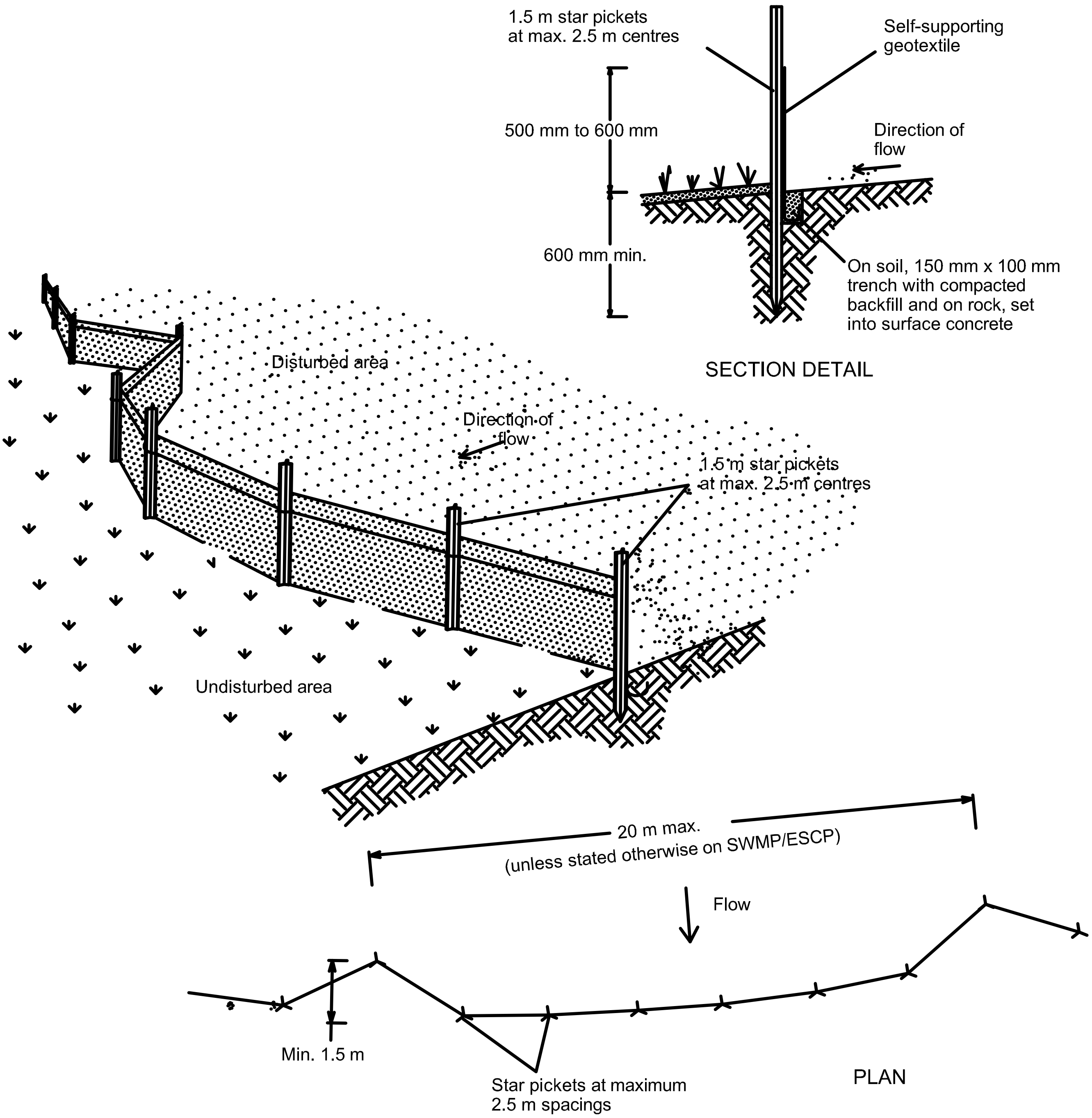
SECTION AA

Construction Notes

1. Construct the straw bale filter as close as possible to being parallel to the contours of the site.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws are to be placed parallel to ground.
3. Ensure that the maximum height of the filter is one bale.
4. Embed each bale in the ground 75 mm to 100 mm and anchor with two 1.2 metre star pickets or stakes. Angle the first star picket or stake in each bale towards the previously laid bale. Drive them 600 mm into the ground and, if possible, flush with the top of the bales. Where star pickets are used and they protrude above the bales, ensure they are fitted with safety caps.
5. Where a straw bale filter is constructed downslope from a disturbed batter, ensure the bales are placed 1 to 2 metres downslope from the toe.
6. Establish a maintenance program that ensures the integrity of the bales is retained - they could require replacement each two to four months.

STRAW BALE FILTER

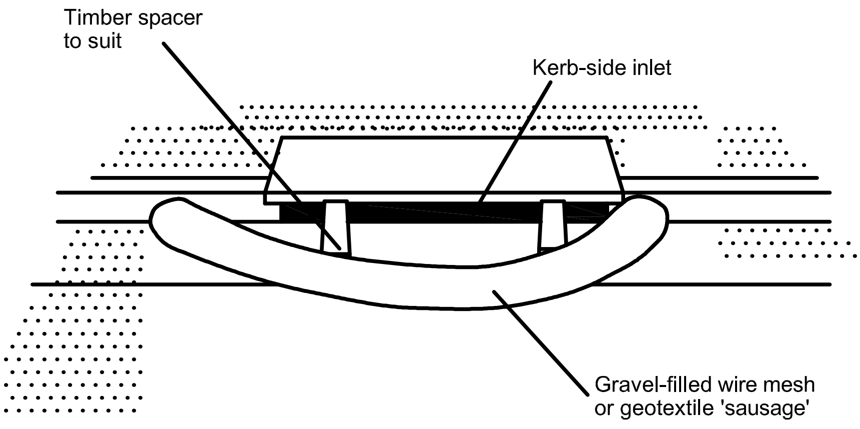
SD 6-7

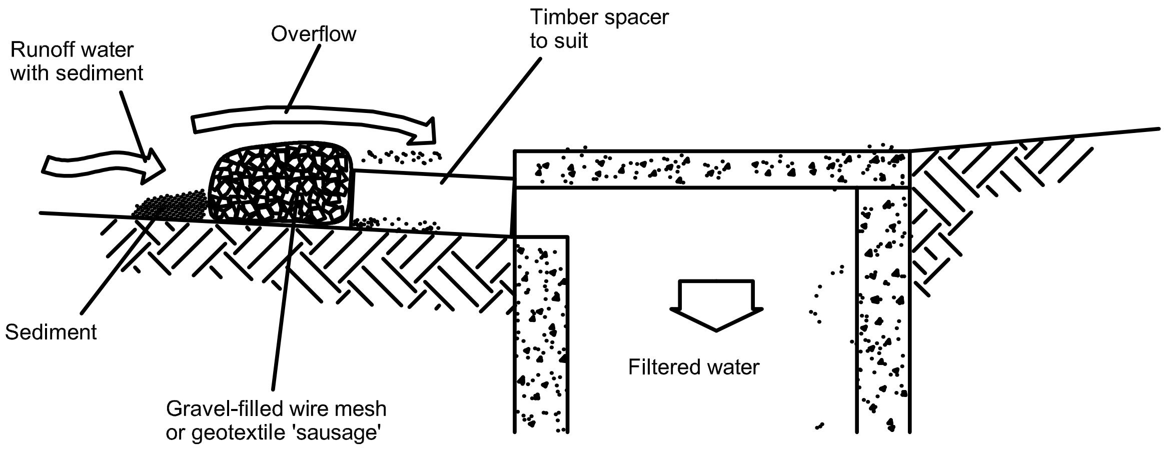


Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE SD 6-8



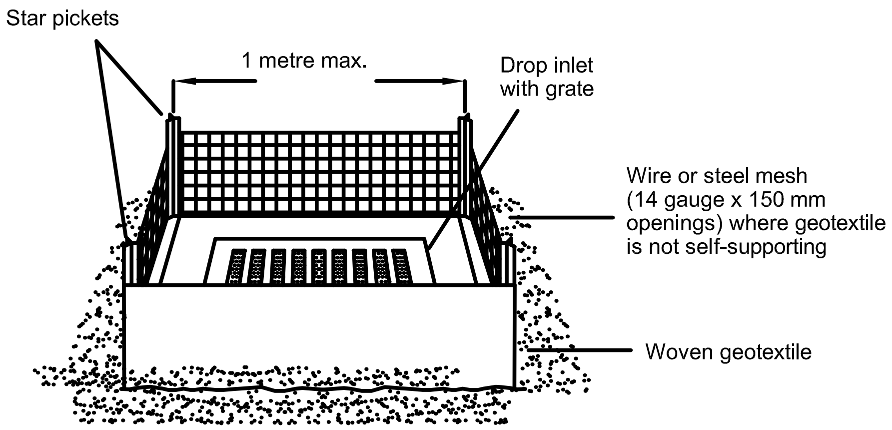


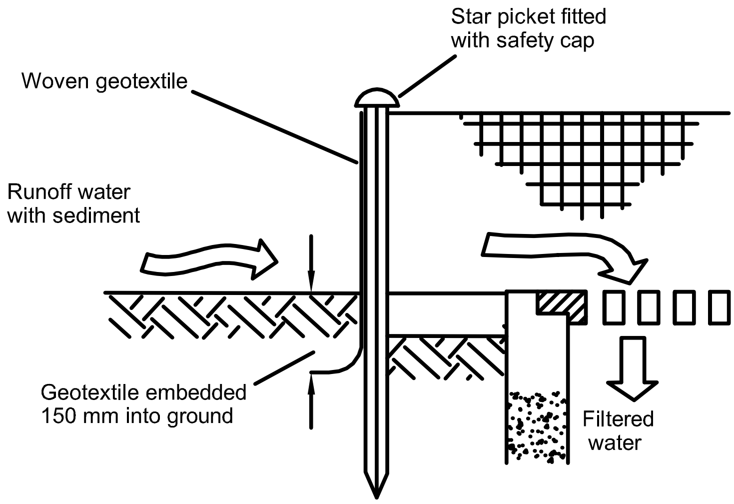
NOTE: This practice only to be used where specified in an approved SWMP/ESCP.

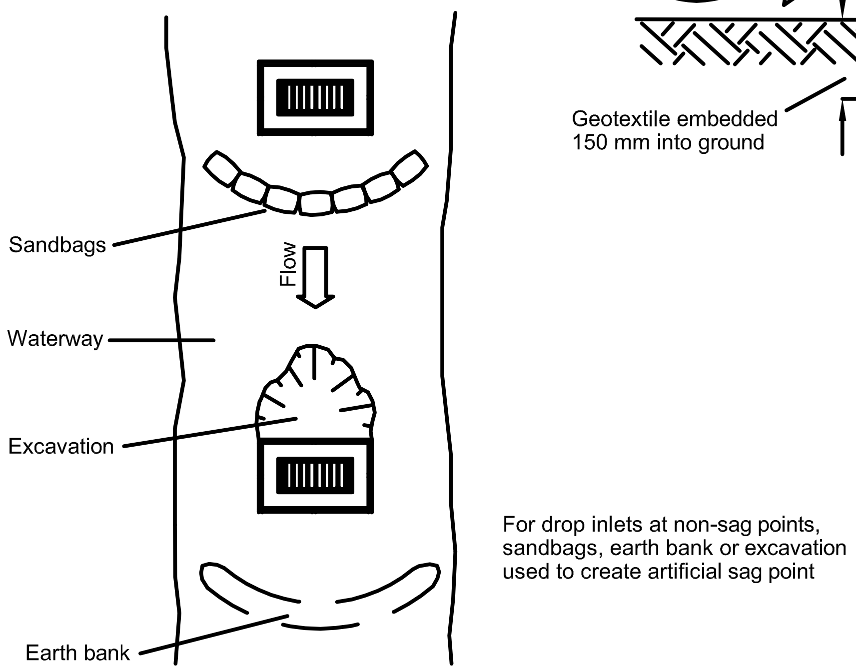
Construction Notes

1. Install filters to kerb inlets only at sag points.
2. Fabricate a sleeve made from geotextile or wire mesh longer than the length of the inlet pit and fill it with 25 mm to 50 mm gravel.
3. Form an elliptical cross-section about 150 mm high x 400 mm wide.
4. Place the filter at the opening leaving at least a 100-mm space between it and the kerb inlet. Maintain the opening with spacer blocks.
5. Form a seal with the kerb to prevent sediment bypassing the filter.
6. Sandbags filled with gravel can substitute for the mesh or geotextile providing they are placed so that they firmly abut each other and sediment-laden waters cannot pass between.

MESH AND GRAVEL INLET FILTER SD 6-11





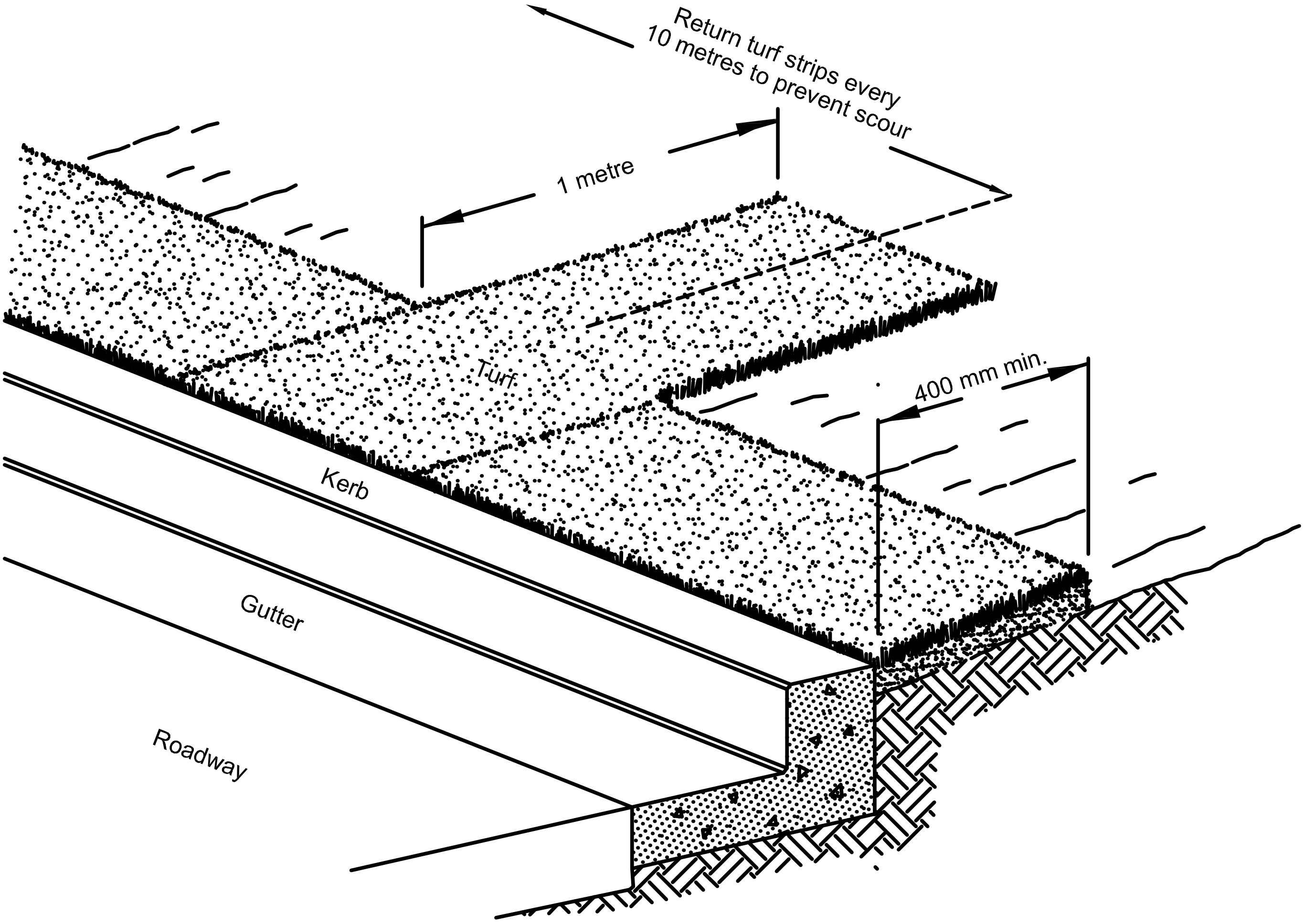


Construction Notes

1. Fabricate a sediment barrier made from geotextile or straw bales.
2. Follow Standard Drawing 6-7 and Standard Drawing 6-8 for installation procedures for the straw bales or geofabric. Reduce the picket spacing to 1 metre centres.
3. In waterways, artificial sag points can be created with sandbags or earth banks as shown in the drawing.
4. Do not cover the inlet with geotextile unless the design is adequate to allow for all waters to bypass it.

GEOTEXTILE INLET FILTER

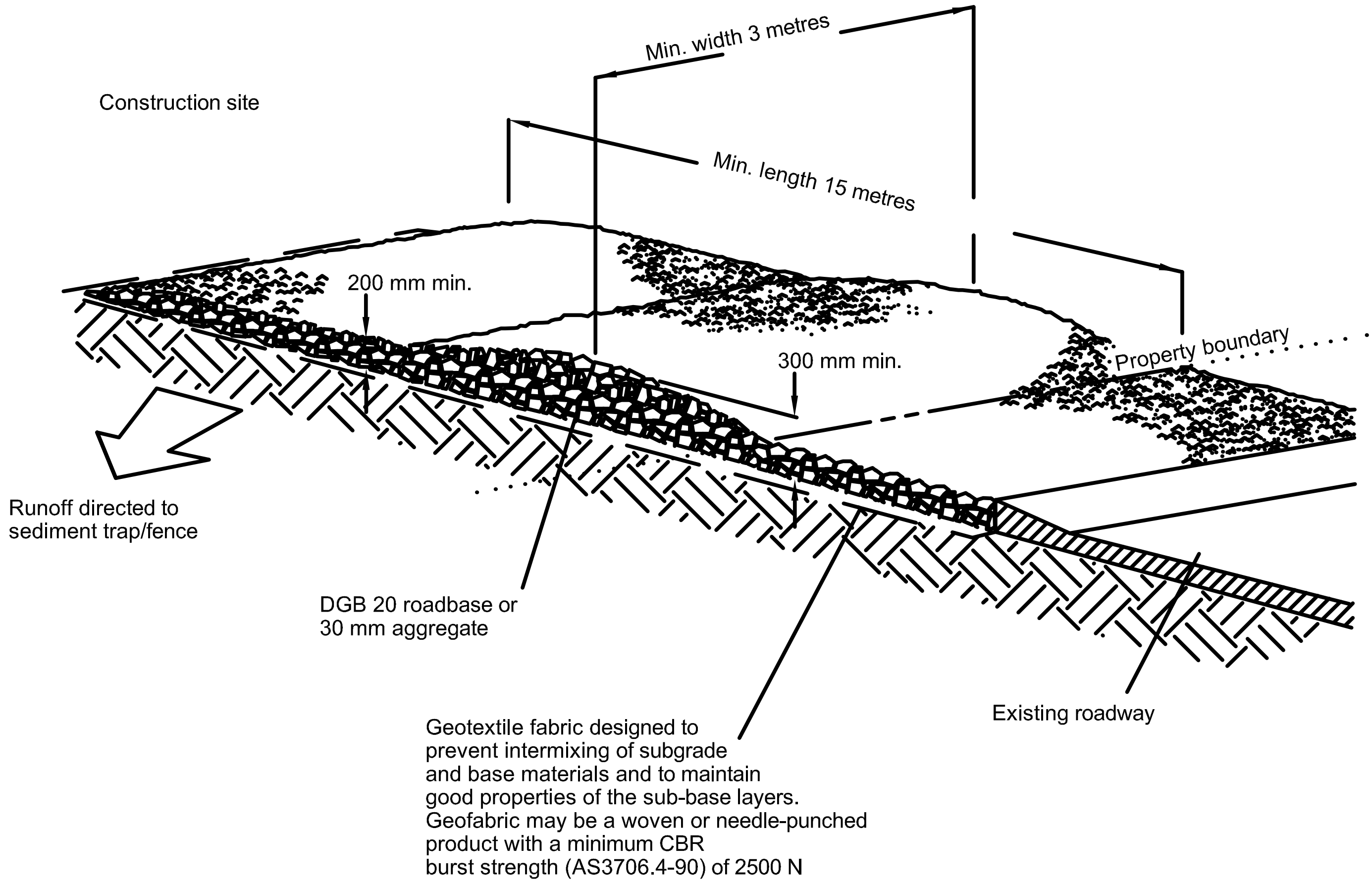
SD 6-12



Construction Notes

1. Install a 400 mm minimum wide roll of turf on the footpath next to the kerb and at the same level as the top of the kerb.
2. Lay 1.4 metre long turf strips normal to the kerb every 10 metres.
3. Rehabilitate disturbed soil behind the turf strip following the ESCP/SWMP.

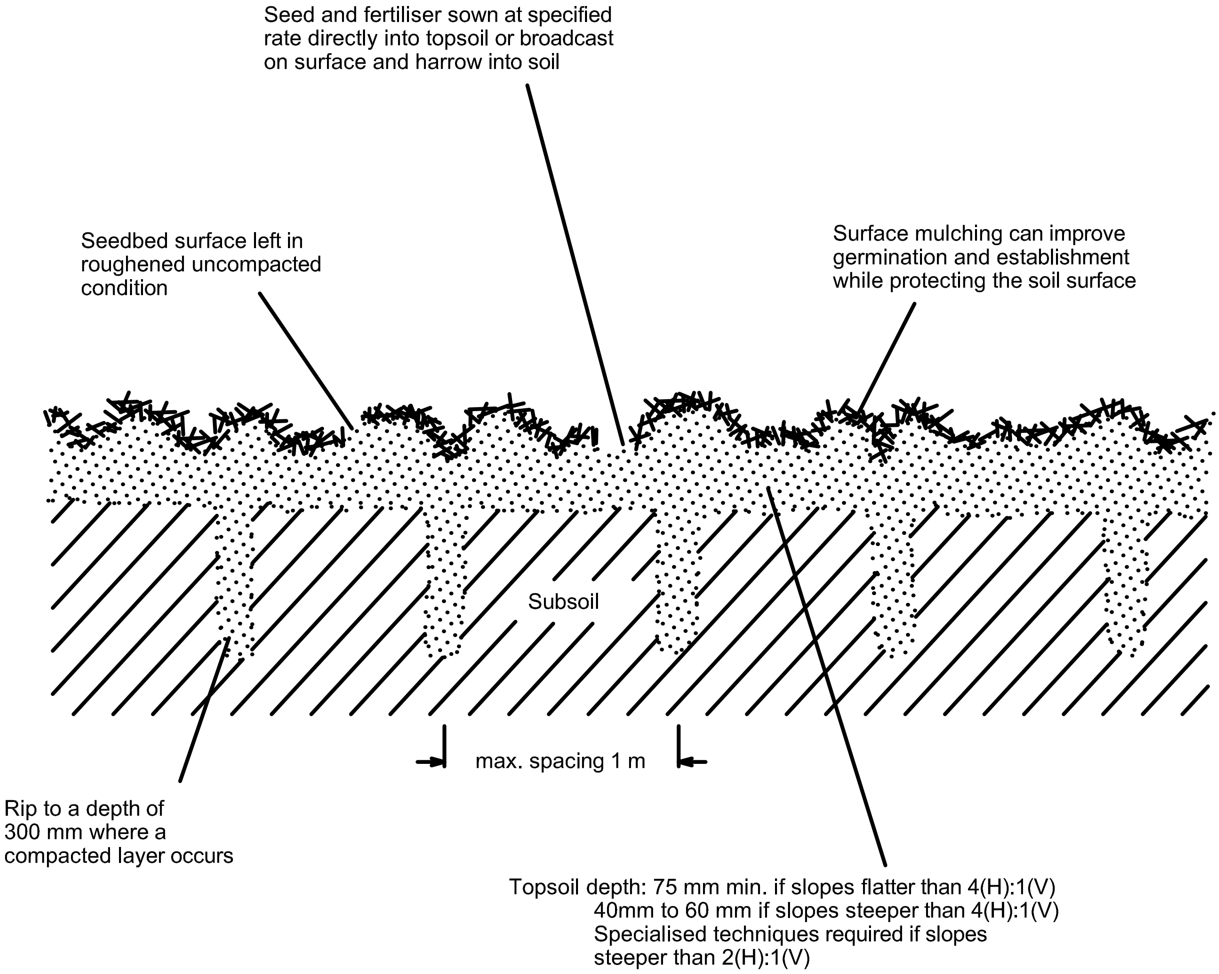
KERBSIDE TURF STRIP SD 6-13



Construction Notes

1. Strip the topsoil, level the site and compact the subgrade.
2. Cover the area with needle-punched geotextile.
3. Construct a 200 mm thick pad over the geotextile using road base or 30 mm aggregate.
4. Ensure the structure is at least 15 metres long or to building alignment and at least 3 metres wide.
5. Where a sediment fence joins onto the stabilised access, construct a hump in the stabilised access to divert water to the sediment fence

STABILISED SITE ACCESS SD 6-14



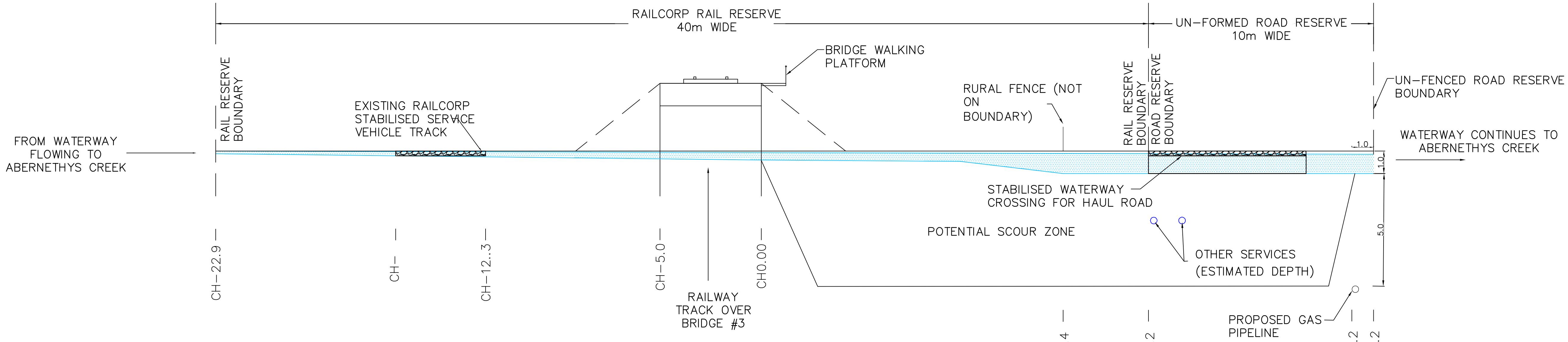
Construction Notes

1. Loosen compacted soil before sowing any seed. If necessary, rip the soil to a depth of 300 mm. Avoid rotary hoe cultivation.
2. Work the ground only as much as necessary to achieve the desired tilth and prepare a good seedbed.
3. Avoid cultivation in very wet or very dry conditions.
4. Cultivate on or close to the contour where possible, not up and down the slope.

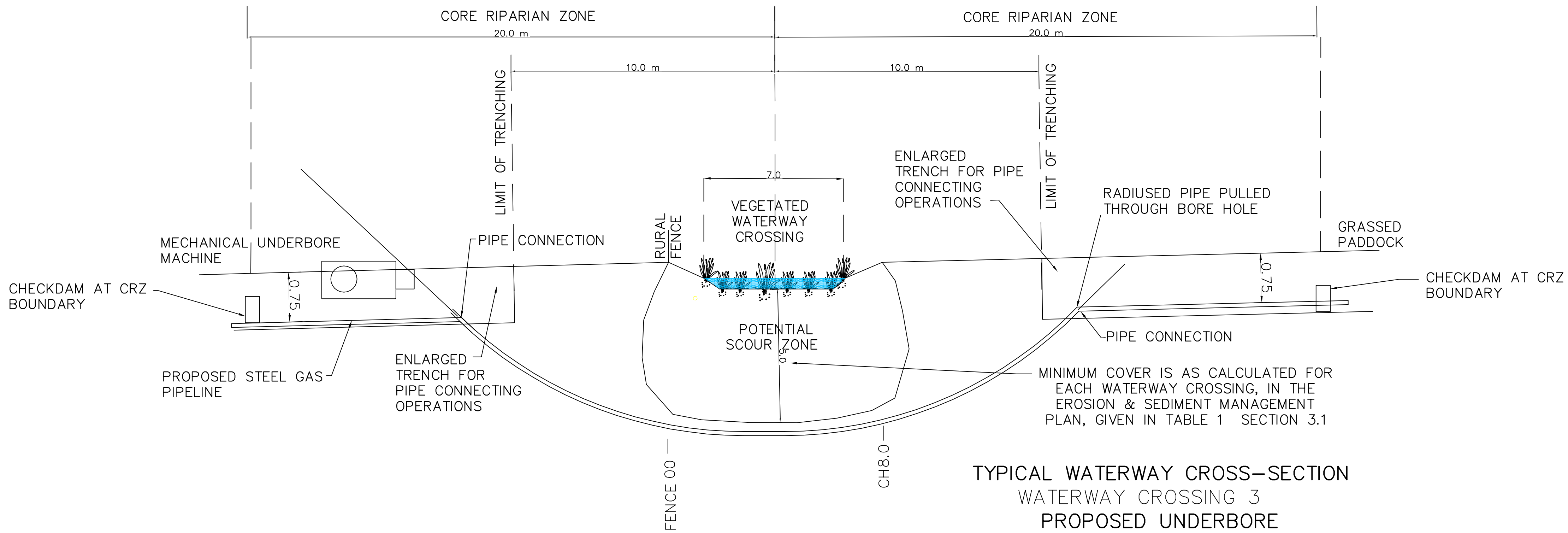
SEEDBED PREPARATION

SD 7-1

Appendix E – Figure 2: Cross Section of Waterway Crossing 3



TYPICAL WATERWAY LONG-SECTION
(WATERWAY CROSSING 3)



TYPICAL WATERWAY CROSS-SECTION
WATERWAY CROSSING 3
PROPOSED UNDERBORE

REVISION	BY	DATE

Liability limited by a scheme approved under Professional Standards Legislation.
COVER OF EXCELLENCE®

0 10 20 30 40 50 100

scale:– 1:1000

RATIO: 1:1000 @ A3

DATUM:

ORIGIN:

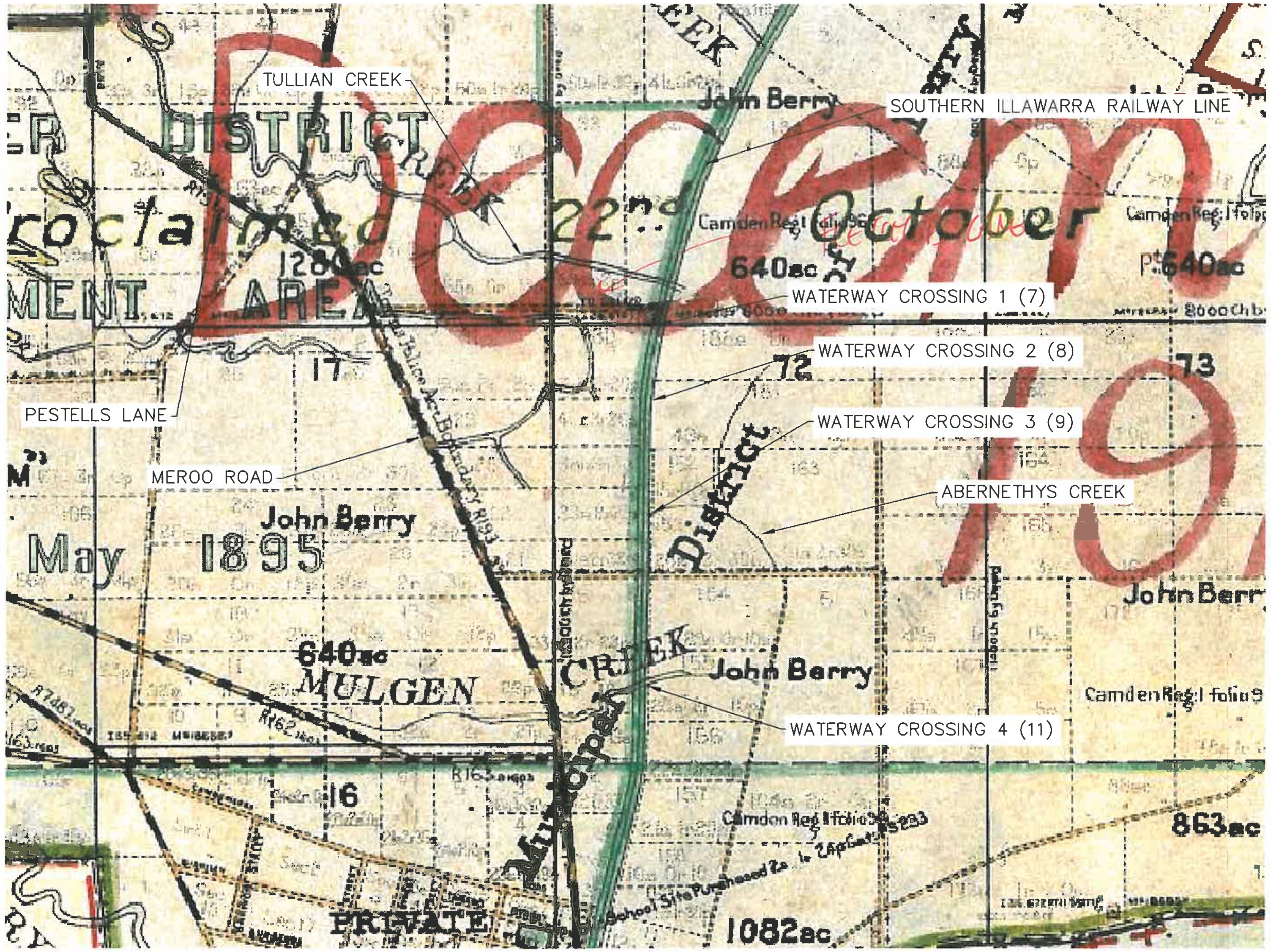
DATE OF PLAN: October 2011

allen, price & associates
land and development consultants
75 plunkett street, nowra, nsw. 2541
phone:(02) 4421 6544 fax:(02) 4422 1821
consultants@allenprice.com.au www.allenprice.com.au

APPENDIX E: YPICAL SECTIONS – WATERWAY CROSSING 3 SHOWING UNDERBORE & SCOUR ZONES FOR PROPOSED GAS PIPELINE AT MEROO MEADOW AND BOMADERRY FOR SHOALHAVEN STARCHES

REF. No. 24710
sheet 1 of 1
REVISION 00

Appendix F: May 1895 Topographic Map Detail



REVISION		BY	DATE

Liability limited by a scheme approved under Professional Standards Legislation.

COVER OF EXCELLENCE®

RATIO: 1:500 @ A3

DATUM:

ORIGIN:

DATE OF PLAN: FEB 2012

allen, price & associates
land and development consultants
75 plunkett street, nowra, nsw. 2541
phone:(02) 4421 6544 fax (02) 4427 1821
consultants@allenprice.com.au www.allenprice.com.au

APPENDIX F – may 1895 1:4000 topographic map for proposed gas pipeline project at Meroo Meadow and Bomaderry, NSW for Shoalhaven Starches

REF. No. 24710
sheet 1 of 1
REVISION 00

Appendix G: Coffey Environments Engineering Log – Excavation (Bore Holes CTP10, CTP12, CTP16 & CTP17)

coffey environments

Engineering Log - Excavation

		Excavation No.	CTP10
		Sheet	1 of 1
		Office Job No.:	ENAUWOLL04006AA
Client:	MANILDRA GROUP	Date started:	21.6.2011
Principal:		Date completed:	21.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282018 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142018 m	datum:	WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N				0.0–0.5			TOPSOIL; Sandy CLAY: Low to medium plasticity, pale yellow/brown, fine to medium grained sand, with some roots.	M	MD		TOPSOIL
						0.5–1.5		CL	Sandy CLAY: Medium plasticity, red/orange, with some silt, and a trace of roots and fine to coarse grained angular sandstone gravel.	<Wp	St		RESIDUAL
			Seepage			1.5–2.5		CL	Sandy Gravelly CLAY: Medium plasticity, orange/brown with some pale yellow/pale brown pockets and fine to medium grained highly weathered sandstone gravel.		H		EXTREMELY WEATHERED MATERIAL End on slow progress
						2.5			Test pit CTP10 terminated at 2.5m				

Sketch

method		support	notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation	penetration 1 2 3 4 — no resistance ranging to refusal	U_{63}	undisturbed sample 63mm diameter	moisture	S	soft
BH	backhoe bucket	water	D	disturbed sample	D dry	F	firm
B	bulldozer blade	water level on date shown	V	vane shear (kPa)	M moist	St	stiff
R	ripper	water inflow	Bs	bulk sample	W wet	VSt	very stiff
E	excavator	water outflow	E	environmental sample	Wp plastic limit	H	hard
			R	refusal	W_L liquid limit	Fb	friable
						VL	very loose
						L	loose
						MD	medium dense
						D	dense
						VD	very dense

coffey environments

Engineering Log - Excavation

Excavation No.	CTP12
Sheet	1 of 1
Office Job No.:	ENAUWOLL04006AA
Client:	MANILDRA GROUP
Principal:	
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541
Date started:	21.6.2011
Date completed:	21.6.2011
Logged by:	CA
Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:	N-S	Easting:	282092 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142461 m	datum:	WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N							TOPSOIL; CLAY: High plasticity, brown, with some silt and roots.	>Wp	S		TOPSOIL
			► (approx. 0.5)			0.5		CH	Sandy CLAY: High plasticity, brown, with some silt, and a trace of roots.			x	ALLUVIAL/ESTUARINE SOIL
				ASS									
				ASS		1.0							
				ASS		1.5		CH	Sandy CLAY: High plasticity, grey, fine grained sand, and some silt.		St	x x x	
				ASS		2.0							
						2.5			Test pit CTP12 terminated at 2.5m				End on steady progress
						3.0							

Sketch

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
N	natural exposure	S shoring	N nil	U_{50}	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
X	existing excavation	penetration 1 2 3 4	no resistance ranging to refusal	U_{63}	undisturbed sample 63mm diameter		S	soft
BH	backhoe bucket	water		D	disturbed sample	moisture	F	firm
B	bulldozer blade	water level on date shown		V	vane shear (kPa)	D dry	St	stiff
R	ripper	water inflow		Bs	bulk sample	M moist	VSt	very stiff
E	excavator	water outflow		E	environmental sample	W wet	H	hard
				R	refusal	Wp plastic limit	Fb	friable
						W_L liquid limit	VL	very loose
							L	loose
							MD	medium dense
							D	dense
							VD	very dense

coffey environments

Engineering Log - Excavation

Excavation No. CTP16
Sheet 1 of 1
Office Job No.: ENAUWOLL04006AA

Client: MANILDRA GROUP
Principal:
Project: CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT
Test pit location: PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541

Date started: 22.6.2011
Date completed: 22.6.2011
Logged by: CA
Checked by: SM

equipment type and model: 5T EXCAVATOR | Pit Orientation: N-S | Easting: 282191 m | R.L. Surface: NOT MEASURED
excavation dimensions: 2m long 0.45m wide | Northing: 6142933 m | datum: WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N							TOPSOIL; CLAY: High plasticity, brown, with some roots.	<Wp	F		TOPSOIL
				ASS		0.5		CH	CLAY: High plasticity, grey with some iron stained orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	Wp	VSt		ALLUVIAL SOIL
				ASS		1.0							
				ASS		1.5							
				ASS		2.0		CH	Sandy CLAY: High plasticity, grey with orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	>Wp Saturated	St		
			▶			2.5			Test pit CTP16 terminated at 2.5m				End on steady progress
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	S shoring N nil penetration 1 2 3 4 no resistance ranging to refusal water water level on date shown water inflow water outflow	U_{50} undisturbed sample 50mm diameter U_{63} undisturbed sample 63mm diameter D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	based on unified classification system moisture D dry M moist W wet Wp plastic limit W_L liquid limit	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense

coffey environments

Engineering Log - Excavation

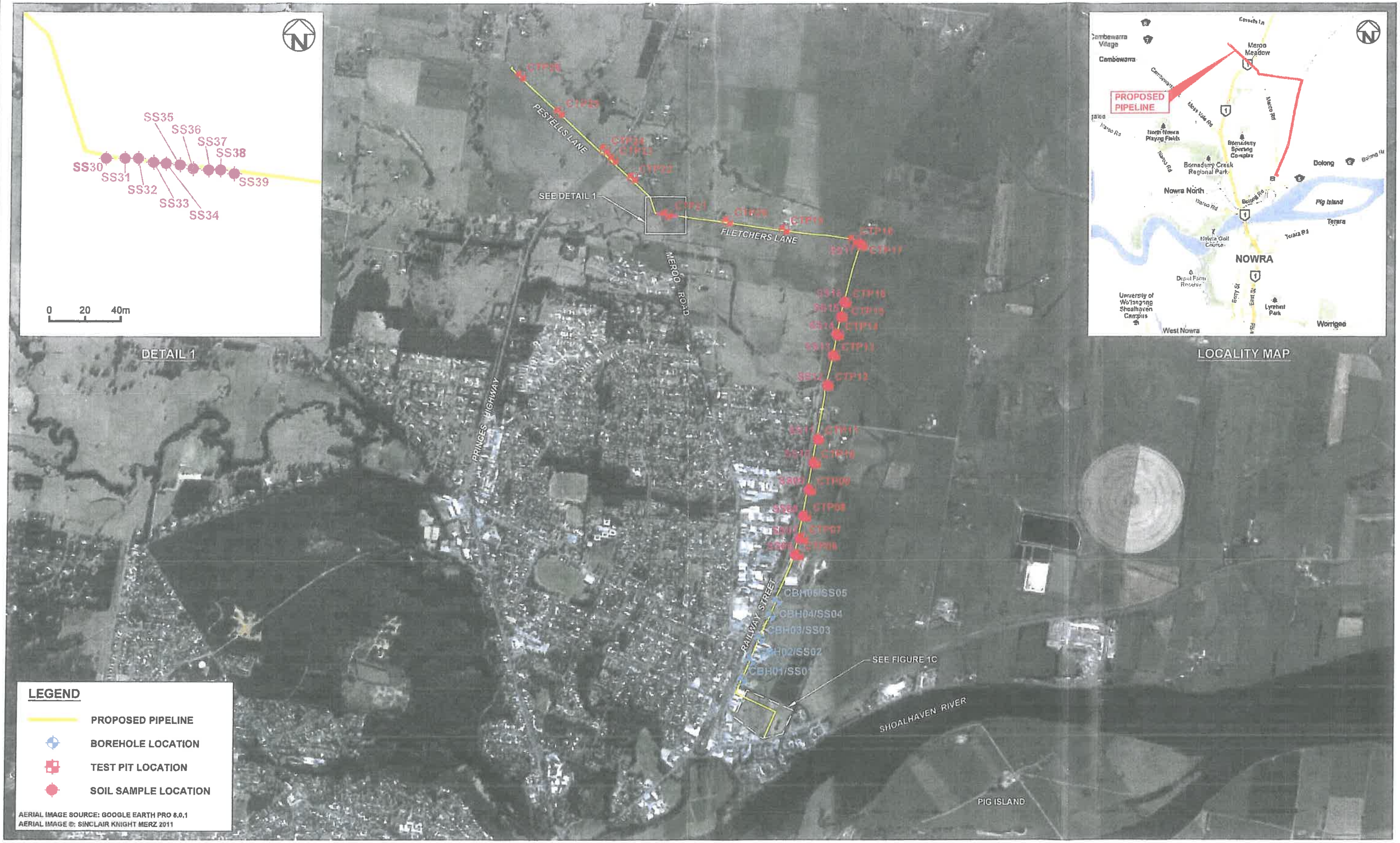
Excavation No.	CTP17
Sheet	1 of 1
Office Job No.:	ENAUWOLL04006AA
Client:	MANILDRA GROUP
Date started:	22.6.2011
Principal:	
Date completed:	22.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT
Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541
Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:		Easting:	282284 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing	6143258 m	datum:	WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N	NONE OBSERVED						TOPSOIL; CLAY: Medium plasticity, brown, with some fine grained roots.	Wp	F		TOPSOIL
								CH	CLAY: High plasticity, brown with some orange pockets, with a trace of fine grained sand, roots and fine to coarse grained gravel.	<Wp	VSt		ALLUVIAL SOIL
				ASS		0.5						X	
				ASS		1.0						X	
				ASS		1.5							
						2.0						X	
						2.5							End on steady progress
									Test pit CTP17 terminated at 2.5m				
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure	S shoring N nil	U_{50} undisturbed sample 50mm diameter	based on unified classification system	VS very soft
X existing excavation	penetration 1 2 3 4	U_{63} undisturbed sample 63mm diameter		S soft
BH backhoe bucket	no resistance ranging to refusal	D disturbed sample	moisture	F firm
B bulldozer blade	water	V vane shear (kPa)	D dry	St stiff
R ripper	water level on date shown	Bs bulk sample	M moist	VSt very stiff
E excavator	water inflow	E environmental sample	W wet	H hard
	water outflow	R refusal	Wp plastic limit	Fb friable
			W_L liquid limit	VL very loose
				L loose
				MD medium dense
				D dense
				VD very dense



revision	description	drawn	approved	date

200 0 200 600 1000

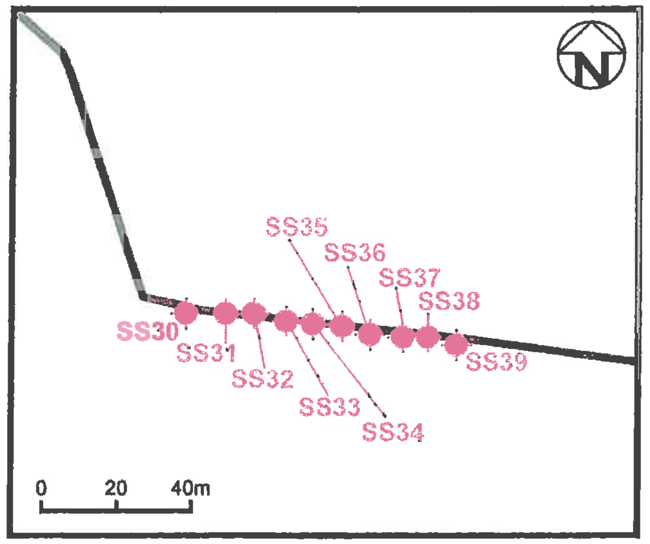
Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	28.07.11
scale	AS SHOWN
original size	A3

coffey environments
SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS
project no: ENAUWOLL04006AA-R01	figure no: FIGURE 1

Map Class Description	Depth to Acid Sulfate Soil Materials	
HIGH PROBABILITY	Below water level	Bottom sediments.
High probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
LOW PROBABILITY	Below water level	Bottom sediments.
Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
NO KNOWN OCCURRENCE		No known occurrences of acid sulfate soil materials.
Acid sulfate soils are not known or expected to occur in these environments.		



