

Orange Drought Relief Connection Concept Investigation Report

Prepared for Orange City Council

6th January 2011

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Orange City council

Orange Drought Relief Connection

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1 Executive Summary

Background

In October of 2009, Orange City had less than two years water supply available and the city was on Level 5 Water Restrictions. In order to provide water security to the city, and as part of an overarching strategy to sustainably diversify water sources to the City, the Council commissioned a feasibility study into the possibility of connecting the city via a pipeline to one of two water sources, Lake Rowlands or the Macquarie River.

These two water sources were identified as a result of the findings of the strategic assessment completed as part of the Centroc Water Security Study (MWH, 2009). Using an environmental, social and economic decision-making framework, this study recommended that, in the long term, Orange be connected via pipeline to the Central Tablelands Water (CTW) system and supplied from an augmented Lake Rowlands dam. It was recognised however, that until the dam augmentation is completed and fully operational, an alternative source is required in the intervening period and despite the recent rains and exceptional runoff water security planning and implementation for the next drought period must proceed.

In the feasibility study several potential pipe corridors to Orange were investigated -two from Lake Rowlands and seven from the Macquarie River. The pipe corridors all had varying constraints and limitations associated with them, in particular, the overall length of the pipeline corridors and the difficult terrain through which they must pass.

The following factors were used to determine which pipe corridors were most suitable:

- Preliminary environmental and cultural heritage constraints;
- Ability of the off-take point to provide a sustainable water supply over time;
- Ability to connect potential pump sites to the power grid;
- The ability to construct the pipeline within a reasonable budget.

A detailed hydrological assessment determined that prior to the augmentation of Lake Rowlands, water supply to the City of Orange from CTW would be expected to impact on the security of the towns presently served by this scheme. As such, this supply source was discounted from further consideration. The investigation concluded that the water supply available from the Macquarie River at points downstream of the confluence with the Turon River (drawing on the sizeable catchment upstream of this point) would meet the expected water needs. A maximum of 1,800 megalitres per annum was assumed to be drawn from the Macquarie River for raw water supply to the City of Orange, in conjunction with the continued preferential use of the City's other water sources. On average this represented approximately 1.3% of the flow in the river below the confluence with the Turon.

The feasibility study concluded that the most feasible solution was to bring water from the Macquarie River via one of two potential pipe corridors shown in Figure 1-1, given:

- the prevailing time pressures;
- environmental and cultural heritage considerations;
- the calculated supply potential of the water sources;
- the estimated project costs; and
- the high level project data available.

The report found that in order to recommend a preferred corridor, additional engineering and environmental investigations were required. This information would be required to inform decision-making as well as environmental assessment and stakeholder and community engagement processes.

Concept Investigation Scope and Process

Consequently, this Concept Investigation study compares and evaluates the benefits of one pipe corridor over another to arrive at a recommended pipeline option to use in the detailed design process.

The following nine essential criteria (which consider key environmental, social and economic factors), by which each option could be subject to a comparative evaluation, were identified as part of this investigation:

1. Capital and operating costs
2. Constructability
3. Environmental and heritage impact
4. Carbon footprint
5. Landholder issues
6. Suitability of off-take point
7. Accessibility of off-take point
8. Geotechnical issues
9. Power availability

This report defines the criteria and how each was evaluated and used in a comparative analysis. Given that several criteria are not quantitative variables, a Multi Criteria Analysis (MCA) was used to evaluate which of the two pipeline corridors was the most appropriate for further detailed design. A significant amount of work was undertaken by a team of professional consultants to establish appropriate assessments of the non-quantitative variables. This included:

- Review of the geotechnical factors affecting the pipeline;
- Engagement to understand the views and requirements of landholders whose properties intersected with the pipeline corridors under consideration;
- Further environmental assessments and field surveys to determine the location, nature and vulnerability of flora, fauna and sites of cultural significance;
- Establishing the constructability issues associated with each corridor in consultation with contractors

The results of these investigations were used to inform the MCA process.

Recommended Corridor

The MCA process resulted in Corridor 1 being chosen as the most appropriate for progression to the detailed design phase of the project. The primary reasons for this recommendation are that Corridor 1 has:

- The lowest capital cost of the options considered;
- The lowest operating cost of the options considered;
- The most suitable sites for construction of infrastructure;
- The least impact on flora, fauna and sites of cultural significance;
- The smallest carbon footprint of the options considered;
- Support from landholders intersecting with it;
- Proximity to the most suitable potential river off-take points (MR4 and MR5a);
- Existing tracks in the vicinity of its off-take points allowing reasonable access to the river; and
- The least hazardous and difficult geotechnical issues.

This report outlines the type and specification of components that will make up the Orange Drought Relief Connection pipe and pump system and makes recommendations regarding the detailed design phase of

the project. The report outlines top down budgets approximating costs for the project corridors and a preliminary timeline which reasonably represents the time required to fully construct and commission the infrastructure required to pump water from the Macquarie River to infrastructure located at Suma Park Dam.

The following map (Figure 1-1) illustrates the preferred pipeline corridor (Corridor 1) from the Macquarie River to Orange and the alternative, Corridor 2, which was also assessed. It should be noted that there are several final pipe alignments possible within this corridor and that a significant amount of detailed engineering and environmental investigation is still required to finalise the most practical and acceptable route.

Recommendation Implementation and Risk Management

The project also has challenges/risks that must be overcome to ensure a timely and cost effective project outcome. The key challenges and processes for managing them are:

- High strength rock deposit around the river and along the first section of the pipe corridor which will make construction slow and difficult, further geotechnical assessments will inform effective construction methodologies to overcome the issues;
- Development of an all-weather access track to the river which can be overcome by upgrading and existing one;
- Finalising land and easement discussions and arrangements. This will be undertaken as part of Council's stakeholder engagement plan and procurement processes;
- Upgrading the power supply to the pump stations. The process of discussing the project with energy utility stakeholders has commenced and will continue as part of the stakeholder engagement plan;
- Managing the health & safety risks on the project. This will be managed in accordance with Council's policies for workplace safety and safety in design;
- Ensuring minimal impact on flora, fauna and cultural heritage sites along the corridor. The approval pathway for the project and the process of obtaining the relevant environmental assessments and approvals has begun and will be completed in consultation with stakeholders; and
- Engaging with stakeholders to obtain, and give due consideration to, feedback on the project.

The detailed design phase, which is the next stage of the project, will provide clarity regarding specifications and construction methodologies. In order to start the detailed design phase it is critical to complete the process of finalising land and easement discussions and arrangements to determine the alignment of the proposed pipeline and then complete a survey of the preferred alignment route, obtain a detailed assessment and report on all geotechnical issues along the pipe corridor and complete a comprehensive budget for the construction of the project.

The detailed design phase will be supported with continuing environmental assessment and stakeholder engagement activities.

Recommendations for Detailed Design Phase

The key considerations for the detailed design phase are:

- Undertake detailed geotechnical investigations of the entire pipeline corridor.
- Complete detailed title survey of the entire pipeline corridor.
- Careful appraisal of the river site and conditions will be required before final design of the river pump station

- Consideration should be given to using multiple smaller pumps at the booster sites to give added system flexibility but this increases the cost of the system.
- Pipeline design considerations:
 - Potential for surge in different operation scenarios.
 - Location of isolation valves along pipeline to allow for servicing. These valves need to be sluice type to allow for pigging of mainline.
 - The use of lower class pipe in the higher sections of the pipeline.
- Pumping stations design needs to incorporate additional safety features:
 - Protection against over pressurization of suction manifolds.
 - Individual pump vibration sensors.
 - Pump station leak detection – sump with level sensor.
 - Heat sensors within the electrical cabinets.
- When locating purge, surge anticipation and quick acting pressure relief valves consideration needs to be given to:
 - Where and how will discharge water be disposed of
 - The PLC system will need to monitor operation of these valves in case one valve does not shut. Simple flow sensor on downstream side of valve

Refer to Appendix B for further details.

Additional Project Benefits

The Concept Investigation has highlighted the following benefits of the Orange Drought Relief Connection project:

- An additional source of water to build on Orange's integrated water supply system and ensure security and diversity of water supply;
- The potential for renewable energy (from hydropower) to be generated as part of the scheme;
- The creation of 55 full time jobs during the construction phase, 20 of which are expected to be filled from the local community;
- The injection of approximately \$15.0 million into the local economy;
- The upgrading and extension of the power supply to the region north of the City to Long Point;
- The provision of fire fighting water resources and infrastructure to residents to the north of the City to Long Point; and
- The improvement of the road between Orange and Long Point.