DETAIL 1

LEGEND

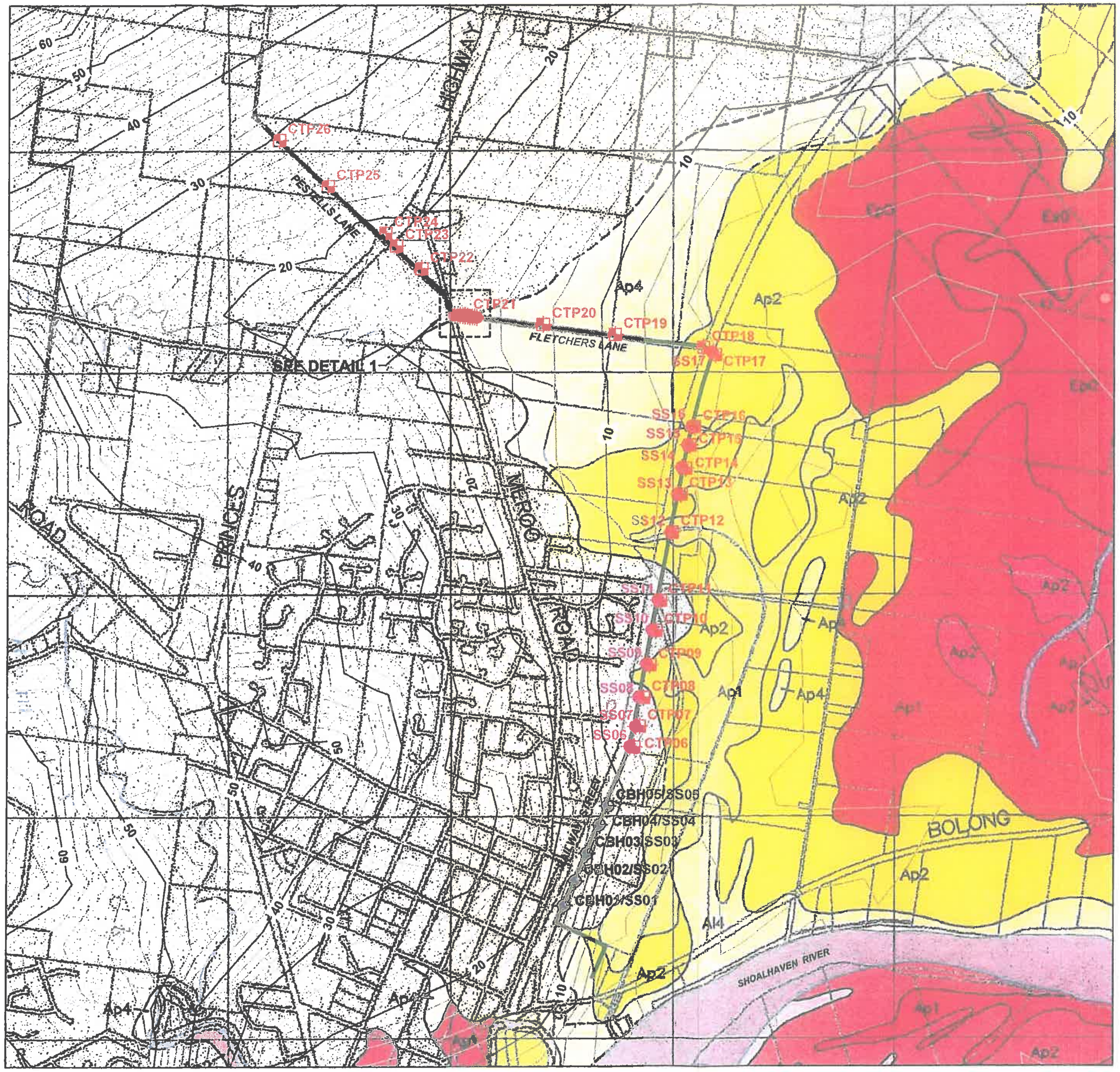
PROPOSED PIPELINE

BOREHOLE LOCATION

TEST PIT LOCATION

SOIL SAMPLE LOCATION

REFERNCE: BURRIER/BERRY 1:25 000 ACID SOIL RISK MAP (1997) EDITION 2, PREPARED BY THE NSW DEPARTMENT OF LAND AND WATER CONSERVATION (DLWC)



revision	description	drawn	approved	date

200 0 200 600 1000

Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	28/07/11
scale	AS SHOWN
original size	A3

coffey environments

SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH 1:25000 BURRIER/BERRY ASS RISK MAP
project no:	ENAUWOLL04006AA-R01
figure no:	FIGURE 2

Appendix H: Catchment Stormwater Runoff Calculations

CATCHMENT 1 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	11.74 ha
Time of Concentration (mins)	20.20 mins
Rainfall Intensity (I)	102 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**2.33 m3/sec**

CATCHMENT 1 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	11.74 ha
Time of Concentration (mins)	20.20 mins
Rainfall Intensity (I)	174 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**3.97 m3/sec**

CATCHMENT RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	545.40 ha
Time of Concentration (mins)	86.88 mins
Rainfall Intensity (I)	47 mm/hr
Runoff Coefficient (C)	0.60
Factor (F)	0.00278
DISCHARGE (Q)	**42.72 m3/sec**

CATCHMENT RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	545.40 ha
Time of Concentration (mins)	86.88 mins
Rainfall Intensity (I)	85 mm/hr
Runoff Coefficient (C)	0.60
Factor (F)	0.00278
DISCHARGE (Q)	**77.27 m3/sec**

CATCHMENT 3 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	896.50 ha
Time of Concentration (mins)	104.94 mins
Rainfall Intensity (I)	41 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**71.47 m3/sec**

CATCHMENT 3 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	896.50 ha
Time of Concentration (mins)	104.94 mins
Rainfall Intensity (I)	76 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**132.48 m3/sec**

CATCHMENT 4 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	115.40 ha
Time of Concentration (mins)	48.15 mins
Rainfall Intensity (I)	66 mm/hr
Runoff Coefficient (C)	0.80
Factor (F)	0.00278
DISCHARGE (Q)	**16.93 m3/sec**

CATCHMENT 4 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	115.40 ha
Time of Concentration (mins)	48.15 mins
Rainfall Intensity (I)	117 mm/hr
Runoff Coefficient (C)	0.80
Factor (F)	0.00278
DISCHARGE (Q)	**30.00 m3/sec**

Appendix I: HY-8 Culvert Analysis Reports for Waterway Crossings 1, 2, 3 and 4, with Scour Depth Calculation Results

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 1

Headwater Elevation (m)	Total Discharge (cms)	Culvert 1A Discharge (cms)	Culvert 1B Discharge (cms)	Culvert 1C Discharge (cms)	Culvert 1D Discharge (cms)	Culvert 1E Discharge (cms)	Culvert 1F Discharge (cms)	Roadway Discharge (cms)	Iterations
0.43	2.33	0.39	0.39	0.39	0.39	0.39	0.39	0.00	16
0.44	2.49	0.42	0.42	0.42	0.42	0.42	0.42	0.00	3
0.46	2.66	0.44	0.44	0.44	0.44	0.44	0.44	0.00	3
0.48	2.82	0.47	0.47	0.47	0.47	0.47	0.47	0.00	3
0.50	2.99	0.50	0.50	0.50	0.50	0.50	0.50	0.00	3
0.52	3.15	0.52	0.52	0.52	0.52	0.52	0.52	0.00	3
0.53	3.31	0.55	0.55	0.55	0.55	0.55	0.55	0.00	3
0.55	3.48	0.58	0.58	0.58	0.58	0.58	0.58	0.00	3
0.57	3.64	0.61	0.61	0.61	0.61	0.61	0.61	0.00	2
0.58	3.81	0.63	0.63	0.63	0.63	0.63	0.63	0.00	2
0.60	3.96	0.66	0.66	0.66	0.66	0.66	0.66	0.00	2
2.00	13.88	2.31	2.31	2.31	2.31	2.31	2.31	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

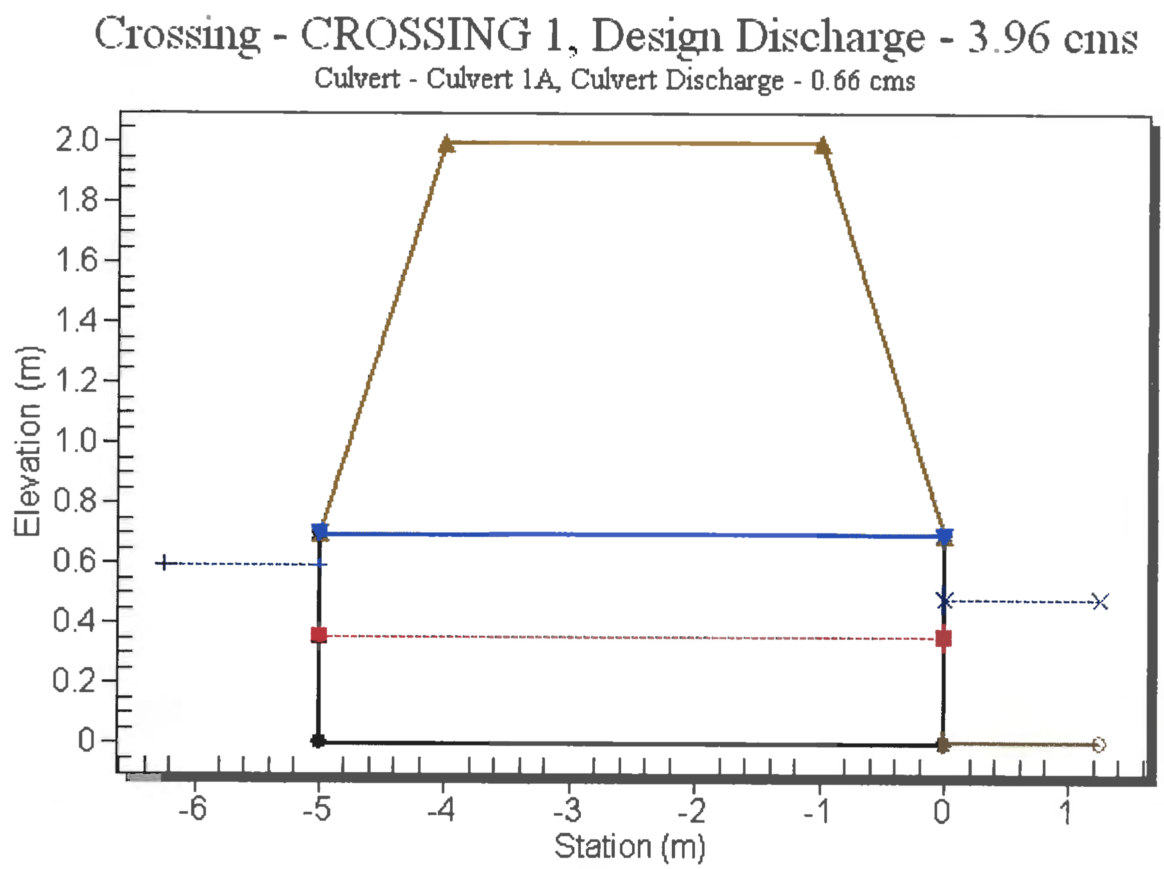
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1A



Site Data - Culvert 1A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1A

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 1B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

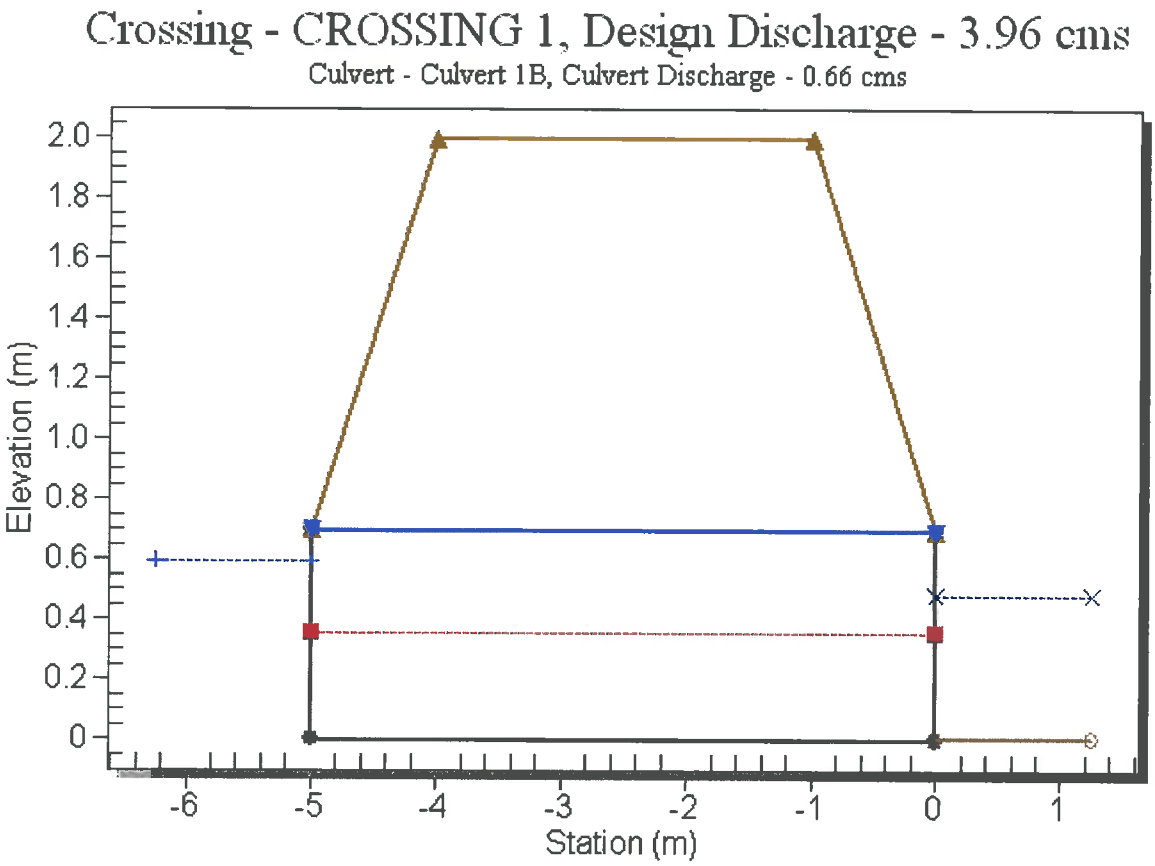
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1B



Site Data - Culvert 1B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1B

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 1C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

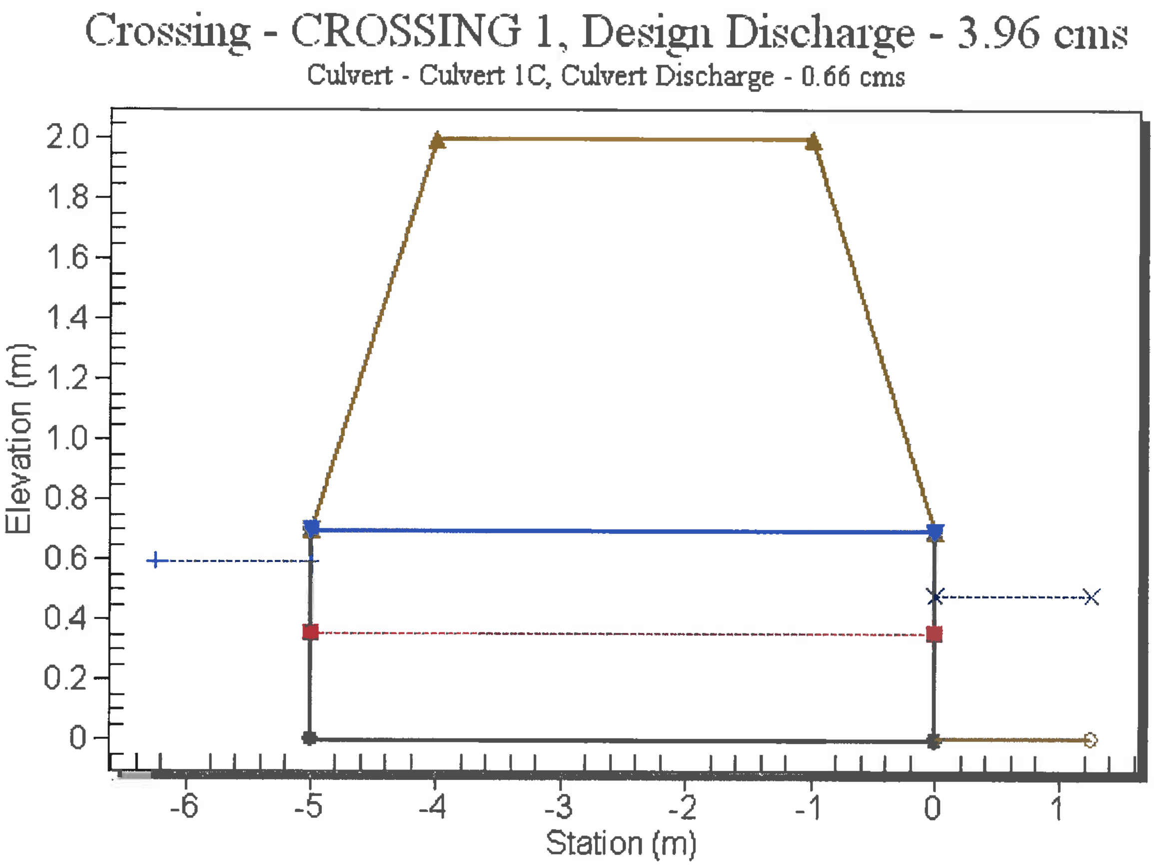
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1C



Site Data - Culvert 1C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1C

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Culvert Summary Table: Culvert 1D

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

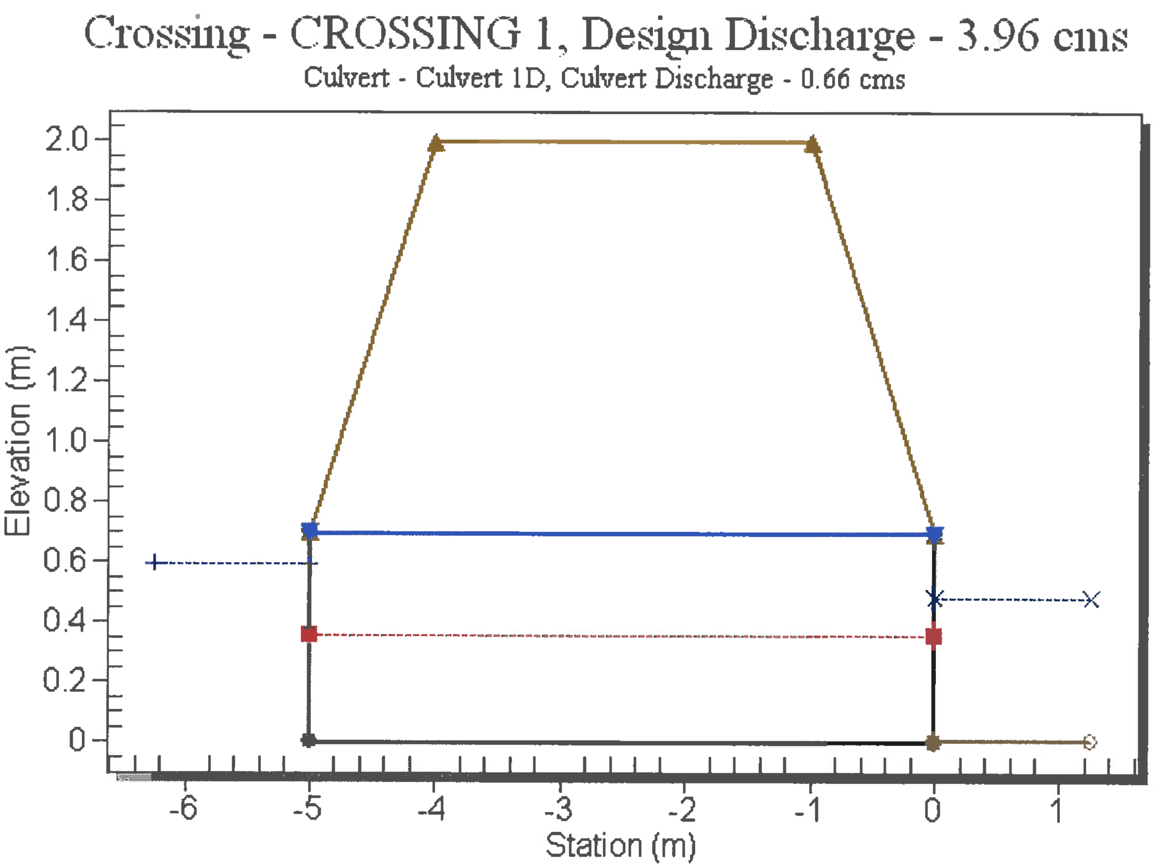
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1D



Site Data - Culvert 1D

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1D

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 6 - Culvert Summary Table: Culvert 1E

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

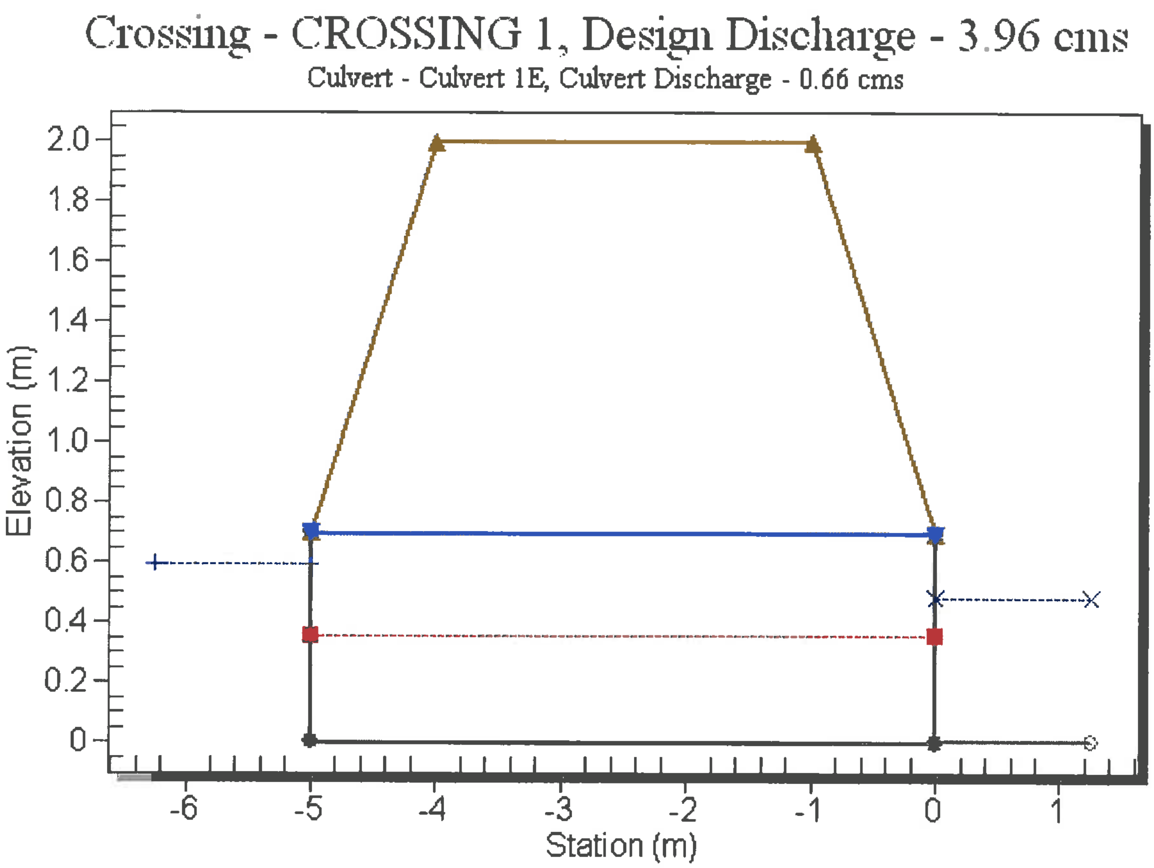
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1E



Site Data - Culvert 1E

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1E

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 7 - Culvert Summary Table: Culvert 1F

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

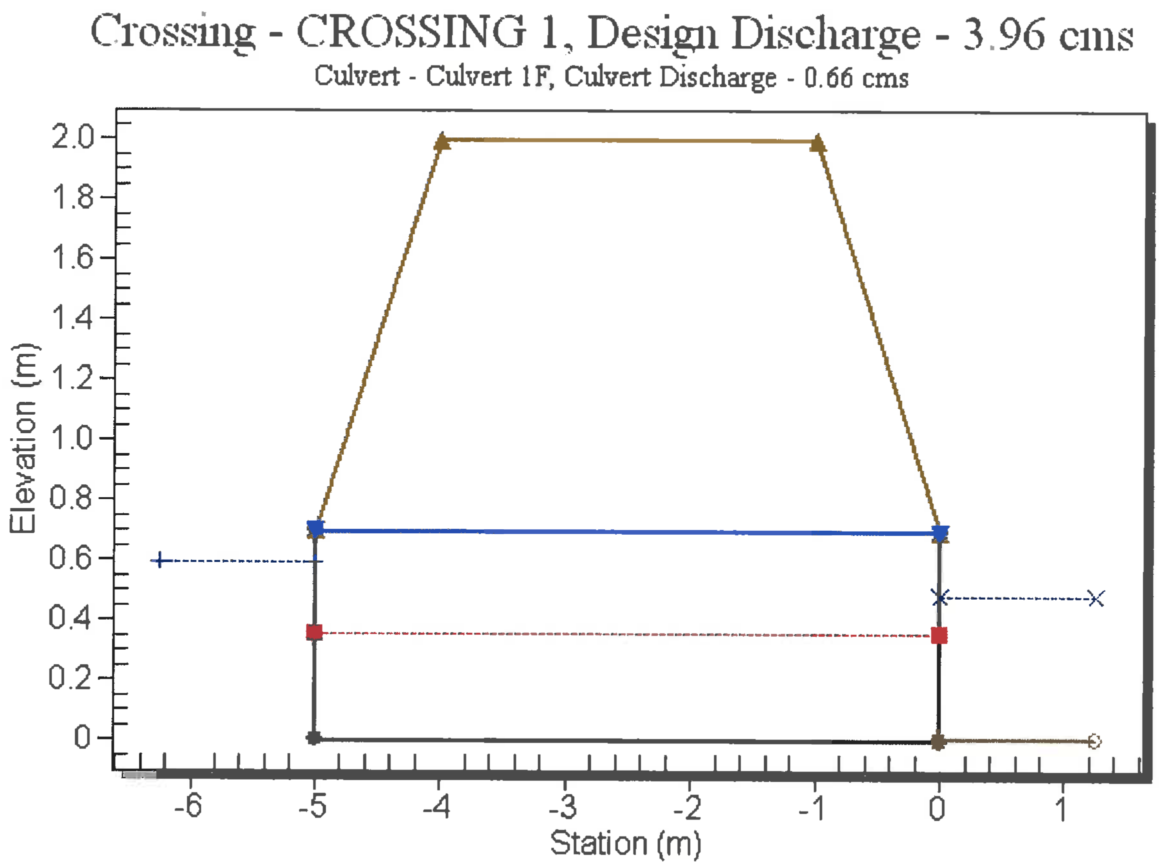
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1F



Site Data - Culvert 1F

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1F

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 8 - Downstream Channel Rating Curve (Crossing: CROSSING 1)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
2.33	0.36	0.36	1.14	34.97	0.65
2.49	0.37	0.37	1.17	36.39	0.65
2.66	0.39	0.39	1.20	37.77	0.65
2.82	0.40	0.40	1.22	39.10	0.66
2.99	0.41	0.41	1.24	40.41	0.66
3.15	0.43	0.43	1.27	41.68	0.66
3.31	0.44	0.44	1.29	42.92	0.67
3.48	0.45	0.45	1.31	44.14	0.67
3.64	0.46	0.46	1.33	45.33	0.67
3.81	0.47	0.47	1.35	46.50	0.67
3.96	0.49	0.49	1.37	47.57	0.68

Tailwater Channel Data - CROSSING 1

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 5.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 m

Crest Elevation: 2.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 1	
Culvert	Culvert 1A	
Flow	3.96	cms
Culvert Data		
Culvert Width (including multiple barrels)	1.0	m
Culvert Height	0.7	m
Outlet Depth	0.70	m
Outlet Velocity	0.94	m/s
Froude Number	0.36	
Tailwater Depth	0.49	m
Tailwater Velocity	1.37	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	100.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.161	kPa
Modified Shear Number	0.264	
Scour Hole Dimensions		
Length (LS)	3.768	m
Width (WS)	3.777	m
Depth (DS)	0.871	m
Volume (VS)	1.464	m^3
DS at 0.4(LS)	1.507	m
Tailwater Depth (TW)	0.485	m
Velocity with TW and WS	0.286	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 2

Headwater Elevation (m)	Total Discharge (cms)	Culvert 2A Discharge (cms)	Culvert 2B Discharge (cms)	Culvert 2C Discharge (cms)	Culvert 2D Discharge (cms)	Roadway Discharge (cms)	Iterations
1.69	42.00	7.86	13.11	13.11	7.86	0.00	32
1.73	45.50	8.05	13.41	13.41	8.05	2.52	9
1.75	49.00	8.13	13.55	13.55	8.13	5.57	6
1.77	52.50	8.20	13.67	13.67	8.20	8.68	5
1.78	56.00	8.27	13.78	13.78	8.27	11.87	5
1.80	59.50	8.33	13.88	13.88	8.33	15.03	4
1.81	63.00	8.35	13.94	13.94	8.35	18.38	4
1.83	66.50	8.20	13.69	13.69	8.20	22.68	4
1.84	70.00	8.04	13.43	13.43	8.04	27.01	4
1.86	73.50	7.88	13.17	13.17	7.88	31.36	4
1.87	76.00	7.77	12.98	12.98	7.77	34.48	4
1.70	42.23	7.92	13.20	13.20	7.92	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 2A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	7.86	1.69	1.687	1.488	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	8.05	1.73	1.730	1.559	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	8.13	1.75	1.750	1.615	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	8.20	1.77	1.768	1.668	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	8.27	1.78	1.783	1.719	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	8.33	1.80	1.797	1.768	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	8.35	1.81	1.802	1.811	4-FFf	1.000	0.926	1.000	1.199	2.783	2.577
66.50	8.20	1.83	1.765	1.827	4-FFf	1.000	0.915	1.000	1.237	2.732	2.626
70.00	8.04	1.84	1.728	1.843	4-FFf	1.000	0.903	1.000	1.275	2.680	2.672
73.50	7.88	1.86	1.692	1.857	4-FFf	1.000	0.891	1.000	1.311	2.628	2.718
76.00	7.77	1.87	1.666	1.868	4-FFf	1.000	0.883	1.000	1.337	2.590	2.749

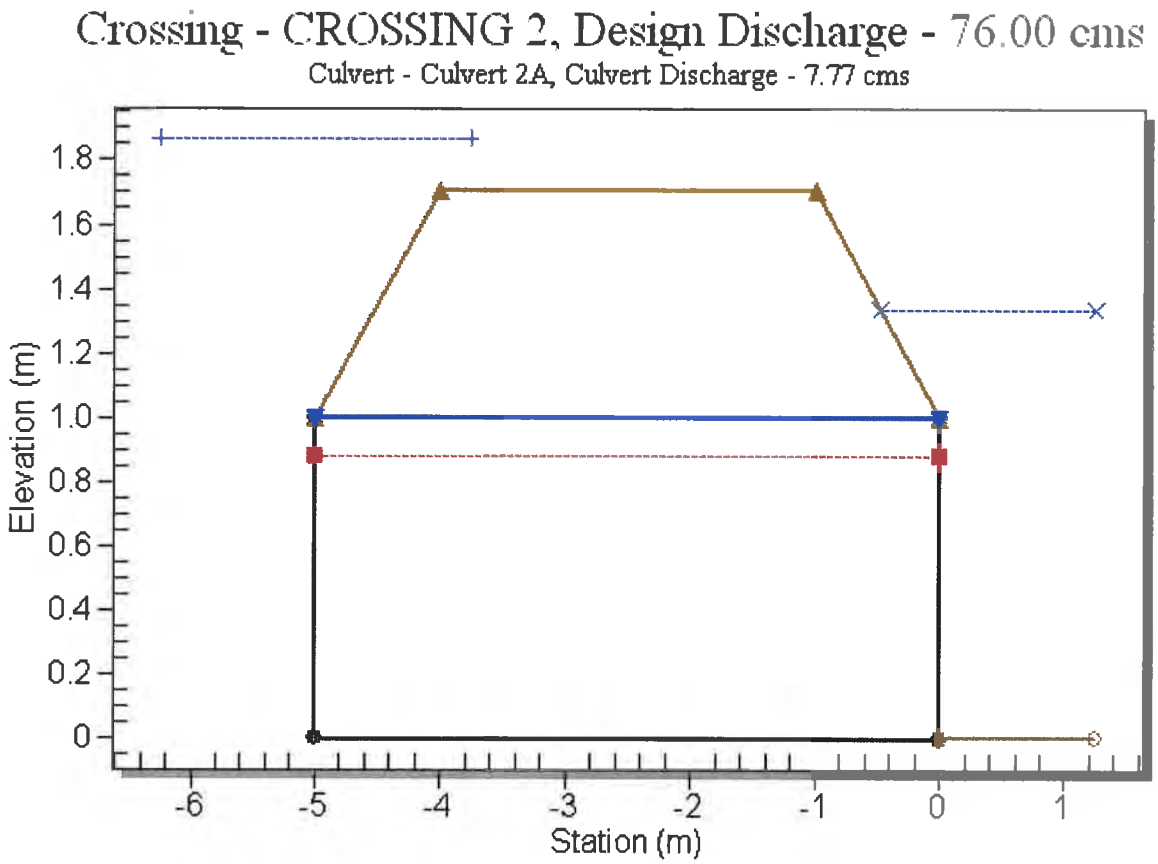
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2A



Site Data - Culvert 2A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2A

Barrel Shape: Concrete Box

Barrel Span: 3000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 2B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	13.11	1.69	1.687	1.486	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	13.41	1.73	1.730	1.556	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	13.55	1.75	1.750	1.613	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	13.67	1.77	1.768	1.666	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	13.78	1.78	1.783	1.717	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	13.88	1.80	1.797	1.765	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	13.94	1.81	1.807	1.811	4-FFf	1.000	0.927	1.000	1.199	2.789	2.577
66.50	13.69	1.83	1.770	1.827	4-FFf	1.000	0.916	1.000	1.237	2.738	2.626
70.00	13.43	1.84	1.733	1.843	4-FFf	1.000	0.904	1.000	1.275	2.686	2.672
73.50	13.17	1.86	1.696	1.857	4-FFf	1.000	0.893	1.000	1.311	2.634	2.718
76.00	12.98	1.87	1.670	1.868	4-FFf	1.000	0.884	1.000	1.337	2.596	2.749

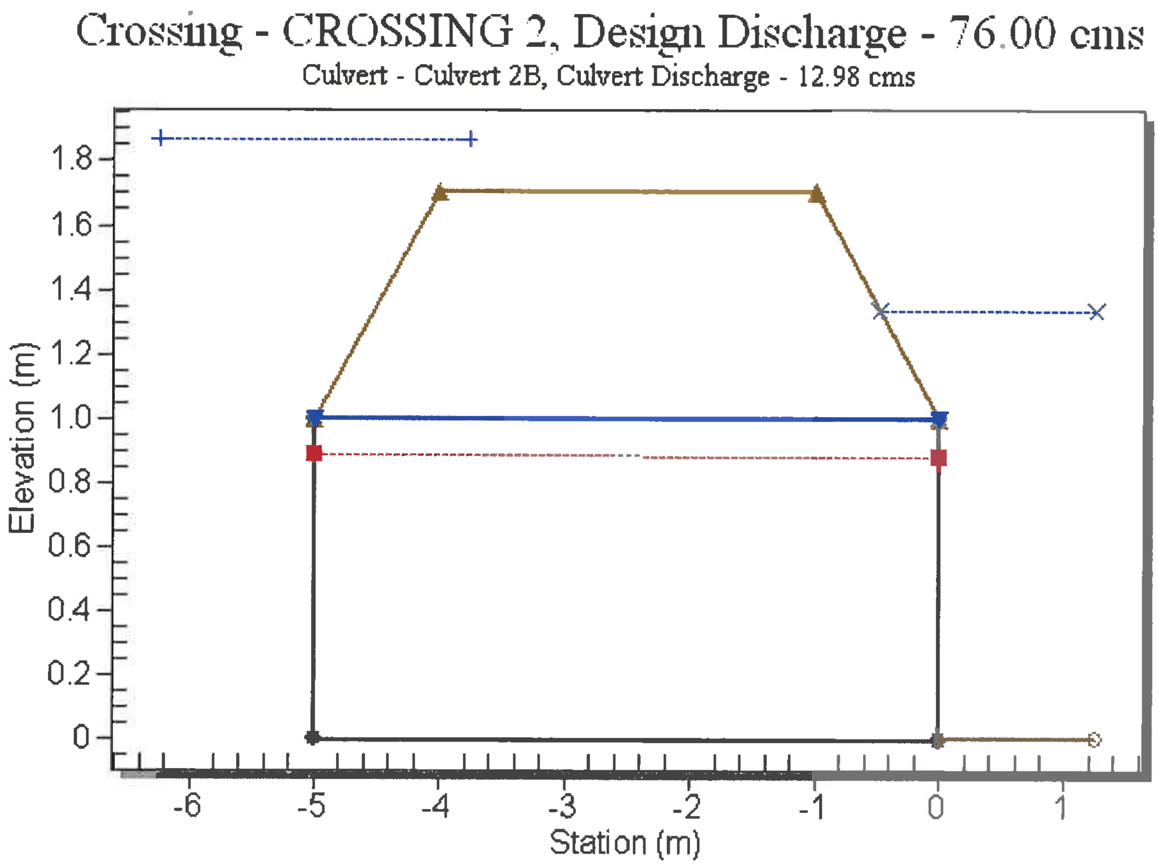
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2B



Site Data - Culvert 2B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2B

Barrel Shape: Concrete Box

Barrel Span: 5000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 2C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	13.11	1.69	1.687	1.486	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	13.41	1.73	1.730	1.556	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	13.55	1.75	1.750	1.613	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	13.67	1.77	1.768	1.666	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	13.78	1.78	1.783	1.717	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	13.88	1.80	1.797	1.765	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	13.94	1.81	1.807	1.811	4-FFf	1.000	0.927	1.000	1.199	2.789	2.577
66.50	13.69	1.83	1.770	1.827	4-FFf	1.000	0.916	1.000	1.237	2.738	2.626
70.00	13.43	1.84	1.733	1.843	4-FFf	1.000	0.904	1.000	1.275	2.686	2.672
73.50	13.17	1.86	1.696	1.857	4-FFf	1.000	0.893	1.000	1.311	2.634	2.718
76.00	12.98	1.87	1.670	1.868	4-FFf	1.000	0.884	1.000	1.337	2.596	2.749

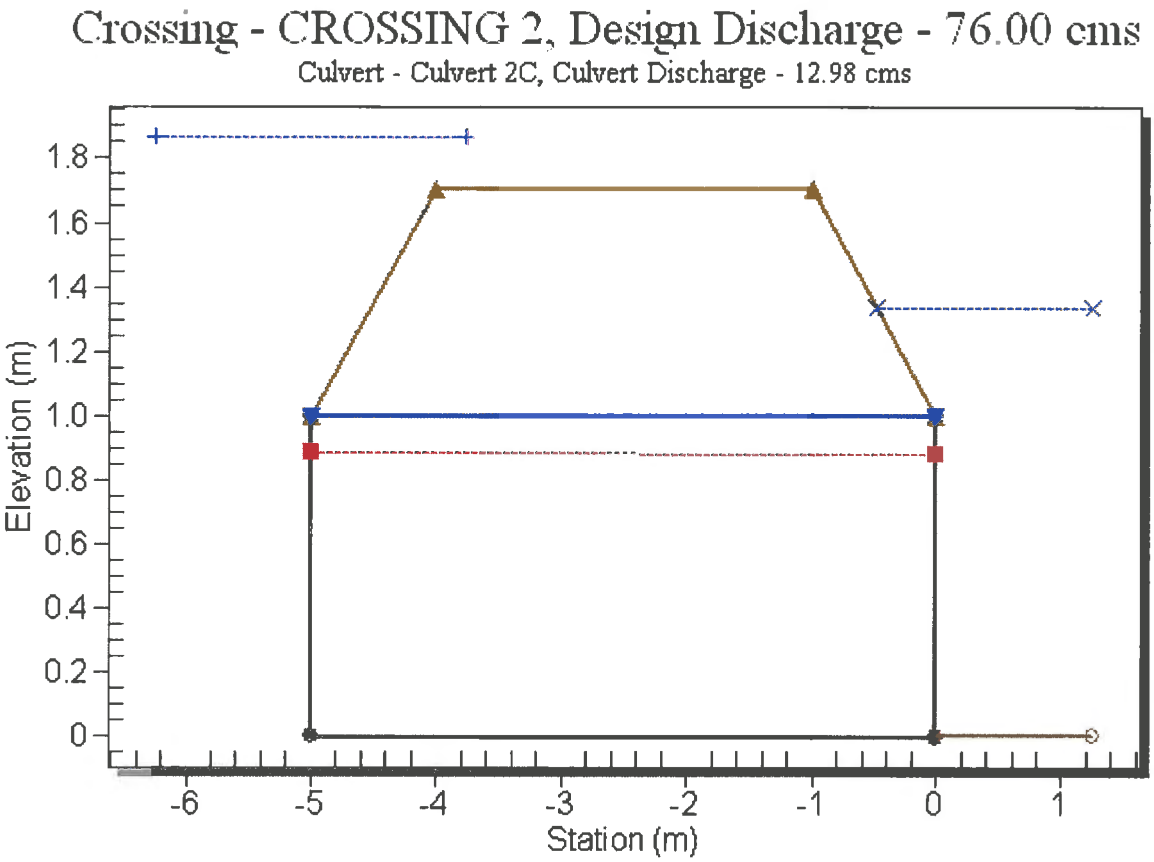
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2C



Site Data - Culvert 2C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2C

Barrel Shape: Concrete Box

Barrel Span: 5000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Culvert Summary Table: Culvert 2D

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	7.86	1.69	1.687	1.488	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	8.05	1.73	1.730	1.559	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	8.13	1.75	1.750	1.615	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	8.20	1.77	1.768	1.668	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	8.27	1.78	1.783	1.719	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	8.33	1.80	1.797	1.768	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	8.35	1.81	1.802	1.811	4-FFf	1.000	0.926	1.000	1.199	2.783	2.577
66.50	8.20	1.83	1.765	1.827	4-FFf	1.000	0.915	1.000	1.237	2.732	2.626
70.00	8.04	1.84	1.728	1.843	4-FFf	1.000	0.903	1.000	1.275	2.680	2.672
73.50	7.88	1.86	1.692	1.857	4-FFf	1.000	0.891	1.000	1.311	2.628	2.718
76.00	7.77	1.87	1.666	1.868	4-FFf	1.000	0.883	1.000	1.337	2.590	2.749

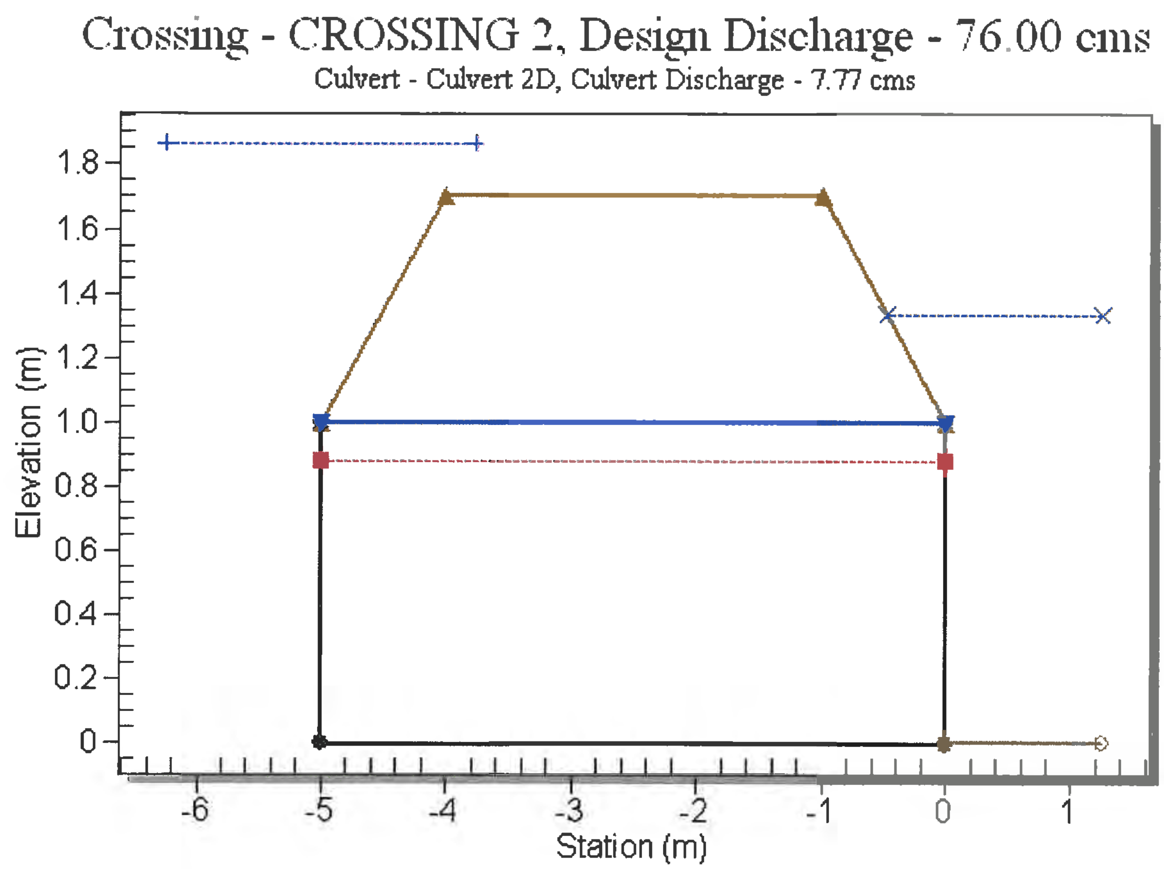
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2D



Site Data - Culvert 2D

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2D

Barrel Shape: Concrete Box

Barrel Span: 3000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: CROSSING 2)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
42.00	0.94	0.94	2.24	92.60	0.77
45.50	0.99	0.99	2.30	97.06	0.77
49.00	1.03	1.03	2.36	101.39	0.78
52.50	1.08	1.08	2.42	105.58	0.78
56.00	1.12	1.12	2.47	109.65	0.79
59.50	1.16	1.16	2.53	113.62	0.79
63.00	1.20	1.20	2.58	117.48	0.79
66.50	1.24	1.24	2.63	121.26	0.80
70.00	1.27	1.27	2.67	124.94	0.80
73.50	1.31	1.31	2.72	128.55	0.80
76.00	1.34	1.34	2.75	131.08	0.81

Tailwater Channel Data - CROSSING 2

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 18.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 2

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 m

Crest Elevation: 1.70 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 2	
Culvert	Culvert 2A	
Flow	76.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	3.0	m
Culvert Height	1.0	m
Outlet Depth	1.00	m
Outlet Velocity	2.59	m/s
Froude Number	0.83	
Tailwater Depth	1.34	m
Tailwater Velocity	2.75	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	200.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.309	kPa
Modified Shear Number	1.040	
Scour Hole Dimensions		
Length (LS)	12.258	m
Width (WS)	9.868	m
Depth (DS)	2.307	m
Volume (VS)	46.408	m^3
DS at 0.4(LS)	4.903	m
Tailwater Depth (TW)	1.337	m
Velocity with TW and WS	0.463	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 3

Headwater Elevation (m)	Total Discharge (cms)	Culvert 3A Discharge (cms)	Culvert 3B Discharge (cms)	Culvert 3C Discharge (cms)	Roadway Discharge (cms)	Iterations
2.14	71.47	23.83	23.83	23.83	0.00	4
2.30	77.57	25.87	25.87	25.87	0.00	4
2.45	83.67	27.90	27.90	27.90	0.00	4
2.61	89.77	29.93	29.93	29.93	0.00	4
2.76	95.87	31.96	31.96	31.96	0.00	4
2.92	101.98	33.98	33.98	33.98	0.00	10
3.03	108.08	34.73	34.73	34.73	3.82	11
3.06	114.18	33.69	33.69	33.69	12.97	6
3.09	120.28	32.49	32.49	32.49	22.66	5
3.12	126.38	31.22	31.22	31.22	32.66	5
3.14	132.00	29.98	29.98	29.98	41.90	4
3.00	109.23	36.41	36.41	36.41	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 3A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