Figure 1-1: Pipeline corridor options

2 Background

The City of Orange has traditionally relied on a single point of supply for its drinking water needs from water storage dams which are fed by rural catchments to the east and south of the city. With the prolonged dry period, plus the need to meet the water requirements of a growing city, it became apparent that the city's existing water supply system was not adequate and that alternative water supplies were needed.

At the same time, in response to the pressure being placed on urban water supplies across the Central West of NSW, the Centroc Regional Water Security Study was undertaken which confirmed that Orange's water supply did not achieve the appropriate levels of long term security required of a major population centre. This study outlined a range of infrastructure options aimed at improving the region's water security, including a recommendation that, in the long term, Orange be connected via pipeline to the Central Tablelands Water (CTW) system and supplied from an augmented Lake Rowland's dam. The approval and design (3-4 years)¹ and delivery (4-5 years²) of a new storage would generally take between 7-9 years. Additional time (the length of which is difficult to estimate as it is dependent on inflows) would need to be allowed for the dam to fill and therefore become fully operational. These timeframe estimates did not take into account the time it may take to secure funds for the capital program or to put in place management arrangements as discussed in the original study. The full security improvements offered by the regional strategy are only achieved at the point in time when all elements of the strategy become fully operational.

It was recognised however, that as the existing Lake Rowland's is unable to supply Orange without impacting on the security of this system until the augmentation is complete and fully operational, that an alternative source may be required in the intervening period. As such, connection to the Macquarie River was identified as an emergency response that warranted further consideration in the advent of an emergency situation³.

In response to ongoing concerns about the city's water security, Council adopted a far sighted water security strategy in late 2009 which focuses on the city's needs for the next 50 years. The key outcomes of this strategy involve:-

- An ongoing water conservation and demand management program and
- Development of a diversified portfolio of water supply sources

Council has commenced implementation of this strategy in both key areas. The water conservation and demand management program which has been put in place has resulted in the Orange community becoming much more aware of the value of water and the need to use it wisely. This is borne out by the reduction in water usage from a high of 7100 ML in 2002 to 3735 ML in 2010 under level 5a restriction.

¹ Recent approval timeframes:

4 years Nathan Dam, Queensland, 1,000,000 ML capacity. Controlled Action under EPBC Act

3 years Traveston B, Queensland 70,000 ML/a. Controlled Action under EPBC Act

3 years Wyalong Dam, 21,000 ML/a. Controlled Action under EPBC Act

It should be noted that the dams above have required both state and federal approvals. The approval path for the Lake Rowlands Augmentation has not been assessed. This information is provided for indication purposes only.

² The construction period or time to build the dam usually takes from 4 to 5 years and sometimes as long as 7 to 10 years for very large multi purpose dam projects (ICOLD, 2007).

³ The ongoing role of the pipeline in the regional supply system, if it was installed as a result of an emergency situation, was not assessed as part of the Water Security Study.

Orange City Council has become an industry leader with the development of two stormwater harvesting schemes which will augment the city's potable water supplies. In addition Council has developed a number of new groundwater sources and is currently investigating the possibility of developing a Managed Aquifer Recharge scheme in the city.

The strategy has identified that, even with these initiatives in place, the current unrestricted demand for water exceeds the secure yield of the city's water supplies. Therefore an additional, large capacity supply option needs to be developed in the short term before the longer term, regionally based solution of access to an augmented Lake Rowland's, which would satisfy the city's demands for up to the next 50 years, becomes available.

The strategy also highlighted that, under the weather conditions that prevailed in late 2009, there would be approximately two years of water supply available (without significant rainfall) to the City taking into account all existing sources of water. Therefore the need to develop an additional supply point became a matter of great urgency and, in response Council commenced investigation into the development of an emergency pipeline to augment the city's supplies.

An initial feasibility investigation focussed on an assessment of two emergency water supply sources, Lake Rowland's (given the Centroc Study had identified it as an ultimate source of additional water for Orange once it was augmented), and the Macquarie River. A series of associated pipeline connection options from these two sources was investigated:

- A pipeline connection between Orange and the Macquarie River, including seven different corridor alternatives. MR-1, MR-2, MR-3 and CNT-1 connect to the Macquarie River downstream of Bathurst. MR-4, MR-5 and MR-6 all draw water from the Macquarie River at points downstream of where the Turon River connects to the Macquarie River; and
- A pipeline connection between Orange and the existing Central Tablelands Water (CTW) system to Lake Rowlands, including two different corridor alternatives (LR-1 and LR-2).

The report addressed two critical issues: the timeline for delivery of the pipeline project and the estimated surety of water supply in the light of the current prevailing weather conditions. The report considered corridor options and provided a project delivery budget and a preliminary consideration of the stakeholder and environmental issues.

Time was a major constraint in the successful completion of the works required to build a pipeline that would deliver additional water supply to Orange. In the best-case scenario the minimum estimated time required to complete the necessary stakeholder engagement, gain approval and civil works was approximately 20 months. This was in the order of the time expected to be remaining before the city's water supply reached a critical level in the prevailing conditions. Therefore, it was recommended that the commencement of pipeline approval, design and construction activities be undertaken as soon as possible.

Preliminary engineering reviews were completed for each of the options and the results were summarised in the feasibility report. This assessment provided an estimate of the ground profile of the corridors and a preliminary budget for the works associated with the preferred option.

A hydrologic assessment was undertaken to determine the most suitable location for sourcing water in an emergency situation. Based on the assessment, the existing Lake Rowlands was unable to provide water without impacting on the security of supply to the towns served from the existing CTW system. The assessment demonstrated that drawing water from the Macquarie River below its confluence with the Turon River was the preferred source of emergency supply.

When evaluated against the available water, impact on stakeholders, the environment and timely completion of works the option MR-6 appeared to be most preferred option, however, the preference was marginal in comparison to MR-4 and MR-5 and would be subject to change based on the triple bottom line analysis made during the assessment. Therefore, a concept investigation process was recommended to test assumptions, potential landholder and environmental issues and develop a clear preference for the

best pipe corridor. In addition, during concept investigation work, the approval pathway would be defined and the stakeholder consultation process planned and implemented.

The investigations that support the concept investigation and environmental approvals process needed to give consideration not only to the installation of the pipeline, but also to the role of the pipeline in terms of its on-going use as part of OCC's supply and integration with the regional water security strategy. While the urgency to construct this pipeline has eased somewhat due to the recent rain, this has no bearing on the overall long term security of the city's water supplies which, as outlined earlier, are unable to meet the existing unrestricted demand over the normal cycle of high and low rainfall years. Therefore construction of this pipeline is vital in order to satisfy the city's immediate water needs and to cater for growth in the city for at least the next 10-15 years, as well as to ensure the city does not find itself in the perilous situation it faced less than 12 months ago of potential failure of its water supply system or prohibitive long term water restrictions.

3 Project Options

Two pipeline corridors which allow access to four potential river off-take pools were considered in the concept investigation (Figure 1-1) and their individual features, benefits and limitations evaluated. The considered corridor and river off-take options are:

- Corridor 1: A pipeline extending from the Macquarie River and passing through private property and connecting to the Long Point Road reserve, onto the Oakey Lane Reserve, the Ophir Road Reserve and onto Suma Park Dam via various routes which require further optimisation. Potential river off-take points on this corridor are described as MR4, MR5a and MR5b.
- Corridor 2: A pipeline extending from a water hole below the confluence of Macquarie and Turon rivers via private land and intersecting with the Root Hog Fire Trail, then onto Gowan Road and Lower Lewis Ponds Road to Orange. The potential river off-take point on this corridor is described as MR6.

The corridors utilise the existing roads along the majority of their length. In Corridor 1, there is a length of approximate 8 km along Oakey Lane in which the road corridor will not be available to the pipeline due to environmental issues (refer to Appendix B). In this section of the pipeline corridor, the pipeline would need to pass through private properties utilising easements. Detailing of the corridor alignment will be undertaken during the Detailed Design stage and will involve considerable stakeholder consultation.

3.1.1 Typical long sections

Typical long sections of the corridor options with different river off-take points are presented in Figure 3-1 to Figure 3-4. These long sections offer an understanding of the steepness of the terrain and the undulating nature of the pipeline. Key parameters for each option are given on each figure.