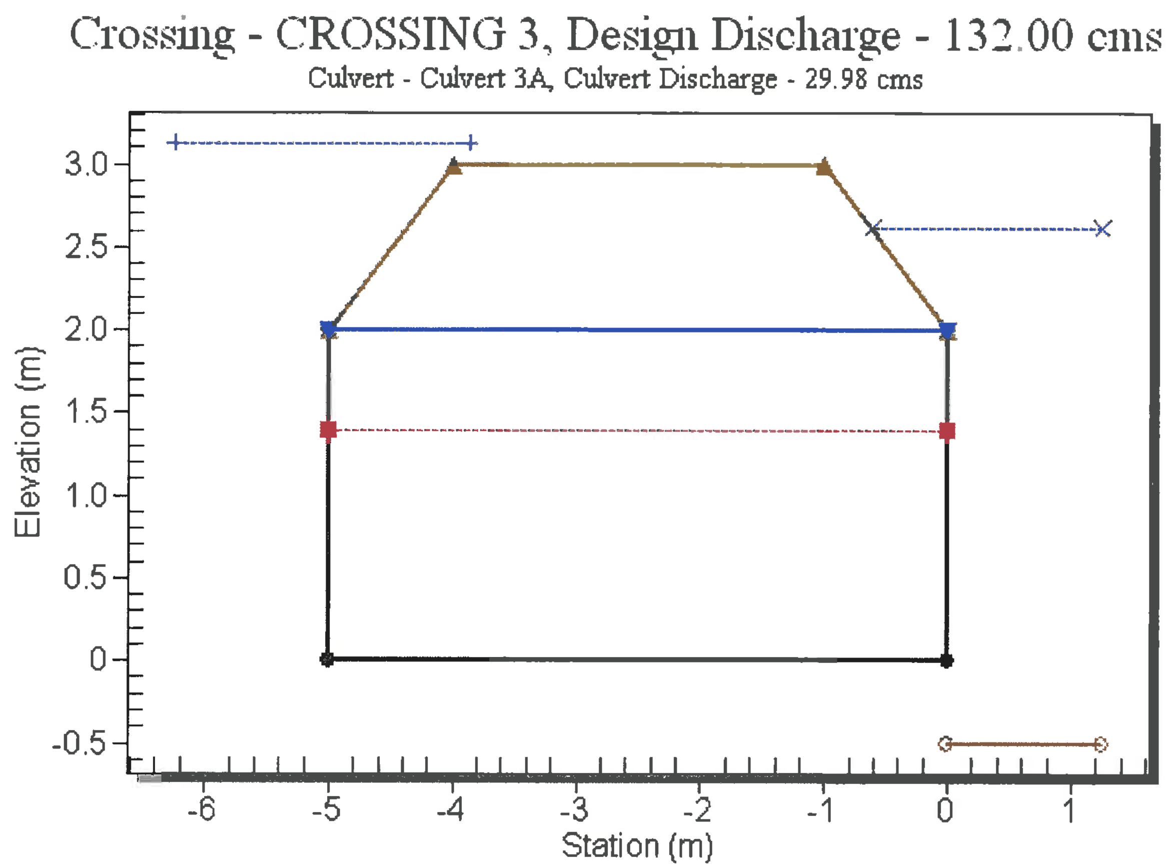
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3A



Site Data - Culvert 3A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3A

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 3B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

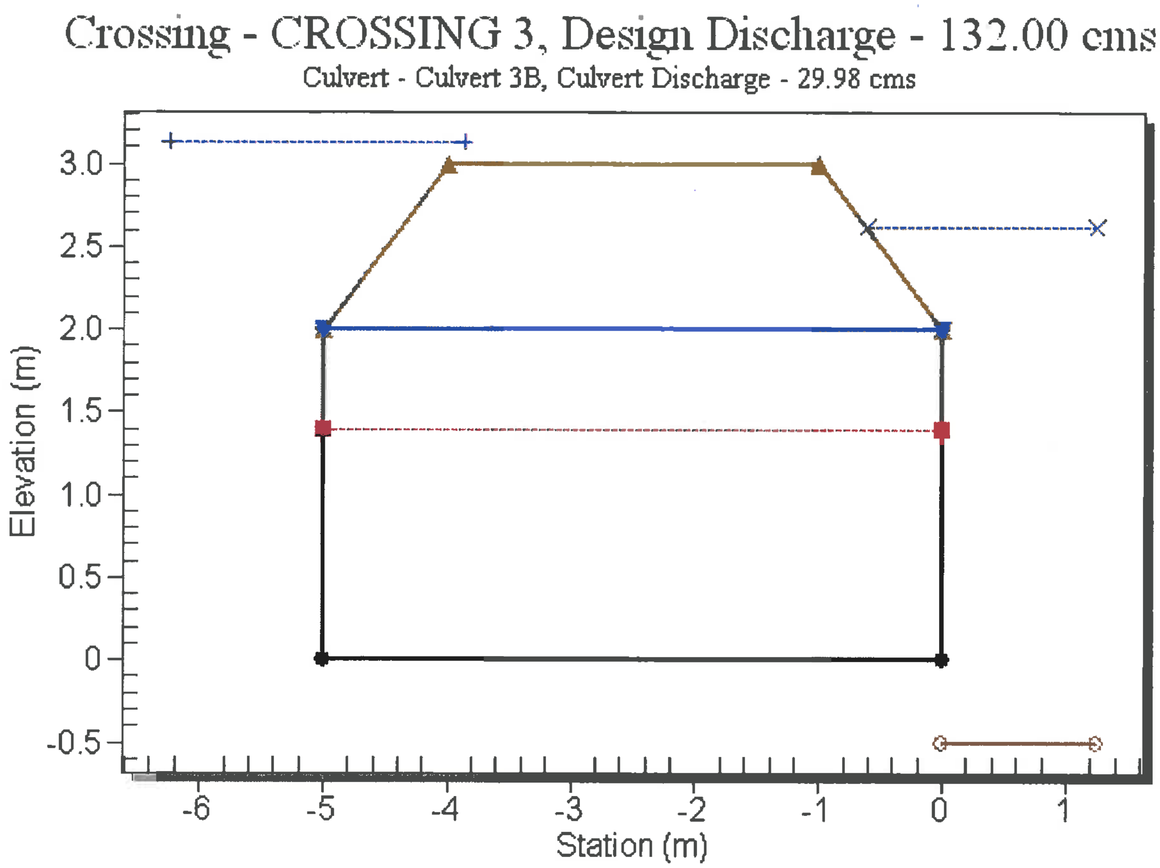
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3B



Site Data - Culvert 3B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3B

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 3C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

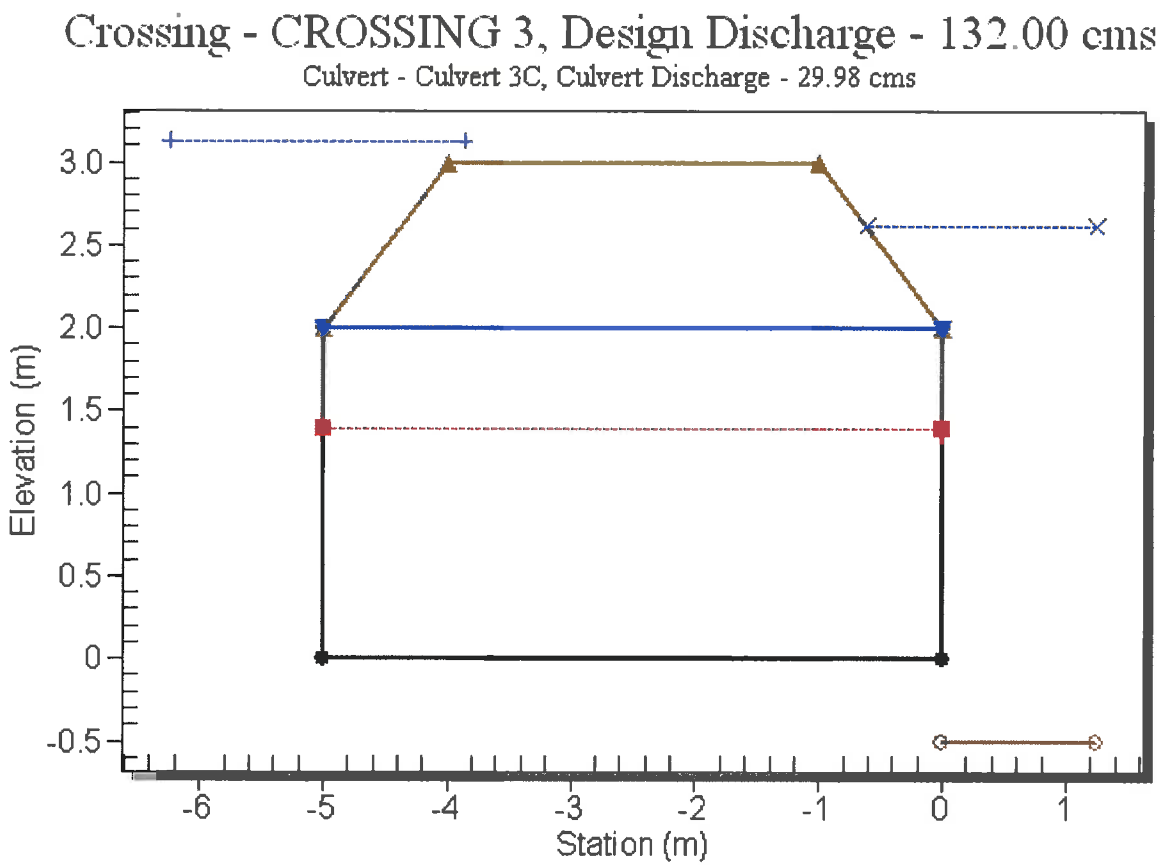
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3C



Site Data - Culvert 3C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3C

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Downstream Channel Rating Curve (Crossing: CROSSING 3)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
71.47	1.81	2.31	3.21	226.92	0.82
77.57	1.91	2.41	3.28	236.29	0.82
83.67	2.00	2.50	3.34	245.25	0.83
89.77	2.09	2.59	3.41	253.84	0.83
95.87	2.17	2.67	3.47	262.10	0.83
101.98	2.26	2.76	3.52	270.06	0.84
108.08	2.33	2.83	3.58	277.75	0.84
114.18	2.41	2.91	3.63	285.19	0.84
120.28	2.48	2.98	3.68	292.40	0.84
126.38	2.55	3.05	3.72	299.40	0.85
132.00	2.62	3.12	3.77	305.67	0.85

Tailwater Channel Data - CROSSING 3

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 5.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: -0.50 m

Roadway Data for Crossing: CROSSING 3

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 500.00 m

Crest Elevation: 3.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 3	
Culvert	Culvert 3A	
Flow	132.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	5.8	m
Culvert Height	2.0	m
Outlet Depth	2.00	m
Outlet Velocity	2.58	m/s
Froude Number	0.58	
Tailwater Depth	3.12	m
Tailwater Velocity	3.77	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	100.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.161	kPa
Modified Shear Number	1.988	
Scour Hole Dimensions		
Length (LS)	29.855	m
Width (WS)	21.665	m
Depth (DS)	5.099	m
Volume (VS)	644.857	m^3
DS at 0.4(LS)	11.942	m
Tailwater Depth (TW)	3.118	m
Velocity with TW and WS	0.345	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 4

Headwater Elevation (m)	Total Discharge (cms)	Culvert 4A Discharge (cms)	Culvert 4B Discharge (cms)	Roadway Discharge (cms)	Iterations
1.02	16.93	8.54	8.54	0.00	11
1.06	18.24	9.20	9.20	0.00	10
1.11	19.54	9.81	9.81	0.00	9
1.15	20.85	10.43	10.43	0.00	8
1.19	22.16	11.12	11.12	0.00	7
1.23	23.47	11.75	11.75	0.00	7
1.27	24.77	12.43	12.43	0.00	6
1.31	26.08	13.06	13.06	0.00	6
1.32	27.39	8.26	8.26	0.00	11
1.32	28.69	18.24	18.24	0.00	6
1.32	29.00	18.24	18.24	0.00	4
3.00	61.39	30.70	30.70	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 4A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
16.93	8.54	1.02	0.807	1.017	6-FFt	1.458	0.470	0.998	0.997	1.007	1.887
18.24	9.20	1.06	0.848	1.062	6-FFt	1.532	0.493	1.040	1.040	1.040	1.932
19.54	9.81	1.11	0.885	1.107	6-FFt	1.601	0.515	1.081	1.081	1.067	1.974
20.85	10.43	1.15	0.922	1.150	6-FFt	1.668	0.537	1.121	1.121	1.095	2.013
22.16	11.12	1.19	0.962	1.192	6-FFt	1.742	0.560	1.160	1.159	1.128	2.051
23.47	11.75	1.23	0.997	1.234	6-FFt	2.000	0.581	1.197	1.197	1.155	2.087
24.77	12.43	1.27	1.033	1.275	6-FFt	2.000	0.603	1.234	1.233	1.186	2.122
26.08	13.06	1.31	1.066	1.315	6-FFt	2.000	0.623	1.269	1.269	1.210	2.155
27.39	8.26	1.32	0.789	1.322	6-FFt	1.426	0.459	1.304	1.304	0.745	2.187
28.69	18.24	1.32	1.322	1.426	6-FFt	2.000	0.779	1.338	1.337	1.604	2.218
29.00	18.24	1.32	1.322	1.434	6-FFt	2.000	0.779	1.346	1.345	1.595	2.225

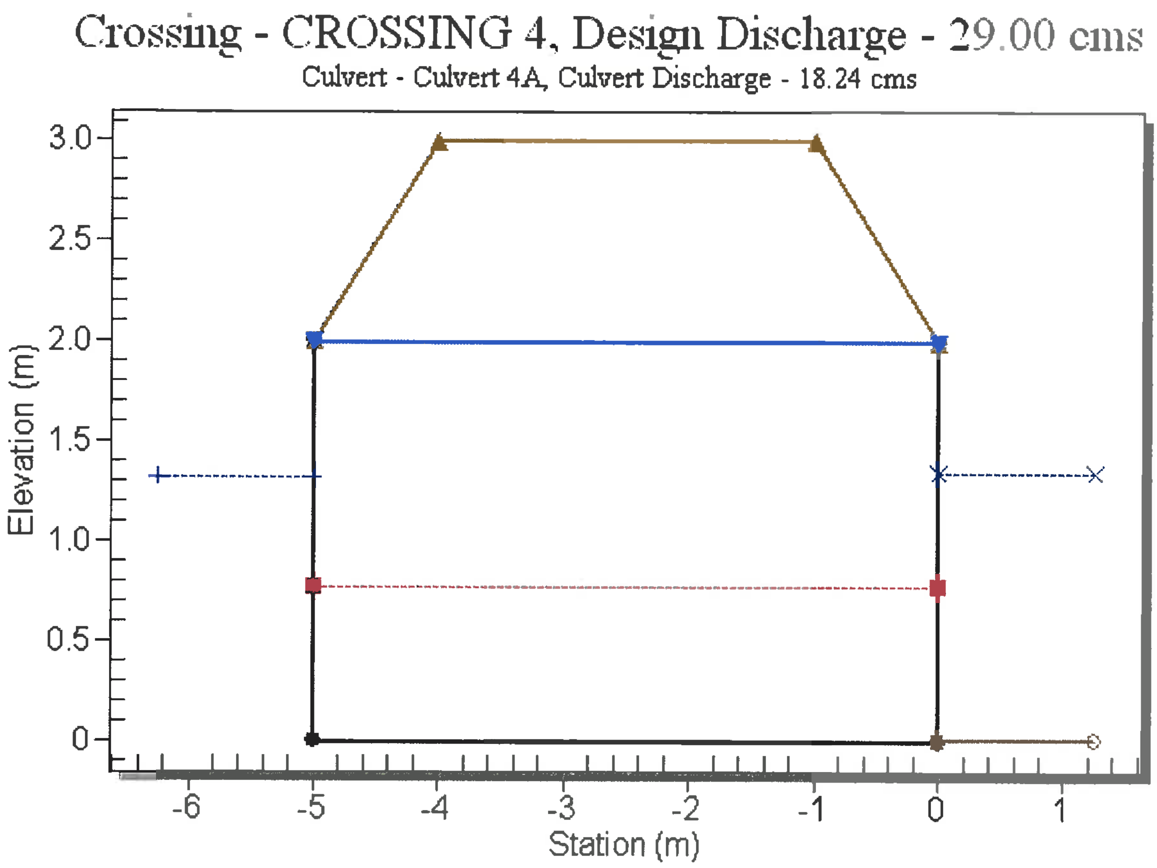
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 4A



Site Data - Culvert 4A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 4A

Barrel Shape: Concrete Box

Barrel Span: 8500.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 4B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
16.93	8.54	1.02	0.807	1.017	6-FFt	1.458	0.470	0.998	0.997	1.007	1.887
18.24	9.20	1.06	0.848	1.062	6-FFt	1.532	0.493	1.040	1.040	1.040	1.932
19.54	9.81	1.11	0.885	1.107	6-FFt	1.601	0.515	1.081	1.081	1.067	1.974
20.85	10.43	1.15	0.922	1.150	6-FFt	1.668	0.537	1.121	1.121	1.095	2.013
22.16	11.12	1.19	0.962	1.192	6-FFt	1.742	0.560	1.160	1.159	1.128	2.051
23.47	11.75	1.23	0.997	1.234	6-FFt	2.000	0.581	1.197	1.197	1.155	2.087
24.77	12.43	1.27	1.033	1.275	6-FFt	2.000	0.603	1.234	1.233	1.186	2.122
26.08	13.06	1.31	1.066	1.315	6-FFt	2.000	0.623	1.269	1.269	1.210	2.155
27.39	8.26	1.32	0.789	1.322	6-FFt	1.426	0.459	1.304	1.304	0.745	2.187
28.69	18.24	1.32	1.322	1.426	6-FFt	2.000	0.779	1.338	1.337	1.604	2.218
29.00	18.24	1.32	1.322	1.434	6-FFt	2.000	0.779	1.346	1.345	1.595	2.225

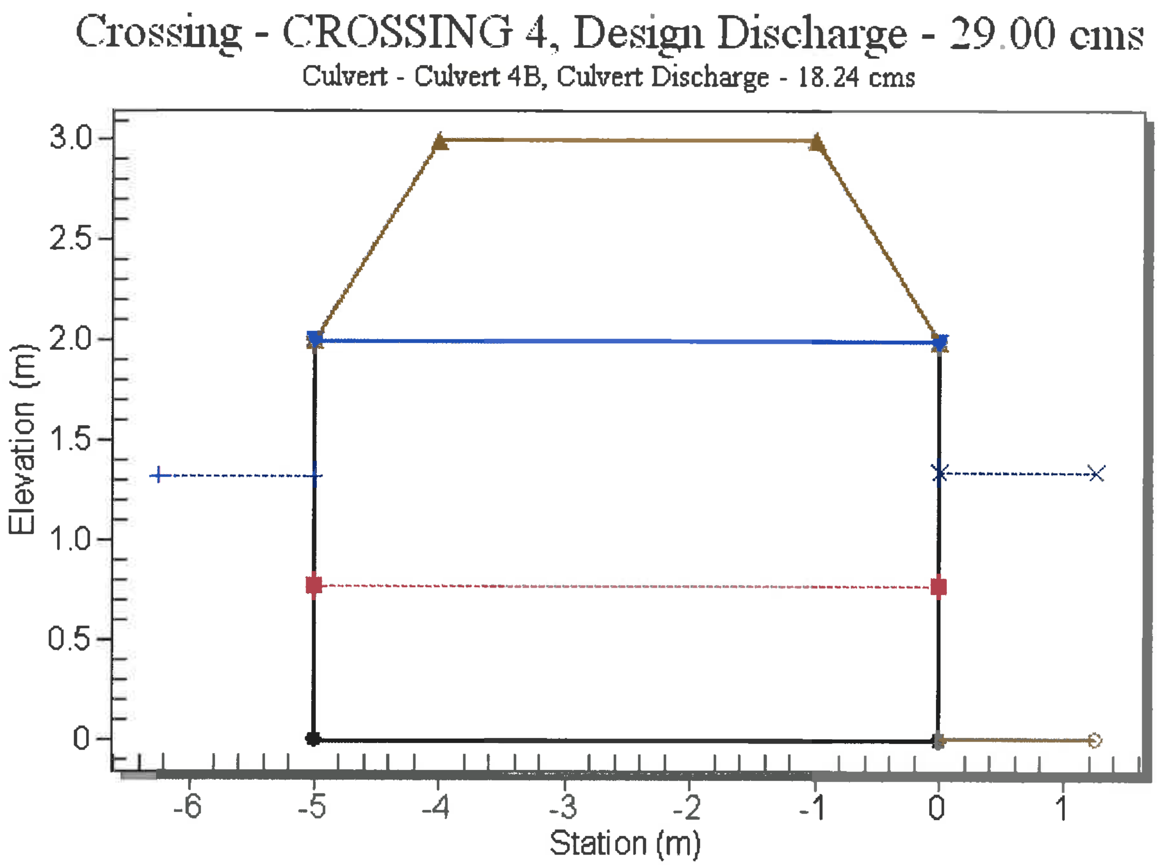
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 4B



Site Data - Culvert 4B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 4B

Barrel Shape: Concrete Box

Barrel Span: 8500.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Downstream Channel Rating Curve (Crossing: CROSSING 4)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
16.93	1.00	1.00	1.89	97.75	0.67
18.24	1.04	1.04	1.93	101.93	0.67
19.54	1.08	1.08	1.97	105.95	0.67
20.85	1.12	1.12	2.01	109.86	0.68
22.16	1.16	1.16	2.05	113.64	0.68
23.47	1.20	1.20	2.09	117.32	0.68
24.77	1.23	1.23	2.12	120.89	0.68
26.08	1.27	1.27	2.15	124.38	0.69
27.39	1.30	1.30	2.19	127.78	0.69
28.69	1.34	1.34	2.22	131.09	0.69
29.00	1.35	1.35	2.22	131.86	0.69

Tailwater Channel Data - CROSSING 4

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 7.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0450

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 4

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 330.00 m

Crest Elevation: 3.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 4	
Culvert	Culvert 4A	
Flow	29.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	8.5	m
Culvert Height	2.0	m
Outlet Depth	1.35	m
Outlet Velocity	1.59	m/s
Froude Number	0.44	
Tailwater Depth	1.35	m
Tailwater Velocity	2.22	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	400.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.605	kPa
Modified Shear Number	0.201	
Scour Hole Dimensions		
Length (LS)	13.920	m
Width (WS)	14.573	m
Depth (DS)	3.352	m
Volume (VS)	74.992	m^3
DS at 0.4(LS)	5.568	m
Tailwater Depth (TW)	1.345	m
Velocity with TW and WS	0.785	m/s

Appendix B

ESCP

Figure 24: Railway Bridge #3 showing main flow path of Abernethys creek with waterway 3 flowing under one cell

Figure 25: Heavy weed infestation at waterway crossing 3, looking upstream.

Figure 26: Vegetation in downstream reach, looking east toward floodplain

Figure 27: Looking south toward Edwards Avenue, at waterway crossing 3

Figure 28: Looking south toward steep section leading down to waterway 3.

3.7.4 Waterway Crossing 4

Figure 29: Looking south along proposed gas pipeline route, on crest of hill before relatively steep down grade to waterway crossing 4, along un-named road reserve.

Figure 30: Looking south down un-named road reserve, toward waterway crossing 4

Figure 31: Large bridge #4 just upstream of waterway crossing 4.

Figure 32: Heavy weed infestation at waterway 4 crossing

Figure 33: Existing stabilised vehicle crossing over waterway 4, immediately upstream of proposed pipeline crossing point

Figure 34: Looking South along un-named road reserve at proposed waterway crossing 4, with vegetation types shown

Figure 35: Waterway crossing 4, showing terrestrial and aquatic vegetation.

Figure 36: Floodplain and downstream reach of waterway crossing 4

Figure 37: Looking East over floodplain (northern bank of Shoalhaven River), downstream of waterway crossing 4

Figure 38: Low lying area downstream of waterway crossing 4

3.7.5 Waterway History

Changes to the waterways seem to have occurred only recently from European settlement in the area. An early Parish map obtained from the Department of Lands was proclaimed on the 31st of May 1895, (Appendix F) and discontinued in December 1916. From this it can be seen that the waterways are approximately in the same locations as they can be seen today.

Information obtained from the NSW Office of Environment and Heritage shows the single track, Illawarra Railway continued from Kiama Station and terminated at Bomaderry Station on the 2nd of June 1893.

It would seem that the culverts and bridges located just upstream of the waterway crossings were built for natural waterways that existed prior to construction of the elevated railway.

The configuration of the waterways, upstream of the railway line was observed to have changed based on the differences noticed between the latest 1:4000 topographic map of the area (Appendix F) and a 1:4000 topographic map dated 31st of May 1895 (Appendix J). It is most likely that natural waterways leading into low lying areas were extended as modified drainage channels and continued through to the Tullian and Abernethys Creeks.

Although these findings show that the waterways being crossed by the gas pipeline have changed slightly over the last 116 years, it is unlikely that significant changes will occur at the waterway crossing positions due to upstream varying conditions. Most of the areas immediately upstream of the waterway crossings are stable due to being occupied and utilized for farming or residential housing. The culverts and bridges at these positions are fixed and are likely to remain fixed points of impact for the lifespan of the pipeline.

3.7.1 Soil and Land

Meroo Meadow and Bomaderry are situated adjacent to and partly on the Lower Shoalhaven River floodplain. Main soils types in this area originate from Permian siltstone and shales of the Berry Formation, and Gerringong Volcanics (mainly west of the Princes Hwy), with quaternary river alluvium in the Shoalhaven floodplain (mainly east of the Princes Hwy).

Soils are typical of the area and do not require special treatment during excavation, except where acid sulphate soils are disturbed. The main component of significance in these soils is iron sulphide, which reacts with the atmosphere to form sulphuric acid. Erosion and excavation provides the means by which

the iron sulphide is uncovered or disturbed and therefore exposed to the atmosphere. The area surrounding Meroo Meadow and Bomaderry contains small wetland areas prone to flooding with a low probability of disturbing acid sulphate soils along the proposed gas main route. These areas are shown in the Shoalhaven LEP and should be identified in the ESCP, with appropriate treatment procedures developed.

Rainfall erosivity factor (R) for soils in the region is approximately 4250 mm/ha.hr.yr, as shown on Map 11: Rainfall Erosivity of the Wollongong 1:250,000 topographic Sheet, obtained from Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition, March 2004. The soils are described as having 'low permeability and low wet bearing strength, High run-on; localized shallow soils with localized rock outcrop'[1].

The proposed route follows a path mainly over 'prime agricultural land'. The current Shoalhaven Local Environmental Plan (1985) states that land classified as 1, 2 or 3 under the Department of Primary Industry's land classification system is regarded as 'prime crop and pasture' land. The proposed route is situated mainly through class 2 classified areas. Even though the proposed route is through prime agricultural land, it is located over existing formed and unformed road reserves, and a small portion of the railway reserve.

The longitudinal and transverse grade of the proposed route is generally flat, with gentle fall predominately toward the south-east. A number of areas along the route are relatively steep both longitudinally and transversely (greater than 1:4). Fortunately the longitudinal grades of waterways at proposed crossings are relatively flat and grade back toward the north and north-west. These positions are located generally at the Edwards Ave intersection, and along the un-named road reserve and Railway Street, adjacent to the train track.

The waterway cross sections at crossing points are trapezoidal, with flat bottomed beds. The longitudinal grade of the waterway beds at proposed crossings points are 0.4%, 0.5%, 0.5% and 0.8% respectively. Gradients were determined from 1:4000 topographic map contours.

The transverse gradient of land at the crossings is flat along the un-named road reserve, except for the land to the south of proposed waterway crossing at position 9, which falls relatively steeply back toward

the waterway from Edwards Avenue. The waterway crossing at position 11 is situated in a gully, with two steep sections either side grading back toward the waterway.

The potential for sedimentation and erosion issues is greatest at the steeper locations of the proposed gas pipeline route, especially adjacent to waterways, table drains, culverts and the Shoalhaven City Council stormwater system.

3.8 Waterway and Riparian Zone Assessment

Riparian lands are transition zones between terrestrial and aquatic environments. Section 5.2 of the Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1 Fourth Edition (Blue Book) describes three broad categories for riparian land. These include;
Category 1 – Environmental Corridor
Category 2 – Terrestrial and Aquatic habitat
Category 3 – Bank stability and water quality

Depending on the category, different management regimes apply to each. Site investigation, and study of the draft Shoalhaven LEP has determined that the riparian zones of the waterways at the crossing locations, as given in Figure 1 Appendix A, are categorised as follows;

- Waterway crossing 1 : Category 3
- Waterway crossing 2 : Category 3
- Waterway crossing 3 : Category 2
- Waterway crossing 4 : Category 2

Although waterway crossings 1 and 2 could be classed as category 2, since they have the potential to allow animals to cross over from one side of the floodplain to the other side, the waterways are greatly modified and located mainly on grazed agricultural land.

Waterway classification is used to identify minimum riparian corridor widths along waterways. Category 2 – Terrestrial and Aquatic Habitat classification aims to provide for a viable and robust node or reach of riparian habitat (both aquatic and terrestrial), with minimum CRZ width of 20m (measure from top of bank) along both sides of the watercourse with a 10m vegetated buffer zone either side.
The aim of maintenance and restoration of Category 2 waterways is to maintain native riparian vegetations, water quality, bank stability and provide suitable native animal habitats.

Due to the nature of these category 2 waterways, at the crossing locations with cattle grazing within the 20m wide CRZ over both banks, and the lack of existing diversified vegetation, the 10m wide vegetation buffer is not considered necessary.

Waterways classified as Category 3 require minimisation of sediment and nutrient transfer to provide bank stability, water quality and native vegetation protection. These are generally achieved where possible by emulating a naturally functioning stream, providing terrestrial and aquatic vegetated habitat refuges, using pipes and other engineering devices as a last resort and treating stormwater runoff before discharging to riparian zones or waterway.

The two Category 3 waterways are highly modified from natural conditions with a lack of diversified native vegetation. Cattle grazes within the 10m wide core riparian zones on either bank.

See Appendix E for further Details

3.8.1 Sea Level Rise

Shoalhaven City Council has commissioned revised flood modeling of the Lower Shoalhaven River Floodplain to assess the impacts on climate change induced sea level rise on flood levels. The information that follows was obtained from their recently made available climate change assessment report titled 'Lower Shoalhaven River Floodplain Management Study and Plan – Climate Change Assessment (CCA).

Based on the following information using the 1% AEP flood event for comparison, during the proposed gas pipeline's minimum service design life of 30 years the amount of flood level rise at the proposed development site due to sea level rise is insignificant. The possible increase in flood levels across the proposed gas main site due to sea level rise is comparatively small with respect to current flood levels during the 1% AEP flood event (0.36% max). Due to this, erosion and sediment control during construction of the proposed gas pipeline will not be affected by sea level rise, nor will there be need to tailor erosion and sediment control to compensate for sea level rise.

The proposed development is located approximately 12 to 15 km from the entrance of the Shoalhaven River. The proposed position of the gas main corresponds to cells 8 & 14 of Figure 1 in the CCA report. Referring to Figure 3 of the CCA report, by 2050 the anticipated benchmark 400mm rise in sea level will possibly cause a corresponding maximum 10 mm flood level rise during the 1%AEP flood event. By

2100 the increase to the flood level during the 1%AEP flood event across the site from an anticipated 900mm rise in sea level will be approximately 20mm.

Figure 46 of the Lower Shoalhaven River Flood Study (April 1990) shows the peak flood level during the 1% AEP flood event to be approximately 5.6m AHD. Comparing Figure 1 of the CCA report which shows the existing 1% AEP flood extent, to figures 2 and 4, the anticipated 1% AEP flood event in the years 2050 and 2100 respectively show there is no significant change to the flood extent across the proposed gas pipeline site.

Referring to figure 3 of the CCA report, the flood hazard category in the year 2050 over the area where the proposed gas pipeline will be situated remains consistent with the existing flood hazard category of 'High Hazard Flood Storage' as shown in figure 2 of the 'Lower Shoalhaven River Floodplain Risk Management Plan'.

Since over half of the proposed gas main will be situated in High Hazard flood storage area on the Shoalhaven River flood plane, an assessment of sea level rise on the proposed gas pipeline was made. It was found that there will be insignificant impacts to the gas pipeline, with respect to erosion and sediment control.

NSW Government Policy on Sea Level Rise

The NSW Department of Planning has issued a policy statement entitled "NSW Sea Level Rise Policy Statement" October 2009 which outlines the NSW Government's attitude towards the impacts of sea level rise on regional planning and new development.

The policy states the following:

The NSW sea level rise planning benchmarks are an increase above 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100, with the two benchmarks allowing for consideration of sea level rise over different timeframes. The benchmarks were established by considering the most credible national and international projections of sea level rise and take into consideration the uncertainty associated with sea level rise projections. The Government will continue to monitor sea level rise observations and projections and will periodically review these planning benchmarks, with the next review likely to coincide with the release of the fifth IPCC report, due in 2014.

and

The sea level rise planning benchmarks will support consistent consideration of the influence of sea level rise on any coastal hazards and flooding risks that may influence a development or redevelopment site. The benchmarks are not intended to be used to preclude development of land that is projected to be affected by sea level rise. The goal is to ensure that such development recognises and can appropriately accommodate the projected impacts of sea level rise on coastal hazards and flooding over time, through appropriate site planning, design and development control.

Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments

The NSW Department of Environment, Climate Change and Water has issued a report entitled "*Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments",* August 2010.

The report adopts the planning benchmarks of the *NSW Government Policy on Sea level Rise* and provides guidance as to how to apply sea level rise benchmarks to flood risk assessments which are undertaken for flood affected areas.

The Guide states the following:

This guide applies to areas where projected sea level rise is likely to have a discernable impact on predicted flood levels. This includes the NSW Coastal Zone and areas in the vicinity of lower coastal waterways, including rivers, creeks, estuaries and ICOLLs. In particular, this is likely to apply if the land is:
• likely to be inundated if water levels were 1.0 m above the upper limit of the current tidal range, generally defined by mean high water springs
• likely to be inundated if water levels were 1.0 m above the current flood planning level
• within 1.5 m of the maximum historic height of the entrance berm or the upper limit for management intervention identified in entrance management plans for any ocean entrance to the waterway which controls flooding (this commonly applies to ICOLLs)
• below 4 m AHD.

The Guide also states:

Where a flood investigation has been prepared, the modeling can be updated to include sea level rise projections or a conservative assumption can be made about sea level rise impacts. Where the site is below 4 m AHD, an appropriate conservative assumption to estimate the 1-in-100 year ARI flood level is to add the sea level rise benchmarks to the 1-in-100 year ARI flood level relevant to the site.

3.8.2 Soil Analysis

Soil data was obtained from a borehole log report prepared by Coffey Environments on the 21-06-2011. Boreholes 17, 16, 12 and 10 correspond to waterway crossing locations 7, 8, 9 and 11 respectively and are available in Appendix G.

In general, the soils at proposed waterway crossings were fine grained, cohesive, highly plastic, clays and sandy clays, with shear saturated shear strengths between 100 and 400 kPa.

A soil sieve analysis for grain size was not made.

3.8.3 Vegetation

Vegetation within the waterways and riparian zones were found to be common between the four waterway crossings. Remnant vegetation adjacent the proposed gas pipeline route on the Shoalhaven floodplain is most likely from forested or saline wetlands, which would have been removed to make way for the railway reserve, train track and agriculture (dairy farming).

Overall condition of existing riparian vegetation was poor with low structural and floristic diversity, significant weed infestation, and exposed soils observed along stream banks.

The main vegetation type found in riparian zones was kikuyu grass with sporadic plantings of native trees and shrubs, mainly at low lying areas downstream on the floodplain.

Waterway vegetation consists mainly of aquatic weeds and reed beds that have grown through the grass lined waterways.

Extensive weed infestations were identified along all of the proposed waterway crossings, which included a number of noxious weeds, listed under class 4 and 5 of the Shoalhaven Local Government Area.

Lantana and blackberry was found at number of locations along the un-named road reserve and waterway crossings. It is recommended that these be removed during work site and haul road preparation to improve overall ecosystem health and allow the re-establishment of native species.

Lantana can be removed by cutting and mulching back into the ground. This method will provide some soil protection following weed removal to reduce both erosion and further weed infestation.

A vegetation management plan (VMP) is generally required to ensure riparian areas are managed appropriately and in accordance with strategic objectives. The VMP outlines management zones and establish guidelines for riparian management, focusing on the required actions to carry out the above recommendations. In addition, the VMP also incorporates site specific measures relating to personnel access, weed management, incident management, ASS, surface drainage and erosion controls.

For the Shoalhaven Starches gas pipeline project, a VMP is not considered necessary due to the proposed route being mainly in road reserves with little to no native vegetation along the route being disturbed. The majority of vegetation being disturbed is Kikuyu grass, which can be replaced by seeding or turfing.

To counteract the lack of a VMP, the ESCP should go into greater detail than normal regarding rehabilitation of disturbed vegetation, making every effort to ensure that disturbed areas are rehabilitated to existing conditions. Areas along the proposed route with native vegetation, such as waterways and road verges that contain shrubs and trees, should be identified in the ESCP and details given of how removed native vegetation will be replaced.

3.9 Erosion and Scour

Fluvial scour and bank erosion was observed at all waterway crossing locations. The majority of scour and erosion has occurred between the proposed waterway crossings and the culvert or bridge in the railway reserve immediately upstream of the crossing points. Limited erosion and scour has occurred downstream of the waterway crossings.

Outlets of culverts and bridges are known areas of significant scour and erosion. The waterway crossings were modelled to estimate the maximum scour depth due to a 1 in 100 year flood event. This is to determine the minimum depth of cover required to mitigate scour impacts on the gas pipeline under the waterway crossings. It should be noted that over time, a balance is reached at scour holes, where the depth remains constant and does not keep on growing, unless a significant morphologic change occurs to the waterway. Eroded sediment is transported from upstream and gets deposited at the scour hole. The 1 in 100 year storm event was chosen since it is used by Shoalhaven Starches for their planning policies.

3.9.1 Scour Depth

There is potential for a buried pipeline to be uncovered at waterway crossings. The minimum depth of burial, or soil cover over the pipeline is stipulated so that damage is prevented to the pipeline. Once buried, the pipeline is to remain in its covered state unless specifically removed.

Determining an adequate amount of cover over a pipeline that crosses under the bed of a waterway requires consideration of the effect of scour caused by the flooding characteristics of the waterway and the floodplain immediately in the vicinity of the crossings. As water flows through a waterway or over a surface, scour or erosion of the surface will occur when conditions are suitable. This is generally dependant on the characteristics of the waterway; materials used to construct the waterway; flow velocity and soil type.

Information from site inspections and desktop studies was used with HY-8 software form the United States Department of Transportation – Federal Highway Administration, to determine the scour potential and minimum depth of cover required between the beds of each waterway crossing. This software is based on the document, 'Hydraulic Design of Energy Dissipaters for Culverts and Channels', Publication No. FHWA-NHI-06-086 July 2006 Hydraulic Engineering Circular No. 14 Third Edition which is also used as a reference manual for the Australian Rainfall and Runoff Manual.

This report presents preliminary scour depth modelling results obtained from a simplified deterministic analysis. Sstatistical variance of the storm events, sediment transport, flow rates etc is not considered. Modelling was determined to be feasible, without the need for detailed survey data of the flood plain and waterways, by obtaining relative measurements of bridges and culverts, waterways, railway track and ballast, and undertaking a desktop study to obtain interpolated data from existing topographic maps and soil test results.

It is recommended that probabilistic modelling of scour depth be undertaken as part of the detailed design of the gas pipeline, and results compared with those presented in this report.

The most significant form of scour occurring at the waterway crossings is localised scour at the outlet of bridge/culverts, due to the large catchment coupled with the size of the bridge/culverts, and constriction of the waterways as they flow under the railway track, increasing the velocity through the opening. Peak flow rate calculations for catchments are available in Appendix H

The following assumptions were made for scour depth modelling presented in this report;

- All culverts are 5m wide.
- There is zero fall through bridge/culverts.
- Railway deck above bridge/culvert is level.
- Mannings is constant for banks and channels.
- Waterway cross sections are trapezoidal and level
- Culvert invert is at the same level as the waterway invert.
- Sub-catchments do not join together during large stormwater events.

A sensitivity analysis was made on important waterway variables including longitudinal waterway gradient, waterway bank and channel Mannings numbers, soil Plasticity Index and saturated shear stress. It was found that the most significant variables to affect scour depth are soil Plasticity Index and saturated soil shear stress.

HY-8 recommends an Atterberg limits test to determine the plasticity index (PI) by using the procedure outlined in ASTM D423-36. This test was not done as part of Coffey Environments Soil Analysis Report. The report does give descriptions of the plasticity of the soil. For all waterway crossings the soils were of

medium to high plasticity'. HY-8 requires an input between the limits of 5-15 for the Plasticity Index, which corresponds to medium and high plasticity soils.

It is also recommended to obtain Saturated Shear Stress values from a test done in accordance with ASTM D211-66-76. The Coffey Environments soil analysis report shows a pocket petrometer test being done, with values of shear stress ranging from approximately 50kPa to 400kPa along the route. This is an equivalent test to the recommended HY-8 test, ASTM D211-66-76.

A sensitivity test of the Plasticity Index (PI) and Saturated Shear Stress (SSS) with respect to scour depth was made between PI values of 10 and 15, and SSS values from +50 and -50 kPa from values given in the Coffey Environments Bore hole log report. The results of the sensitivity analysis showed that incrementing the HY-8 plasticity Index from 10 to the upper limit of 15 caused the modelled scour depth to increase by approximately 200mm, (5.7%). By altering the SSS results, a 180mm (5.5%) change in scour depth resulted. This can be considered insignificant as a factor of safety will need to be considered which will result in the depth of covers increasing well beyond these values.

Scour depth results are available in Appendix I. A summary table of each waterway crossing is provided in the following section, including calculated scour depth.

3.10 Geomorphic Assessment Conclusions and Recommendations

- Changes to waterway morphology is limited with no major changes to waterways observed in 116 year period.
- Minor morphological changes are occurring at outlets of bridges/culverts under railway tracks, just upstream of proposed waterway crossings.
- The major cause of morphological change is erosion occurring at proposed waterway crossings, from localised fluvial scour at outlet of culvert/bridges.
- Velocity of flow over proposed waterway crossings is above 2.0m/s, at three of the four waterway crossings, meaning there is a very high chance of scour occurring at these locations.
- The lack of healthy, diverse and continuous riparian vegetation along the bank of each waterway within the unnamed road reserve is contributing to bank erosion and instability.
- It is likely that revegetation works within the riparian zone will prevent bank recession continuing due to fluvial scour during small stormwater events.

- Protecting the toe and banks of waterway crossings along the width of the road reserve, increasing groundcover and promoting binding root growth as close to the toe of the bank as possible may be adequate to resist scour.
- The Core Riparian Zones of all waterways at their proposed crossings are highly degraded due to weed infestation, large flows and velocities, and the lack of an appropriate cattle grazing setback. It is recommended that waterway crossings 1 and 2 be classified as Category 3, and waterway crossings 3 and 4 be classified as Category 2, as per the draft Shoalhaven LEP, and section 5.2 of Landcoms Blue Book;
- Category 3 waterways have no CRZ width requirements, whilst Category 2 waterways require a 40m wide CRZ over the waterways with 10m wide vegetation buffer zone either side of the CRZ.
- Table 1 below shows scour depths and expected length of scour hole in meters downstream of culvert/bridge outlet. It can be seen that the calculated scour depths may not be reached at the pipeline crossing, especially if the proposed crossing points are at the outer boundary of the un-named road reserve. Since there is approximately 15m of railway reserve between the culvert/bridge and the common boundary between railway reserve and road reserve, it is estimated that greatest amount of scour will occur mainly within the railway reserve, and possibly decrease in depth as it approaches the waterway crossings.
- From the scour depth results, the minimum pipeline depth of cover at waterway crossing 3 will need to be increased from the minimum 2.0m, to a minimum of 5.1m. The minimum 2m depth of cover under the waterway beds at waterway crossings 1, 2, and 4 should be satisfactory.
- Further variance based modelling of scour at the waterway crossings is required, during detailed design, to take into consideration statistical variance of scour depth variables. The estimated scour hole lengths show that the calculated scour depths may be reached at waterway crossings 2 and 4. See Appendix E for further Detail

Table 1: Summary of Waterway Crossings and Scour Results

Water-way	*Waterway cross-section*			*Long-Grade*	*1%AEP Flow Rate*	*Soil Shear Strength*	*Culvert Outlet Velocity*	*Scour Depth*	*Scour Hole length*
	Depth (m)	*Bed Width (m)*	*Bank Widths (m)*	*%*	*(m^3/s)*	*(kPa)*	*(m/s)*	*(m)*	*From Culvert outlet (m)*
1	0.5	5.0	1	0.3	2.84	100	1.20	0.9	4
2	1.5	6.5	2	0.5	64.4	200	3.06	2.3	12
3	1.0	7.0	1	0.5	132	100	3.72	5.1	30
4	0.8	5.0	1	0.8	30.0	400	2.72	3.4	14

3.11 Site Rehabilitation, Maintenance and Monitoring

Continual site remediation and restoration is required during the proposed pipeline construction process. Progressive re-vegetation, removal of temporary erosion & sediment control measures, and site stabilization requires detailed planning.

Rehabilitation, maintenance and monitoring of the pipeline route shall be established as part of the ESCP. The photographic evidence presented in this report can be used to aid rehabilitation of disturbed sites, back to pre-existing conditions shown in the photos.

A vegetation management plan (VMP) should not be required from a qualified Landscape Architect shall due to the lack of diversified vegetation found along the proposed route and waterway crossings. To ensure adequate rehabilitation of each waterway's CRZ, vegetation rehabilitation and maintenance should be included as part of the ESCP, with all native trees and shrubs along the proposed route identified, and all native trees requiring removal to facilitate pipeline construction identified on the plan. For those areas requiring removal of native species, the ESCP should outline replacement species and their proposed location.

Top soils removed for trenching and work site preparation shall be stockpiled and reutilised over backfilled trenches and at rehabilitated work sites. If required, a top soil mix shall be prepared and approved by a qualified Landscape architect if further topsoil is required for adequate site rehabilitation.

Vehicle waterway crossings are to remain in place for the full rehabilitation period. Once rehabilitation has been established, vehicle crossings shall be removed and the waterways filled and regarded to match upstream and downstream conditions. Jute mesh is to be laid and secured over disturbed waterway crossing locations and the area re-vegetated through the jute mesh. If heavy flows are expected through re-vegetated waterways before adequate vegetation is established to protect the waterway, a temporary bypass around the disturbed waterway may be required, which is to be installed in accordance with the blue book.

Staged construction provides favorable conditions for re-vegetation. Progressive re-vegetation aims to minimize the area of disturbance during construction. Works should be staged and each stage stabilised immediately on completion of trench backfilling, or on removal of stockpiles placed over previously backfilled trenches. Since the majority of disturbed soils are within agricultural land (pasture), the

predominant vegetation affected is grass (kikuyu). The most immediately effective method of stabilization is to seed the disturbed area. More information regarding re-vegetation and site stabilization is available in Volume 1, section 7 of the Blue Book.

Maintenance and monitoring of erosion and sediment controls and rehabilitated areas is required on a periodic basis, to ensure the effectiveness of any mitigation measures implemented during and following the completion of the construction phase. Erosion and sediment controls are to remain in place after site works are officially completed, for a period not less than 6 months, or until 75% of the site has been adequately rehabilitated. This is to be decided by the superintendant of the project. The following table gives Monitoring requirements, frequency of monitoring and the person responsible for monitoring and maintenance;

Table 2: Rehabilitation Monitoring Requirements

Monitoring Requirement	Frequency	Responsibility
Erosion & Sediment Control Inspections	Weekly during construction and rehabilitation periods, and immediately after any storm event	Project Environmental Officer
Inspection of Waterways	Fortnightly until completion of entire project	Project Environmental Officer
Inspection of Vegetation	As per Vegetation Management Plan	Landscape Architect
Photographic Evidence (Riparian Zones and Waterways)	Fortnightly	Project Environmental Officer

4 Conclusion

Shoalhaven Starches have proposed to construct a 5.5km coated mild steel gas main to enable competitively priced gas to be sourced for the manufacturing operations at Bomaderry including a proposed gas co-generation plant,. The proposed pipeline will also provide for any future expansion at the Bomaderry site.

This report was written to address erosion and sediment control issues outlined under the heading of Soil and Water in the Director General's Requirements, Shoalhaven Starches Project (MP 10_0108), dated 8th November 2010, as part of the development application process.

Details of legislative requirements, project planning principles, documentation requirements, assessment of constraints and opportunities, site restoration and remediation, and general erosion and sediment control management procedures have been provided in this report.

Erosion and sediment control of linear service projects, such as the Shoalhaven Starches gas main, is legislated in NSW. The legislation relating to erosion and sediment control of service installation projects fall under the development assessment framework and provisions of the Environmental Planning and Assessment Act 1979 which include; Protection of the Environment Operations Act 1997, Water Management Act 2000, and the Fisheries Management Act 1984. Other legislation may affect the project which is listed in section 2.1.
Effective management of erosion and sediment control on linear service installation projects requires addressing planning activities which include developing systems for documentation and communication, assessing constraints and opportunities, preparing an ESCP, restoring and remediating sites and other planning considerations.

The project principal is responsible for ensuring all personnel are made aware of responsibilities for proper environmental management and care. The is achieved through the Environmental Management System (EMS).The principal and/or contractor(s) are required to develop an EMS, which is presented as part of the developers construction environmental management plan (CEMP). The CEMP is an active document, constantly being updated that; outlines environmental objectives and targets, describes how to manage and control the environmental aspects of the project, interfaces with all other plans, describes the overall project management system, and expands on the environmental section of the project business plan.