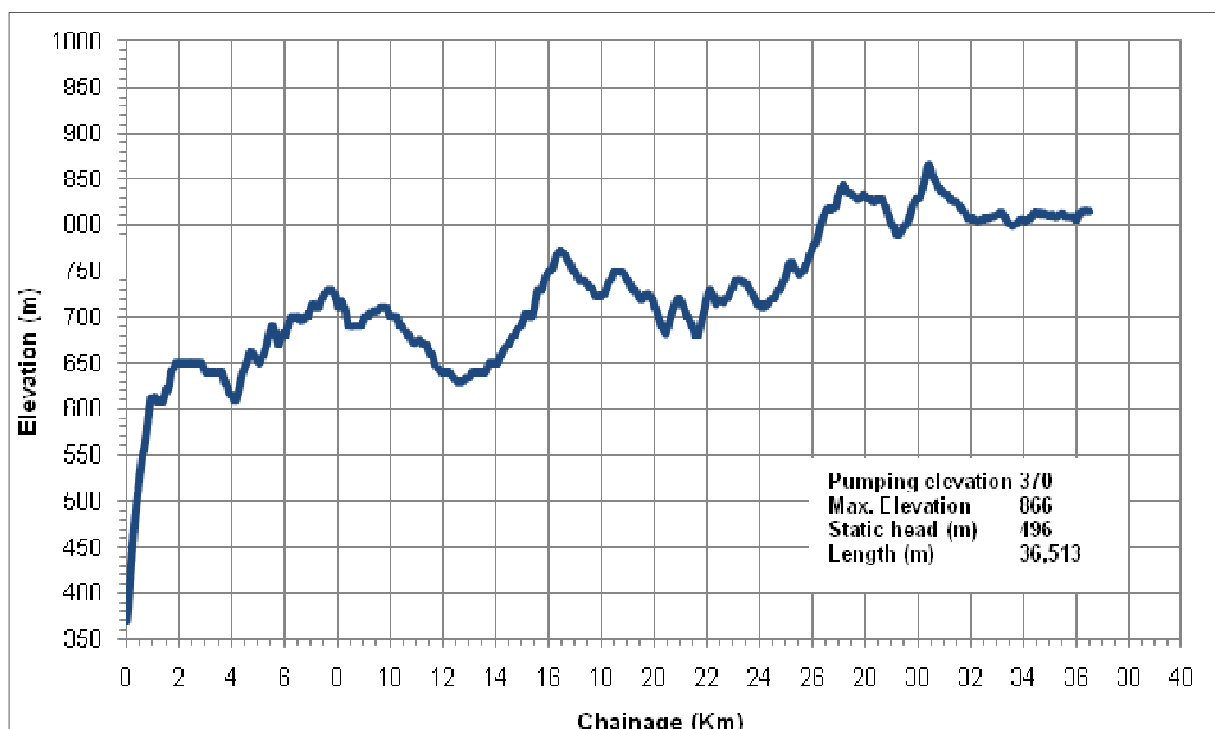


Figure 3-1: Approximate long section of Corridor 1-MR4

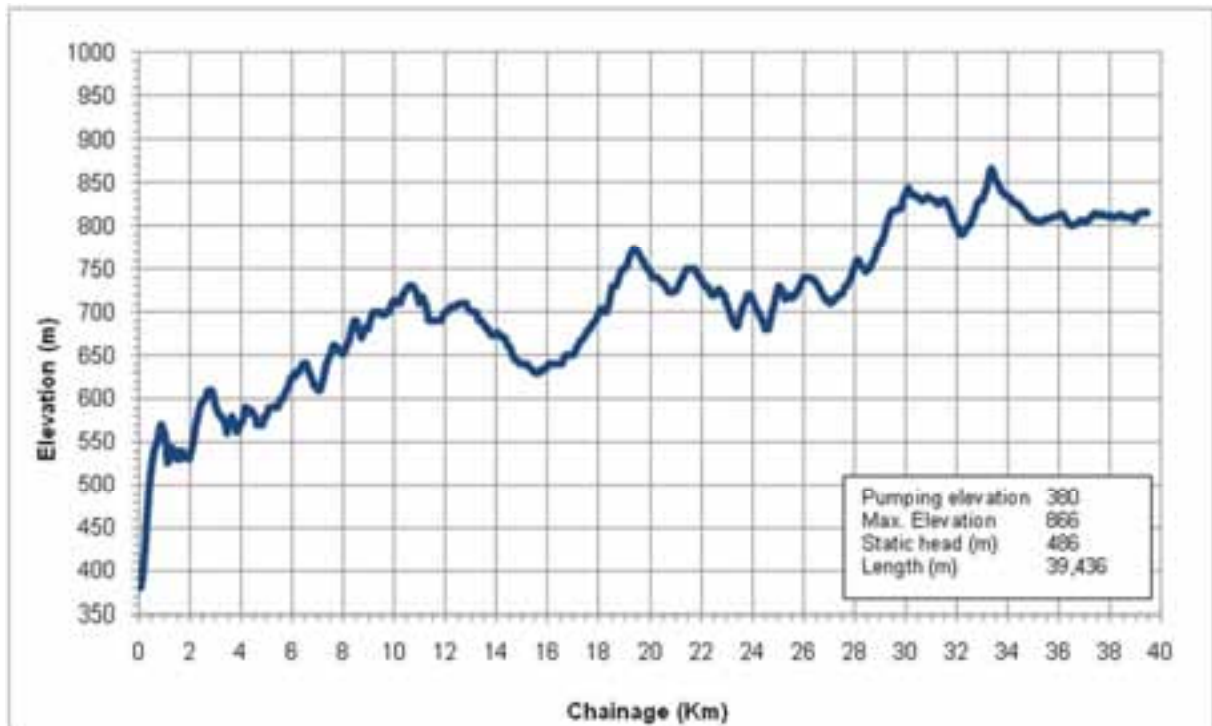


Figure 3-2: Approximate long section of Corridor 1-MR5a

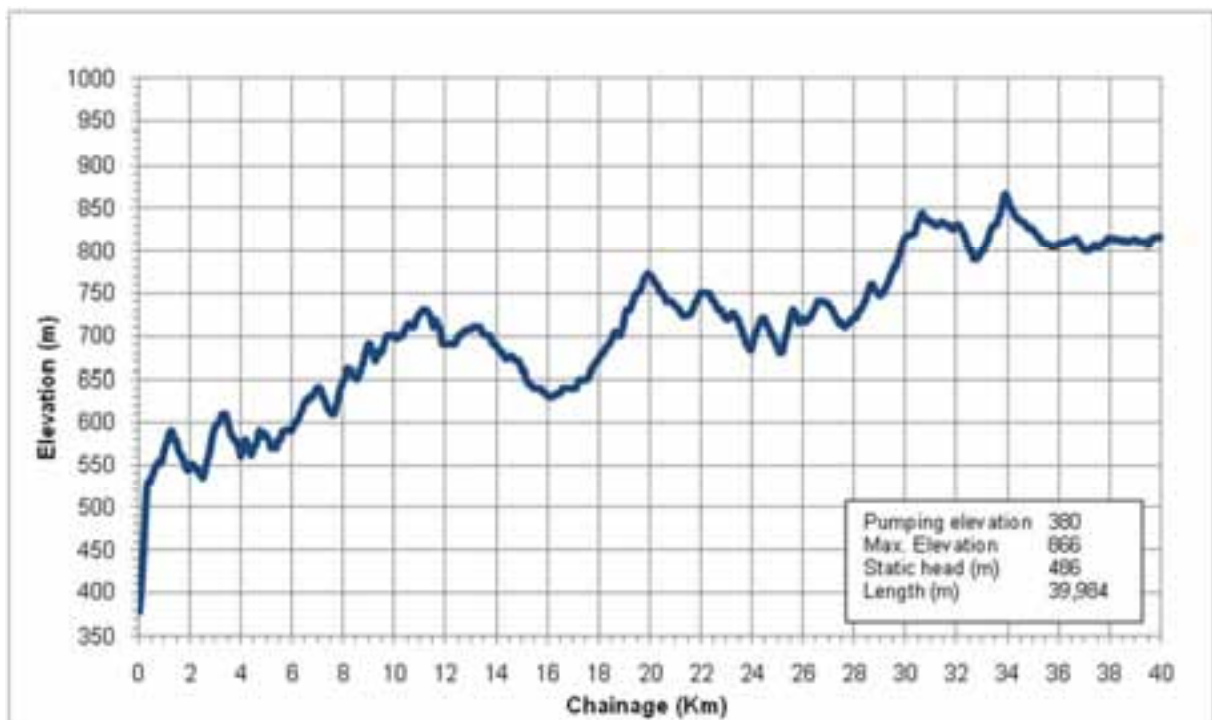


Figure 3-3: Approximate long section of Corridor 1-MR5b

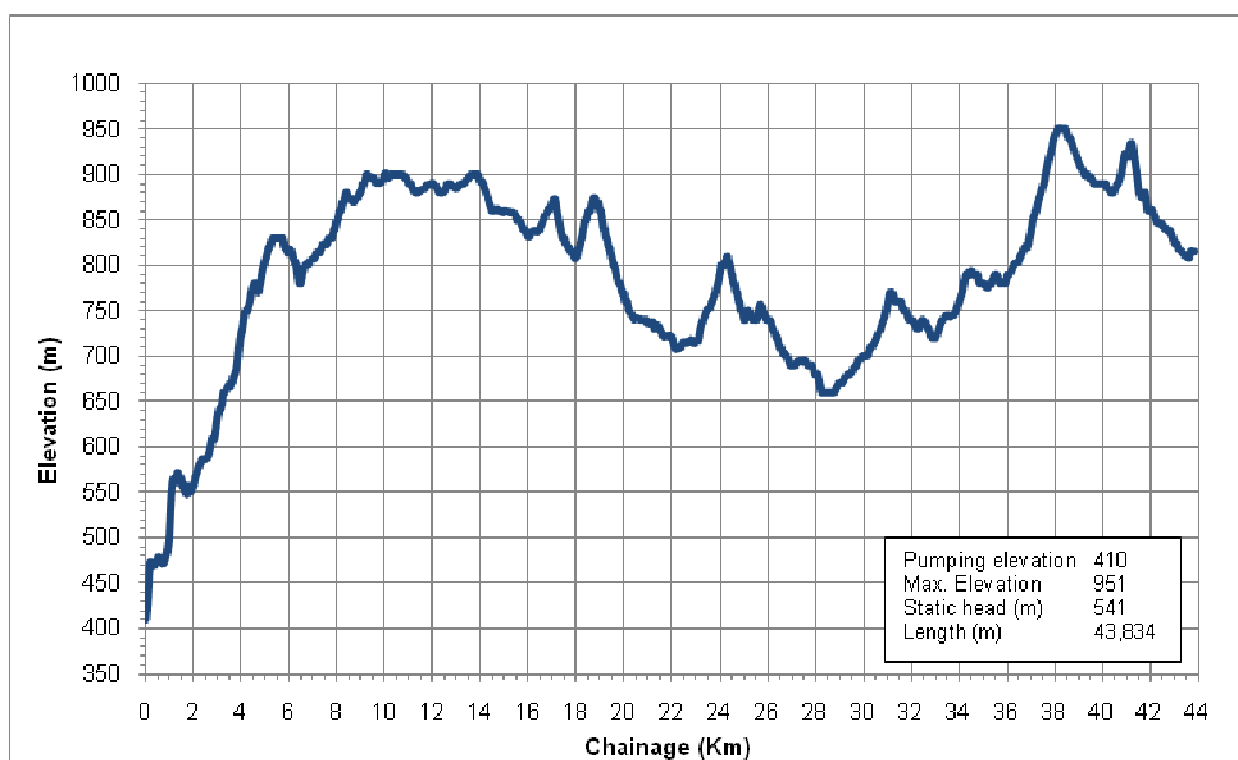


Figure 3-4: Approximate long section of Corridor 2-MR6

3.1.2 Summary of options

A summary of the characteristics of the corridor options is presented below in Table 3-1.

Table 3-1: Pipeline corridor options

Characteristics	Corridor options			
		Corridor 1		Corridor 2
	MR4	MR5a	MR5b	MR6
Off-take point elevation (m)	370	380	380	410
Length (km)	36.5	39.4	40	44
Max. elevation along the corridor (m)	866	866	866	951
Overall static lift (m)	496	486	486	541

The details of Table 3-1 highlight the following key considerations:

- MR4 off-take point has the lowest elevation as it is the last downstream off-take point option along Macquarie River;
- MR6 off-take point has the highest elevation as it is the most upstream off-take point option, but it also has the largest overall static lift due to higher elevations along the corridor;
- Corridor 1-MR4 is the shortest and Corridor 2-MR6 the longest corridor; and
- Corridor 1-MR5a and Corridor 1-MR5b both have the lowest overall static lift. The overall static lift of Corridor 1-MR4 is around 10 m higher, but it is around 3.0 and 3.5 km shorter than Corridor 1-MR5a and Corridor 1-MR5b, respectively, which will result in very close total pumping heads along the 2 corridors.

4 Assessment of Options

4.1 Introduction

The Orange Drought Relief Connection is part of the overall integrated water supply infrastructure required to secure the water supply for the City of Orange in NSW. This concept investigation leads to a preferred corridor option for the pipeline which will connect the Macquarie River to Orange's existing water supply infrastructure at the base of Suma Park dam.

The purpose of this report is to further investigate the corridor options that remained viable at the end of the feasibility study and subsequently propose the corridor which is most suitable for detailed assessment and design. Landholder's views and expectations, environment and cultural heritage factors and the cost of constructing and operating the system have all been considered in the concept investigation phase.

4.2 Methodology

The selection of a preferred corridor in this project requires the assessment of various options. Many of the variables that require assessment cannot be quantified in terms of economics and as a result it is necessary to undertake a comparison outside of the traditional benefit cost analysis (BCA).

The term for techniques (such as impact assessment and the weighted scoring method) which make a comparative assessment of options, taking account of several criteria simultaneously is Multi Criteria Analysis (MCA). An MCA is commonly understood to be used to assess impacts that cannot be readily quantified in money terms.

MCA is a method to resolve difficult decisions with multiple options. A decision making problem exists when an individual or group perceives a difference between the present state and a desired state when alternative courses of action are available and the individual or group is uncertain as to which alternative should be selected.