The CEMP should include the following to identify the aims, actions and outcomes required to meet the project's environmental objectives;

- Description of the principal's or contractor's environmental management system.
- CEMP objectives and targets.
- Risk Assessment.
- Constraints.
- Roles, responsibilities and contact details.
- Environmental controls.
- Monitoring and Compliance. [1]

Stabilised haul roads and machinery storage and stockpile sites are required along the route. These constrain pipeline construction. They require large surface areas to be disturbed and their position is critical for the efficient construction of the gas pipeline. Their location should be planed during the detailed erosion and sediment control plan construction stage. Stabilised work sites will be required at all waterway crossings, with adequate erosion and sediment controls put in place as per the Blue Book.

Since the majority of the proposed gas main route is over flat land, the use of simple erosion and sediment controls can be used. This includes sediment fence and straw bale filters which can be made to form almost any shape or follow any contour, and will divert and filter stormwater runoff. Geo-textile material placed to form temporary table drains can be used to divert water around work sites, and can be reused during later stages of the project.

Steeper sections along the route will also incorporate the same simple controls although additional controls will be required to adequately control runoff. This will depend on the steepness of the trench and how the contours grade around it. On steep sections along the route, check dams, trench stops and bulkheads placed within the trench will stop transportation of sediment and water toward the waterways. Trenches shall be stopped and a check dam installed at the boundary of all CRZs, before reaching the waterways. Appropriate waterway crossing techniques as described in Chapter 2 of this report, which were obtained from Landcoms Managing Urban Stormwater – Soils and Construction, Volume 1 , 4th Edition are to be used.

It is recommended that where possible, excavated soil is placed adjacent to the proposed main trench on the upstream side, so that stormwater runoff will push the soil back into the trench and not into any adjacent waterways. The mound can be used as a diversion drain by placing geo-textile material at the base of the stockpiles.

Location of waterway crossings was discussed. The recommended method of pipeline waterway crossing is by underbore as it will minimize the disturbance to the waterway and surrounding areas, and reduce the re-vegetation and stabilization stages. Trenching across waterways shall not occur.

Staged construction of the proposed gas main is recommended and should be planned for as it not only benefits re-vegetation and re-stabilisation of disturbed areas, it enables efficient management of topsoil, and material stockpiles along the route.

A geomorphic assessment of the four proposed pipeline waterway crossings determined that the waterways had not changed significantly over a 116 year period, and would not likely change during the lifespan of the gas pipeline.

Waterway crossings lacked adequate riparian zones, with cattle allowed to graze right up to the bank of waterways, contributing to the lack of diverse vegetation, and outbreak of weed varieties. Waterways were also choked with aquatic weeds. An adequate core riparian zone should be established at all waterway crossings, in accordance with the Blue Book, as a Category 2 – Terrestrial and Aquatic habitat, to increase bank stability thereby reducing the erosion potential at the site.

An assessment of scour at the waterway crossings was made with HY-8 modeling software. It was found that velocities through the culverts and bridges just upstream of the crossings were high enough to cause scour at the crossing points along the route. The minimum 2.0m depth of cover needs to be increased to take scour into consideration, in accordance with the scour depths calculated and presented under the Heading of Geomorphic Assessment Conclusions and Recommendations.

A rehabilitation, maintenance and monitoring program is to be established prior to construction, utilizing a vegetation management plan to ensure the environment along the route is returned to the same if not better condition it was in before construction commenced. Erosion and sediment controls will need to be maintained for a minimum period of 6 months, and regular site visits also made to monitor the condition of the erosion and sediment controls and determine when the site has stabilised.

5 Recommendations

Based on the site investigation conducted by Allen, Price and Associates, the Shoalhaven Starches gas pipeline project is achievable with the installation and maintenance off simple erosion and sediment controls during construction. To move the project forward with regards to erosion and sediment control of the proposed project, the following recommendations are made ;

- Determine the exact route that the proposed gas pipeline will follow.
- Begin development of the Environmental Management System, and the Construction Environmental Management Plan.

- Prepare Erosion and Sediment Control Plan for the site.
- Prepare Vegetation Management Plan.
- Obtain detailed survey of the entire site, including upstream and downstream floodplain and waterways, and areas beyond the road reserves where sediment laden waters may be carried.
- Undertake variance based modelling to determine scour depth at waterway crossings.
- Ensure all erosion and sediment control requirements will be met by becoming familiar with the legislative requirements relating to Erosion and sediment management of linear service projects.
- Notify land owners along the proposed route of any erosion and sediment controls that require construction on their property. Obtain written permission.
- Discuss requirements with Shoalhaven City Council.

Allen, Price & Associates

13 February 2012

6 References

1. *2008, Managing Urban Stormwater-Soils and Construction, Volume 2A-Installation of Services*, Department of Environment and Climate Change, Sydney, NSW.
2. *2004, Managing Urban Stormwater-Soils and Construction, Volume 1- 4th Edition*, Landcom, Sydney, NSW
3. Coffey Environments (2011). *Engineering Log – Borehole CBH100, CBH103 and CBH104*. Additional
4. Cowman Stoddart (2007). Preliminary *Environmental Assessment Report, Proposed Ethanol Production Upgrade*. Prepared for Shoalhaven Starches, Bomaderry, NSW.
5. DLWC (2000). *Soil and Landscape Issues in Environmental Impact Assessment, Technical Report*
6. DNR (2008). *Water legislation and policies: NSW Government Natural Resource*.
7. http://naturalresources.nsw.gov.au/water/wma2000.shtml, accessed 15 March 2008.
8. DIPNR (2004). *Riparian Corridor Management Study Guidelines*. Former Dept. of Water
9. DWE (2008a). *Guidelines for Controlled Activities: Riparian Corridors*. Water Management Act 2000. NSW Dept. of Water and Energy.
10. DWE (2008b). *Guidelines for Controlled Activities: Vegetation Management Plans*. Water Management, Act 2000. NSW Dept. of Water and Energy.
11. Weeds Australia, (n.d.). *Weed Identification, Kikuyu grass Pennisetum clandestinum*.
12. http://www.weeds.org.au/cgi-bin/weedident.cgi?tpl=plant.tpl&ibra=all&card=E27, accessed 10 Jan 2012

Appendix A – Figure 1

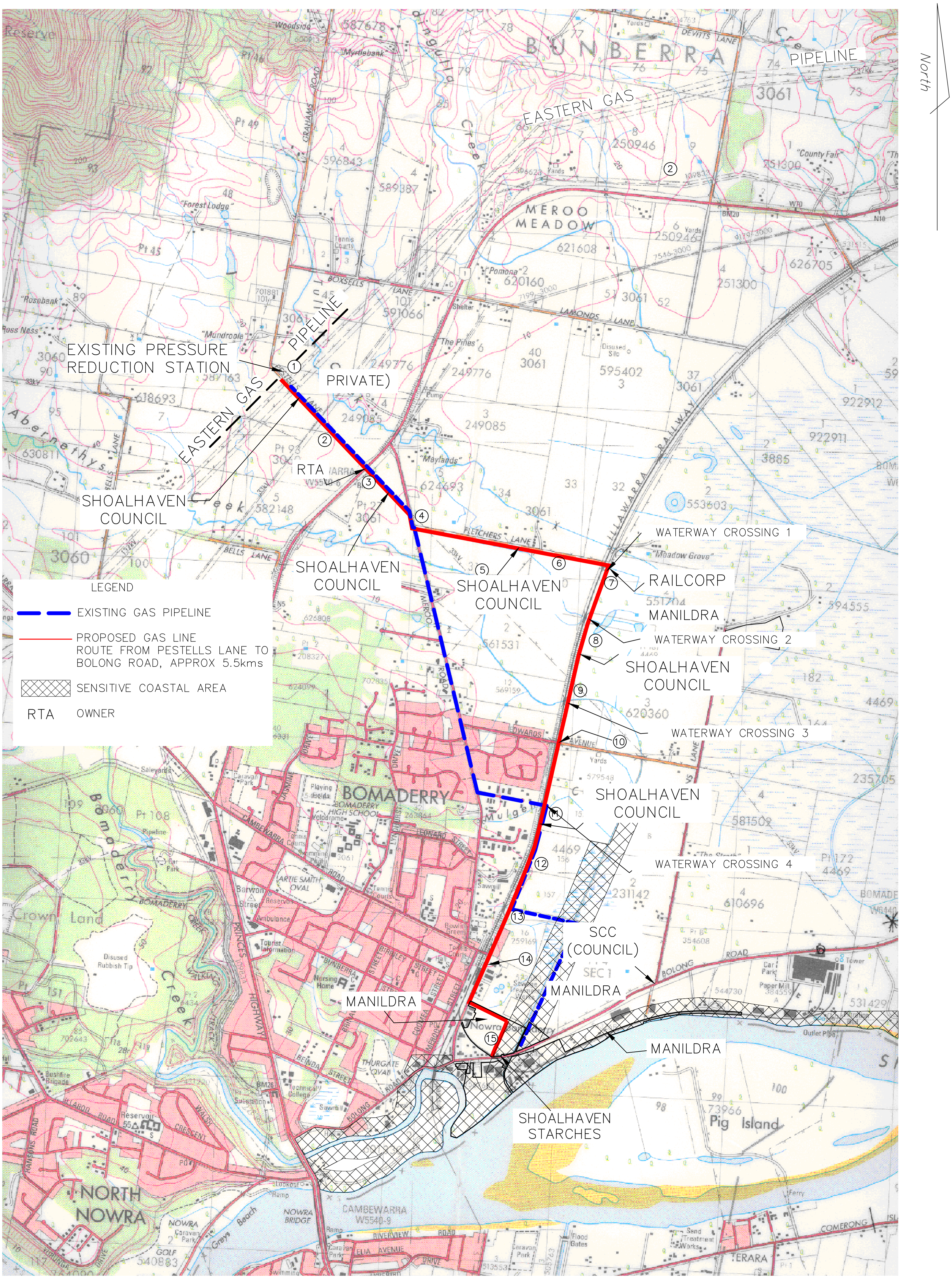


FIGURE 1

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FIGURE SHOWING, PROPERTY OWNERS & WATERWAY CROSSINGS ALONG THE PROPOSED GAS LINE ROUTE, FROM EXISTING EASTERN GAS LINE TO SHOALHAVEN STARCHES BOLONG ROAD FACTORY

Rev: 01

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Appendix B – Photographic Investigation of Proposed Route

Appendix B

Photo 1- Eastern Gas Pipeline tie-in point at Pestells Lane (valve and meter station)

Photo 2 Eastern Gas Pipeline tie-in point for existing ActewAGL gas pipeline at Pestells Lane

Photo 3-Pestells Lane verge (south side)

Photo 4-Cattle Loading Station and driveway on Pestells Lane

Photo 5- Existing ActewAGL gas main marker adjacent rural fence at Princes Highway Intersection

Photo 6- Proposed gas main route across Princes Highway

Photo 7- Table drain and culvert on Princes Highway intersection with Pestells Lane

Photo 8- Unformed section of Pestells Lane

Photo 9- Looking down embankment of Princess Highway, along existing gas pipe route

Photo 10- Un-formed Pestells Lane

Photo 11-Intersection of Pestells Lane with Meroo Road

Photo 12-Table drain along Meroo Road

Photo 13- Culvert headwall (bottom right) on Meroo Road and Fletchers lane intersection

Photo 14-Fletchers Lane intersection with Meroo Road

Photo 15-Possible stabilised machinery access and storage area on Fletchers lane intersection

Photo 16- Culvert Headwall and drain leading in Paddock

Photo 17-Open channel drain through paddock on south side of Fletchers Lane

Photo 18- Example of tail-out drains on south side of Fletchers Lane, leading into Open channel drain

Photo 19- Middle of Fletchers Lane

Photo 20-End of Fletchers Lane toward Railcorp railway reserve

Photo 21- Ramp crossing over train tracks at intersection of Fletchers lane and un-named road reserve

Photo 22-Large culvert in Railcorp railway reserve, beyond proposed railway track under-bore location

Photo 23- Gates to Railcorp railway reserve and un-named road reserve

Photo 24a- First waterway crossing, approximately 50m south of ramp over train tracks at end of Fletchers Lane

Photo 24b- First waterway crossing, showing culvert under railway tracks

Photo 24c- First waterway crossing, showing boundary between road reserve and Railcorp rail reserve

Photo 25a-Culvert between first and second waterway crossings for low lying area in rail reserve, adjacent to road reserve

Photo 25b-Vegetation within rail reserve at between first and second waterway crossings

Photo 26a-Low lying area at outlet of second waterway crossing, adjacent to Railcorp rail reserve

Photo 26b-Second waterway crossing, adjacent to Railcorp rail reserve

Photo 26c-Low lying area on approach of proposed gas main toward second waterway crossing

Photo 27a-Scour valve in un-named road reserve adjacent to third proposed waterway crossing, north of Edwards Avenue

Photo 27b-Third proposed waterway crossing, looking north along proposed gas main alignment

Photo 27c- Large railway bridge/culvert at third proposed waterway crossing

Photo 27d- Overhead view of third proposed waterway crossing

Photo 28- Looking north from third waterway crossing, along proposed gas main route

Photo 29- Water main marker at steep approach to Edwards Avenue, in un-named road reserve

Photo 30- Looking north along proposed gas main route in un-named road reserve, toward water main marker

Photo 31- Edwards Avenue crossing point on north side

Photo 32- South side Edwards Avenue crossing in un-named road reserve

Photo 33- Water main infrastructure in un-named road reserve

Photo 34- At gate on crest in un-named road reserve, looking south down into gully to the south of Edwards Ave

Photo 35a- Fourth waterway crossing, looking north, along proposed gas main route

Photo 35a- Approach to fourth waterway crossing, looking north

Photo 35b- Fourth waterway crossing

Photo 35c- Looking along stabilised vehicle track that crosses waterway number three

Photo 36- ActewAGL existing gas main marker on boundary of un-named road reserve, looking south along proposed gas pipeline alignment

Photo 37- Rural fence and gate at end of un-named road reserve and beginning of Railway Street

Photo 38- un-formed section of Railway Street, looking at ActewAGL existing gas main testing station

Photo 39- Railway Street

Photo 40- Water main infrastructure in Railway Street road reserve

Photo 41-Sewer rising main manhole and vent pipe

Photo 42- Water main infrastructure in Railway Street road reserve

Photo 43-Water main, power pole and existing gas main infrastructure in Railway Street

Photo 44- Beginning of sealed section of Railway Street

Photo 45- Stormwater headwall and culvert in Railway Street

Photo 46a- Scour valve shown with Large pipe culvert in background leading into drainage system under Railway Street

Photo 46b- Large pipe culvert in rail reserve on west side of Railway Street

Photo 46c- Small headwall for pipe culvert under Railway Street, taking stormwater from large pipe culvert shown in previous photo.

Photo 47- East side Railway Street road reserve-

Photo 48- West side Railway Street road reserve showing water main marker

Photo 49- Railway Street

Photo 50- Looking at Cambewarra Road intersection with Railway Street

Photo 51- Infrastructure at intersection between Cambewarra Road and Railway Street, on west side road reserve

Photo 52- Example of Railway Street Infrastructure in west side of road reserve

Photo 53a- Stormwater infrastructure in rail reserve on west side of Railway Street

Photo 53b- Stormwater infrastructure under road reserve beginning on west side of Railway Street, leading into pit on east, shown in following photo 53c

Photo 53c- Stormwater pit on east side of Railway Street

Photo 54- Open channel drain through lot 1 DP825808 Railway Street, taking water from pit shown in previous Photo.

Photo 55- Headwall and culvert under Railway Street, at direction change of proposed gas main

Photo 56- Sewer pipe through open channel drain in lot 1 DP825808

Photo 57- Culvert and support for sewer pipe accross open channel drain in lot 1 DP825808

Photo 58-Open channel drain in Lot 1 DP 825808

Photo 59- Sewer man hole in open drain along north boundary of Lot1 DP 825808

Photo 60- North boundary of Lot1 DP825808

Photo 61-Proposed gas main route in Shoalhaven Starches property lot 1 DP 825808

Photo 62- Looking toward Shoalhaven Starches Factory (Manildra), along existing sewer rising main alignment

Photo 63- Proposed gas main route through Shoalhaven Starches paddock, looking toward interim packing plant

Photo 64- Sewer pump station on Shoalhaven Starches land, with location of proposed gas main route and pressure reduction station in background

Photo 65- Civil works at most likely position of proposed gas main crossing of Bolong Road

Photo 66 - Bolong Road showing infrastructure in vicinity of proposed gas main crossing

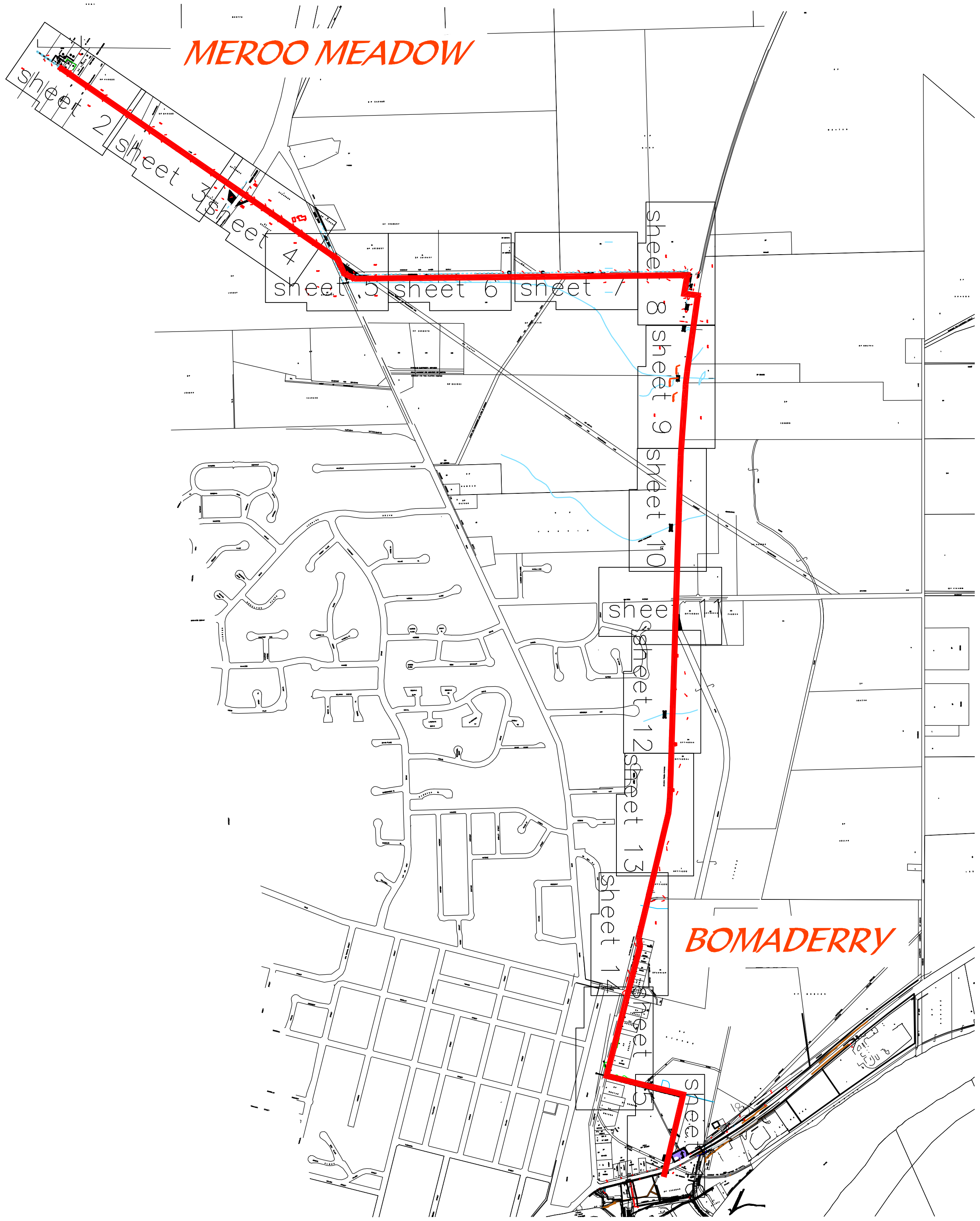
Photo 67-Bolong Road showing infrastructure in vicinity of proposed gas main crossing

Photo 68- Shoalhaven Starches interim packing plant on south side of Bolong Road

Appendix C – APA Drawing 24710-04 Sheets 1 to 16

SHOALHAVEN STARCHES PROPOSED GAS PIPELINE

AT MEROO MEADOW AND BOMADERRY, NSW



APPENDIX C

This drawing complements two reports written by Allen, Price and Associates for the proposed Shoalhaven Starches gas pipeline project. To better understand the content of this drawing, the reports titled, 'Impacts on Infrastructure Report' and 'Erosion and Sediment Control Management Plan' should be read prior. This drawing is located in Appendix C of both reports.

Items shown on these sheets have not been located by detailed survey. They are indicatively shown based on field observation and measurement, and information given by service and infrastructure owners and operators.

LEGEND

- 1 2 DP 595402 — EXISTING BOUNDARY FENCE (SCC CADASTRE)
- EXISTING RURAL FENCE
- EXISTING GAS MAIN
- PROPOSED GAS MAIN
- GAS — EASTERN GAS LINE
- E — EXISTING OVERHEAD ELECTRICAL POWER SERVICE
- W — EXISTING WATER MAIN
- S — EXISTING SEWER MAIN
- SRM — EXISTING SEWER RISING MAIN
- T — EXISTING UNDERGROUND TELSTRA LINE
- EXISTING TAIL-OUT OR TABLE DRAIN
- EXISTING CREEK OR SWALE DRAIN LESS THAN 5m WIDE
- EXISTING TREE SHOWING APPROX. DRIP LINE
- PP — POWER POLE (SCC INFRASTRUCTURE)
- TP — TELEGRAPH POLE (RAIL INFRASTRUCTURE)
- EXISTING BRIDGE
- EXISTING CULVERT
- AV — EXISTING AIR VALVE FOR WATER MAIN
- SV — EXISTING STOP VALVE FOR WATER MAIN
- SCV — SCOUR VALVE
- RAILWAY TRACK
- LAND SLOPE
- TEMPORARY STABILISED SITE AND ACCESS FOR MACHINERY STORAGE AND UNDERBORE OPERATIONS

REVISION	BY	DATE

RATIO:	DATUM:
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	DATE OF PLAN: AUGUST 2011

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Plan for 'Infrastructure Impacts' and 'Erosion and Sediment Control Management' Reports for the proposed Shoalhaven Starches Gas Pipeline project at Meroo Meadow and Bomaderry, NSW

REF. No. 24710-04
sheet 1 of 16
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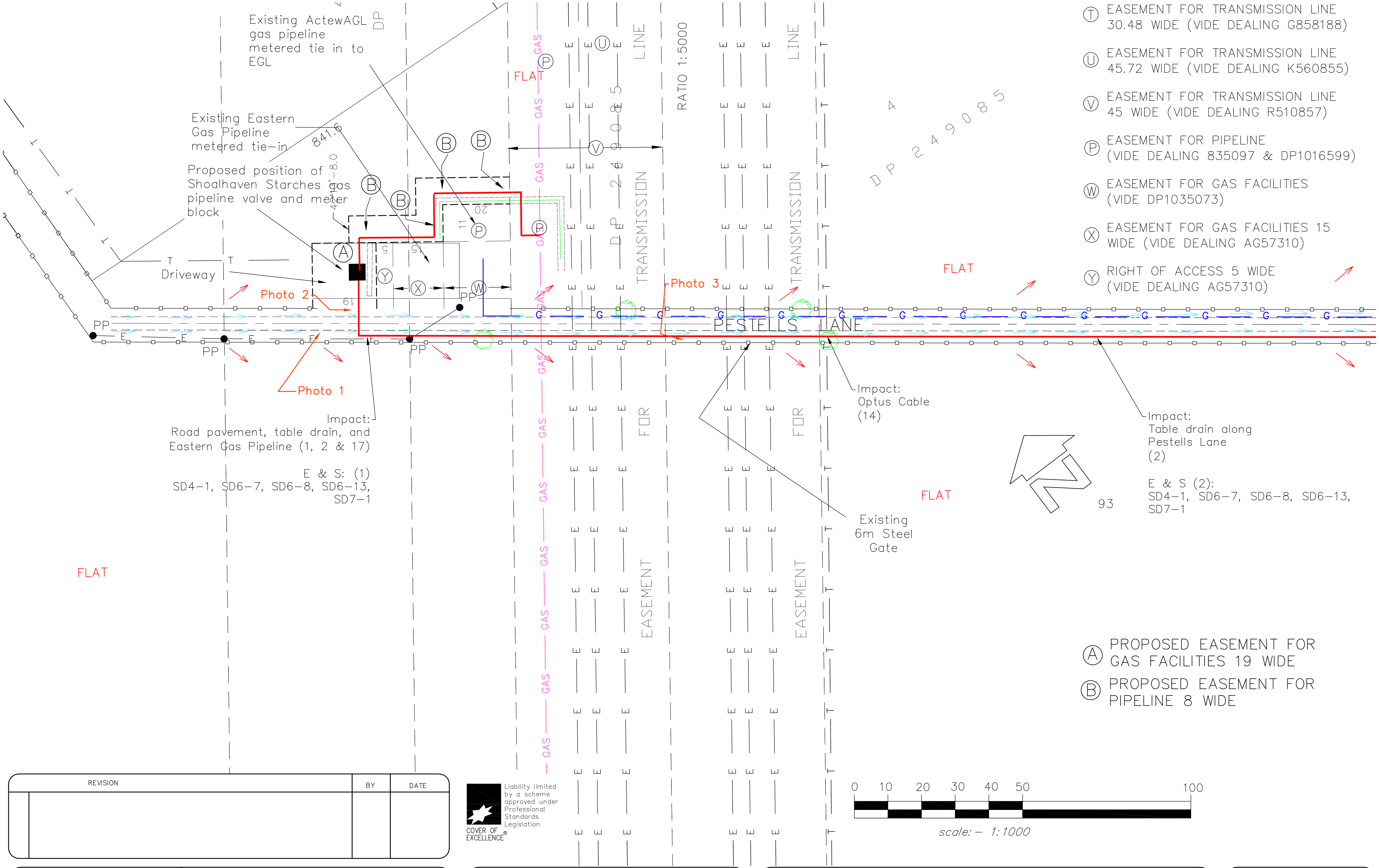

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DATE OF PLAN: AUGUST 2011

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Plan for 'Infrastructure Impacts' and 'Erosion and Sediment Control Management' Reports for the proposed Shoalhaven Starches Gas Pipeline project at Meroo Meadow and Bomaderry, NSW

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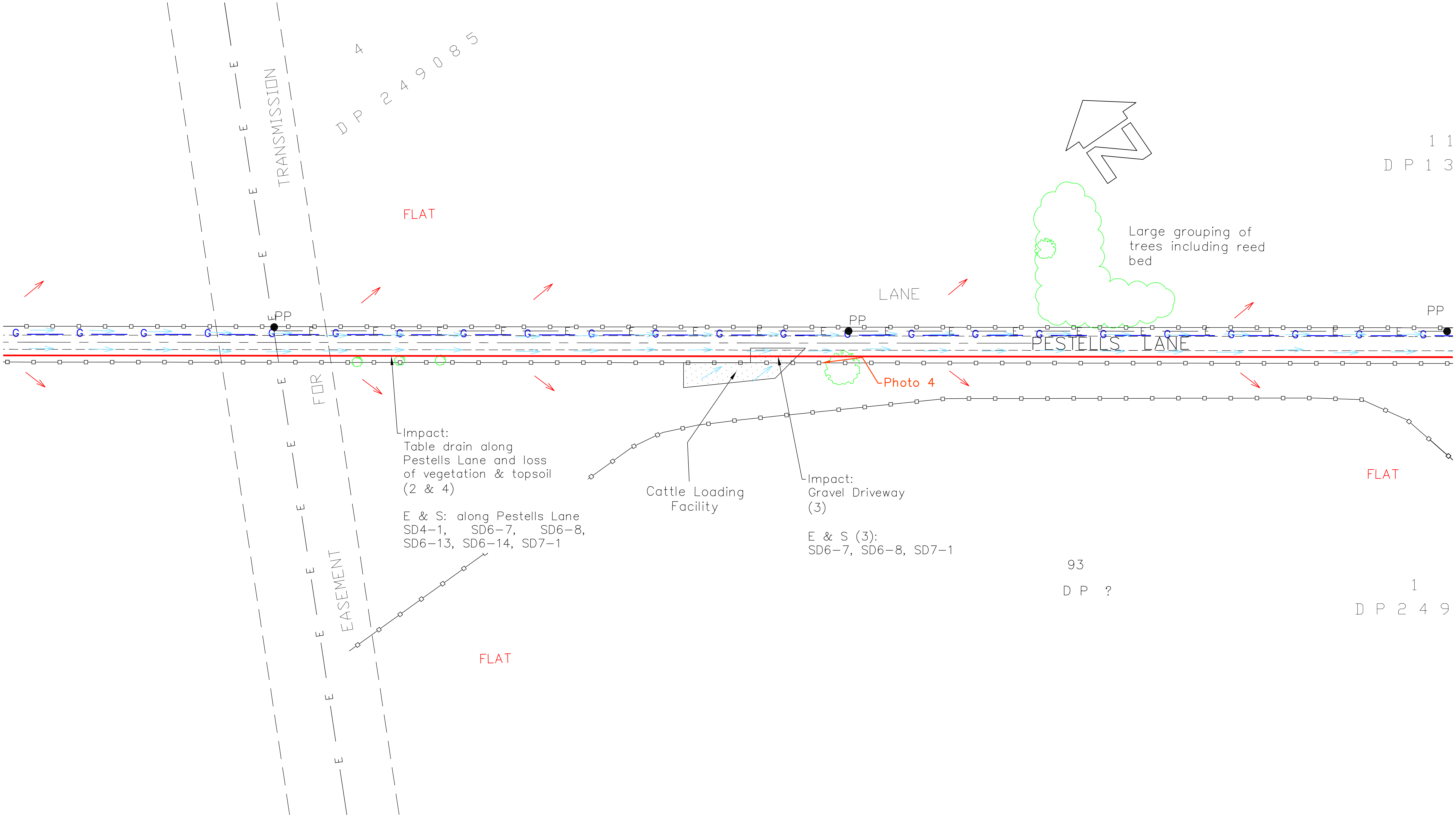

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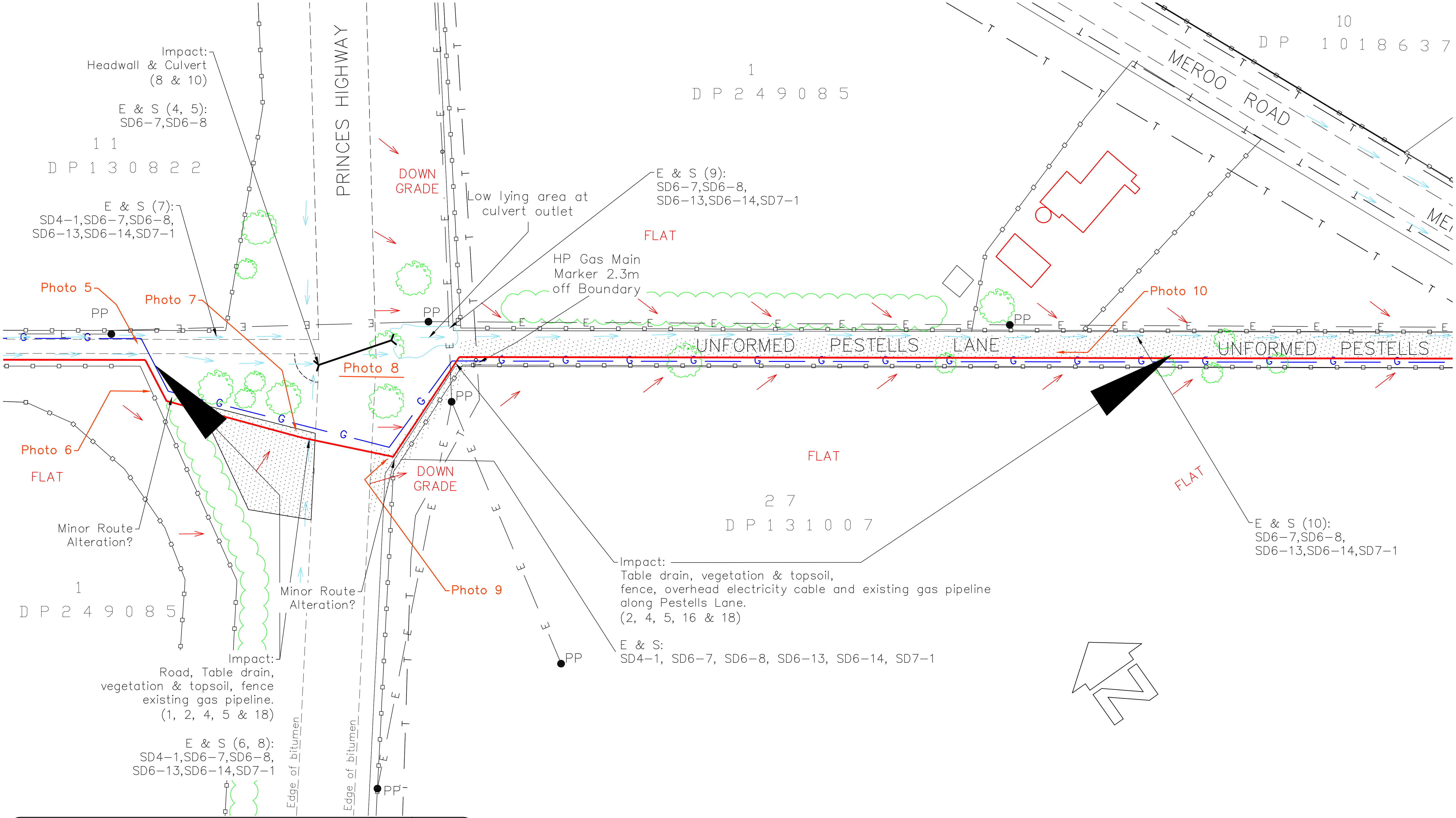

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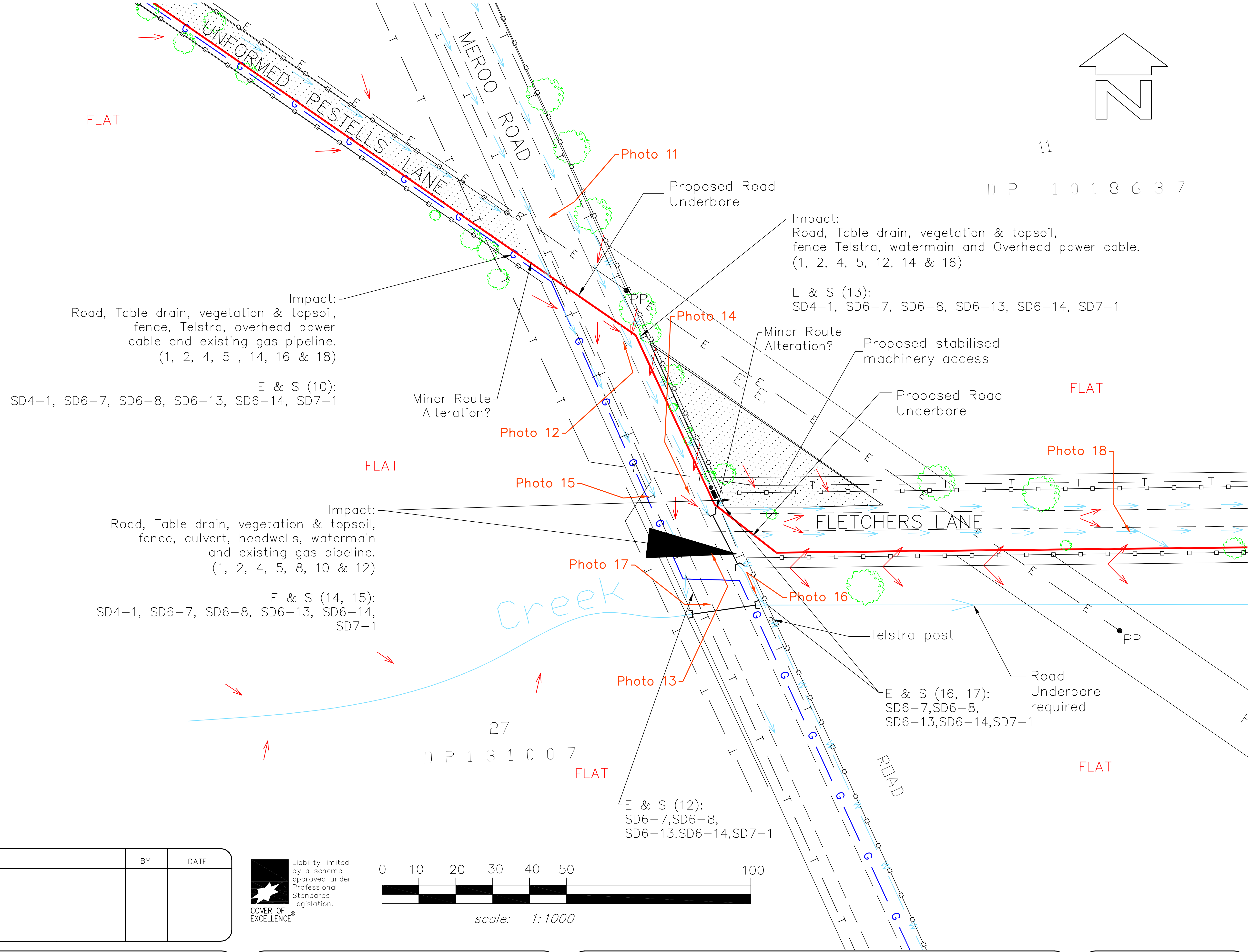

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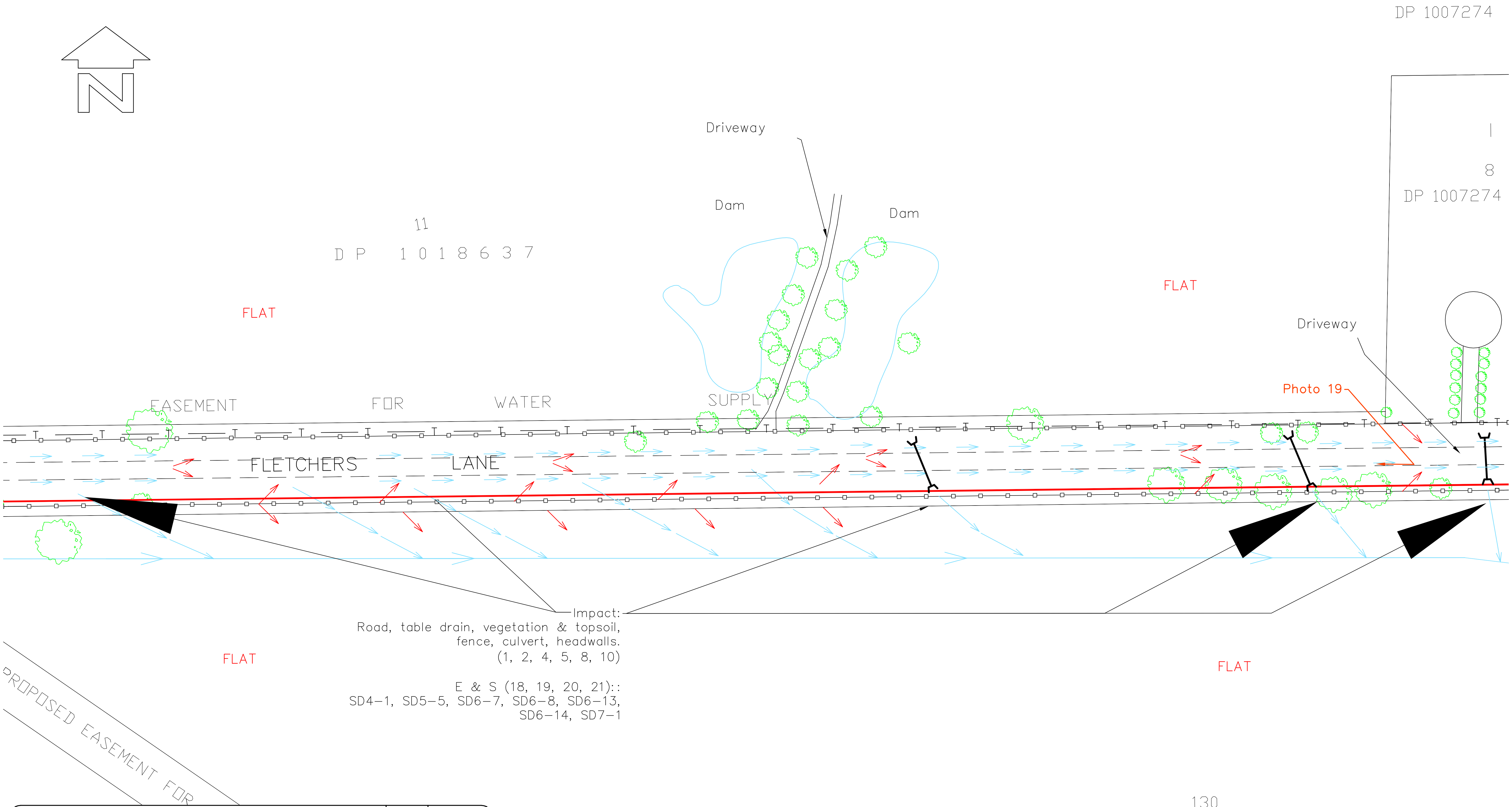

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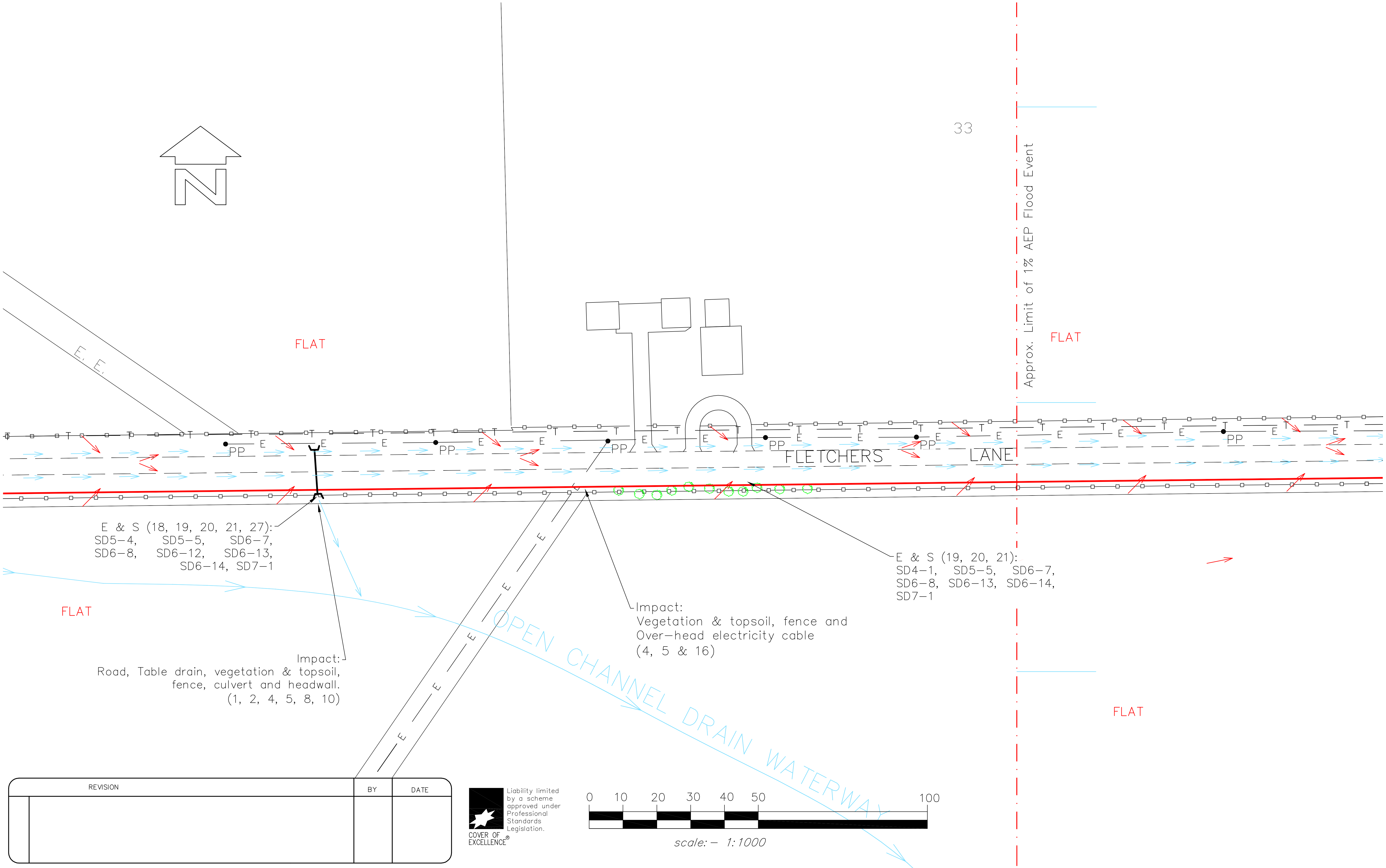

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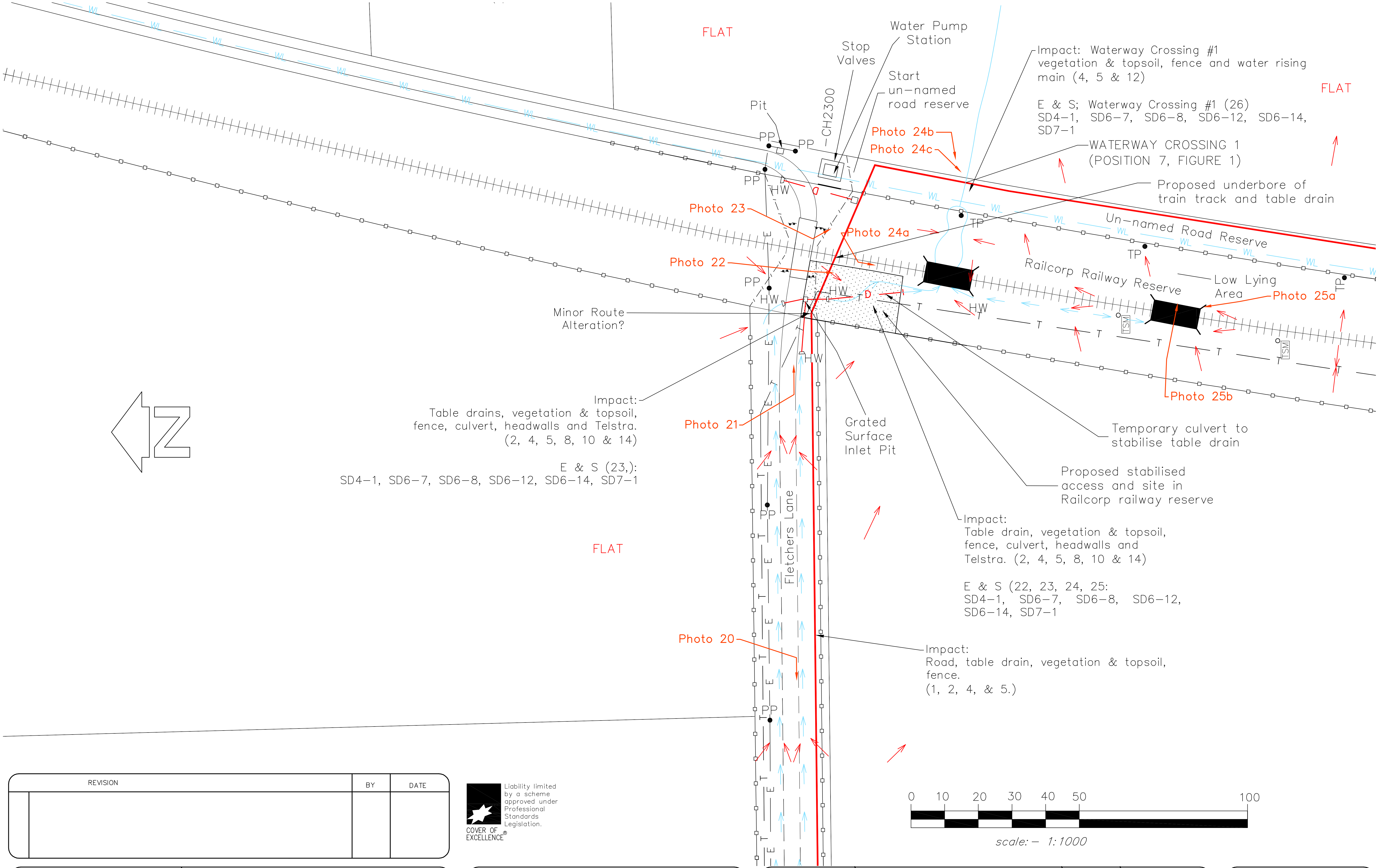

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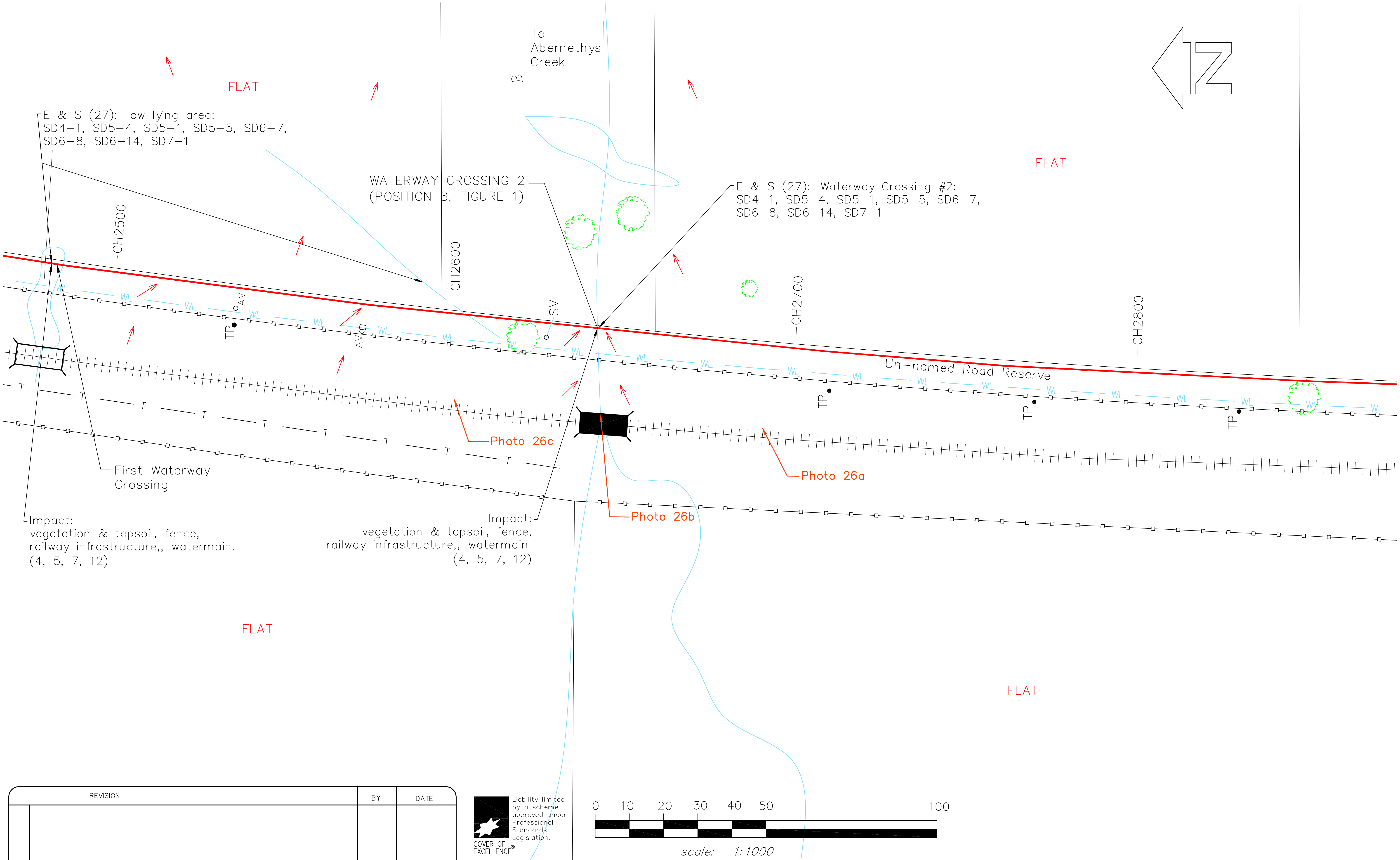

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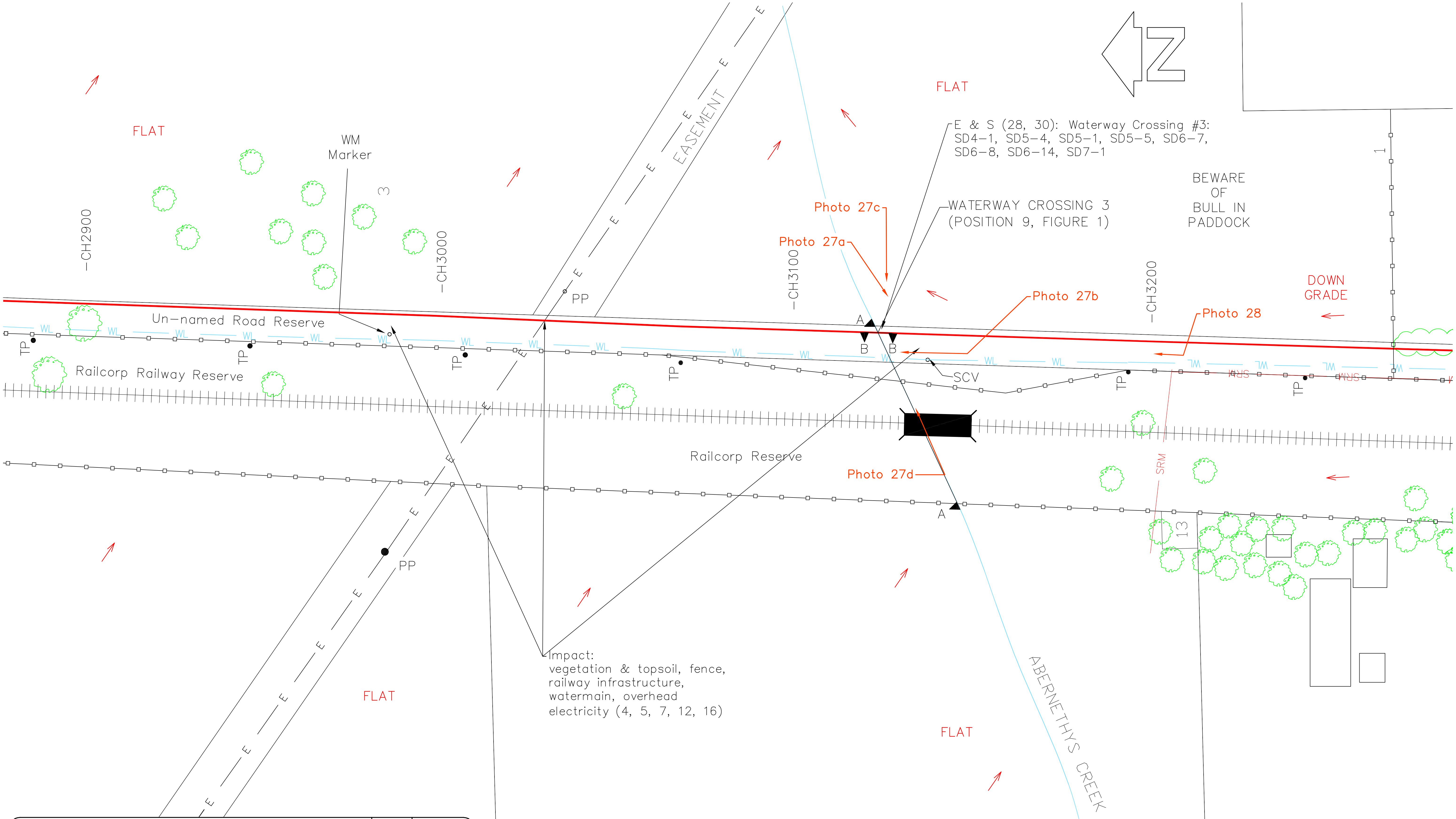

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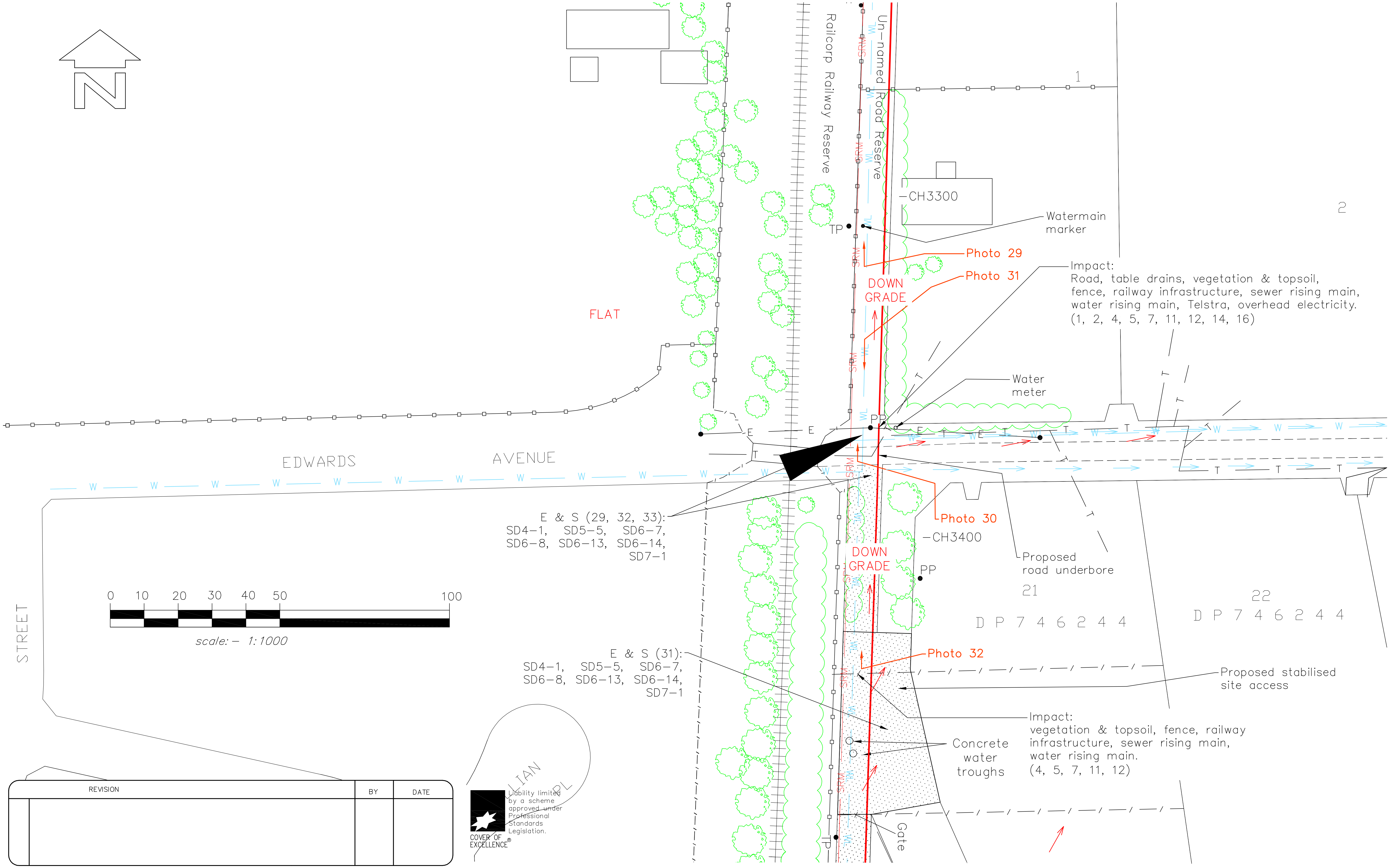

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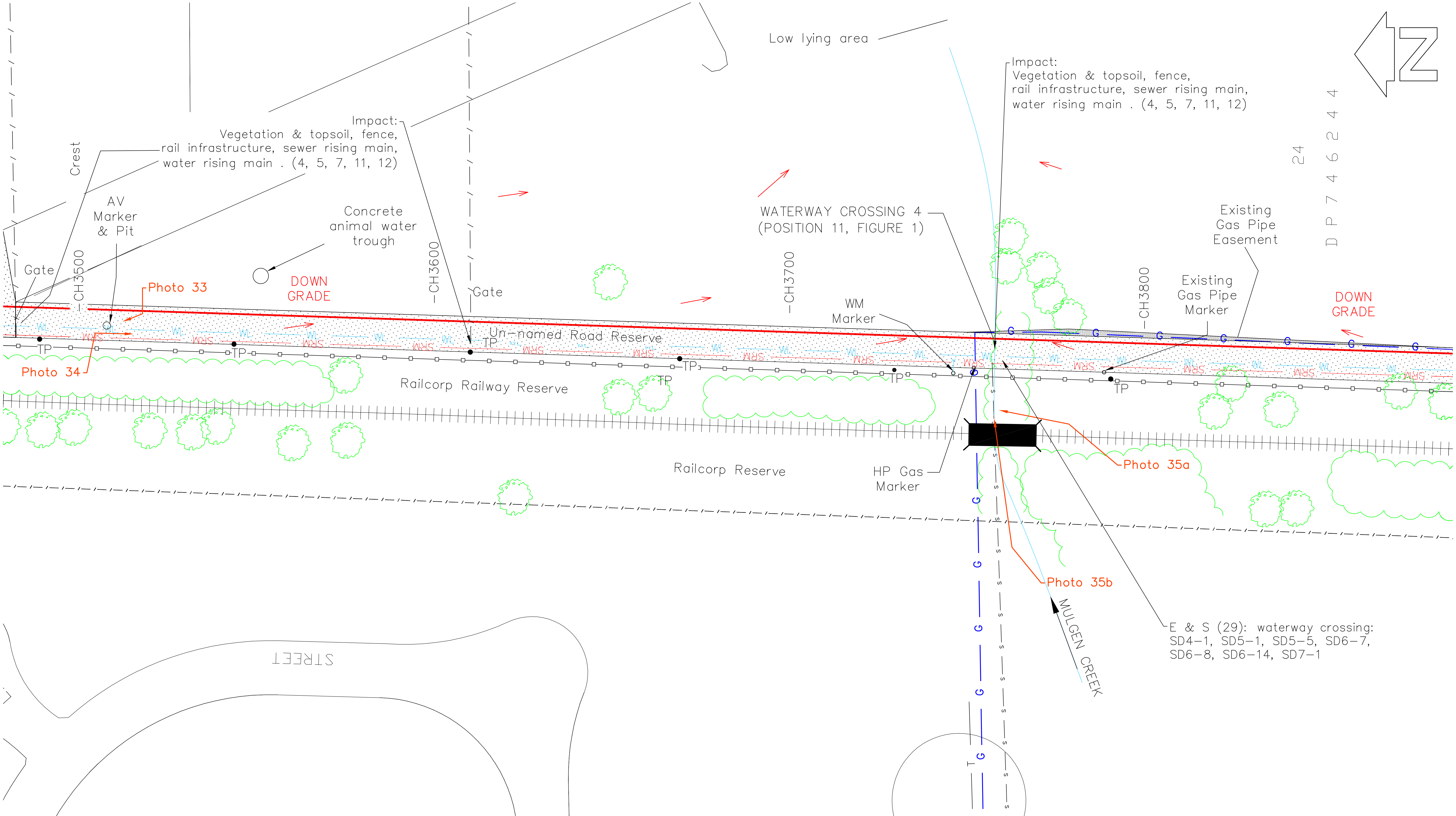

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EROSION & SEDIMENT CONTROL MANAGEMENT PLAN FOR PROPOSED SHOALHAVEN STARCHES GAS PIPELINE, FROM PESTELLS LANE TO THE BOLONG ROAD FACTORY

REF. No. 24710–04

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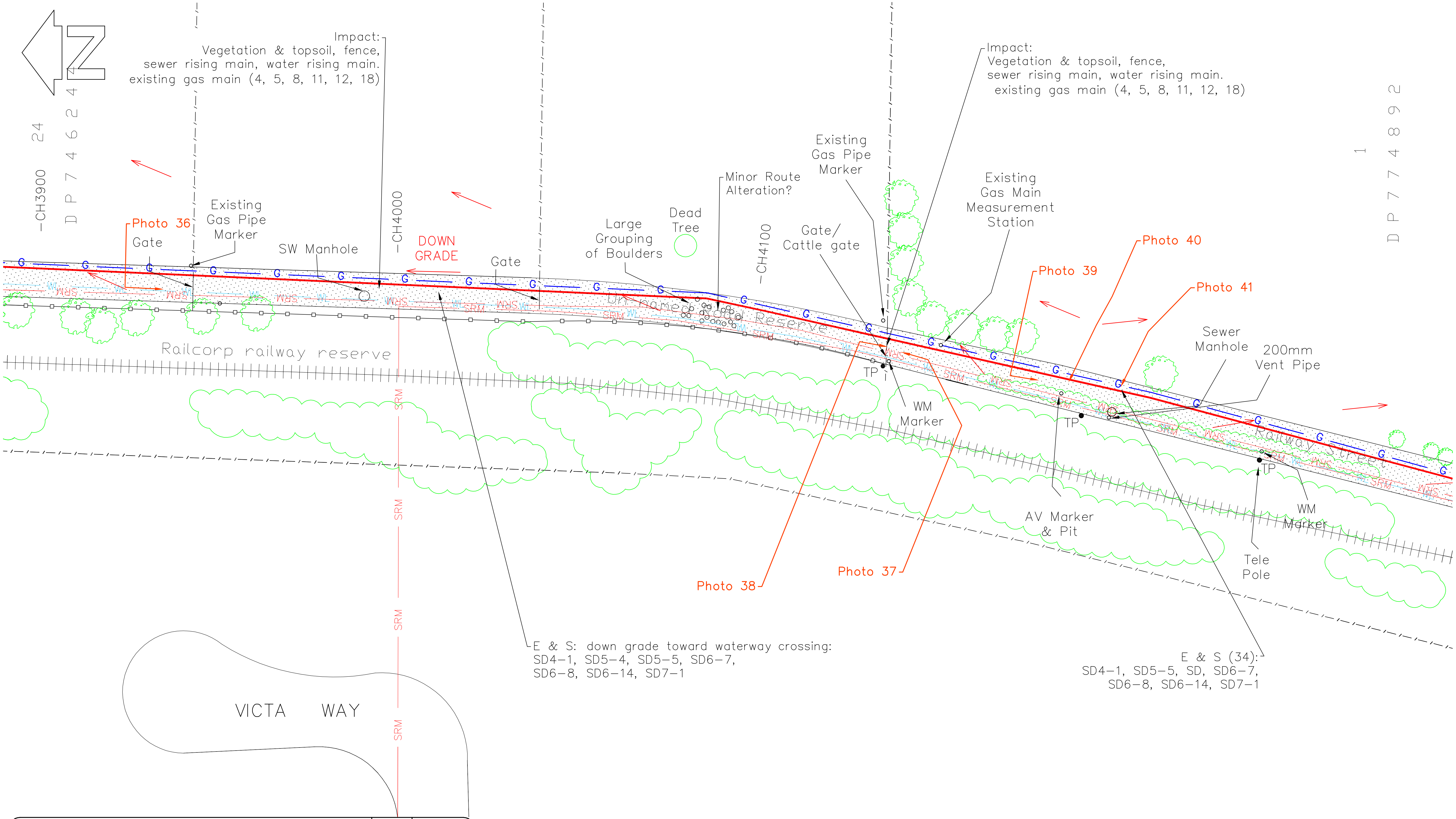

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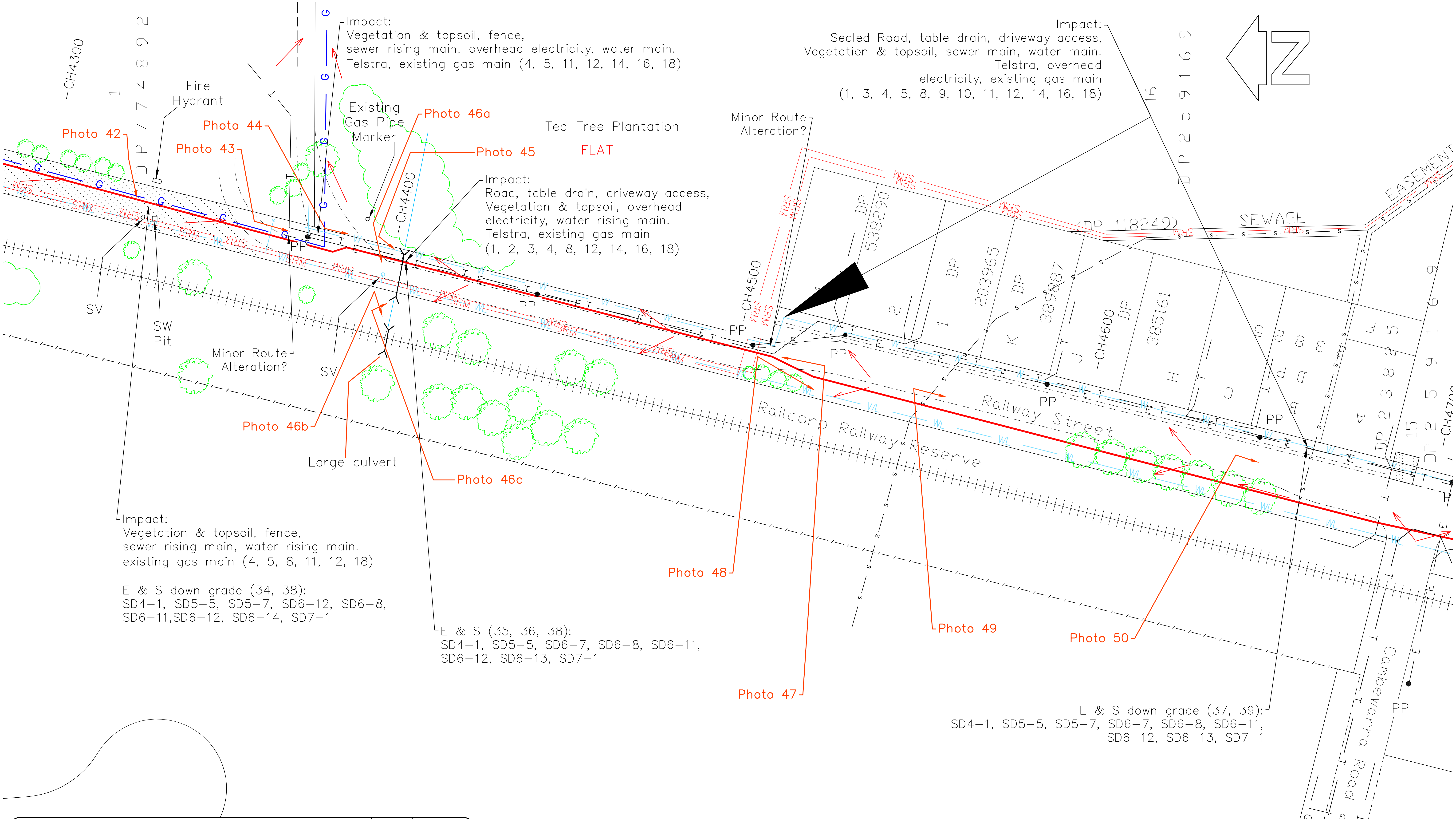

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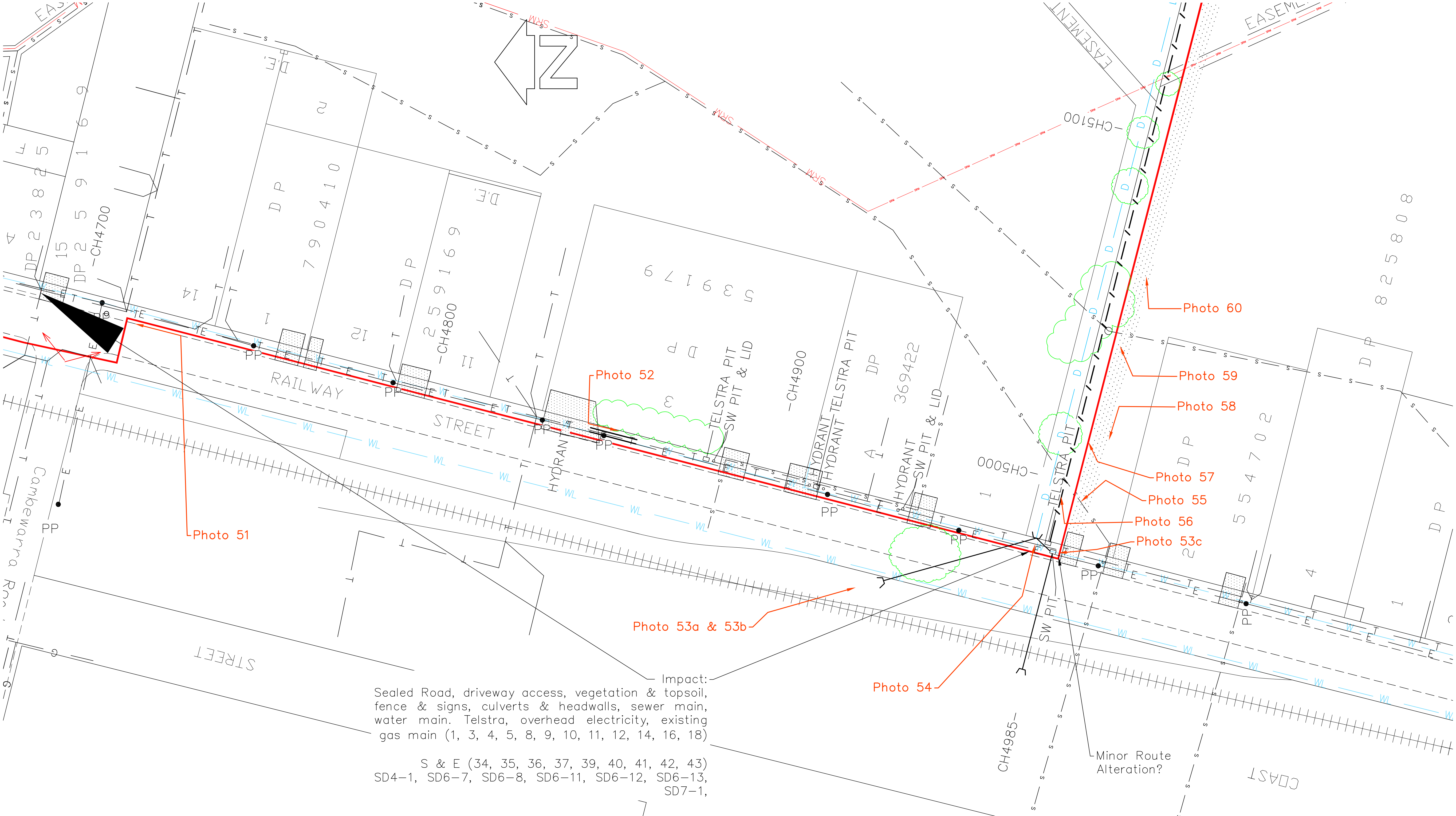

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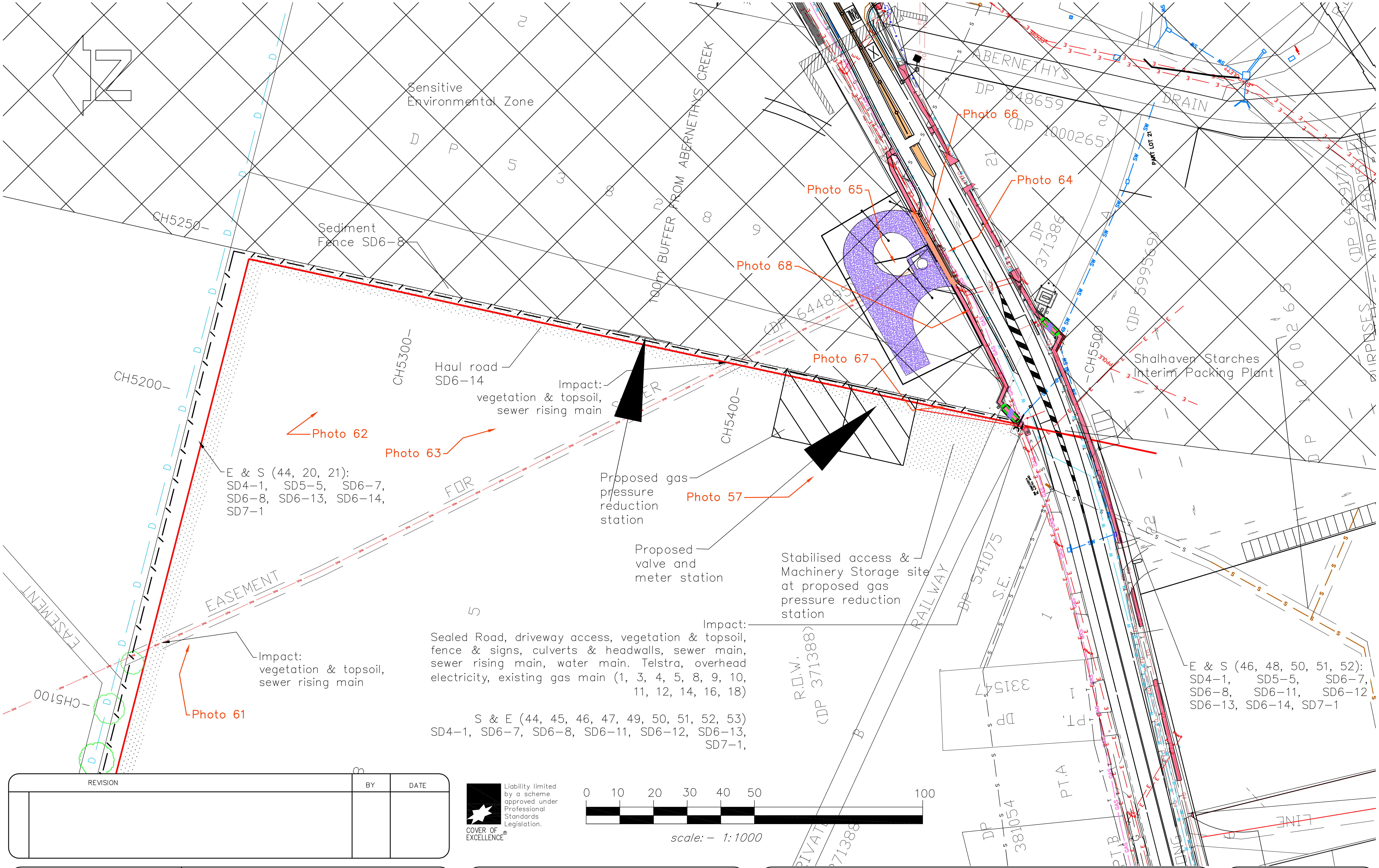

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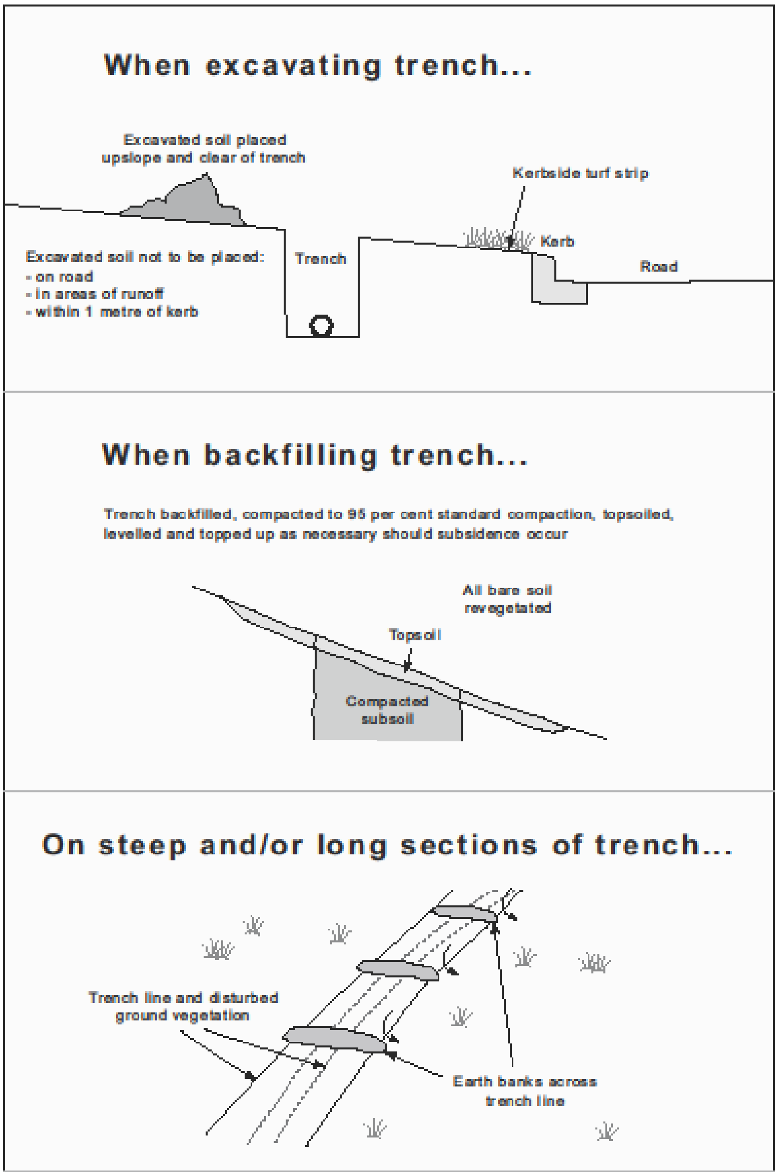
Appendix D – Erosion and Sediment Control Figures

Appendix D:



Construction notes for figure 6.1

1. Do not open any trench unless it is likely to be closed in three days
2. Place excavated material up-slope of the trench
3. Stockpile topsoil separately from subsoil
4. Divert runoff from the line of the cut with diversions as directed by SD 5-2
5. Rehabilitate in accordance with specification

Figure 2: Erosion and sediment control details for trench construction on steep sites

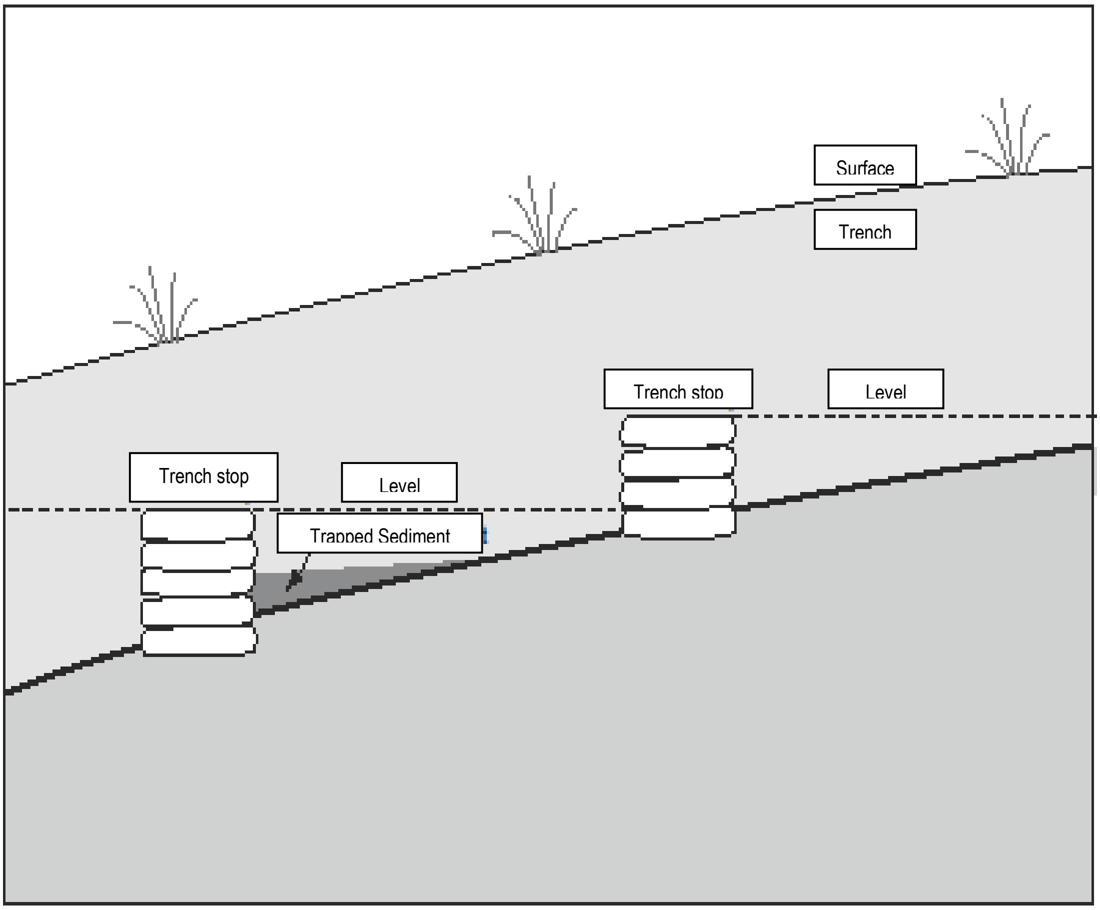
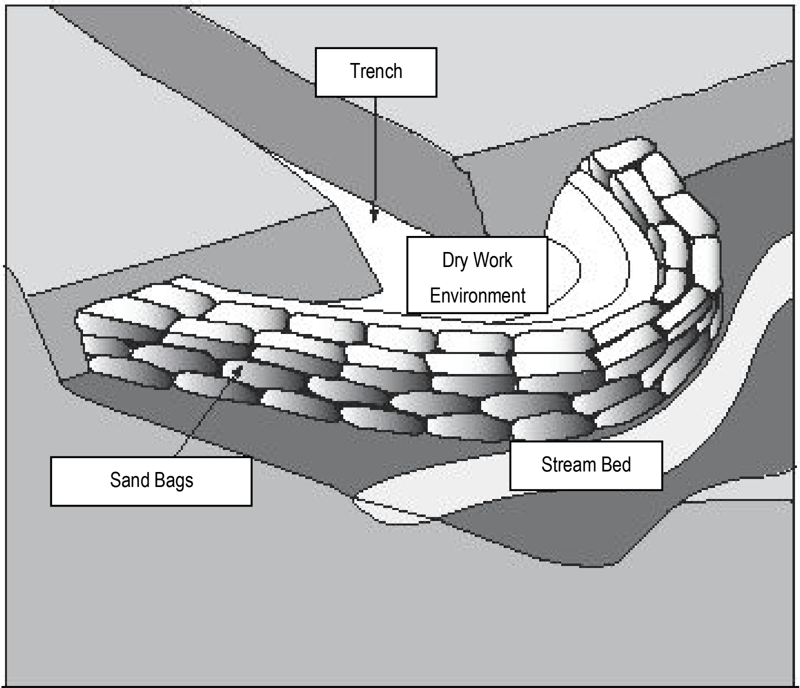
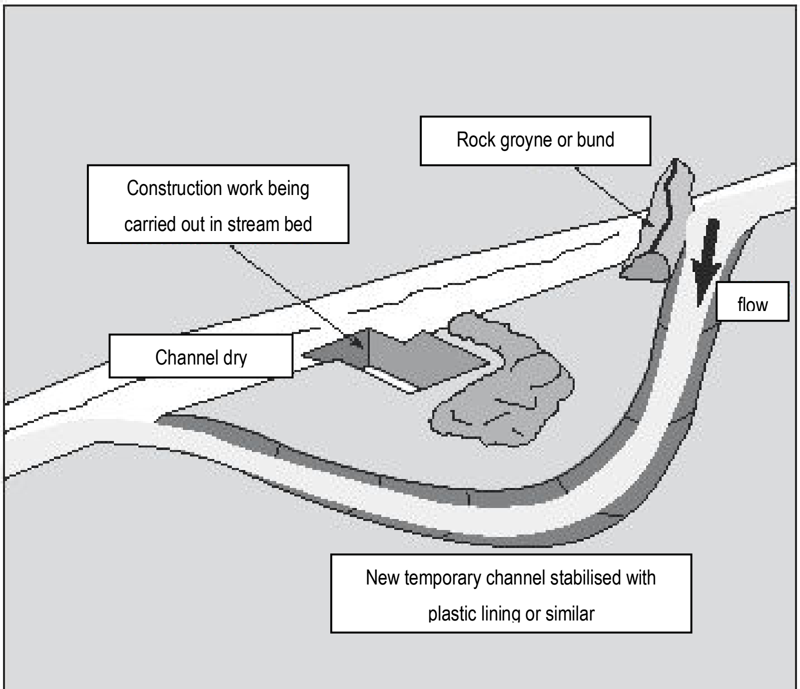


Figure 3: Typical trench stop detail for steep grades

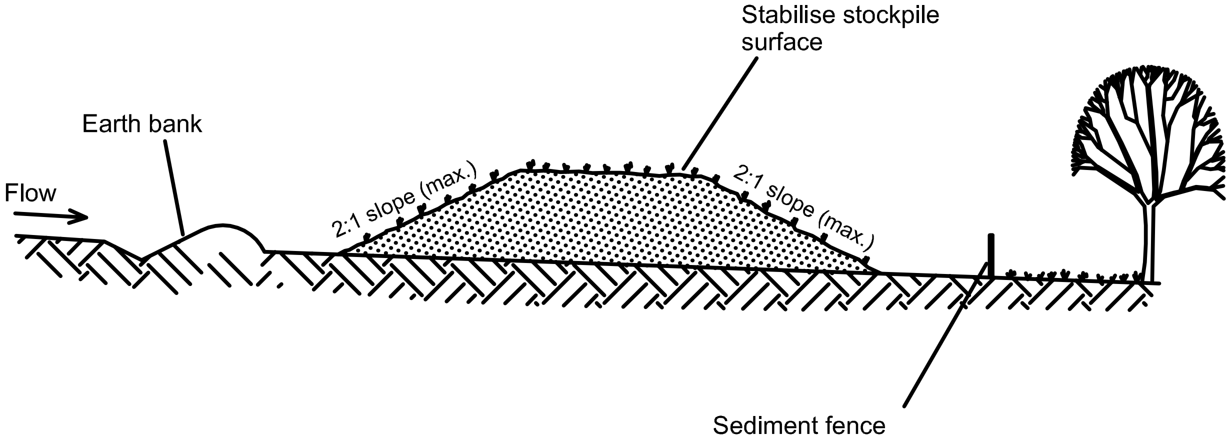


Option 1 – Stream diversion located within stream bed



Option 2 – Stream diversion via a new excavated channel

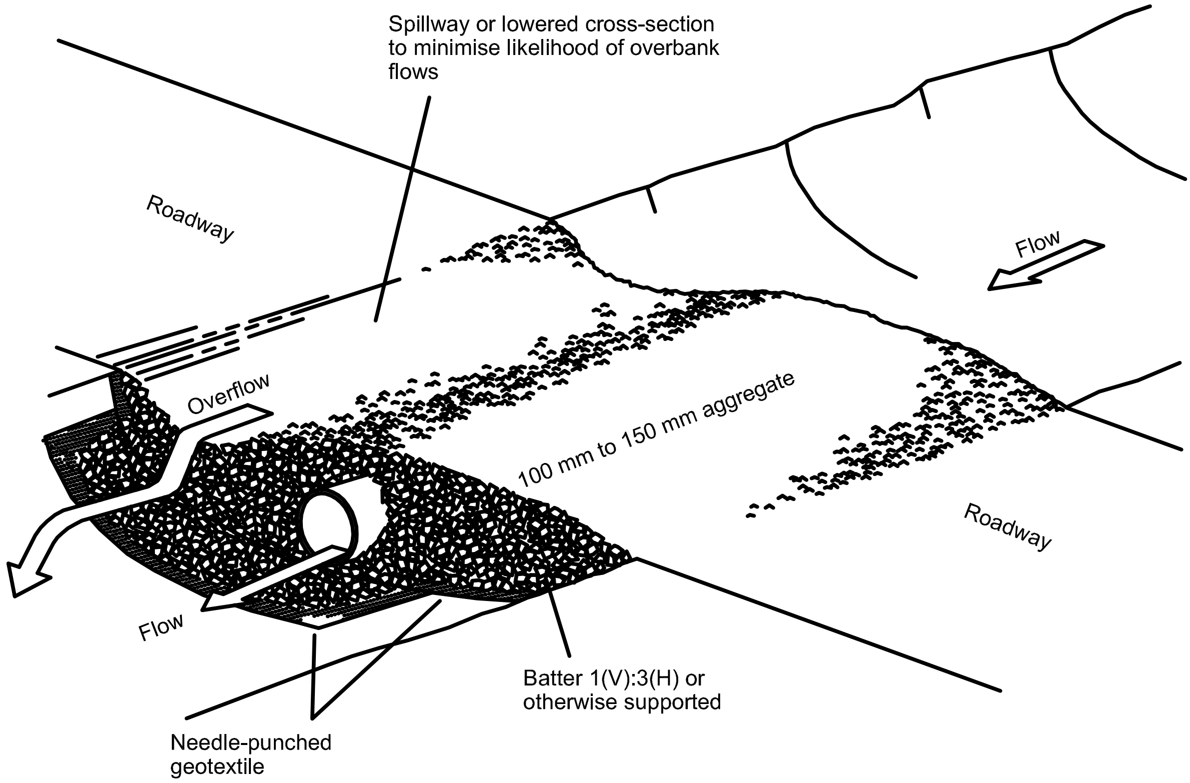
Figure 4: Typical options for waterway crossings



Construction Notes

1. Place stockpiles more than 2 (preferably 5) metres from existing vegetation, concentrated water flow, roads and hazard areas.
2. Construct on the contour as low, flat, elongated mounds.
3. Where there is sufficient area, topsoil stockpiles shall be less than 2 metres in height.
4. Where they are to be in place for more than 10 days, stabilise following the approved ESCP or SWMP to reduce the C-factor to less than 0.10.
5. Construct earth banks (Standard Drawing 5-5) on the upslope side to divert water around stockpiles and sediment fences (Standard Drawing 6-8) 1 to 2 metres downslope.

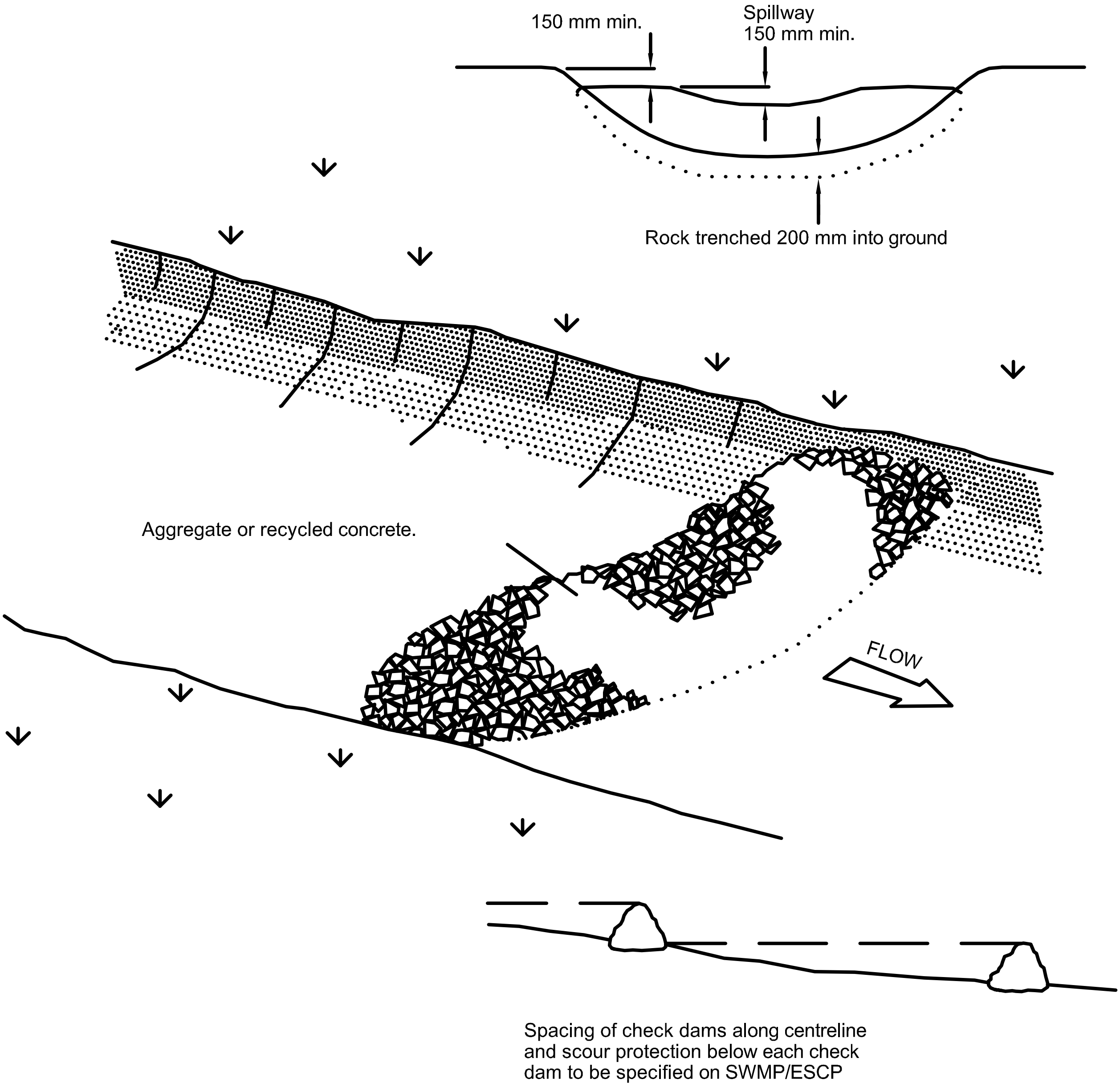
STOCKPILES SD 4-1



Construction Notes

1. Prohibit all traffic until the access way is constructed.
2. Strip any topsoil and place a needle-punched textile over the base of the crossing.
3. Place clean, rigid, non polluting aggregate or gravel in the 100 mm to 150 mm size class over the fabric to a minimum depth of 200 mm.
4. Provide a 3-metre wide carriageway with sufficient length of culvert pipe to allow less than a 3(H): 1 (V) slope on side batters.
5. Install a lower section to act as an emergency spillway in greater than design storm events.
6. Ensure that culvert outlets extend beyond the toe of fill embankments.