According to the above definition, comparing, ranking and selection of the desired pipeline corridor option for the Orange Drought Relief Connection, is considered as a decision making problem which can be addressed by MCA. In this project the MCA methodology was used over a BCA due to the fact there was insufficient details upon which to base a BCA combined with the fact that there are several comparisons requiring non-monetary assessment. The detail design phase should test all critical decisions with BCA and MCA modes. The detail design will provide finite data and costs associated with a single corridor which will allow for cost comparisons around installation and material options. This will provide for route definition within the corridor chosen.

A MCA analysis starts with the building of an evaluation matrix which includes options and criteria. The evaluation matrix is then improved to a decision matrix by assigning weights to the criteria and assessing the adequacy of each option with regards to each criterion.

The MCA evaluates all the options and provides a final score for each of them. The option with the highest score is considered the preferred option.

Finally, a sensitivity analysis will provide an understanding of how the weights of the individual criteria impact the final results.

4.3 Assessment Criteria

Nine decision criteria, as listed below, were identified and used for comparing, ranking and selecting the preferred corridor option.

1. Capital and operating costs
2. Constructability
3. Environmental and heritage impact
4. Carbon footprint

5. Landholder issues
6. Suitability of off-take point
7. Accessibility of off-take point
8. Geotechnical issues
9. Power availability

Below is an explanation of each criteria and the process by which each criteria was used in the assessment.

4.3.1 Capital and operating costs

A high level budget estimate for supply and installation of pump stations and a pipeline within the two corridors was compiled. Estimates for the construction of pipelines from each of the four potential river off take points was considered within the corridors in the evaluation. Many of the estimates are derived from costs on similar projects or by obtaining information from contractors are accurate to +/- 10%. The cost of each option is most affected by the: length of pipe, extent of excavation of rock and soil, site establishment costs, cost of power connection and overall time of installation.

A more accurate estimate of costs will be possible once details of a particular pipe alignment are investigated. It should be noted that expectations of the final price of the project should not be entirely based on these estimates as there may be additional costs uncovered in the detail design process.

As part of the cost estimation, high level estimates were compiled for the operating costs of each system. The following assumptions were used in developing the operational costs.

- 1.5 FTE's will be required to operate and maintain the pipeline
- On average 7 mega litres per day will be pumped through the pipe
- The system could operate for 4000 hours per annum
- Power tariff will be approximately \$0.10/kW hr

4.3.2 Constructability

Constructability is a term referring to the ease with which a pump station or pipeline can be constructed. Factors such as hardness and extent of rock, grade of a particular hill or set of hills, stability of slopes, remoteness and length of time to construct are all part of the evaluation criteria described as constructability.