TEMPORARY WATERWAY CROSSING SD 5-1

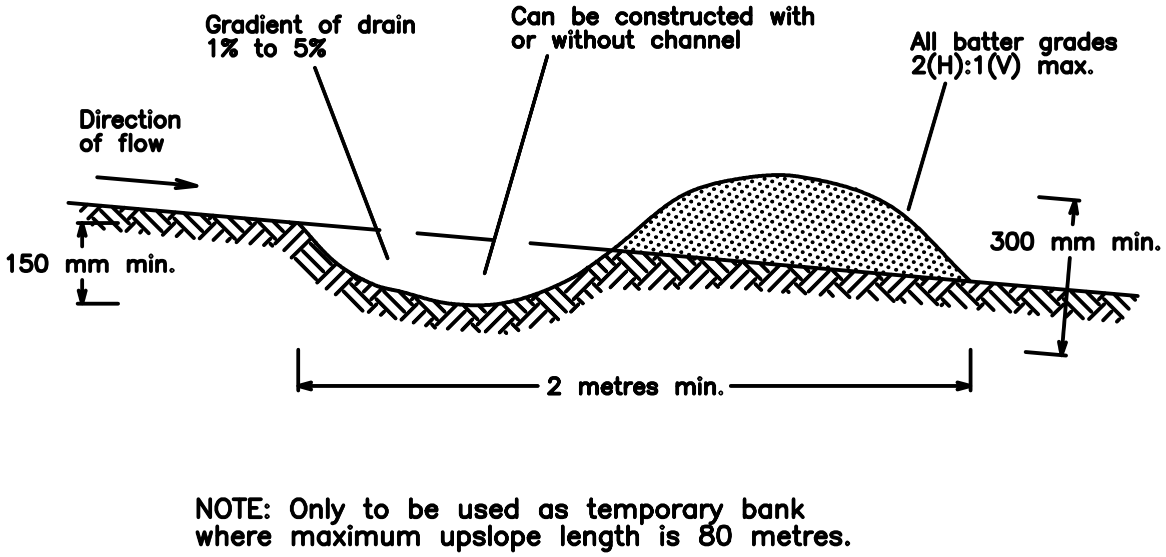


Construction Notes

1. Check dams can be built with various materials, including rocks, logs, sandbags and straw bales. The maintenance program should ensure their integrity is retained, especially where constructed with straw bales. In the case of bales, this might require their replacement each two to four months.
2. Trench the check dam 200 mm into the ground across its whole width. Where rock is used, fill the trenches to at least 100 mm above the ground surface to reduce the risk of undercutting.
3. Normally, their maximum height should not exceed 600 mm above the gully floor. The centre should act as a spillway, being at least 150 mm lower than the outer edges.
4. Space the dams so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM

SD 5-4

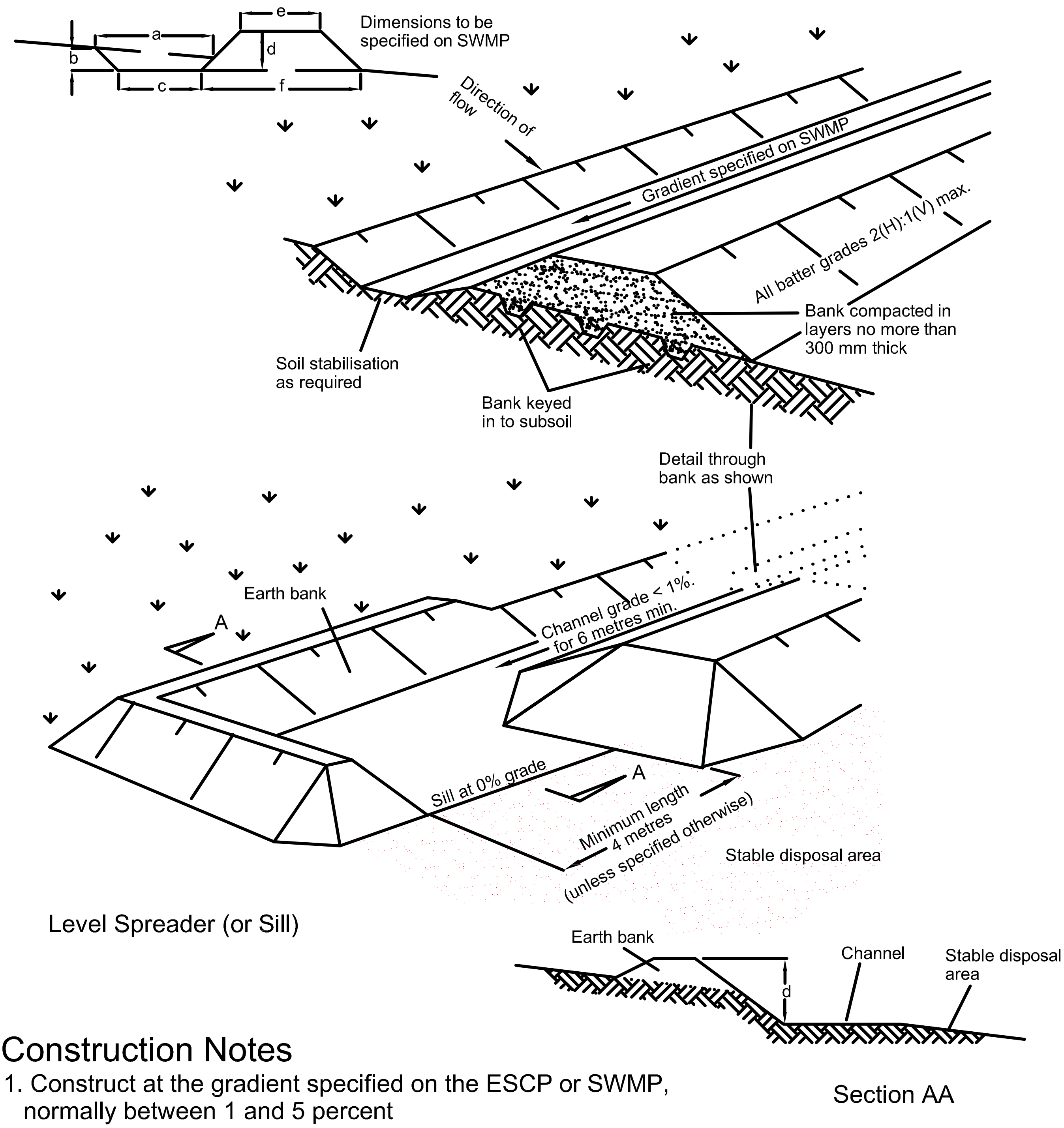


Construction Notes

1. Build with gradients between 1 percent and 5 percent.
2. Avoid removing trees and shrubs if possible - work around them.

3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V shaped.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction.

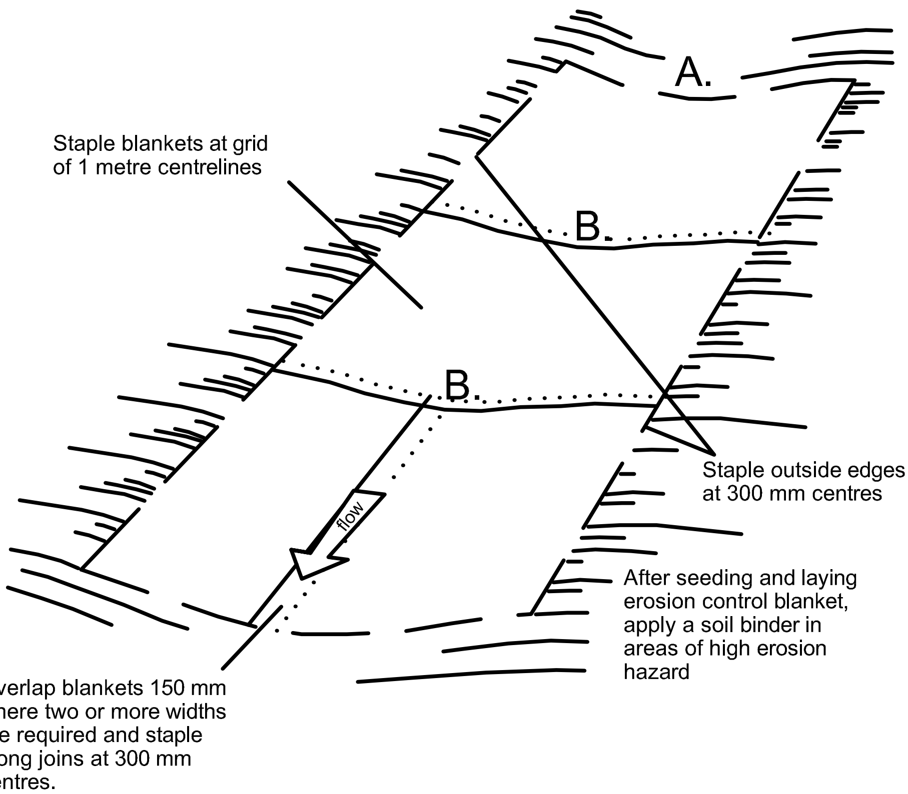
EARTH BANK (LOW FLOW) SD 5-5

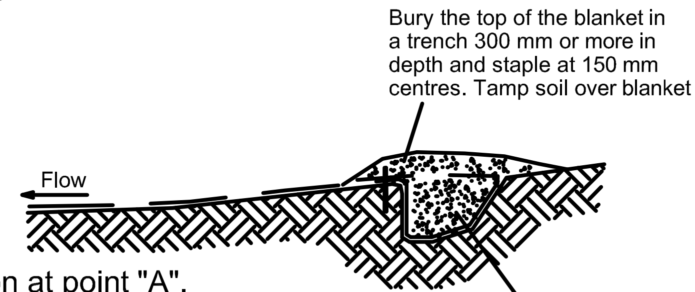


Construction Notes

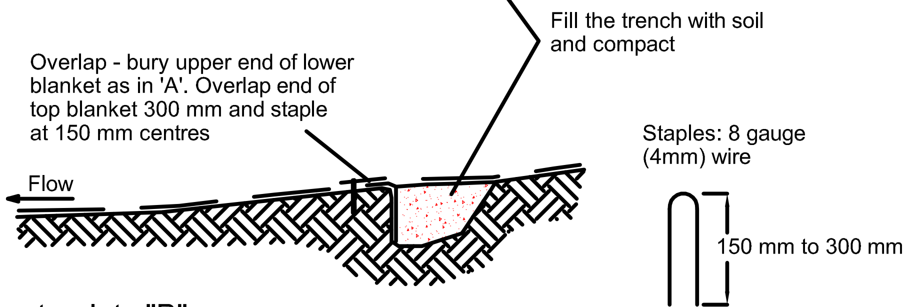
1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V-shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

EARTH BANK (HIGH FLOWS) SD 5-6





Centreline section at point "A".

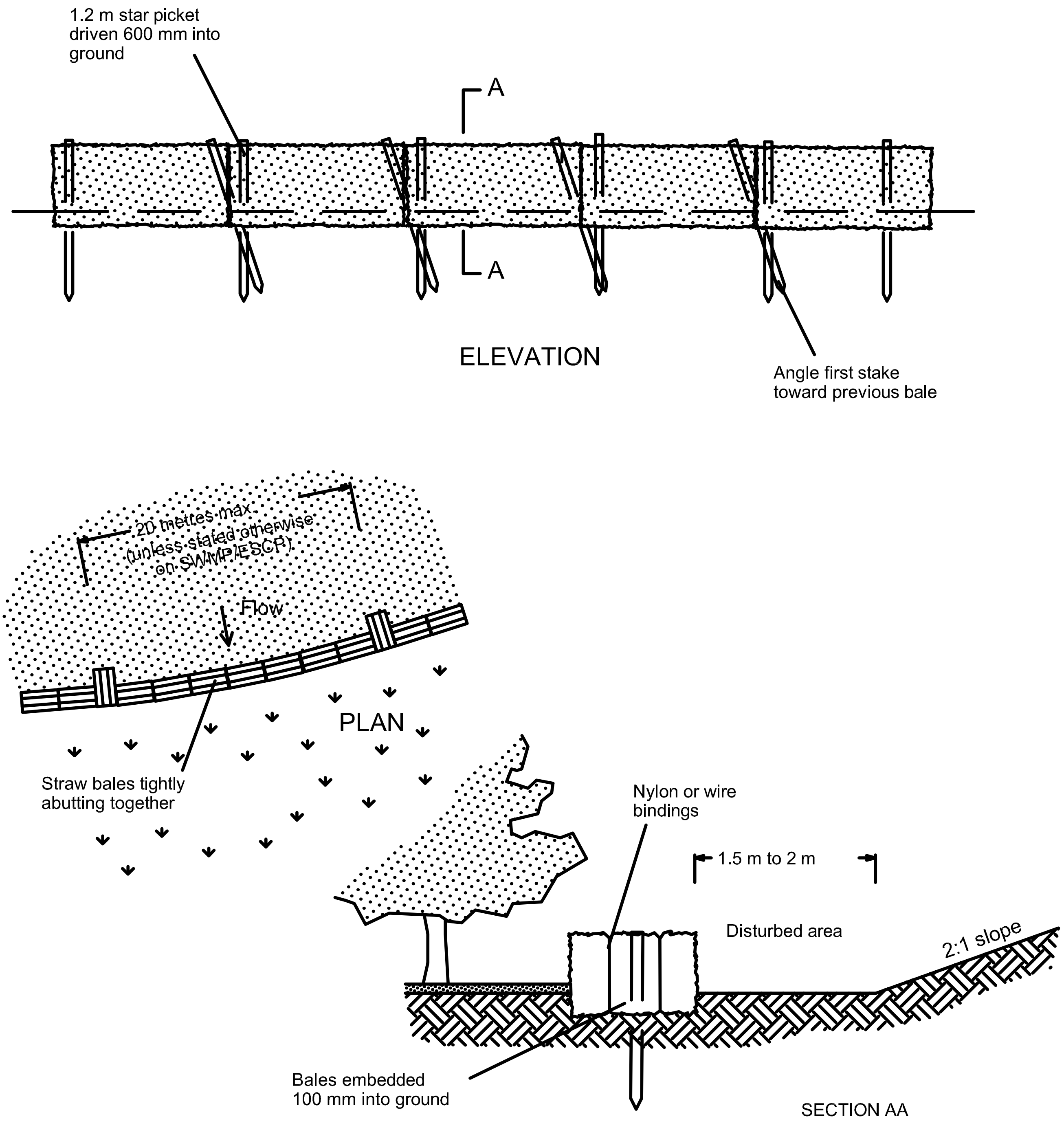


Centreline section at points "B".

Construction Notes

1. Remove any rocks, clods, sticks or grass from the surface before laying matting
2. Ensure that topsoil is at least 75 mm deep.
3. Complete fertilising and seeding before laying the matting.
4. Ensure fabric will be continuously in contact with the soil by grading the surface carefully first.
5. Lay the fabric in "shingle-fashion", with the end of each upstream roll overlapping those downstream. Ensure each roll is anchored properly at its upslope end (Standard Drawing 5-7b).
6. Ensure that the full width of flow in the channel is covered by the matting up to the design storm event, usually in the 10-year ARI time of concentration storm event.
7. Divert water from the structure until vegetation is stabilised properly.

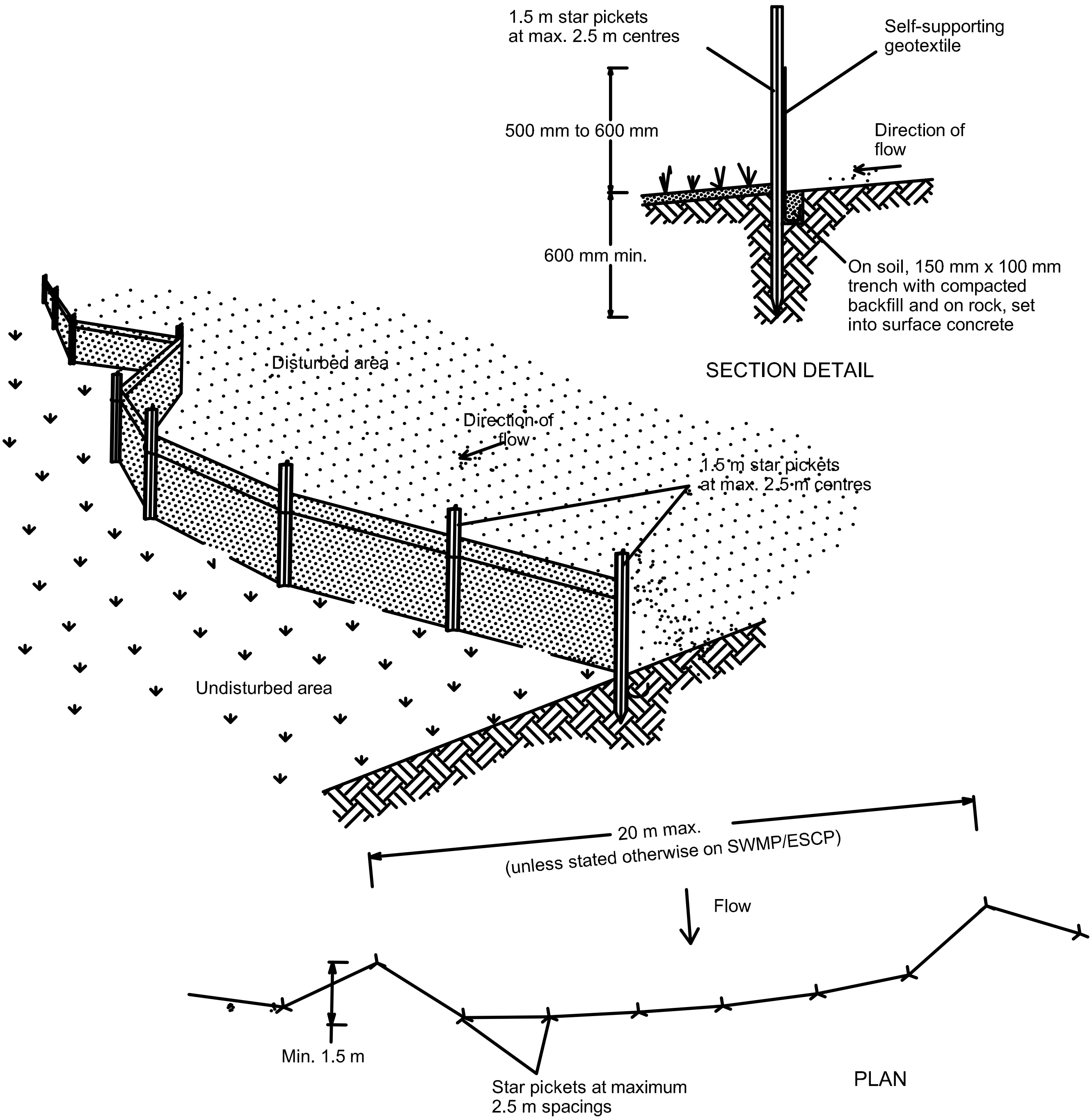
RECP : CONCENTRATED FLOW SD 5-7



Construction Notes

1. Construct the straw bale filter as close as possible to being parallel to the contours of the site.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws are to be placed parallel to ground.
3. Ensure that the maximum height of the filter is one bale.
4. Embed each bale in the ground 75 mm to 100 mm and anchor with two 1.2 metre star pickets or stakes. Angle the first star picket or stake in each bale towards the previously laid bale. Drive them 600 mm into the ground and, if possible, flush with the top of the bales. Where star pickets are used and they protrude above the bales, ensure they are fitted with safety caps.
5. Where a straw bale filter is constructed downslope from a disturbed batter, ensure the bales are placed 1 to 2 metres downslope from the toe.
6. Establish a maintenance program that ensures the integrity of the bales is retained - they could require replacement each two to four months.

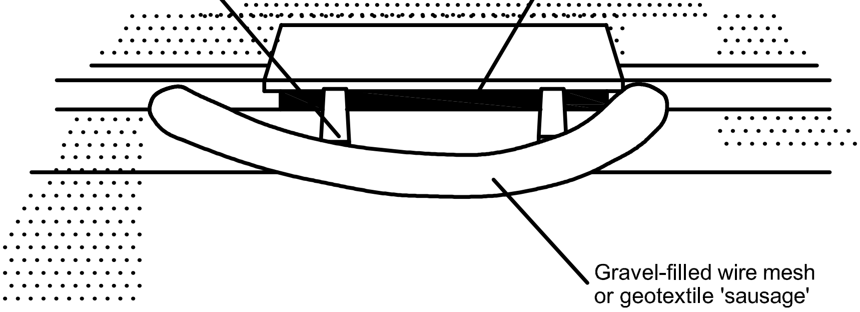
STRAW BALE FILTER — SD 6-7

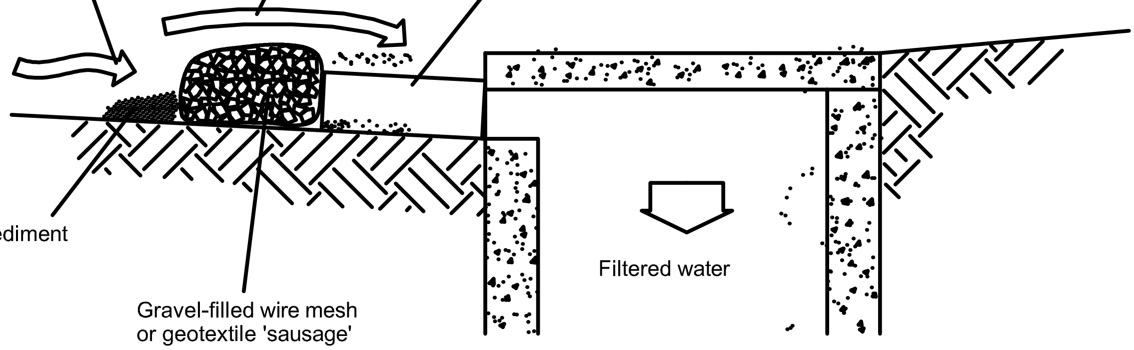


Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE SD 6-8



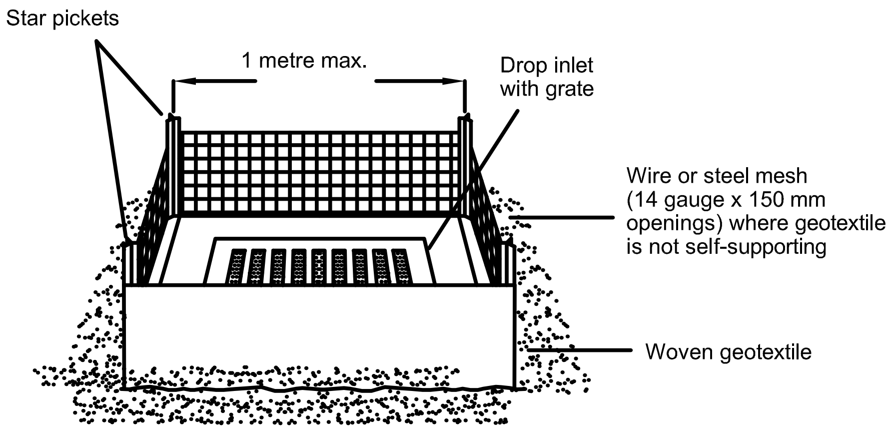


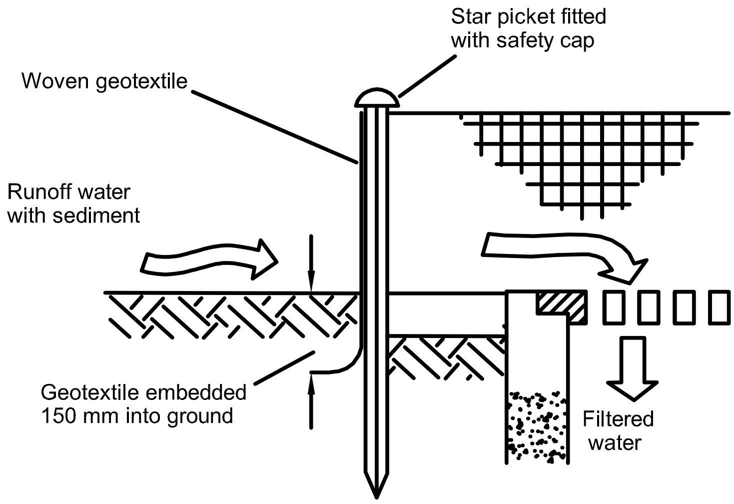
NOTE: This practice only to be used where specified in an approved SWMP/ESCP.

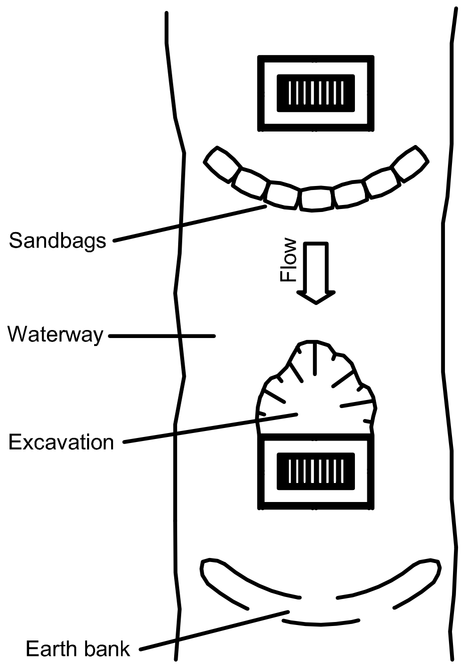
Construction Notes

1. Install filters to kerb inlets only at sag points.
2. Fabricate a sleeve made from geotextile or wire mesh longer than the length of the inlet pit and fill it with 25 mm to 50 mm gravel.
3. Form an elliptical cross-section about 150 mm high x 400 mm wide.
4. Place the filter at the opening leaving at least a 100-mm space between it and the kerb inlet. Maintain the opening with spacer blocks.
5. Form a seal with the kerb to prevent sediment bypassing the filter.
6. Sandbags filled with gravel can substitute for the mesh or geotextile providing they are placed so that they firmly abut each other and sediment-laden waters cannot pass between.

MESH AND GRAVEL INLET FILTER SD 6-11





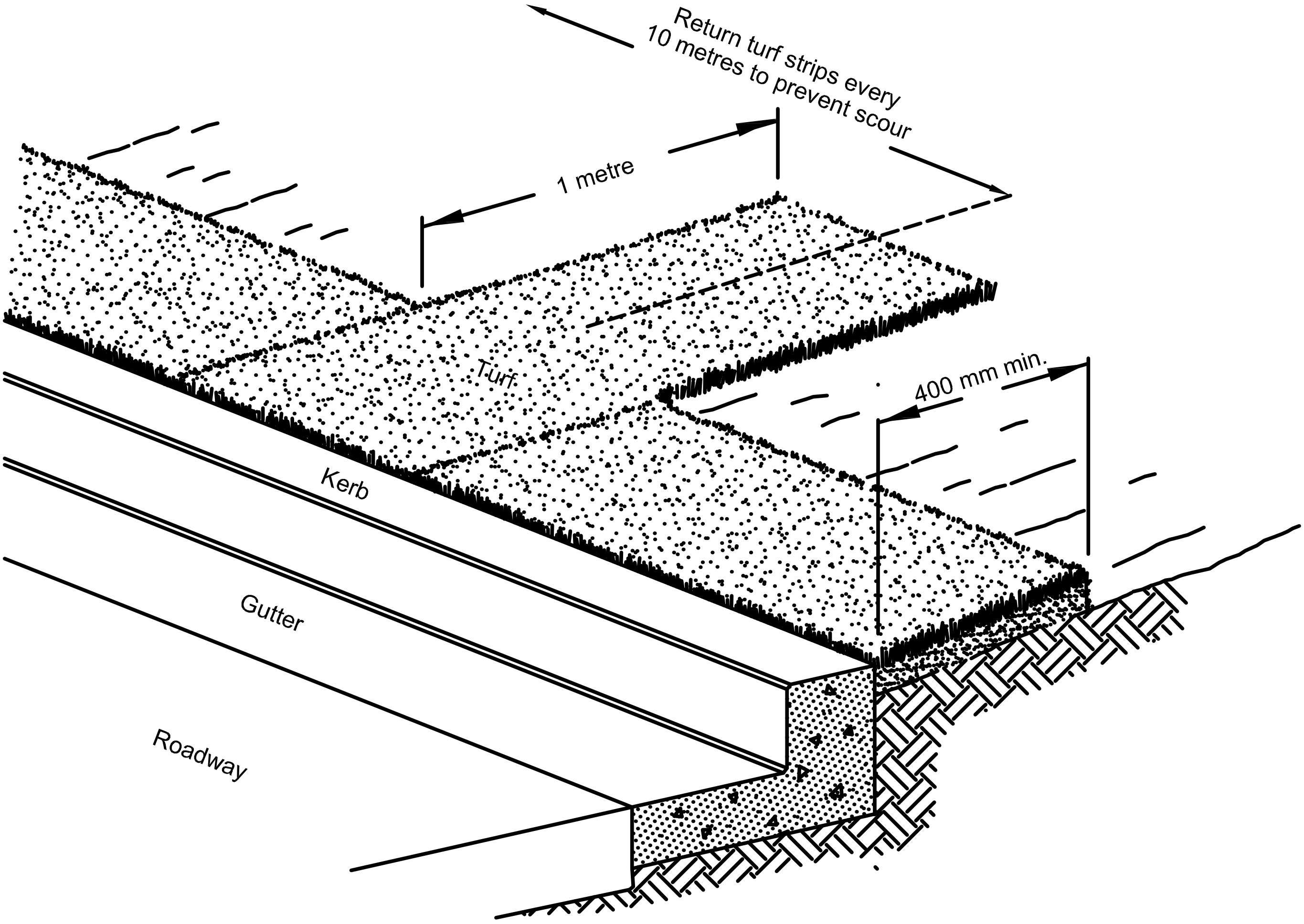


For drop inlets at non-sag points, sandbags, earth bank or excavation used to create artificial sag point

Construction Notes

1. Fabricate a sediment barrier made from geotextile or straw bales.
2. Follow Standard Drawing 6-7 and Standard Drawing 6-8 for installation procedures for the straw bales or geofabric. Reduce the picket spacing to 1 metre centres.
3. In waterways, artificial sag points can be created with sandbags or earth banks as shown in the drawing.
4. Do not cover the inlet with geotextile unless the design is adequate to allow for all waters to bypass it.

GEOTEXTILE INLET FILTER SD 6-12

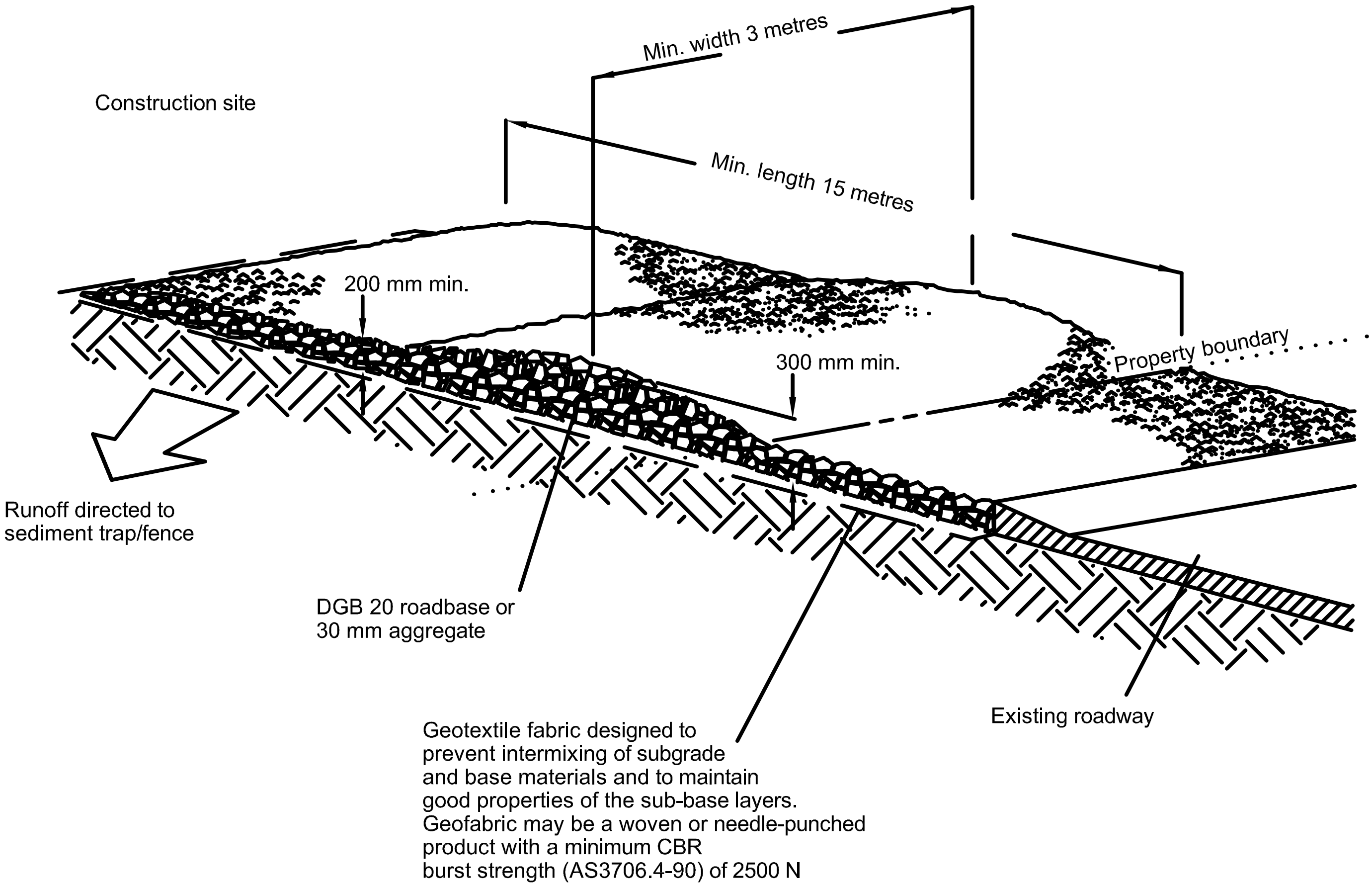


Construction Notes

1. Install a 400 mm minimum wide roll of turf on the footpath next to the kerb and at the same level as the top of the kerb.
2. Lay 1.4 metre long turf strips normal to the kerb every 10 metres.
3. Rehabilitate disturbed soil behind the turf strip following the ESCP/SWMP.

KERBSIDE TURF STRIP

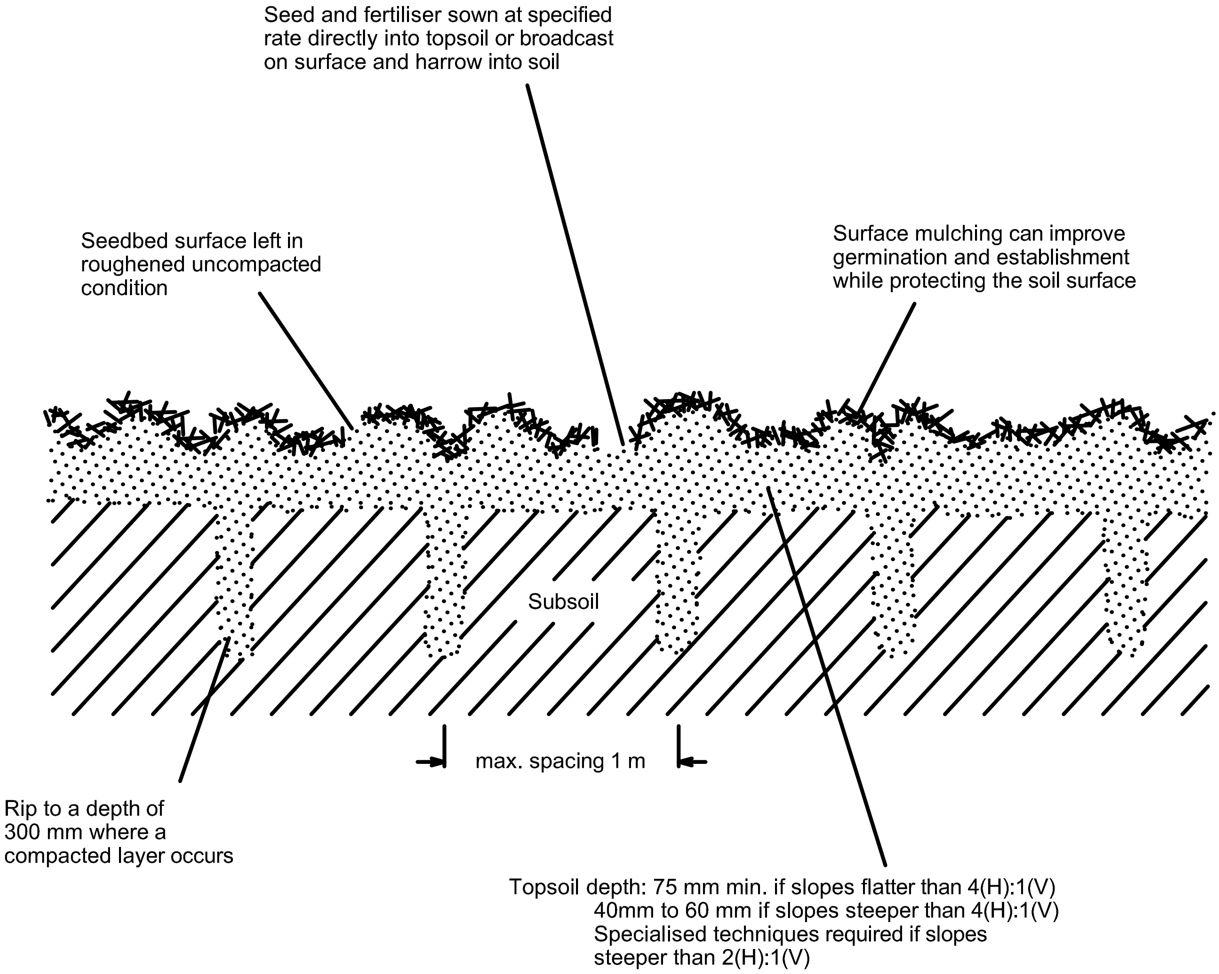
SD 6-13



Construction Notes

1. Strip the topsoil, level the site and compact the subgrade.
2. Cover the area with needle-punched geotextile.
3. Construct a 200 mm thick pad over the geotextile using road base or 30 mm aggregate.
4. Ensure the structure is at least 15 metres long or to building alignment and at least 3 metres wide.
5. Where a sediment fence joins onto the stabilised access, construct a hump in the stabilised access to divert water to the sediment fence

STABILISED SITE ACCESS SD 6-14



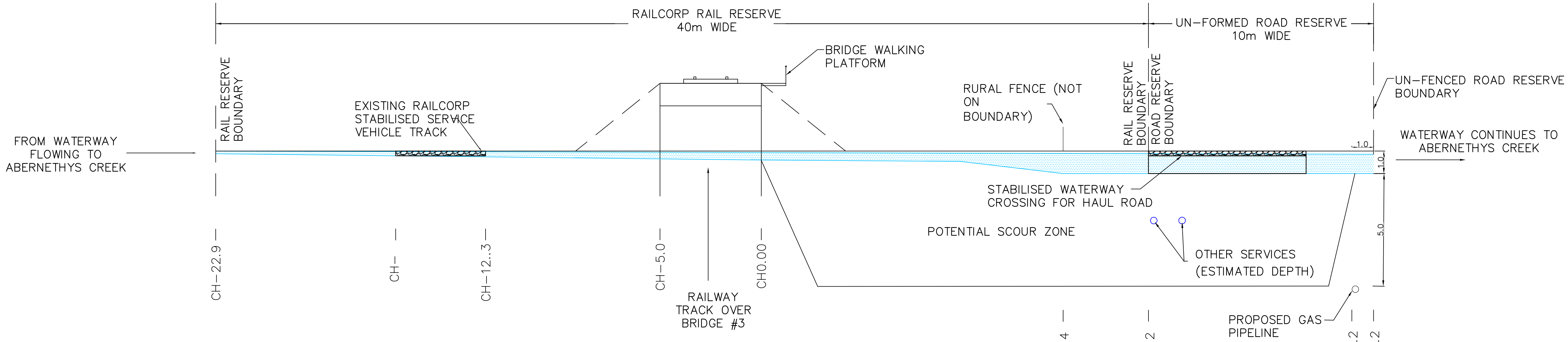
Construction Notes

1. Loosen compacted soil before sowing any seed. If necessary, rip the soil to a depth of 300 mm. Avoid rotary hoe cultivation.
2. Work the ground only as much as necessary to achieve the desired tilth and prepare a good seedbed.
3. Avoid cultivation in very wet or very dry conditions.
4. Cultivate on or close to the contour where possible, not up and down the slope.