The more difficult it is to construct a particular option the more it is downgraded in the evaluation process. For example a pump site that may be situated on high to very high strength rock will be more difficult to construct than one that is positioned on deep clay loam therefore its constructability rating will be lower. Similarly a pipeline that is to be constructed over a high to very high strength rock ridge will be more difficult to construct than one that passes through a gently undulating paddock with deep topsoil. The constructability of the pipeline over the rock ridge will be lower than that for the paddock pipe.

4.3.3 Environmental and heritage impact

This criterion compares the relative impact of a pipeline installation within the two corridors from an environmental and cultural heritage perspective. The degrees to which flora, fauna and heritage sites are impacted are assessed. The criterion was established to ensure that the project avoided any threatened or endangered species or impact in any way sites of cultural significance where ever possible.

4.3.4 Carbon footprint

Orange City Council set out to ensure this project has the smallest carbon footprint possible. As a result this criterion was established to ensure that the carbon footprint of the options was evaluated in the MCA

process and the relative impact of the options taken into account when making a decision on the preferred corridor.

4.3.5 Landholder issues

Landholder issues are defined as considerations that must be met in order to obtain support for the project from landholders along the corridors. Support is essential to establish easements and to purchase freehold land parcels upon which critical infrastructure such as tanks and pump stations can be built.

The ability to work effectively with landholders to resolve issues was evaluated during the MCA process.

4.3.6 Suitability of off-take point

This criterion allows the suitability of potential take off points along the river to be considered in the evaluation of each corridor. A range of factors including bank stability, flood and silting resistance, and resistance to vandalism and the overall distance from Orange were all part of the evaluation.

4.3.7 Accessibility of off-take point

The ability to obtain practical, long term access to the potential off take points was a key criterion used to evaluate the corridors. Having a "perfect" off-take point that is inaccessible due to vegetation, terrain or slope stability is not practical in this project. It was considered essential that the off-take point on the river be accessible from a construction and operations point of view. If a potential off-take point was considered to be more difficult to access than another point it was downgraded in its rating during the MCA process.

4.3.8 Geotechnical issues

Each of the corridors and potential off-take points had individual geological attributes and limitations. The geotechnical issues along each corridor informed both the constructability and cost criteria. It was determined that Geotechnical issues should be considered as a relative measure of suitability between the corridors in the MCA process.

4.3.9 Power availability

The ability to connect potential off-take points and booster pump sites to the power grid is essential for the success of the project. It would not be possible to operate an interactive pumping and control system without "online" power 24 hours per day. The use of diesel powered pumps would be noisy, much more expensive to run and maintain and present an ongoing environmental and bush fire threat.

There are no "24 hour per day" alternative energy systems available within the immediate area of this project so the option of totally operating on green power is not available. The project has however determined that there are two options for offsetting the carbon foot print of the project by generating green power from a mini hydro generator and a solar array. The revenue from these power systems will also serve to offset the cost of running the system.

This criterion was established to ensure that the criticality of mains power was taken into account when evaluating the most appropriate corridor for the pipeline.

4.4 Assessment of pipeline corridors against criteria

4.4.1 Criteria 1 – System costs

A “top down” estimate of the materials and construction costs associated with building a pipeline and three pump stations was developed. The estimates assumed that the pipe and pumps were located within the two corridors and originating from one of the four potential off-take points along the river.

The findings of high level budget estimates (+/- 10%) are consistent with the thesis that the shortest, most direct pipeline with a relatively low pumping head will be the cheapest option to construct and operate.

The findings of this analysis indicates that a pipeline emanating from a point approximating MR4 and connecting to the infrastructure of Suma Park Dam via corridor 1 will have the lowest capital and on ongoing operational costs.

Budget estimates			MR4	MR5a	MR5b	MR6
	Item	Comment	Total	Total	Total	Total
DIRECT COSTS						
Pumps and tanks						
1	Pump stations and tanks	River plus 3 booster pumps	\$3,000,000	\$3,250,000	\$3,450,000	\$3,500,000
2	Power Supply	4 locations	\$7,000,000	\$7,400,000	\$7,400,000	\$9,000,000
3	Pump Buildings (conc block) + Site Works		\$600,000	\$600,000	\$600,000	\$600,000
4	Security fence with gate + Landscaping		\$45,000	\$45,000	\$45,000	\$45,000
Pipeline						
5	Pipe length	Lenght according to report				
6	Supply only of Pipe	375mm various class	\$6,387,500	\$6,895,000	\$7,000,000	\$7,700,000
7	Supply only of Pipe Fittings		\$1,277,500	\$1,379,000	\$1,400,000	\$1,540,000
8	Supply only Bedding Materials		\$875,000	\$980,000	\$980,000	\$1,050,000
9	Installation	various rates per day	\$6,424,000	\$6,934,400	\$7,040,000	\$7,744,000
10	Fencing		\$110,000	\$110,000	\$110,000	\$200,000
11	Services locations along Power Easement		\$150,000	\$150,000	\$150,000	\$200,000
12	E/O for laying close to services		\$150,000	\$150,000	\$150,000	\$200,000
13	Concrete - encasement - structures etc		\$500,000	\$500,000	\$500,000	\$600,000
14	Road restoration		\$2,000,000	\$2,100,000	\$2,200,000	\$2,500,000
Crossings:						
15	Municipal Road		\$160,000	\$160,000	\$160,000	\$180,000
16	Small creek (open cut)		\$300,000	\$300,000	\$300,000	\$400,000
17	Major Creek (suspended pipe)		\$1,000,000	\$1,000,000	\$1,000,000	\$1,500,000
18	Restoration & Landscaping		\$100,000	\$100,000	\$100,000	\$120,000
19	Allowance for other pipeline items (i.e. concrete		\$958,125	\$1,034,250	\$1,050,000	\$1,155,000
Modification to Suma Park Dam Transfer Pump Station						
20	Tank at Suma Dam 6 meg		\$1,850,000	\$1,850,000	\$1,850,000	\$1,850,000
21	Manifold + Valves + Fittings		\$157,000	\$157,000	\$157,000	\$157,000
22	Controls system		\$75,000	\$75,000	\$75,000	\$75,000
Telemetry						
23	All Facilities - Field Elements + RTU + Data		\$194,400	\$194,400	\$194,400	\$194,400
24	Communication Facility		\$200,000	\$200,000	\$200,000	\$200,000
INDIRECT COSTS						
25	Site Office Establishment & Disestablishment		\$150,000	\$150,000	\$150,000	\$150,000
26	Environmental System (f&f, Heritage, etc)		\$100,000	\$100,000	\$100,000	\$100,000
27	OHS&R System		\$100,000	\$100,000	\$100,000	\$100,000
28	Traffic Management System		\$200,000	\$200,000	\$200,000	\$200,000
29	QA + Others		\$120,000	\$120,000	\$120,000	\$120,000
CONSULTING FEES						
30	Investigation, Design and Documentation		\$920,000	\$920,000	\$920,000	\$920,000
31	Geotechnical investigation		\$500,000	\$500,000	\$550,000	\$600,000
32	Surveying		\$400,000	\$400,000	\$400,000	\$440,000
33	Project managment		\$800,000	\$800,000	\$800,000	\$800,000
34	Aboriginal Heritage Management		\$100,000	\$100,000	\$100,000	\$100,000
COUNCIL COSTS						
35	Costs to date		\$350,000	\$350,000	\$350,000	\$350,000
36	Community Consultation		\$350,000	\$350,000	\$350,000	\$390,000
37	Land matters and easements		\$2,028,313	\$2,191,089	\$2,222,200	\$2,434,975
38	Permits and liscences		\$500,000	\$500,000	\$500,000	\$500,000
39	Insurance		\$1,000,000	\$1,000,000	\$1,000,000	\$1,000,000
CONTINGENT RISKS						
40	Rock excavations		\$3,000,000	\$3,000,000	\$3,500,000	\$4,000,000
41	River site road construction		\$350,000	\$350,000	\$350,000	\$400,000
42	Contingency		\$2,200,000	\$2,200,000	\$2,200,000	\$2,500,000
TOTAL			\$46,681,838	\$48,895,139	\$50,023,600	\$55,815,375

ALTERNATIVE ENERGY SOURCES						
43	1.0 MW solar array		\$5,000,000	\$5,000,000	\$5,000,000	\$5,000,000
44	Mini hydro		\$150,000	\$150,000	\$150,000	\$150,000
TOTAL			\$5,150,000	\$5,150,000	\$5,150,000	\$5,150,000
OPERATING COSTS						
45	Power costs		\$802,300	\$802,300	\$802,300	\$925,000
46	Running costs		\$451,000	\$462,700	\$473,000	\$516,000
TOTAL			\$1,253,300	\$1,265,000	\$1,275,300	\$1,441,000

It is important to note that the costs of power would be offset considerably if the alternative energy source projects, being the mini hydro power generator or the solar array, are further investigated and approved for construction. The benefit cost analysis of these options requires detailed investigation and negotiations with Country Energy in the detailed design phase.

4.4.2 Criteria two – constructability

Each corridor and potential pump site was visited by a group of engineers from Council and MWH to address constructability issues. Information from the sites, contour plans and aerial imagery was used in a constructability workshop to review each corridor. The workshop was held with a group of independent contractors who have experience in constructing similar projects and who understand the key issues such as machinery access, material logistics, construction times, construction costs, system operation and work site safety. All this information was made available during the subsequent MCA analysis to adequately evaluate the most suitable corridor option.

This is not an easy project to construct. The workshop and evaluation process highlighted the importance of addressing the following issues in the selection of a preferred corridor:

- Establishing an all-weather track to the river which can be used for the construction and operation of the river pump station.
- Establishing a construction track for the transport of materials to construct the first part of the rising main across steep and rocky terrain.
- Managing site safety.
- Minimising noise during construction.
- Excavating rock with minimum impact on the environment in an economically sustainable manner.
- Designing above ground pipework in areas where rock excavation is not economical or practical.
- Ensuring that component selection allows for handling and removal during the operational phase of the project. The size and weight of individual components must be considered for repairs and maintenance.
- The impact of prolonged wet weather on the installation.
- The potential impact of vandalism or shooting on the infrastructure.
- The ability to clean pipes, tanks and pumps over time and in particular flush silt from the system.
- Traffic management.

The thorough review of constructability issues determined that Corridor 1 was preferred over Corridor 2 for the following reasons:

- Corridor 1 was shorter and requires less excavation.
- Geologically Corridor 1 is more stable around the river.
- Corridor 1 has more options to access the river via existing trafficable tracks.
- The existing tracks could be improved to allow long term all weather access.
- The majority of the preferred pipe corridor is within or adjacent to road reserves and consequently construction equipment and materials can be transported with relative ease for the majority of the corridor.

During the evaluation some of the key points that require further detailed consideration were noted below:

- It will not be possible to restrict access to the roads or properties for long periods of time and access for emergency vehicles must be possible at all times.
- Landholders and business owners must be able to go about their normal business and farming practices with minimal disruption. The construction methodologies and practices must understand and respect the day to day needs of landholders and business operators. It will not be possible to cut fence lines or leave gates open and unattended for any period of time. The project must co-exist with farmers and business owners in a cooperative considerate manner.
- Strict Occupational Health and Safety procedures and practices will continue to be reviewed and implemented during all phases of the project.

4.4.3 Criteria three – Environmental and heritage impact

A comparative assessment of the pipeline corridor was undertaken in relation to environment and heritage. The assessment was based on the results of field investigations carried out by Ozark Environmental Heritage and Management, an independent consulting company which has experience and qualifications to assess the environmental and heritage value of each corridor.

To facilitate comparison, a range of assessment criteria relating to ecology and heritage were identified. These included Aboriginal and non-Aboriginal cultural sites, potential vegetation clearing, threatened flora and fauna, conservation significance and mitigation potential. Comparison of the pipeline corridors was carried out using a ranking approach against these assessment criteria using expert judgment from Ozark as required.

The results of the field and desktop assessment indicate that Corridor 1 is the preferred option as it:

- Requires the least amount of potential vegetation clearing.
- Largely comprised of scattered trees, which have poor connectivity to other patches and are more common in these landscapes than larger patches.
- Avoids a known archaeologically sensitive site adjacent to the Macquarie River.
- Consists predominately of re-growth (albeit of Box-Gum Woodland EEC) which has lower conservation significance than remnant vegetation in Corridor 2.

It is noted that there is high potential for heritage impacts at the potential off-take point of MR5b and this must be avoided. Similarly, the potential for ecological and heritage impacts in Corridor 2 is relatively high because of large patches of high quality vegetation and a number of important heritage areas.

Overall, Corridor 1 is considered to provide the lowest impact to ecological and heritage values and the best outcome for the proposed pipeline corridor.

The full heritage and ecology assessment report provides a description of the constraints and opportunities associated with each of the corridors and off-takes, as well as the justification of the ranking of each option. The full report is included in Appendix B of this report.

4.4.4 Criteria four – Carbon Footprint

A high level estimate of the carbon foot print of each option was assessed. The carbon foot print of both the construction and operational phases of the project were taken into account and also included an estimate of the embedded carbon in the system components.

The following factors had the greatest impact on the carbon footprint of each option:

- Length of pipeline.
- Total system head.
- Distance from existing power grid.
- Potential for vegetation to be cleared.

The evaluation process concluded in corridor 1 being chosen as the preferred route for the following reasons:

- Corridor 1 has the shortest overall pipeline length and consequently contains the lowest amount of embedded carbon and requires the lowest carbon foot print to install.
- A system installed in corridor 1 would have the lowest overall system head and therefore has the lowest ongoing carbon emission from an operational perspective.

- The upgrade of power in Corridor 1 will have the lowest carbon foot print due to the extent of the existing network and the fact that a large number of existing poles can be used.
- There is much less vegetation which may require clearing in corridor 1 than in corridor 2.

4.4.5 Criteria five – Landholder issues

This project has many stakeholders. The stakeholder group with the greatest interest are the landholders whose properties intersect with the pipeline corridors being investigated. This group was included in the concept study as their views and expectations were critical to informing the MCA process that would lead to the selection of a preferred route.

Manidis Roberts Pty Ltd, a leading stakeholder engagement consultancy, was commissioned to work with Council to undertake a series of landholder discussions to describe the proposed project and to listen to their concerns, comments and requirements in terms of project implementation. Orange City Council supplied copies of GIS data for the area showing the areas and assets that will be potentially affected by the construction of the Drought Relief Connection.

The majority of key landholders consulted along the corridors appear to be open to the project, provided the following conditions are met:

- There is adequate response to the nine primary issues raised during the consultation; and
- That a robust consultation process is maintained for the duration of the project and includes all stakeholder groups.

Manidis Roberts collected views by contacting landholders individually. Face-to-face meetings were undertaken on site where possible and by phone with those unable to attend face-to-face meetings. A council representative was present at all face to face meetings.

It must be noted that not every potentially affected landholder had been contacted at the time of writing this report. It is also important to note that the identity and details of landholders and their conversations are private and confidential and will not be detailed in this report. The majority of landholders contacted clearly expressed that their views and discussions were to be treated confidentially.

During the landholder consultation program, nine major issues emerged from the community, with many containing a number of sub issues. Of the nine major issues, three primary issues were identified. Primary issues were defined by their ability to cause significant emotional distress for landholders, to consistently emerge across the landholder group and to significantly impact Council/landholder relations. Primary issues are as follows:

- Council Transparency
- Project Justification
- Operational/Legacy Issues

Within Council transparency the most significant sub issue was trust of Council staff and Councillors. Within project justification the most significant sub issue was the perceived capacity of the Macquarie River to provide sufficient flow. Within operational/legacy issues the most significant sub issues were privacy and noise from pumps.

All other issues were defined as secondary issues:

- Construction Impacts
- Sustainability
- Quality Assurance

- Cost
- Social Impacts
- Compensation

Within construction impacts noise was the most significant sub issue. Within sustainability, down stream flows was the most significant issue. Within quality assurance, remediation was the only sub issue identified. Within cost the energy costs associated with pumps was the most significant sub issue. Within social impacts, quality of life was the most significant sub issue. Within compensation, easement price was the most significant sub issue.

The majority of key landholders (75%) were not strongly opposed to the Orange Drought Connection Project. Where landholders had strong concerns, these were:

- Transparency of council staff and councillors during the concept planning phase.
- The capacity of the Macquarie River to provide adequate flow in dry periods. There is widespread belief that the pipeline will be ineffective.
- That cost and to a lesser extent construction and operational impacts are not justified in consideration of the above.
- Potential noise impacts from pumping stations.
- Privacy - Increased presence of council staff accessing and maintaining infrastructure.