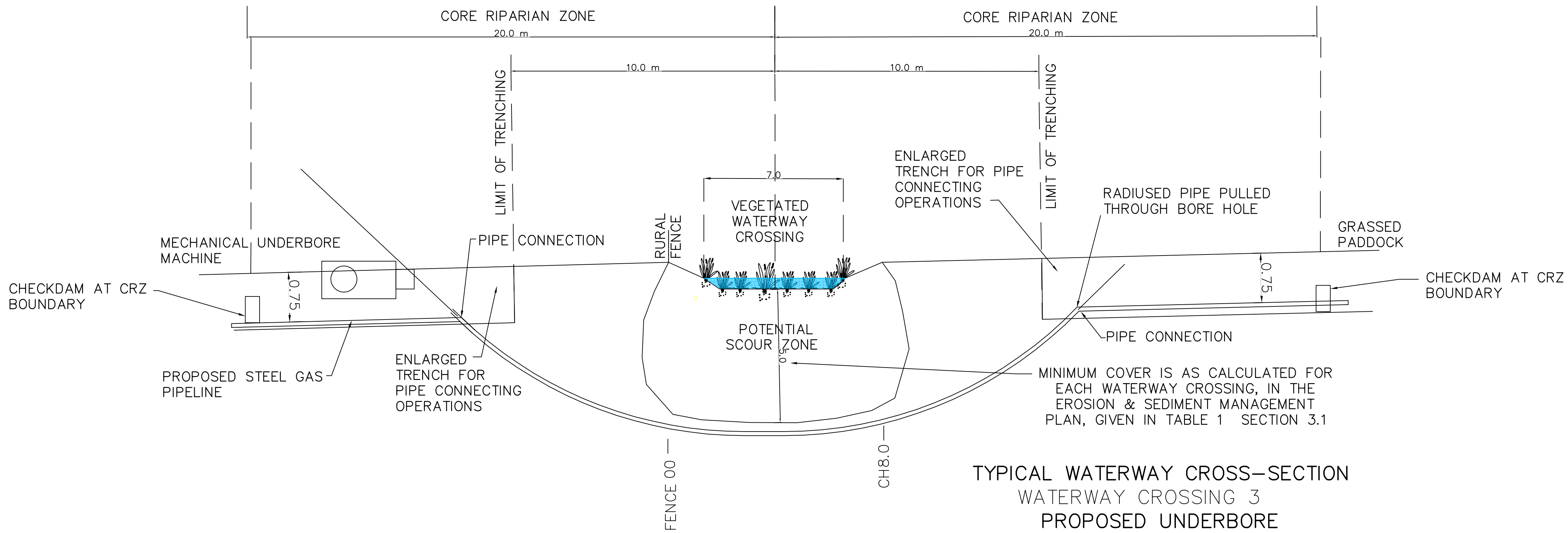
SEEDBED PREPARATION

SD 7-1

Appendix E – Figure 2: Cross Section of Waterway Crossing 3



TYPICAL WATERWAY LONG-SECTION
(WATERWAY CROSSING 3)



TYPICAL WATERWAY CROSS-SECTION
WATERWAY CROSSING 3
PROPOSED UNDERBORE

REVISION	BY	DATE

Liability limited by a scheme approved under Professional Standards Legislation.
COVER OF EXCELLENCE®

0 10 20 30 40 50 100

scale:— 1:1000

RATIO: 1:1000 @ A3

DATUM:

ORIGIN:

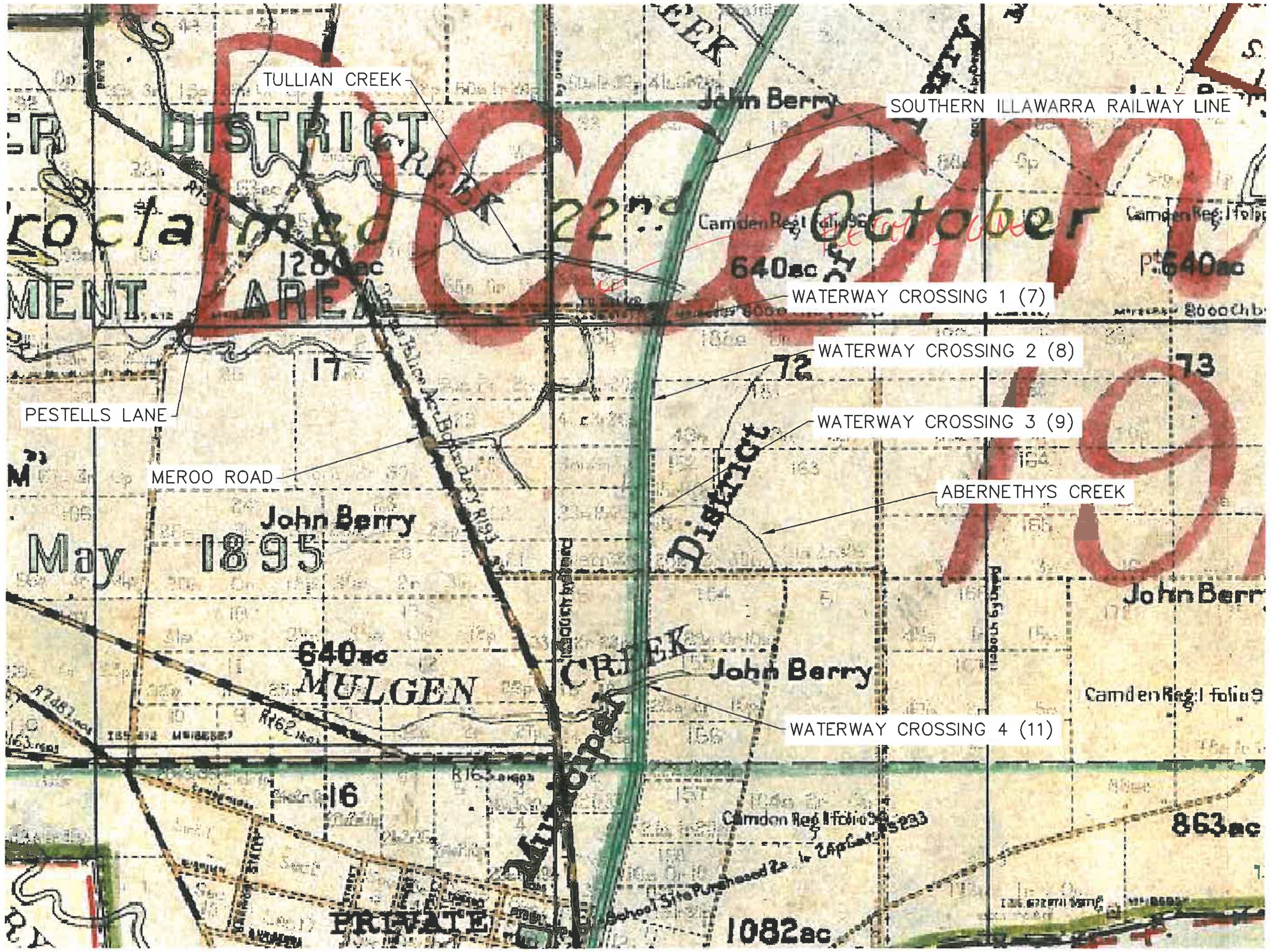
DATE OF PLAN: October 2011

allen, price & associates
land and development consultants
75 plunkett street, nowra, nsw. 2541
phone:(02) 4421 6544 fax:(02) 4422 1821
consultants@allenprice.com.au www.allenprice.com.au

APPENDIX E: YPICAL SECTIONS — WATERWAY CROSSING 3 SHOWING UNDERBORE & SCOUR ZONES FOR PROPOSED GAS PIPELINE AT MEROO MEADOW AND BOMADERRY FOR SHOALHAVEN STARCHES

REF. No. 24710
sheet 1 of 1
REVISION 00

Appendix F: May 1895 Topographic Map Detail



REVISION		BY	DATE

RATIO:	DATUM:
1:500 @ A3	ORIGIN:
	DATE OF PLAN: FEB 2012

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consultants@allenprice.com.au www.allenprice.com.au

APPENDIX F – may 1895 1:4000 topographic map for proposed gas pipeline project at Meroo Meadow and Bomaderry, NSW for Shoalhaven Starches

REF. No. 24710
sheet 1 of 1
REVISION 00

Appendix G: Coffey Environments Engineering Log – Excavation (Bore Holes CTP10, CTP12, CTP16 & CTP17)

coffey environments

Engineering Log - Excavation

Excavation No. **CTP10**

Sheet 1 of 1

Office Job No.: **ENAUWOLL04006AA**

Client:	MANILDRA GROUP	Date started:	21.6.2011
Principal:		Date completed:	21.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation: N-S		Easting:	282018 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing:	6142018 m	datum:	WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N				0.0–0.5			TOPSOIL: Sandy CLAY: Low to medium plasticity, pale yellow/brown, fine to medium grained sand, with some roots.	M	MD		TOPSOIL
						0.5–1.5		CL	Sandy CLAY: Medium plasticity, red/orange, with some silt, and a trace of roots and fine to coarse grained angular sandstone gravel.	<Wp	St		RESIDUAL
			Seepage			1.5–2.5		CL	Sandy Gravelly CLAY: Medium plasticity, orange/brown with some pale yellow/pale brown pockets and fine to medium grained highly weathered sandstone gravel.		H		EXTREMELY WEATHERED MATERIAL End on slow progress
						2.5			Test pit CTP10 terminated at 2.5m				

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure	S shoring N nil	U_{50} undisturbed sample 50mm diameter	based on unified classification system	VS very soft
X existing excavation	penetration 1 2 3 4	U_{63} undisturbed sample 63mm diameter	moisture	S soft
BH backhoe bucket	no resistance ranging to refusal	D disturbed sample	D dry	F firm
B bulldozer blade	water	V vane shear (kPa)	M moist	St stiff
R ripper	water level on date shown	Bs bulk sample	W wet	VSt very stiff
E excavator	water inflow	E environmental sample	Wp plastic limit	H hard
	water outflow	R refusal	W_L liquid limit	Fb friable
				VL very loose
				L loose
				MD medium dense
				D dense
				VD very dense

Form GEO 5.2 Issue 3 Rev.2

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COF GDT 29.7.11

coffey environments

Engineering Log - Excavation

Client:	MANILDRA GROUP	Excavation No.	CTP12
		Sheet	1 of 1
		Office Job No.:	ENAUWOLL04006AA
		Date started:	21.6.2011
Principal:		Date completed:	21.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model: 5T EXCAVATOR | Pit Orientation: N-S | Easting: 282092 m | R.L. Surface: NOT MEASURED

excavation dimensions: 2m long 0.45m wide | Northing: 6142461 m | datum: WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E		N							TOPSOIL; CLAY: High plasticity, brown, with some silt and roots.	>Wp	S		TOPSOIL
			▶ (0.5)			0.5		CH	Sandy CLAY: High plasticity, brown, with some silt, and a trace of roots.				ALLUVIAL/ESTUARINE SOIL
				ASS								x	
				ASS		1.0							
				ASS		1.5		CH	Sandy CLAY: High plasticity, grey, fine grained sand, and some silt.		St	x	
												x	
				ASS		2.0						x	
						2.5							End on steady progress
									Test pit CTP12 terminated at 2.5m				
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	S shoring N nil penetration 1 2 3 4 no resistance ranging to refusal water water level on date shown water inflow water outflow	U_{50} undisturbed sample 50mm diameter U_{63} undisturbed sample 63mm diameter D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	based on unified classification system moisture D dry M moist W wet Wp plastic limit W_L liquid limit	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense

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TESTPIT ENAUWOLL04006AA - LOGS.GPJ COF .GDT 29.7.11

coffey environments

Engineering Log - Excavation

Excavation No. CTP16
Sheet 1 of 1
Office Job No.: ENAUWOLL04006AA

Client: MANILDRA GROUP
Principal:
Project: CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT
Test pit location: PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541

Date started: 22.6.2011
Date completed: 22.6.2011
Logged by: CA
Checked by: SM

equipment type and model: 5T EXCAVATOR — Pit Orientation: N-S — Easting: 282191 m — R.L. Surface: NOT MEASURED
excavation dimensions: 2m long 0.45m wide — Northing: 6142933 m — datum: WGS84 (Approx)

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
E		N							TOPSOIL; CLAY: High plasticity, brown, with some roots.	<Wp	F		TOPSOIL
				ASS		0.5		CH	CLAY: High plasticity, grey with some iron stained orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	Wp	VSt	x	ALLUVIAL SOIL
				ASS		1.0							
				ASS		1.5							
				ASS		2.0		CH	Sandy CLAY: High plasticity, grey with orange/brown pockets, with a trace of roots and fine to coarse grained sub-angular gravel.	>Wp Saturated	St	x	
			▶			2.5			Test pit CTP16 terminated at 2.5m				End on steady progress
						3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure X existing excavation BH backhoe bucket B bulldozer blade R ripper E excavator	S shoring N nil penetration 1 2 3 4 no resistance ranging to refusal water water level on date shown water inflow water outflow	U_{50} undisturbed sample 50mm diameter U_{63} undisturbed sample 63mm diameter D disturbed sample V vane shear (kPa) Bs bulk sample E environmental sample R refusal	based on unified classification system moisture D dry M moist W wet Wp plastic limit W_L liquid limit	VS very soft S soft F firm St stiff VSt very stiff H hard Fb friable VL very loose L loose MD medium dense D dense VD very dense

coffey environments

Engineering Log - Excavation

Excavation No. CTP17
Sheet 1 of 1
Office Job No.: ENAUWOLL04006AA

Client:	MANILDRA GROUP	Date started:	22.6.2011
Principal:		Date completed:	22.6.2011
Project:	CONTAMIN, ASS, GEOTECH + GWATER ASSESSMENT	Logged by:	CA
Test pit location:	PROPOSED GAS PIPELINE, BOMADERRY, NSW, 2541	Checked by:	SM

equipment type and model:	5T EXCAVATOR	Pit Orientation:		Easting:	282284 m	R.L. Surface:	NOT MEASURED
excavation dimensions:	2m long 0.45m wide			Northing	6143258 m	datum:	WGS84 (Approx)

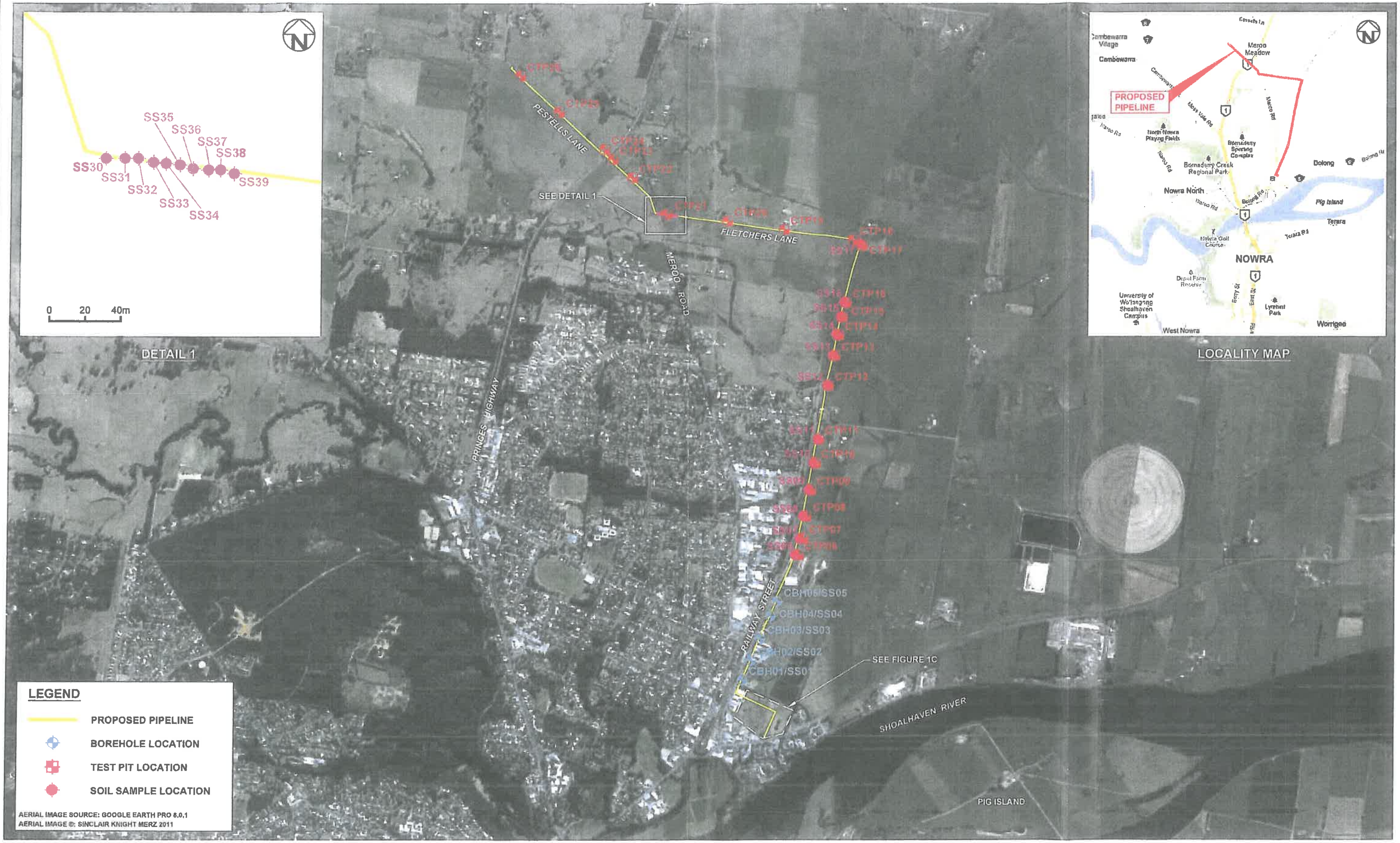
excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E		N	NONE OBSERVED					TOPSOIL; CLAY: Medium plasticity, brown, with some fine grained roots.	Wp	F		TOPSOIL
					0.5		CH	CLAY: High plasticity, brown with some orange pockets, with a trace of fine grained sand, roots and fine to coarse grained gravel.	<Wp	VSt	X	ALLUVIAL SOIL
				ASS								
					1.0						X	
				ASS								
					1.5							
				ASS								
					2.0						X	
					2.5							End on steady progress
								Test pit CTP17 terminated at 2.5m				
					3.0							

Sketch

method	support	notes, samples, tests	classification symbols and soil description	consistency/density index
N natural exposure	S shoring N nil	U_{50} undisturbed sample 50mm diameter	based on unified classification system	VS very soft
X existing excavation	penetration 1 2 3 4 no resistance ranging to refusal	U_{63} undisturbed sample 63mm diameter	moisture	S soft
BH backhoe bucket	water	D disturbed sample	D dry	F firm
B bulldozer blade	water level on date shown	V vane shear (kPa)	M moist	St stiff
R ripper	water inflow	Bs bulk sample	W wet	VSt very stiff
E excavator	water outflow	E environmental sample	Wp plastic limit	H hard
		R refusal	W_L liquid limit	Fb friable
				VL very loose
				L loose
				MD medium dense
				D dense
				VD very dense

TESTPIT ENAUWOLL04006AA - LOGS.GPJ COF DT 29.7.11

Form GEO 5.2 Issue 3 Rev.2



revision	description	drawn	approved	date

200 0 200 600 1000

Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	28.07.11
scale	AS SHOWN
original size	A3

coffey environments

SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

client: MANILDRA GROUP PTY LTD

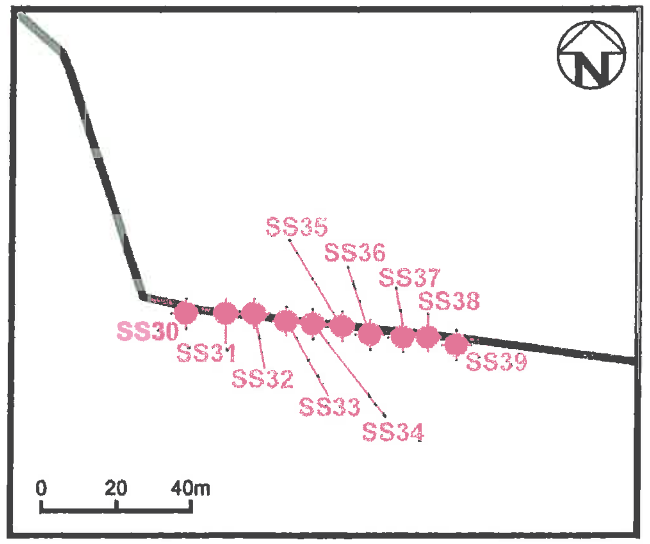
project: ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW

title: PROPOSED PIPELINE ROUTE WITH COFFEY TEST LOCATIONS

project no: ENAUWOLL04006AA-R01

figure no: FIGURE 1

Map Class Description	Depth to Acid Sulfate Soil Materials	
HIGH PROBABILITY High probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has been suitable for the formation of acid sulfate soil materials. Acid sulfate soil materials are widespread or sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.
		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
LOW PROBABILITY Low probability of occurrence of acid sulfate soil materials within the soil profile. The environment of deposition has generally not been suitable for the formation of acid sulfate soil materials. Soil materials are often Pleistocene in age. Acid sulfate soil materials, if present, are sporadic and may be buried by alluvium or windblown sediments.	Below water level	Bottom sediments.
		At or near the ground surface.
		Within 1 metre of the ground surface.
		Between 1 and 3 metres below the ground surface.
		Greater than 3 metres below the ground surface.*
NO KNOWN OCCURRENCE Acid sulfate soils are not known or expected to occur in these environments.		No known occurrences of acid sulfate soil materials.

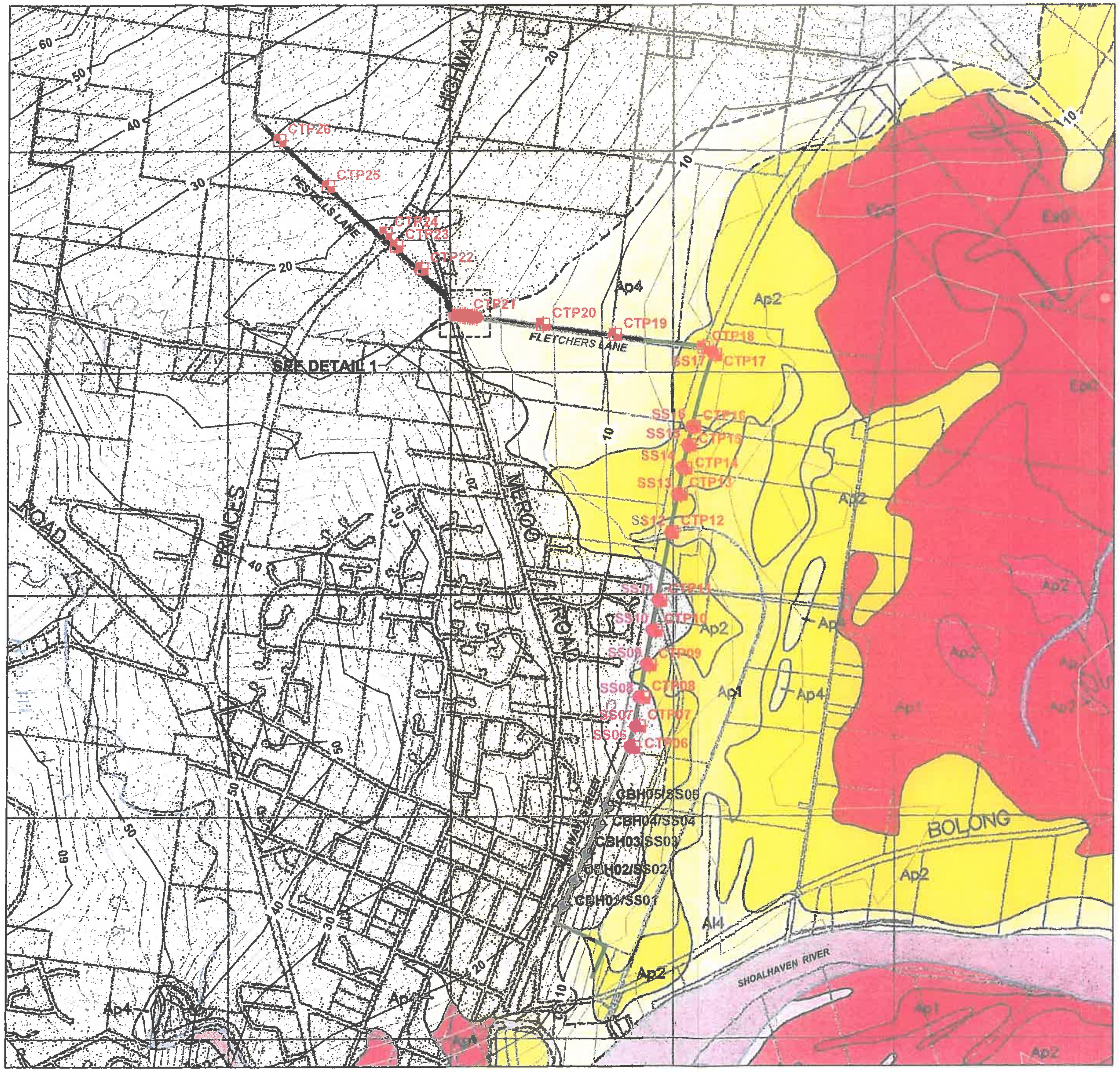


DETAIL 1

LEGEND

- PROPOSED PIPELINE
- BOREHOLE LOCATION
- TEST PIT LOCATION
- SOIL SAMPLE LOCATION

REFERNCE: BURRIER/BERRY 1:25 000 ACID SOIL RISK MAP (1997) EDITION 2, PREPARED BY THE NSW DEPARTMENT OF LAND AND WATER CONSERVATION (DLWC)



revision	description	drawn	approved	date

200 0 200 600 1000

Horizontal Scale (metres) 1:20 000

drawn	CA/AW
approved	CA
date	29/07/11
scale	AS SHOWN
original size	A3

coffey environments

SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

client:	MANILDRA GROUP PTY LTD
project:	ACID SULFATE SOIL, CONTAMINATION AND GEOTECHNICAL INVESTIGATION PROPOSED GAS PIPLINE, BOMADERRY, NSW
title:	PROPOSED PIPELINE ROUTE WITH 1:25000 BURRIER/BERRY ASS RISK MAP
project no: ENAUWOLL04006AA-R01	figure no: FIGURE 2

Appendix H: Catchment Stormwater Runoff Calculations

CATCHMENT 1 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	11.74 ha
Time of Concentration (mins)	20.20 mins
Rainfall Intensity (I)	102 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**2.33 m3/sec**

CATCHMENT 1 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	11.74 ha
Time of Concentration (mins)	20.20 mins
Rainfall Intensity (I)	174 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**3.97 m3/sec**

CATCHMENT RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	545.40 ha
Time of Concentration (mins)	86.88 mins
Rainfall Intensity (I)	47 mm/hr
Runoff Coefficient (C)	0.60
Factor (F)	0.00278
DISCHARGE (Q)	**42.72 m3/sec**

CATCHMENT RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	545.40 ha
Time of Concentration (mins)	86.88 mins
Rainfall Intensity (I)	85 mm/hr
Runoff Coefficient (C)	0.60
Factor (F)	0.00278
DISCHARGE (Q)	**77.27 m3/sec**

CATCHMENT 3 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method   Q = FCIA

Total Area (A)	896.50 ha
Time of Concentration (mins)	104.94 mins
Rainfall Intensity (I)	41 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**71.47 m3/sec**

CATCHMENT 3 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method   Q = FCIA

Total Area (A)	896.50 ha
Time of Concentration (mins)	104.94 mins
Rainfall Intensity (I)	76 mm/hr
Runoff Coefficient (C)	0.70
Factor (F)	0.00278
DISCHARGE (Q)	**132.48 m3/sec**

CATCHMENT 4 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:5 ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	115.40 ha
Time of Concentration (mins)	48.15 mins
Rainfall Intensity (I)	66 mm/hr
Runoff Coefficient (C)	0.80
Factor (F)	0.00278
DISCHARGE (Q)	**16.93 m3/sec**

CATCHMENT 4 RUNOFF CALCULATIONS

Shoalhaven City Council

Discharges for 1:100ARI

Nowra

Rational Method Q = FCIA

Total Area (A)	115.40 ha
Time of Concentration (mins)	48.15 mins
Rainfall Intensity (I)	117 mm/hr
Runoff Coefficient (C)	0.80
Factor (F)	0.00278
DISCHARGE (Q)	**30.00 m3/sec**

Appendix I: HY-8 Culvert Analysis Reports for Waterway Crossings 1, 2, 3 and 4, with Scour Depth Calculation Results

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 1

Headwater Elevation (m)	Total Discharge (cms)	Culvert 1A Discharge (cms)	Culvert 1B Discharge (cms)	Culvert 1C Discharge (cms)	Culvert 1D Discharge (cms)	Culvert 1E Discharge (cms)	Culvert 1F Discharge (cms)	Roadway Discharge (cms)	Iterations
0.43	2.33	0.39	0.39	0.39	0.39	0.39	0.39	0.00	16
0.44	2.49	0.42	0.42	0.42	0.42	0.42	0.42	0.00	3
0.46	2.66	0.44	0.44	0.44	0.44	0.44	0.44	0.00	3
0.48	2.82	0.47	0.47	0.47	0.47	0.47	0.47	0.00	3
0.50	2.99	0.50	0.50	0.50	0.50	0.50	0.50	0.00	3
0.52	3.15	0.52	0.52	0.52	0.52	0.52	0.52	0.00	3
0.53	3.31	0.55	0.55	0.55	0.55	0.55	0.55	0.00	3
0.55	3.48	0.58	0.58	0.58	0.58	0.58	0.58	0.00	3
0.57	3.64	0.61	0.61	0.61	0.61	0.61	0.61	0.00	2
0.58	3.81	0.63	0.63	0.63	0.63	0.63	0.63	0.00	2
0.60	3.96	0.66	0.66	0.66	0.66	0.66	0.66	0.00	2
2.00	13.88	2.31	2.31	2.31	2.31	2.31	2.31	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

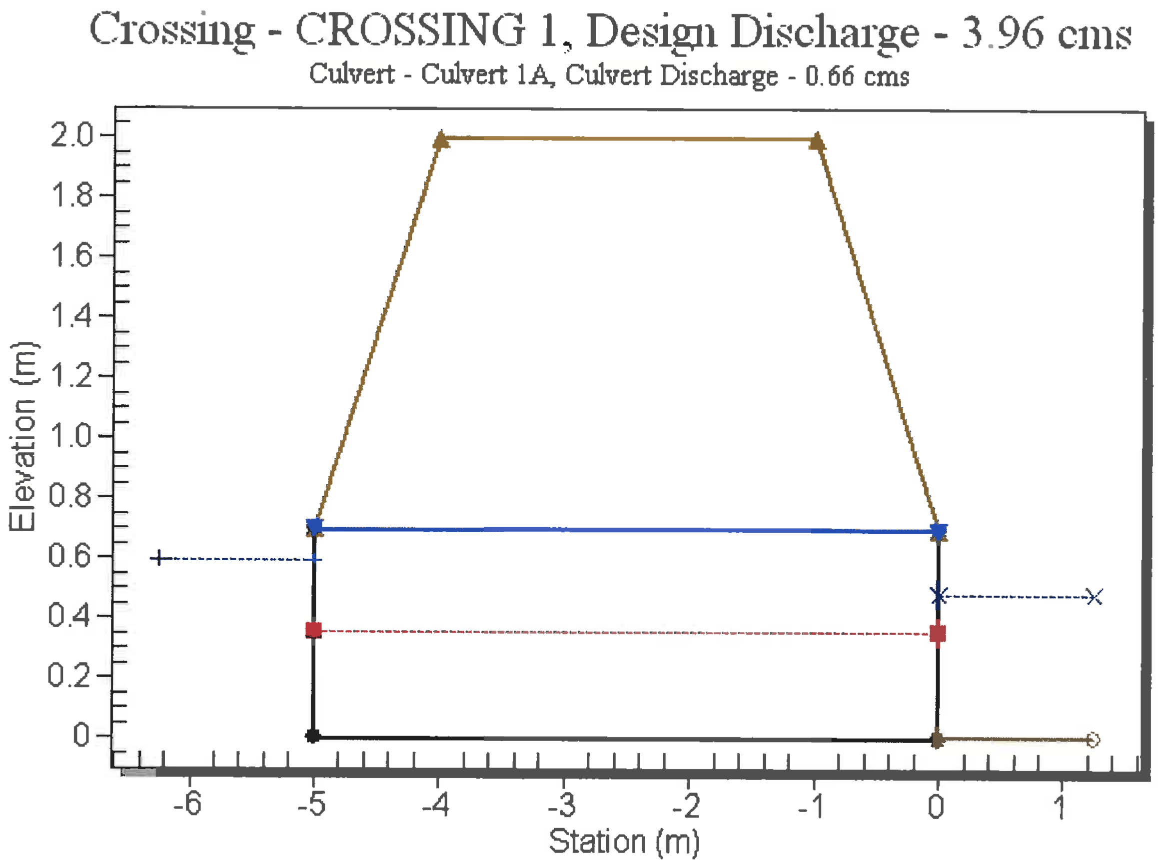
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1A



Site Data - Culvert 1A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1A

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 1B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

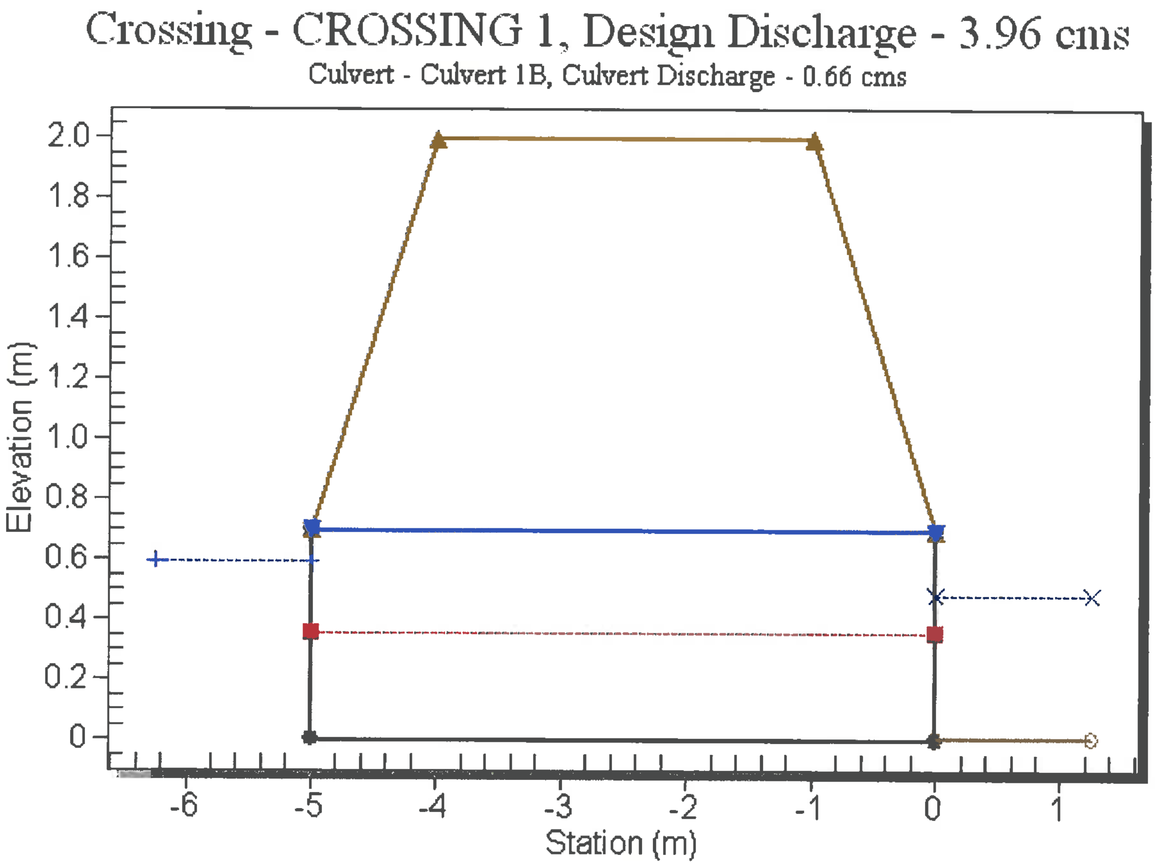
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1B



Site Data - Culvert 1B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1B

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 1C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

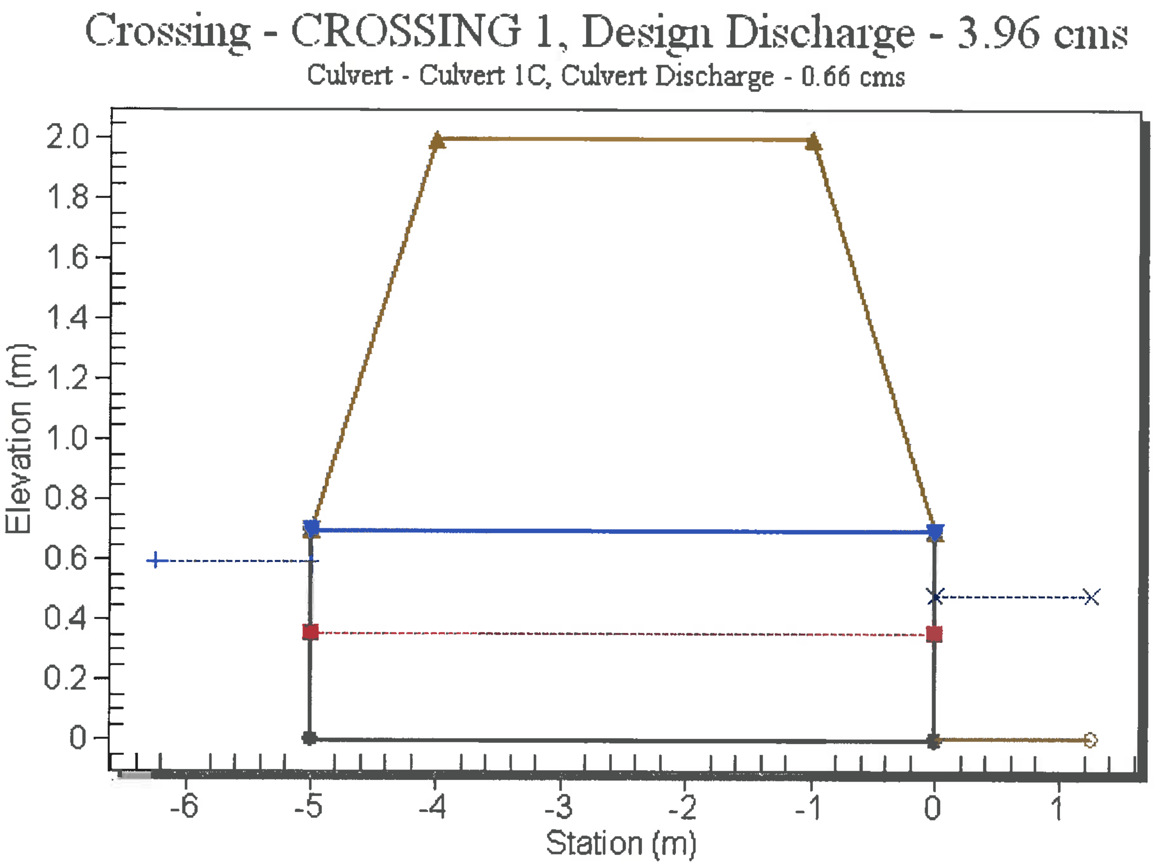
****

Inlet Elevation (invert): 0.00 m,   Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m,   Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1C



Site Data - Culvert 1C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1C

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Culvert Summary Table: Culvert 1D

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

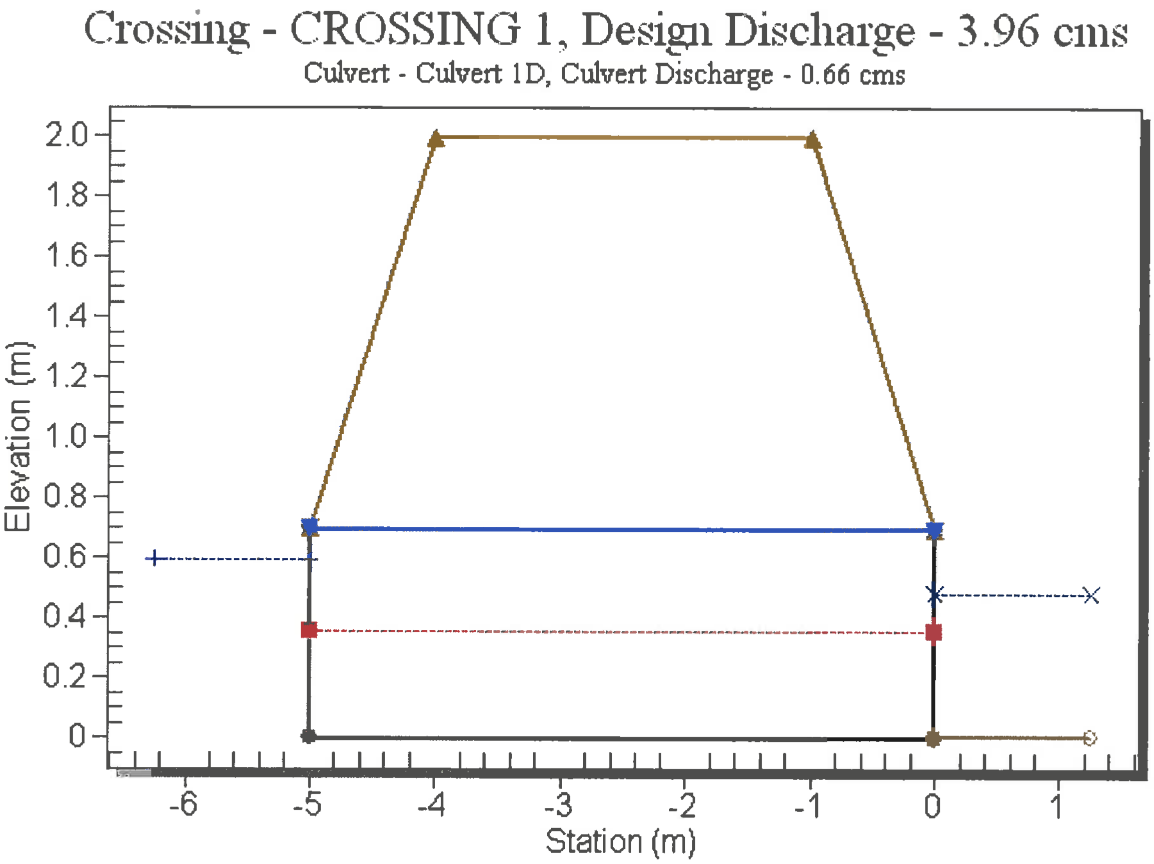
****

Inlet Elevation (invert): 0.00 m,   Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m,   Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1D



Site Data - Culvert 1D

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1D

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 6 - Culvert Summary Table: Culvert 1E

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

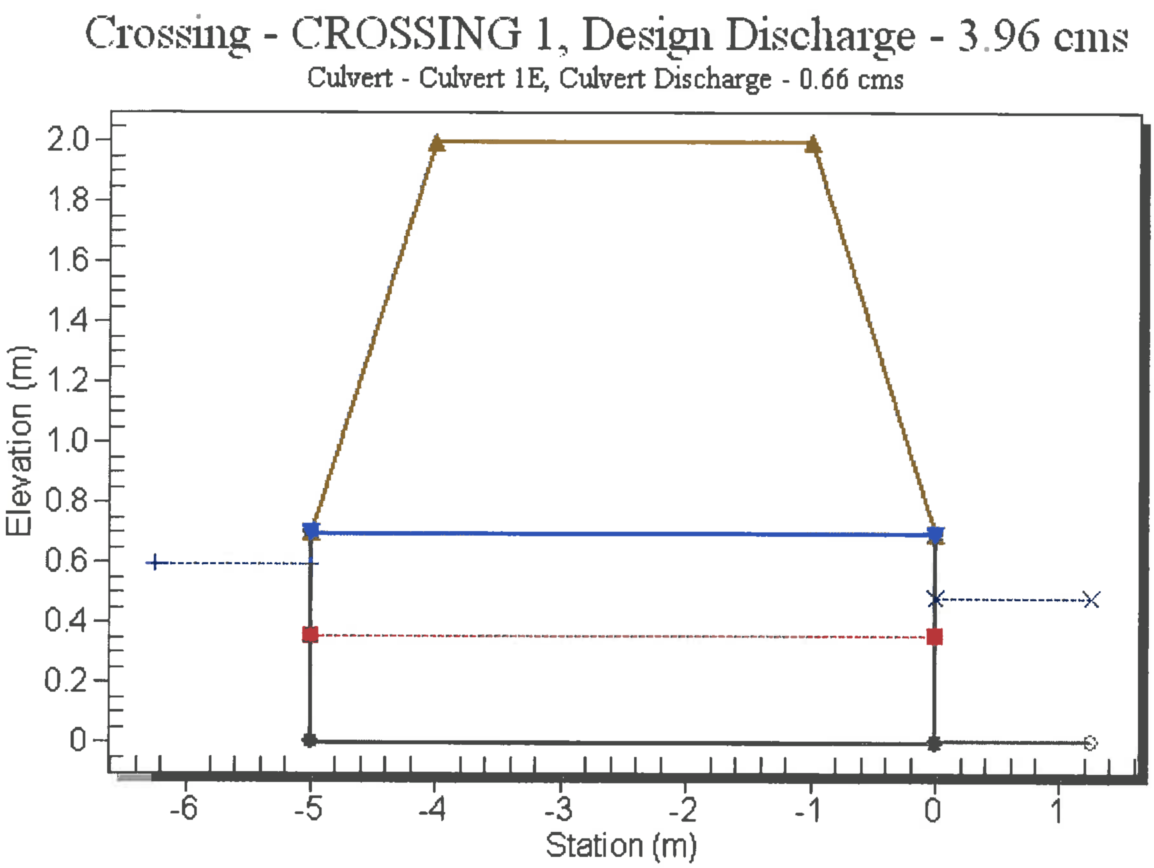
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1E



Site Data - Culvert 1E

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1E

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 7 - Culvert Summary Table: Culvert 1F

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
2.33	0.39	0.43	0.425	0.382	6-FFt	0.700	0.250	0.700	0.357	0.557	1.143
2.49	0.42	0.44	0.443	0.400	6-FFt	0.700	0.261	0.700	0.371	0.594	1.170
2.66	0.44	0.46	0.462	0.418	6-FFt	0.700	0.272	0.700	0.385	0.633	1.196
2.82	0.47	0.48	0.480	0.436	6-FFt	0.700	0.283	0.700	0.399	0.672	1.220
2.99	0.50	0.50	0.498	0.454	6-FFt	0.700	0.294	0.700	0.412	0.711	1.244
3.15	0.52	0.52	0.515	0.471	6-FFt	0.700	0.305	0.700	0.425	0.750	1.266
3.31	0.55	0.53	0.533	0.489	6-FFt	0.700	0.315	0.700	0.438	0.789	1.288
3.48	0.58	0.55	0.550	0.507	6-FFt	0.700	0.325	0.700	0.450	0.828	1.309
3.64	0.61	0.57	0.567	0.524	6-FFt	0.700	0.335	0.700	0.462	0.867	1.329
3.81	0.63	0.58	0.583	0.542	6-FFt	0.700	0.345	0.700	0.474	0.906	1.349
3.96	0.66	0.60	0.599	0.558	6-FFt	0.700	0.355	0.700	0.485	0.942	1.367

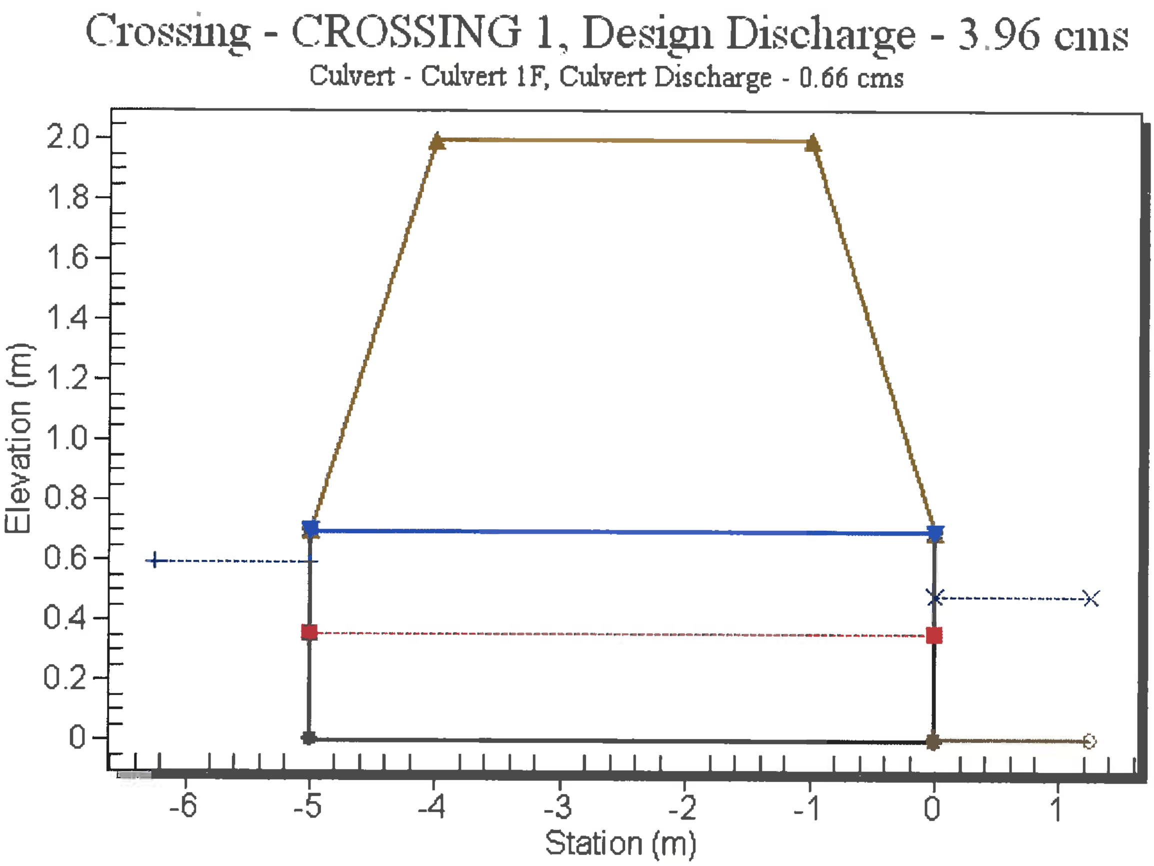
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 1F



Site Data - Culvert 1F

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 1F

Barrel Shape: Concrete Box

Barrel Span: 1000.00 mm

Barrel Rise: 700.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 8 - Downstream Channel Rating Curve (Crossing: CROSSING 1)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
2.33	0.36	0.36	1.14	34.97	0.65
2.49	0.37	0.37	1.17	36.39	0.65
2.66	0.39	0.39	1.20	37.77	0.65
2.82	0.40	0.40	1.22	39.10	0.66
2.99	0.41	0.41	1.24	40.41	0.66
3.15	0.43	0.43	1.27	41.68	0.66
3.31	0.44	0.44	1.29	42.92	0.67
3.48	0.45	0.45	1.31	44.14	0.67
3.64	0.46	0.46	1.33	45.33	0.67
3.81	0.47	0.47	1.35	46.50	0.67
3.96	0.49	0.49	1.37	47.57	0.68

Tailwater Channel Data - CROSSING 1

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 5.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 m

Crest Elevation: 2.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 1	
Culvert	Culvert 1A	
Flow	3.96	cms
Culvert Data		
Culvert Width (including multiple barrels)	1.0	m
Culvert Height	0.7	m
Outlet Depth	0.70	m
Outlet Velocity	0.94	m/s
Froude Number	0.36	
Tailwater Depth	0.49	m
Tailwater Velocity	1.37	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	100.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.161	kPa
Modified Shear Number	0.264	
Scour Hole Dimensions		
Length (LS)	3.768	m
Width (WS)	3.777	m
Depth (DS)	0.871	m
Volume (VS)	1.464	m^3
DS at 0.4(LS)	1.507	m
Tailwater Depth (TW)	0.485	m
Velocity with TW and WS	0.286	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 2

Headwater Elevation (m)	Total Discharge (cms)	Culvert 2A Discharge (cms)	Culvert 2B Discharge (cms)	Culvert 2C Discharge (cms)	Culvert 2D Discharge (cms)	Roadway Discharge (cms)	Iterations
1.69	42.00	7.86	13.11	13.11	7.86	0.00	32
1.73	45.50	8.05	13.41	13.41	8.05	2.52	9
1.75	49.00	8.13	13.55	13.55	8.13	5.57	6
1.77	52.50	8.20	13.67	13.67	8.20	8.68	5
1.78	56.00	8.27	13.78	13.78	8.27	11.87	5
1.80	59.50	8.33	13.88	13.88	8.33	15.03	4
1.81	63.00	8.35	13.94	13.94	8.35	18.38	4
1.83	66.50	8.20	13.69	13.69	8.20	22.68	4
1.84	70.00	8.04	13.43	13.43	8.04	27.01	4
1.86	73.50	7.88	13.17	13.17	7.88	31.36	4
1.87	76.00	7.77	12.98	12.98	7.77	34.48	4
1.70	42.23	7.92	13.20	13.20	7.92	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 2A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	7.86	1.69	1.687	1.488	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	8.05	1.73	1.730	1.559	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	8.13	1.75	1.750	1.615	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	8.20	1.77	1.768	1.668	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	8.27	1.78	1.783	1.719	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	8.33	1.80	1.797	1.768	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	8.35	1.81	1.802	1.811	4-FFf	1.000	0.926	1.000	1.199	2.783	2.577
66.50	8.20	1.83	1.765	1.827	4-FFf	1.000	0.915	1.000	1.237	2.732	2.626
70.00	8.04	1.84	1.728	1.843	4-FFf	1.000	0.903	1.000	1.275	2.680	2.672
73.50	7.88	1.86	1.692	1.857	4-FFf	1.000	0.891	1.000	1.311	2.628	2.718
76.00	7.77	1.87	1.666	1.868	4-FFf	1.000	0.883	1.000	1.337	2.590	2.749