Several key landholders were receptive to discussing opportunities for obtaining short cuts through private property along the corridor.

Participants were generally not encouraged by the potential shared community benefits (road upgrades, improved fire management systems, etc.) resulting from the project.

The stakeholder engagement process will continue to be a key part of the project development and implementation process through to completion. Council is committed to working with all stakeholders to achieve the best possible outcomes for all parties encompassed by this project.

4.4.6 Criteria six - Suitability of off-take point

A group of engineers from Council and MWH visited the potential off-take points to assess the suitability of each as a long term pump off-take point on the river. The key attributes of each site that were considered were:

- River bank stability – a point that will not erode at an accelerated rate or adversely suffer from the effects of floods.
- The presence of a deep water hole suitable to accommodate a pump suction or off-take. Note that the depth of hole is not related to pumping depth of water but rather to ensure some resistance to silting or filling of the hole with sand and sediment.
- A hole with reasonable flow through capability – i.e. at the end of a section of rapids in order to improve water quality or in a section where the river narrows and velocity may increase in normal flow conditions.
- A location not frequently visited for campers.
- A location that may not be easily accessed by those wishing to vandalise the site.
- A site that did not require removal of vegetation.

The results of the visits and selection criteria determined that corridor 1 was preferred over corridor 2 as it contained a greater number of potential off-take points with the optimal conditions.

Some of the site conditions found along pipeline Corridor 1 are depicted in Figure 4-1 to Figure 4-8.



Figure 4-1: The river conditions around the Corridor 1 area showing bank stability that is clear of major vegetation



Figure 4-2: Deep water hole found in the Corridor 1 section of river



Figure 4-3: Typical terrain heading south from the Macquarie River within Corridor 1



Figure 4-4: Possible site for gauging station and section of rapids found in Corridor 1

4.4.7 Criteria seven – Accessibility of off-take point

Each of the potential off-take points was visited by a team of engineers and the accessibility of each assessed.

The terrain around the Macquarie River at all of the potential off-take points could only be described as difficult in terms of trafficability. A 1.5km section of fire trail near the confluence of the Turon and Macquarie Rivers took more than 1.0hr to travel over in a 4WD. This type of access is not sustainable for construction or operational activities.

All potential off-take points were evaluated in terms of:

- Steepness of terrain.
- Stability of terrain.
- Trafficability of existing tracks.
- Ability to construct new track.
- Distance from existing council road.
- Potential to be vandalised

The long sections shown in figures 3-1 to 3-4 indicate the steepness of the terrain around the river. The slopes around the potential off-take points of MR5b and MR6 are extreme and almost impassable. The slopes around MR4 and MR5a are considerably better and examples of some of the access tracks in these locations can be seen below.



Figure 4-5 typical track accessing the river in Corridor 1



Figure 4-6: Typical access track around Corridor 1

The slopes around the area adjacent to the river in Corridor 2 are considered to be unstable and highly erodible. This can be observed in the condition of the fire trails accessing the river. There are some

slopes around Corridor 1 that are also considered unstable however there are existing tracks on stable slopes accessing the river and some of these could be upgraded to improve access to a river pump site.

Corridor 1 contains council road reserves that are within 4km of several potential river off-take sites.



Figure 4-7: Corridor 1 (open area with moderate slope shows a good potential site for the proposed Booster Pumping Station & Tank)



Figure 4-8: Corridor 1, Long Point Road

The potential off-take points along corridor 1 are relatively isolated whereas the area around the confluence of the Turon and Macquarie Rivers is a popular camping destination and would be more likely to be vandalised.

When all aspects of this criterion are considered corridor 1 emerges as the preferred option.

4.4.8 Criteria eight – Geotechnical Issues

Geotechnical issues prevail in much of the evaluation process discussed in this section. These issues will be the focal point of much of the design and construction processes and as such have a large impact on the project in terms of project costs, time to complete the works and exaction techniques.

Douglas Partners Pty Ltd was engaged to complete a field study and desktop assessment of the pipe corridors from a geotechnical perspective. The key objective of the consultancy was to provide an overview of the predominant geological formations and soil structures that would be encountered along the various pipe corridors. The scope also included an assessment of the type, hardness and incidence of rock along the corridors and to review any geotechnical issues that may affect the constructability of the pipelines. The full report from Douglas Partners is included as Appendix C of this report.

The geological investigation report that was completed as part of this concept investigation phase states that:

Previous slope instability is noted in several natural slopes adjacent to or at the proposed pipeline corridors.

Steep slopes, at the periphery of a basalt covered plateau crossed by MR-4, include scattered fallen joint blocks to in excess of 3 m greatest dimension.

Along most of the lengths of all pipeline corridor options, bedrock is present at shallow depth (typically <0.3 m to 1 m) below colluvial or residual soils. Shallow deposits of often erratically distributed alluvium also mantle gully and creek floors which may have eroded down onto high or very high strength rock.

Overburden alluvial, colluvial and residual soils, Very Low, Low and Medium strength rocks may be expected to be readily excavated by heavy bulldozers (e.g. D9 class or larger) in open excavations for access roads and construction platforms. Significantly reduced (potentially uneconomic) productivity may be expected in High and Very High strength rocks and may require blasting or heavy rock breaker use. The use of these excavation techniques may result in additional fracturing of the rock mass in the batters and a consequent need for surface treatment.

In detailed excavations for the pipeline trench, footings for pumping stations and drainage/services lines, allowance should be made for use of hydraulic rock hammers for breakage of Medium or greater strength rocks. Blasting may also be required where jointing is widely spaced in the higher strength materials.

The presence of rock is unavoidable in this project. It is critical that during the detailed design phase of the project that a detailed geotechnical investigation including core drilling be completed for the entire length of the preferred corridor. This detailed investigation is required to be able to estimate the type and extent of rock and will inform specifications and tenders for the removal of rock or for above ground pipe installation.

Douglass Partners concluded that:

- There are significant amounts of rock in the medium, high and very high strength categories that will require cutting, drilling and potentially blasting to effectively excavate. The report outlined that it is not possible to determine the exact amount of rock that will be encountered by trenching machines without more detailed investigations.
- The geology around MR 6 is particularly unstable and rock or landslides were quite likely during construction in this region.
- The geology around MR4, 5a and 5b has areas of instability that require further investigation

Douglas Partners recommendations for further work are:

- Further investigation after the pegging of the selected pipeline corridor including a more comprehensive walk-over geological survey of the entire corridor by a senior engineering geologist to assess soil and rock distribution and potential for instability or erosion;
- Selection of test pit locations for investigation of excavatability and sampling of materials for laboratory assessment of suitability for use as trench backfilling and access road construction. It is suggested that an initial phase of test pitting be carried out using a tractor mounted backhoe to enable rapid movement along the corridor. A second phase of test pit excavation is suggested and would employ a larger (say 20 – 22 tonne) excavator with rock bucket and hydraulic hammer attachments to investigate areas of difficult excavation conditions assessed during the site walkover and initial phase of test pitting;
- In situ electrical resistivity testing, using the Wenner method, to determine areas of potential high conductivity and corrosion potential; and
- A program of laboratory testing including classification tests, compaction parameters, California Bearing Ratio values for assessment of access roads and pavements associated with new pumping stations, together with soil aggressivity for assessment of corrosion of buried concrete and steel elements.

After reviewing all the information presented by Douglass Partners corridor 1 was determined to be the most appropriate for the pipeline as it was shorter in overall length and would require the least amount of excavation. Corridor 1 provided several options for accessing the river via existing tracks which have been stable for some time as opposed to the unstable and highly erodible slopes around the river within corridor 2.

4.4.9 Criteria nine – Power availability

Country Energy representatives were consulted throughout the feasibility and concept investigations with respect to power requirements and the overall need for power supply to sites along the corridors. Country Energy attended several site visits to review the potential for each site to be connected to the power grid.

Meetings were held with Country Energy where maps of their existing power grid were examined and options for power supply discussed. It became obvious at an early stage that there was no power supply available for either corridor and that an upgrade of the existing network would be required.

The extension of existing power grids from Bathurst, Hill End and Orange were all considered however Country Energy advised that the cheapest and most reliable option would be to extend the power supply from Orange and subsequently recommended that a corridor heading towards Long Point would be the most suitable from a power supply point of view.

The issues identified by Country Energy were used extensively during the MCA process.

The details of the power supply upgrade will be the subject further work during the detail design phase.