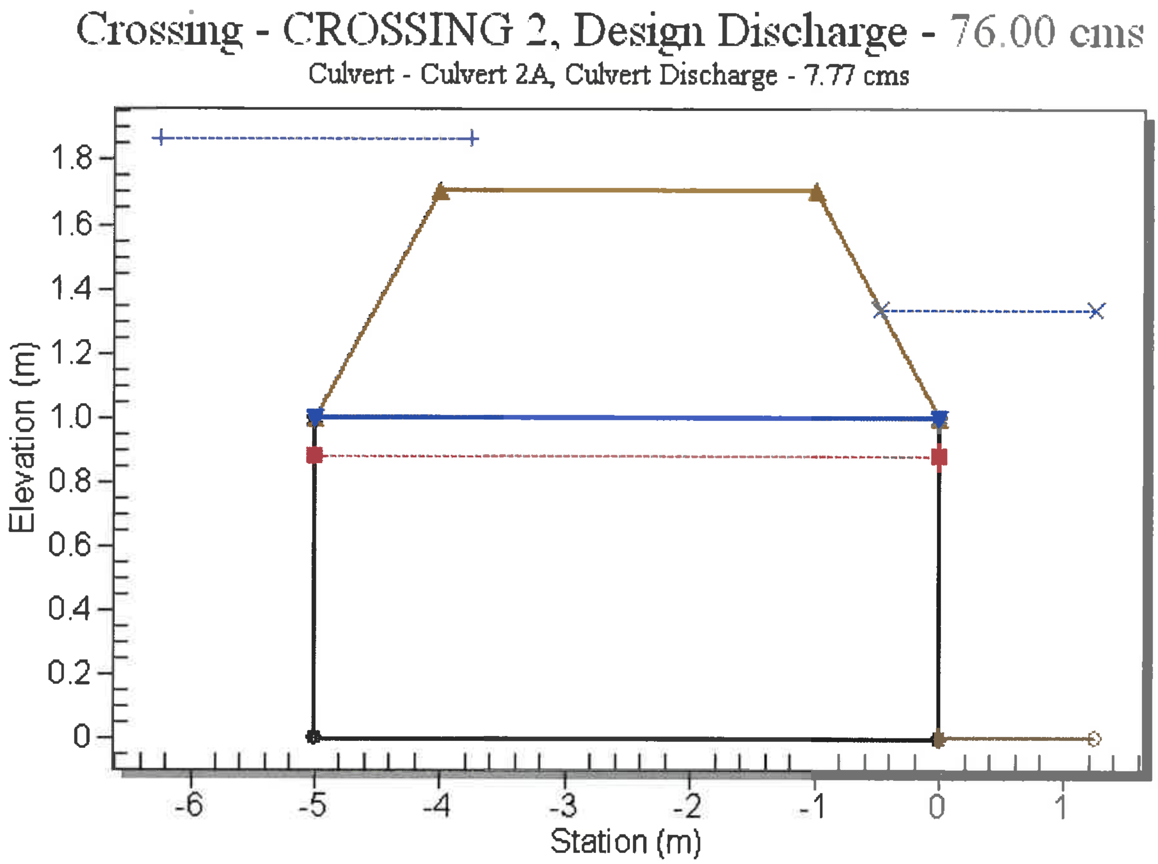
****

Inlet Elevation (invert): 0.00 m,   Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m,   Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2A



Site Data - Culvert 2A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2A

Barrel Shape: Concrete Box

Barrel Span: 3000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 2B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	13.11	1.69	1.687	1.486	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	13.41	1.73	1.730	1.556	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	13.55	1.75	1.750	1.613	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	13.67	1.77	1.768	1.666	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	13.78	1.78	1.783	1.717	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	13.88	1.80	1.797	1.765	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	13.94	1.81	1.807	1.811	4-FFf	1.000	0.927	1.000	1.199	2.789	2.577
66.50	13.69	1.83	1.770	1.827	4-FFf	1.000	0.916	1.000	1.237	2.738	2.626
70.00	13.43	1.84	1.733	1.843	4-FFf	1.000	0.904	1.000	1.275	2.686	2.672
73.50	13.17	1.86	1.696	1.857	4-FFf	1.000	0.893	1.000	1.311	2.634	2.718
76.00	12.98	1.87	1.670	1.868	4-FFf	1.000	0.884	1.000	1.337	2.596	2.749

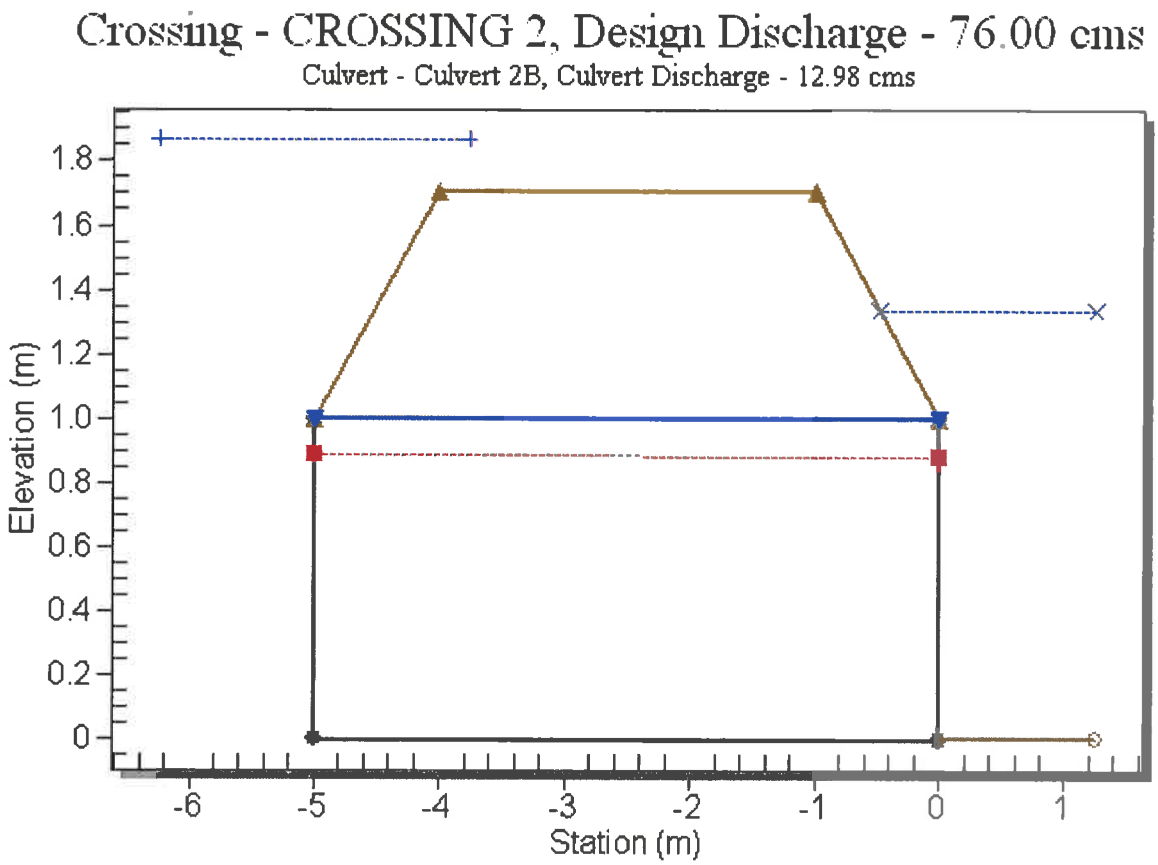
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2B



Site Data - Culvert 2B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2B

Barrel Shape: Concrete Box

Barrel Span: 5000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 2C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	13.11	1.69	1.687	1.486	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	13.41	1.73	1.730	1.556	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	13.55	1.75	1.750	1.613	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	13.67	1.77	1.768	1.666	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	13.78	1.78	1.783	1.717	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	13.88	1.80	1.797	1.765	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	13.94	1.81	1.807	1.811	4-FFf	1.000	0.927	1.000	1.199	2.789	2.577
66.50	13.69	1.83	1.770	1.827	4-FFf	1.000	0.916	1.000	1.237	2.738	2.626
70.00	13.43	1.84	1.733	1.843	4-FFf	1.000	0.904	1.000	1.275	2.686	2.672
73.50	13.17	1.86	1.696	1.857	4-FFf	1.000	0.893	1.000	1.311	2.634	2.718
76.00	12.98	1.87	1.670	1.868	4-FFf	1.000	0.884	1.000	1.337	2.596	2.749

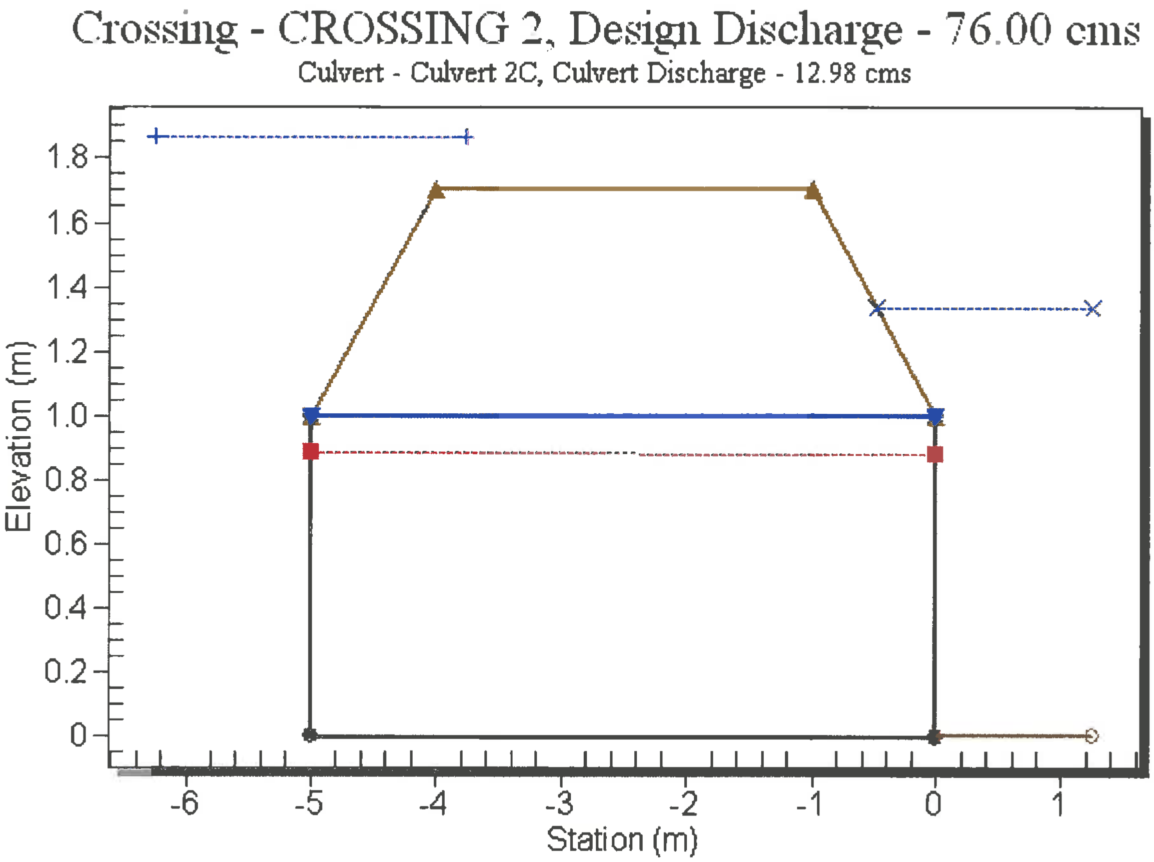
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2C



Site Data - Culvert 2C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2C

Barrel Shape: Concrete Box

Barrel Span: 5000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 5 - Culvert Summary Table: Culvert 2D

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
42.00	7.86	1.69	1.687	1.488	6-FFt	1.000	0.890	1.000	0.945	2.621	2.235
45.50	8.05	1.73	1.730	1.559	6-FFt	1.000	0.904	1.000	0.990	2.682	2.300
49.00	8.13	1.75	1.750	1.615	4-FFf	1.000	0.910	1.000	1.034	2.711	2.361
52.50	8.20	1.77	1.768	1.668	4-FFf	1.000	0.915	1.000	1.077	2.735	2.418
56.00	8.27	1.78	1.783	1.719	4-FFf	1.000	0.920	1.000	1.119	2.756	2.474
59.50	8.33	1.80	1.797	1.768	4-FFf	1.000	0.924	1.000	1.159	2.775	2.526
63.00	8.35	1.81	1.802	1.811	4-FFf	1.000	0.926	1.000	1.199	2.783	2.577
66.50	8.20	1.83	1.765	1.827	4-FFf	1.000	0.915	1.000	1.237	2.732	2.626
70.00	8.04	1.84	1.728	1.843	4-FFf	1.000	0.903	1.000	1.275	2.680	2.672
73.50	7.88	1.86	1.692	1.857	4-FFf	1.000	0.891	1.000	1.311	2.628	2.718
76.00	7.77	1.87	1.666	1.868	4-FFf	1.000	0.883	1.000	1.337	2.590	2.749

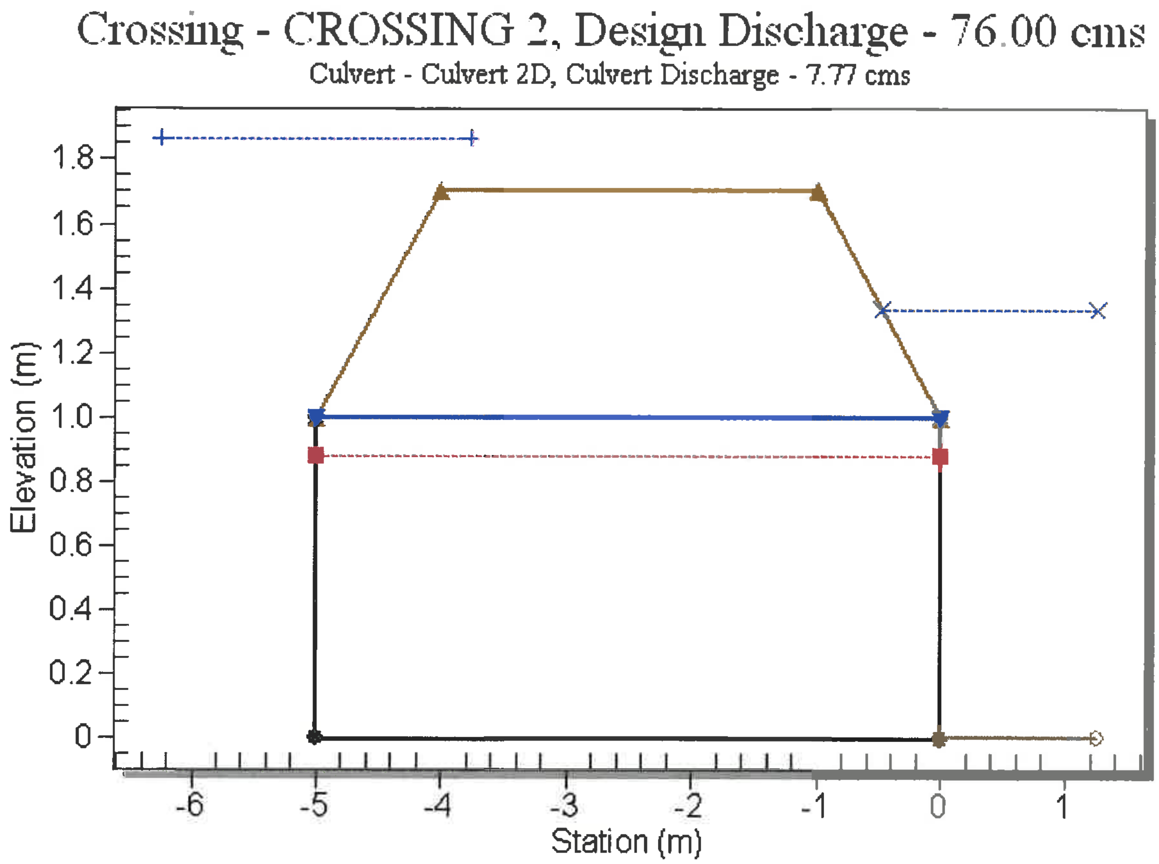
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 2D



Site Data - Culvert 2D

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 2D

Barrel Shape: Concrete Box

Barrel Span: 3000.00 mm

Barrel Rise: 1000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: CROSSING 2)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
42.00	0.94	0.94	2.24	92.60	0.77
45.50	0.99	0.99	2.30	97.06	0.77
49.00	1.03	1.03	2.36	101.39	0.78
52.50	1.08	1.08	2.42	105.58	0.78
56.00	1.12	1.12	2.47	109.65	0.79
59.50	1.16	1.16	2.53	113.62	0.79
63.00	1.20	1.20	2.58	117.48	0.79
66.50	1.24	1.24	2.63	121.26	0.80
70.00	1.27	1.27	2.67	124.94	0.80
73.50	1.31	1.31	2.72	128.55	0.80
76.00	1.34	1.34	2.75	131.08	0.81

Tailwater Channel Data - CROSSING 2

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 18.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 2

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 m

Crest Elevation: 1.70 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 2	
Culvert	Culvert 2A	
Flow	76.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	3.0	m
Culvert Height	1.0	m
Outlet Depth	1.00	m
Outlet Velocity	2.59	m/s
Froude Number	0.83	
Tailwater Depth	1.34	m
Tailwater Velocity	2.75	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	200.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.309	kPa
Modified Shear Number	1.040	
Scour Hole Dimensions		
Length (LS)	12.258	m
Width (WS)	9.868	m
Depth (DS)	2.307	m
Volume (VS)	46.408	m^3
DS at 0.4(LS)	4.903	m
Tailwater Depth (TW)	1.337	m
Velocity with TW and WS	0.463	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 3

Headwater Elevation (m)	Total Discharge (cms)	Culvert 3A Discharge (cms)	Culvert 3B Discharge (cms)	Culvert 3C Discharge (cms)	Roadway Discharge (cms)	Iterations
2.14	71.47	23.83	23.83	23.83	0.00	4
2.30	77.57	25.87	25.87	25.87	0.00	4
2.45	83.67	27.90	27.90	27.90	0.00	4
2.61	89.77	29.93	29.93	29.93	0.00	4
2.76	95.87	31.96	31.96	31.96	0.00	4
2.92	101.98	33.98	33.98	33.98	0.00	10
3.03	108.08	34.73	34.73	34.73	3.82	11
3.06	114.18	33.69	33.69	33.69	12.97	6
3.09	120.28	32.49	32.49	32.49	22.66	5
3.12	126.38	31.22	31.22	31.22	32.66	5
3.14	132.00	29.98	29.98	29.98	41.90	4
3.00	109.23	36.41	36.41	36.41	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 3A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

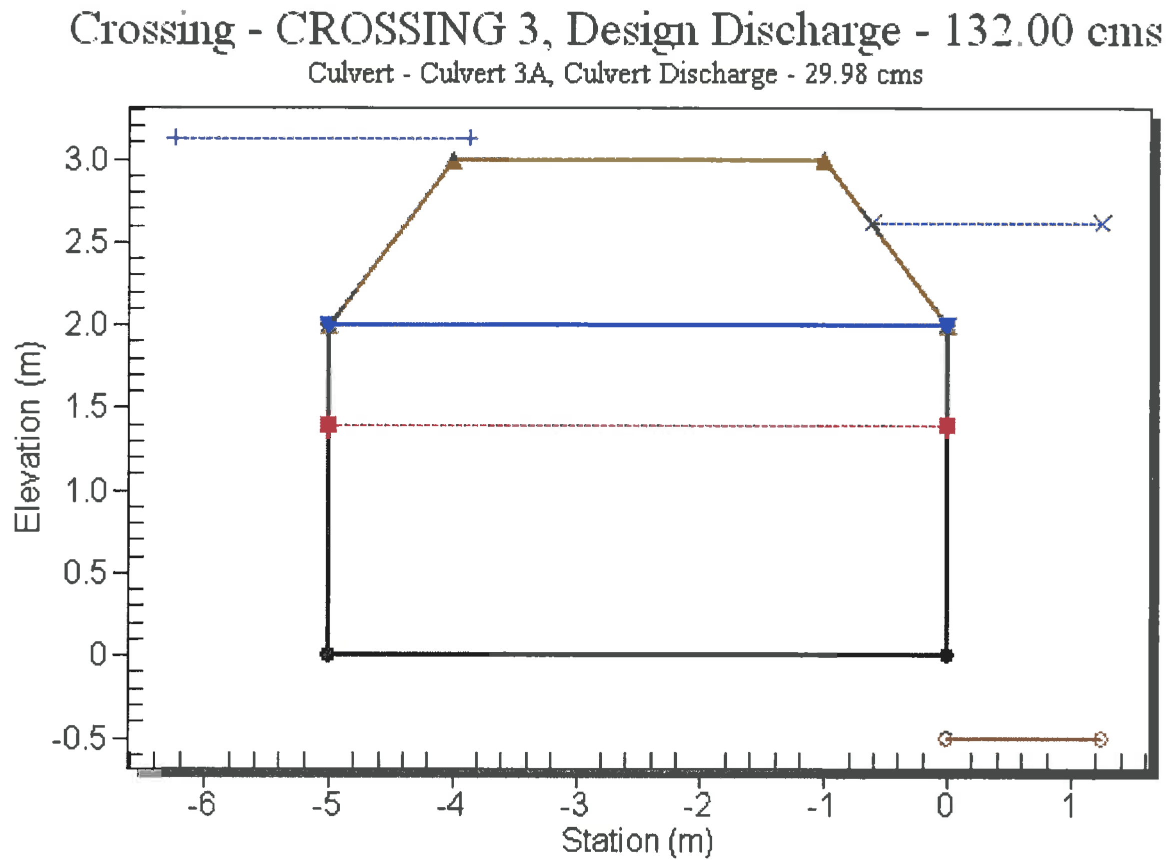
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3A



Site Data - Culvert 3A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3A

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 3B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

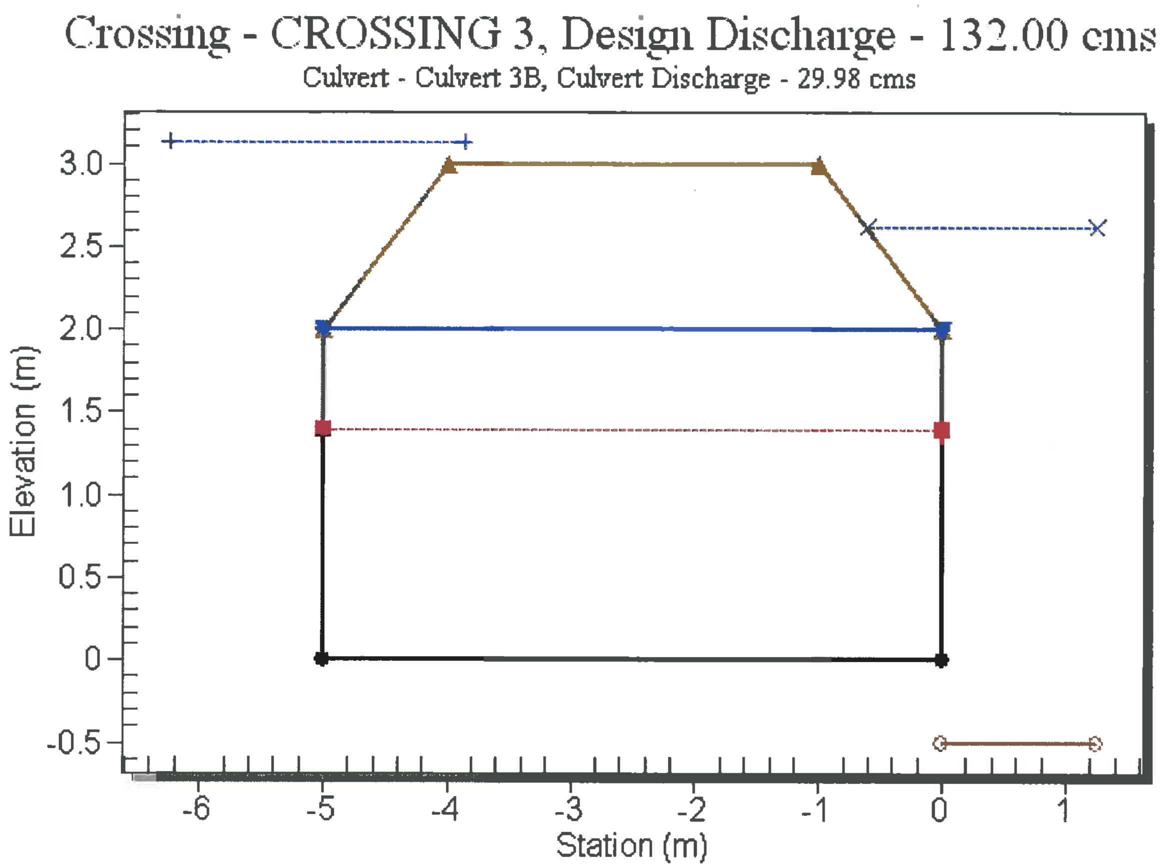
****

Inlet Elevation (invert): 0.00 m,   Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m,   Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3B



Site Data - Culvert 3B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3B

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Culvert Summary Table: Culvert 3C

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
71.47	23.83	2.14	2.036	2.142	6-FFt	2.000	1.201	1.815	2.315	2.263	3.206
77.57	25.87	2.30	2.160	2.296	6-FFt	2.000	1.268	1.911	2.411	2.334	3.276
83.67	27.90	2.45	2.285	2.450	4-FFf	2.000	1.334	2.000	2.502	2.405	3.343
89.77	29.93	2.61	2.414	2.605	4-FFf	2.000	1.398	2.000	2.590	2.580	3.406
95.87	31.96	2.76	2.548	2.762	4-FFf	2.000	1.460	2.000	2.674	2.755	3.465
101.98	33.98	2.92	2.685	2.920	4-FFf	2.000	1.521	2.000	2.755	2.929	3.522
108.08	34.73	3.03	2.737	3.028	4-FFf	2.000	1.543	2.000	2.834	2.994	3.576
114.18	33.69	3.06	2.665	3.063	4-FFf	2.000	1.512	2.000	2.909	2.904	3.627
120.28	32.49	3.09	2.583	3.091	4-FFf	2.000	1.476	2.000	2.983	2.801	3.677
126.38	31.22	3.12	2.498	3.116	4-FFf	2.000	1.438	2.000	3.054	2.691	3.725
132.00	29.98	3.14	2.418	3.136	4-FFf	2.000	1.399	2.000	3.118	2.584	3.767

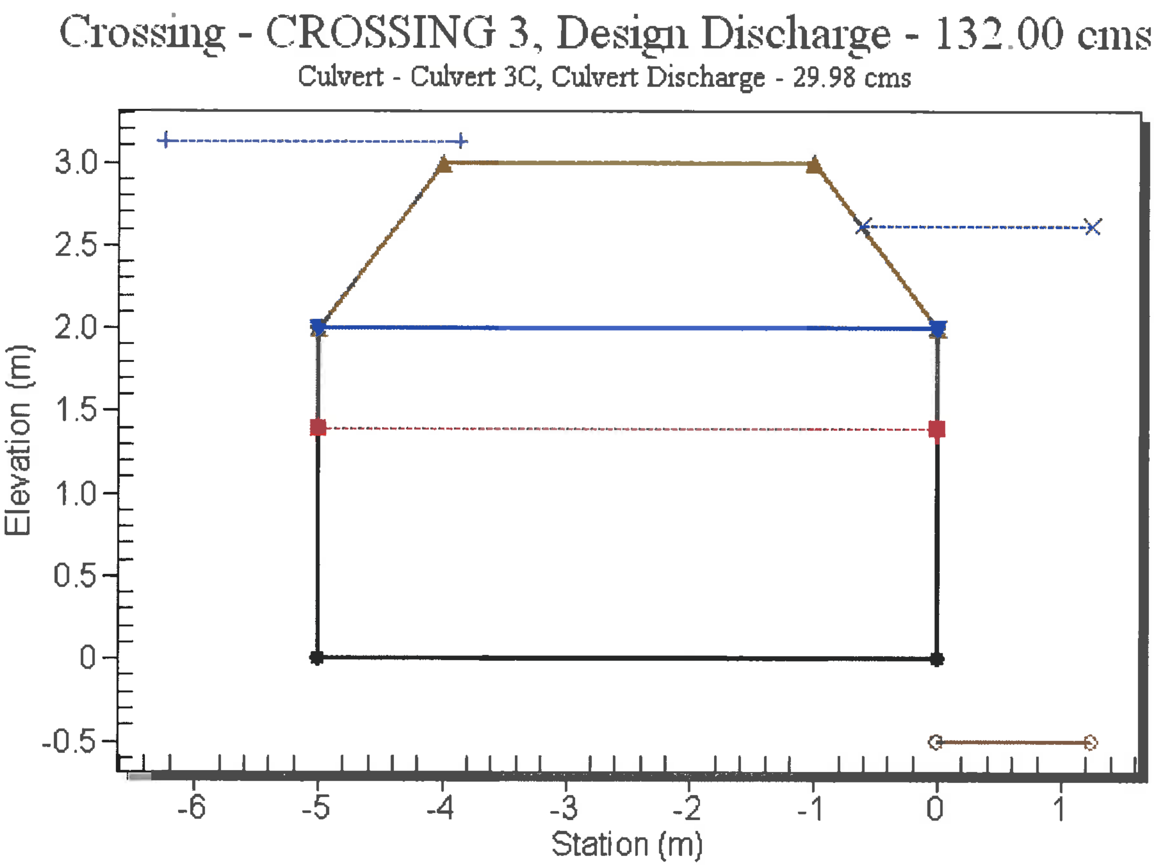
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 3C



Site Data - Culvert 3C

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 3C

Barrel Shape: Concrete Box

Barrel Span: 5800.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 5 - Downstream Channel Rating Curve (Crossing: CROSSING 3)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
71.47	1.81	2.31	3.21	226.92	0.82
77.57	1.91	2.41	3.28	236.29	0.82
83.67	2.00	2.50	3.34	245.25	0.83
89.77	2.09	2.59	3.41	253.84	0.83
95.87	2.17	2.67	3.47	262.10	0.83
101.98	2.26	2.76	3.52	270.06	0.84
108.08	2.33	2.83	3.58	277.75	0.84
114.18	2.41	2.91	3.63	285.19	0.84
120.28	2.48	2.98	3.68	292.40	0.84
126.38	2.55	3.05	3.72	299.40	0.85
132.00	2.62	3.12	3.77	305.67	0.85

Tailwater Channel Data - CROSSING 3

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 5.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: -0.50 m

Roadway Data for Crossing: CROSSING 3

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 500.00 m

Crest Elevation: 3.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 3	
Culvert	Culvert 3A	
Flow	132.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	5.8	m
Culvert Height	2.0	m
Outlet Depth	2.00	m
Outlet Velocity	2.58	m/s
Froude Number	0.58	
Tailwater Depth	3.12	m
Tailwater Velocity	3.77	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	100.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.161	kPa
Modified Shear Number	1.988	
Scour Hole Dimensions		
Length (LS)	29.855	m
Width (WS)	21.665	m
Depth (DS)	5.099	m
Volume (VS)	644.857	m^3
DS at 0.4(LS)	11.942	m
Tailwater Depth (TW)	3.118	m
Velocity with TW and WS	0.345	m/s

HY-8 Culvert Analysis Report

Table 1 - Summary of Culvert Flows at Crossing: CROSSING 4

Headwater Elevation (m)	Total Discharge (cms)	Culvert 4A Discharge (cms)	Culvert 4B Discharge (cms)	Roadway Discharge (cms)	Iterations
1.02	16.93	8.54	8.54	0.00	11
1.06	18.24	9.20	9.20	0.00	10
1.11	19.54	9.81	9.81	0.00	9
1.15	20.85	10.43	10.43	0.00	8
1.19	22.16	11.12	11.12	0.00	7
1.23	23.47	11.75	11.75	0.00	7
1.27	24.77	12.43	12.43	0.00	6
1.31	26.08	13.06	13.06	0.00	6
1.32	27.39	8.26	8.26	0.00	11
1.32	28.69	18.24	18.24	0.00	6
1.32	29.00	18.24	18.24	0.00	4
3.00	61.39	30.70	30.70	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 4A

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
16.93	8.54	1.02	0.807	1.017	6-FFt	1.458	0.470	0.998	0.997	1.007	1.887
18.24	9.20	1.06	0.848	1.062	6-FFt	1.532	0.493	1.040	1.040	1.040	1.932
19.54	9.81	1.11	0.885	1.107	6-FFt	1.601	0.515	1.081	1.081	1.067	1.974
20.85	10.43	1.15	0.922	1.150	6-FFt	1.668	0.537	1.121	1.121	1.095	2.013
22.16	11.12	1.19	0.962	1.192	6-FFt	1.742	0.560	1.160	1.159	1.128	2.051
23.47	11.75	1.23	0.997	1.234	6-FFt	2.000	0.581	1.197	1.197	1.155	2.087
24.77	12.43	1.27	1.033	1.275	6-FFt	2.000	0.603	1.234	1.233	1.186	2.122
26.08	13.06	1.31	1.066	1.315	6-FFt	2.000	0.623	1.269	1.269	1.210	2.155
27.39	8.26	1.32	0.789	1.322	6-FFt	1.426	0.459	1.304	1.304	0.745	2.187
28.69	18.24	1.32	1.322	1.426	6-FFt	2.000	0.779	1.338	1.337	1.604	2.218
29.00	18.24	1.32	1.322	1.434	6-FFt	2.000	0.779	1.346	1.345	1.595	2.225

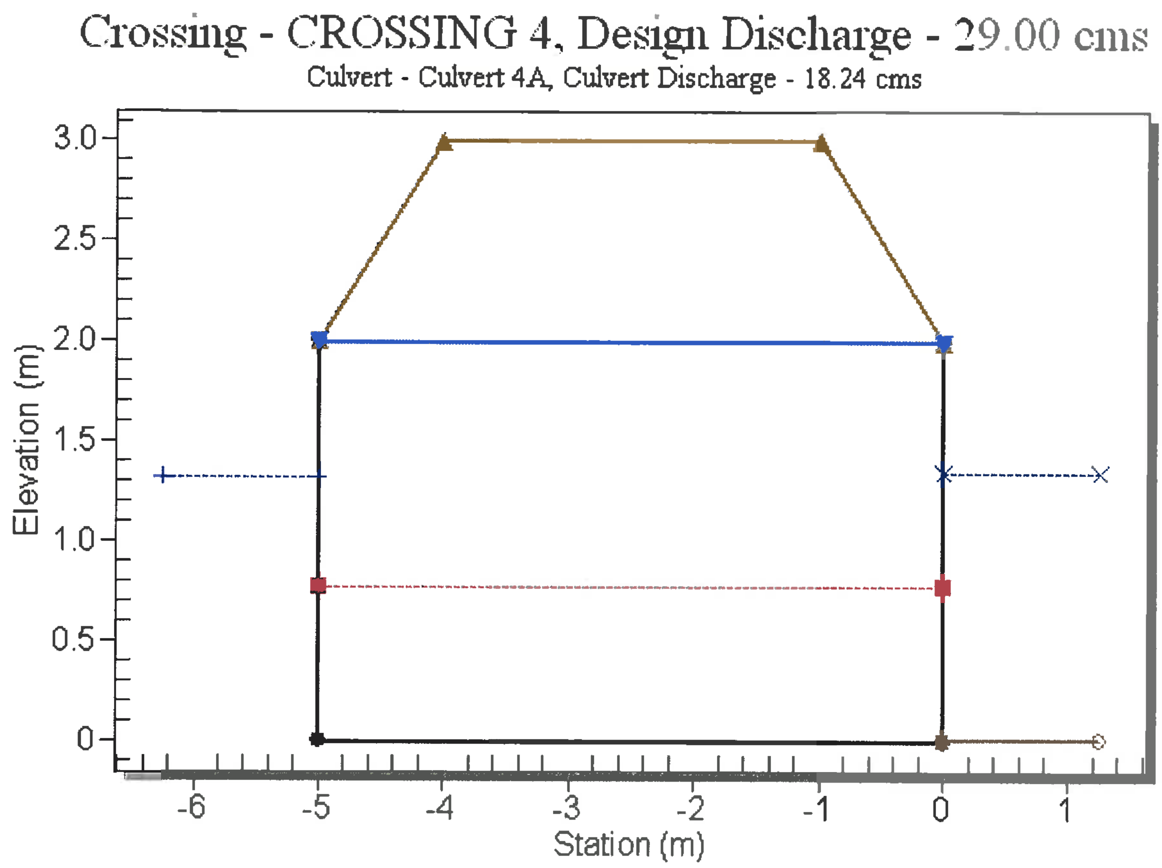
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 4A



Site Data - Culvert 4A

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 4A

Barrel Shape: Concrete Box

Barrel Span: 8500.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 3 - Culvert Summary Table: Culvert 4B

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
16.93	8.54	1.02	0.807	1.017	6-FFt	1.458	0.470	0.998	0.997	1.007	1.887
18.24	9.20	1.06	0.848	1.062	6-FFt	1.532	0.493	1.040	1.040	1.040	1.932
19.54	9.81	1.11	0.885	1.107	6-FFt	1.601	0.515	1.081	1.081	1.067	1.974
20.85	10.43	1.15	0.922	1.150	6-FFt	1.668	0.537	1.121	1.121	1.095	2.013
22.16	11.12	1.19	0.962	1.192	6-FFt	1.742	0.560	1.160	1.159	1.128	2.051
23.47	11.75	1.23	0.997	1.234	6-FFt	2.000	0.581	1.197	1.197	1.155	2.087
24.77	12.43	1.27	1.033	1.275	6-FFt	2.000	0.603	1.234	1.233	1.186	2.122
26.08	13.06	1.31	1.066	1.315	6-FFt	2.000	0.623	1.269	1.269	1.210	2.155
27.39	8.26	1.32	0.789	1.322	6-FFt	1.426	0.459	1.304	1.304	0.745	2.187
28.69	18.24	1.32	1.322	1.426	6-FFt	2.000	0.779	1.338	1.337	1.604	2.218
29.00	18.24	1.32	1.322	1.434	6-FFt	2.000	0.779	1.346	1.345	1.595	2.225

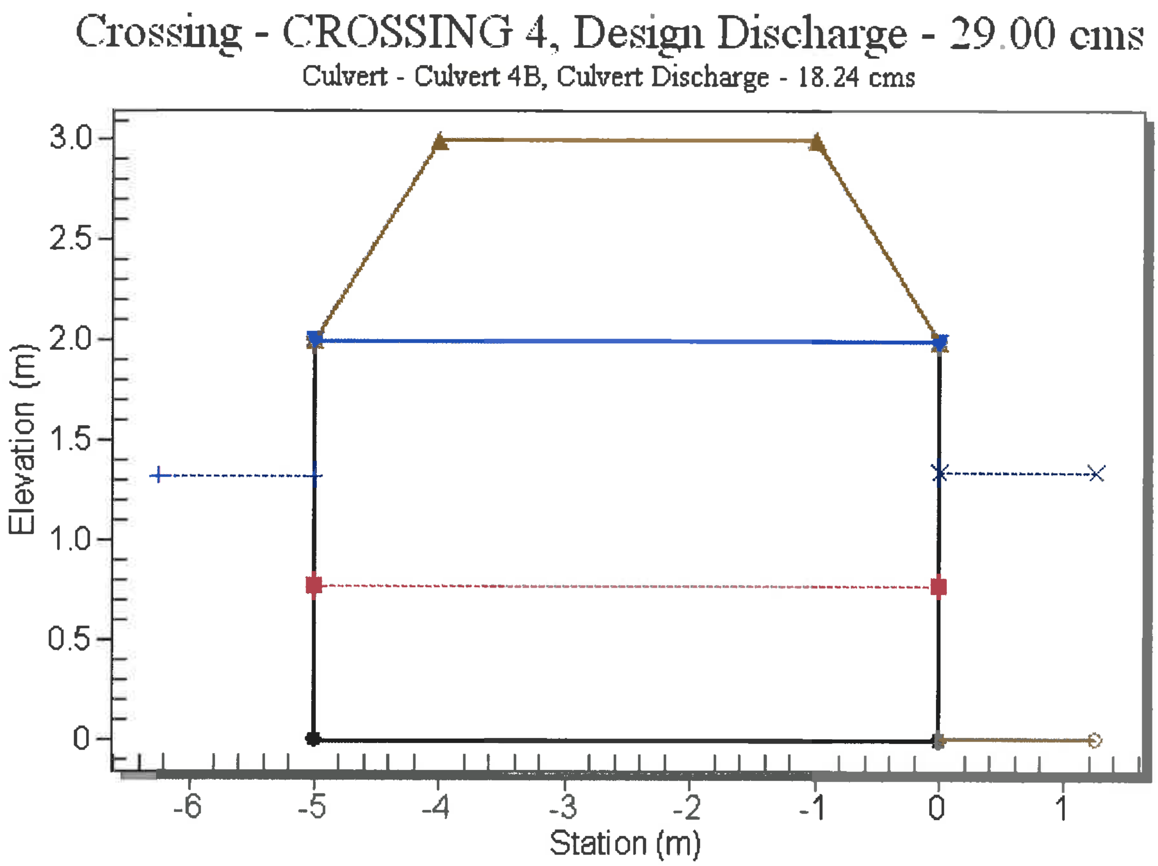
****

Inlet Elevation (invert): 0.00 m, Outlet Elevation (invert): -0.00 m

Culvert Length: 5.00 m, Culvert Slope: 0.0001

****

Water Surface Profile Plot for Culvert: Culvert 4B



Site Data - Culvert 4B

Site Data Option: Culvert Invert Data

Inlet Station: -5.00 m

Inlet Elevation: 0.00 m

Outlet Station: 0.00 m

Outlet Elevation: -0.00 m

Number of Barrels: 1

Culvert Data Summary - Culvert 4B

Barrel Shape: Concrete Box

Barrel Span: 8500.00 mm

Barrel Rise: 2000.00 mm

Barrel Material: Concrete

Embedment: 0.00 mm

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90°) Headwall

Inlet Depression: NONE

Table 4 - Downstream Channel Rating Curve (Crossing: CROSSING 4)

Flow (cms)	Water Surface Elev (m)	Depth (m)	Velocity (m/s)	Shear (Pa)	Froude Number
16.93	1.00	1.00	1.89	97.75	0.67
18.24	1.04	1.04	1.93	101.93	0.67
19.54	1.08	1.08	1.97	105.95	0.67
20.85	1.12	1.12	2.01	109.86	0.68
22.16	1.16	1.16	2.05	113.64	0.68
23.47	1.20	1.20	2.09	117.32	0.68
24.77	1.23	1.23	2.12	120.89	0.68
26.08	1.27	1.27	2.15	124.38	0.69
27.39	1.30	1.30	2.19	127.78	0.69
28.69	1.34	1.34	2.22	131.09	0.69
29.00	1.35	1.35	2.22	131.86	0.69

Tailwater Channel Data - CROSSING 4

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 7.00 m

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0100

Channel Manning's n: 0.0450

Channel Invert Elevation: 0.00 m

Roadway Data for Crossing: CROSSING 4

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 330.00 m

Crest Elevation: 3.00 m

Roadway Surface: Paved

Roadway Top Width: 3.00 m

HY-8 Energy Dissipation Report

Scour Hole Geometry

Parameter	Value	Units
Select Culvert and Flow		
Crossing	CROSSING 4	
Culvert	Culvert 4A	
Flow	29.00	cms
Culvert Data		
Culvert Width (including multiple barrels)	8.5	m
Culvert Height	2.0	m
Outlet Depth	1.35	m
Outlet Velocity	1.59	m/s
Froude Number	0.44	
Tailwater Depth	1.35	m
Tailwater Velocity	2.22	m/s
Tailwater Slope (SO)	0.0001	
Scour Data		
Time to Peak		
Note:	if Time to Peak is unknown, enter 30 min	
Time to Peak	30.000	min
Cohesion	Cohesive	
Saturated Shear Strength		
Note:	ASTM D211-66-76	
Saturated Shear Strength	400.000	kPa
Plasticity Index		
Note:	ASTM D423-36	
Note:	Plasticity must be between 5 and 16	
Plasticity Index	15.0	
Tailwater Flow Depth after Culvert Outlet	Normal Depth	
Results		
Assumptions		
Tractive shear stress	0.605	kPa
Modified Shear Number	0.201	
Scour Hole Dimensions		
Length (LS)	13.920	m
Width (WS)	14.573	m
Depth (DS)	3.352	m
Volume (VS)	74.992	m^3
DS at 0.4(LS)	5.568	m
Tailwater Depth (TW)	1.345	m
Velocity with TW and WS	0.785	m/s

Appendix C

Agency consultation

From: Jane Curran <jane.curran@nrar.nsw.gov.au>
Sent: Thursday, 30 September 2021 9:27 AM
To: Elliot Holland; David Zerafa
Subject: RE: 12560160 - Shoalhaven Starches Gas Pipeline Project: Construction Management Plans consultation

Hi Elliot,

Thanks for getting in contact. Can you please send the CEMP through when it is ready for review. Please send it to nrar.enquiries@nrar.nsw.gov.au

I note condition 17 requests the CEMP to include modelling of scour depth and riparian zone setbacks, please ensure the CEMP references and considers the requirements within the Guidelines for Controlled Activities on waterfront land found on NRARs website here https://www.dpie.nsw.gov.au/nrar/how-to-apply/controlled-activities/guidelines-for-controlled-activities.
In relation to condition 18, please ensure groundwater interception information includes expected dewatering volumes and proposed treatment/disposal methods. Riparian rehabilitation proposed should also refer to NRARs Controlled Activity guidelines.

Thanks

Kind regards,

Jane Curran
A/Manager Licensing & Approvals (East)
Natural Resources Access Regulator | Department of Planning, Industry and Environment
P: 02 4275 9327 | **M:** +61 437 832 227 | **E** jane.curran@nrar.nsw.gov.au
Level 0, 84 Crown Street, Wollongong NSW 2500
PO Box 53 Wollongong NSW 2520
www.industry.nsw.gov.au/nrar

NSW GOVERNMENT | Natural Resources Access Regulator

From: Elliot Holland <Elliot.Holland@ghd.com>
Sent: Thursday, 30 September 2021 7:41 AM
To: David Zerafa <david.zerafa@nrar.nsw.gov.au>; Jane Curran <jane.curran@nrar.nsw.gov.au>
Subject: 12560160 - Shoalhaven Starches Gas Pipeline Project: Construction Management Plans consultation
Importance: High

Hi David/Jane,

GHD Pty Ltd (GHD) has been engaged by NAP to assist with the development of the construction environmental management plan (CEMP) and associated sub-plans. Schedule 3, Conditions 17 and 18 of MP10_0108 require the development of Watercourse Crossing Construction Method Statements for underboring works and a Soil and Water Management Plan respectively.

A requirement of these conditions is consultation with the former NSW Office of Water (NOW) (now Natural Resources Access Regulator (NRAR)). Therefore, we are writing to invite comment from NRAR in regard to the development of these plans.

A copy of the development consent has also been attached for your information.

Regards,

Elliot Holland
B Env. Sc. & Mgt.
Exemplar Global – Lead Auditor: EMS
Senior Environmental Scientist

GHD

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24 Honeysuckle Drive Newcastle NSW 2300 Australia

D +612 4979 9923 **E** elliot.holland@ghd.com

From: Andre Vernez <Andre.Vernez@shoalhaven.nsw.gov.au>
Sent: Tuesday, 9 November 2021 9:59 AM
To: Elliot Holland
Subject: RE: 12560160 - Shoalhaven Starches Gas Pipeline Project: Construction Management Plans consultation

Importance: High

Good morning Elliot,

I have requested comment on development of the following plans from relevant Council staff:

Condition 1 – Infrastructure Management Plan
Condition 18 – Soil and Water Management Plan
Condition 19 – Acid Sulphate Soils Management Plan
Condition 30 – Traffic Management Plan

Whilst it is acknowledged that these conditions require consultation with Council in the preparation of these plans, it is noted that the project approval document details the necessary items that are to be included in each plan.

As such, it is requested that you prepare a draft plan in accordance with each plans respective condition and submit to Council for comment.

Should you have any questions in relation to the above please give me a call.

Regards,

Andre Vernez
Senior Development Planner
Shoalhaven City Council

02 4429 3111
Bridge Rd (PO Box 42) Nowra NSW 2541
council@shoalhaven.nsw.gov.au

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From: Elliot Holland <Elliot.Holland@ghd.com>
Sent: Thursday, 30 September 2021 7:39 AM
To: Andre Vernez <Andre.Vernez@shoalhaven.nsw.gov.au>; Council Email <Council@shoalhaven.nsw.gov.au>
Subject: RE: 12560160 - Shoalhaven Starches Gas Pipeline Project: Construction Management Plans consultation

Hi Andre

GHD Pty Ltd (GHD) has been engaged by NAP to assist with the development of the construction environmental management plan (CEMP) and associated sub-plans. Schedule 3, Conditions 1, 18, 19 and 30 of MP10_0108 require the development of an Infrastructure Management Plan (IMP), Soil & Water Management Plan (SWMP) and Acid Sulphate Soils Management Plan (ASSMP) respectively.

A requirement of these conditions is consultation with Shoalhaven City Council (Council). Therefore, we are writing to invite comment from Council in regard to the development of these plans.

A copy of the development consent has also been attached for your information.

Regards,

Elliot Holland
B Env. Sc. & Mgt.
Exemplar Global – Lead Auditor: EMS
Senior Environmental Scientist

GHD

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