The project team has investigated alternative power supplies and opportunities to offset the carbon footprint of the pipeline. A mini hydro power generation scheme and a solar array have been identified as opportunities that required more detailed examination and business case testing.

It appears possible to install at 20 to 30kW mini hydro power generator in the pipeline where there is residual head in the system. More detailed investigation needs to be carried out with respect to the opportunity and the costs of connecting such a system to the grid and the subsequent revenue contract need to be negotiated with Country Energy.

It is also proposed that a 1 mega watt solar array be built in the grounds of the Suma Park Dam pump site and be connected to the grid to export power. The opportunity to install a solar array as part of this project should be further investigated and a business case developed as part of the detailed design phase

4.5 Results of the MCA

The options considered in the Orange Drought Relief Connection concept study are the following:

- Corridor 1
- Corridor 2

The following matrix was used as part of the MCA process.

Table 4-1: Evaluation matrix for pipeline options

Evaluation Criteria	Criteria Weights	Option comparison ratings	
		Corridor 1	Corridor 2
Life-cycle cost			
Constructability			
Environmental and Heritage impact			
Carbon footprint			
Landholder issues			
Suitability of off-take point			
Accessibility of off-take point			
Geotechnical issues			
Power availability			

To undertake the MCA, Criterium DecisionPlus software was used.

Setting up the MCA consists of two main steps:

1. Assigning weights to each criterion; and
2. Comparison of options with regards to each criterion

Assigning weights to the criteria will determine which criterion plays a more important role in the decision goal. The criteria have been ranked using a numerical scale from 1 to 100. The scores can also be transformed into a quantitative scale as follows:

- 100 - Critical
- 75 - Very important
- 50 - Important
- 25 - Unimportant
- 1 - Trivial

There criteria ratings used in the MCA were provided by OCC as a result of the MCA workshop carried out in Orange on December 8th 2010. There were ten stakeholders involved in the MCA workshop and the final scores were obtained as the average of the inputs from all attendees. The ratings are summarised in Table 4-2.

The option comparison was undertaken by ranking the four options from 1 to 4, being 1 “The Worst” and 4 “The Best” option. Ratings for each for the options and criteria are presented in Table 4-2.

Table 4-2: MCA decision matrix for pipeline corridor options

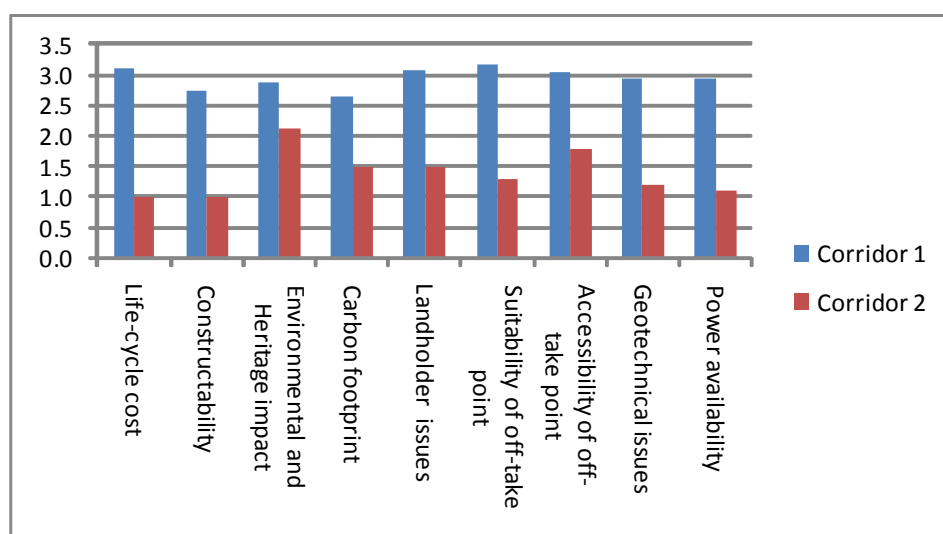
Evaluation Criteria	Criteria Weights	Option comparison ratings	
		Corridor 1	Corridor 2
Life-cycle cost	78	3.1	1.0
Constructability	84	2.7	1.0
Environmental and Heritage impact	72	2.9	2.1
Carbon footprint	72	2.6	1.5
Landholder issues	100	3.1	1.5
Suitability of off-take point	88	3.2	1.3
Accessibility of off-take point	76	3.0	1.8
Geotechnical issues	68	2.9	1.2
Power availability	84	2.9	1.1

4.5.1 Results of the MCA

As described above, the MCA model determines ranking of the options by taking into account the importance (weight) of each criterion and the score of the options against each criterion. The model calculates an overall score for each option.

In the case of the Orange Drought Relief Connection MCA, the results of the model show that Corridor 1 is the preferred option with a score of 2129. The results of the MCA showed that Corridor 2 was by far the least preferred option, with a score below 1000. Results of the MCA are shown in Figure 4-10.

Life-cycle cost, power availability and carbon footprint are significantly better in Corridor 1 compared to any of the other alternatives. These three factors, together with landholder issues, contribute the most to the high rating of Corridor 1. The project would also benefit from the power cost offset available from an alternative energy source such as the mini hydro system or solar array mentioned. These offsets have not been included in this evaluation as their individual business cases needs further development. A full evaluation of these should be carried out in the detailed design phase of the project.


Figure 4-9: Criteria scores for the investigated options

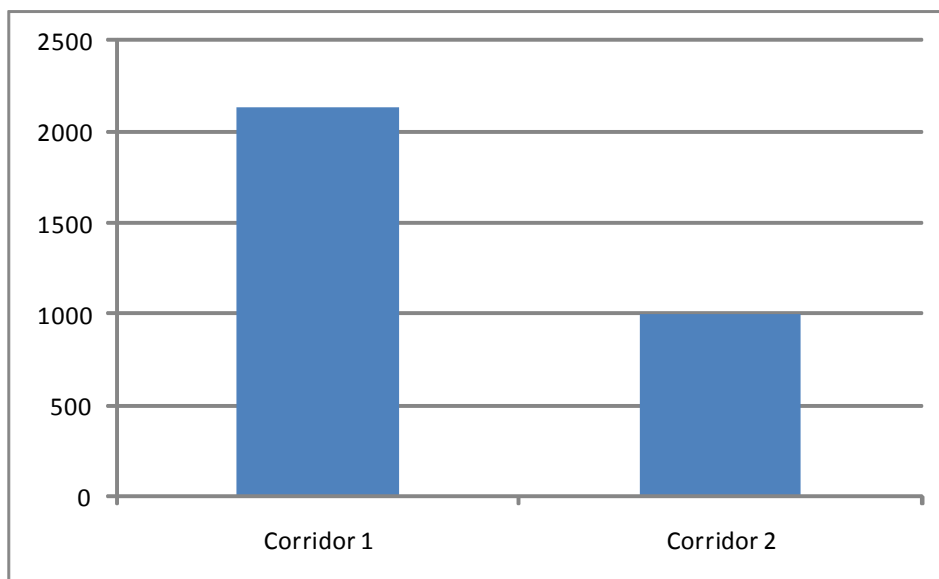


Figure 4-10: Weighted scores of the corridor options

4.5.2 Sensitivity analysis

Ranking of alternatives is only certain if the effects, weights of criteria and priorities can be measured with complete certainty and if all evaluation methods yield the same ranking order. However, most decision problems include different uncertainty factors and evaluation methods involve different assumptions. Hence, in order to obtain an overview of the impact of uncertainties on decision making, sensitivity analysis should be undertaken.

The aim of the sensitivity analysis is to understand how a variation in the criticality of the criteria would affect the final result. For the sensitivity analysis, a $\pm 20\%$ variation in weights is considered and then it is analysed whether the change in weights would result in a different “Preferred Option” and ranking order of the alternatives.

The sensitivity analysis for Orange Drought Relief Connection MCA shows that varying the criticality of any given criteria (while leaving the rest unchanged) would not affect the result of the preferred option.

The results of the sensitivity analysis demonstrate that Corridor 1 is the preferred option for a number of reasons. This means that altering one of the criteria, would not impact the overall suitability of Corridor, because this option is robustly supported by not only one, but a number of contributing factors.

5 Design Philosophy

5.1 Technical considerations

A summary of the technical considerations is presented here and details can be found in Appendix B.

5.1.1 Flow

Based on the design parameters and assumptions of the Feasibility Study and discussions with OCC, the pipeline and pumping stations are to be designed to transfer 1800 ML per annum (7.0 to 12.0 ML over 22 to 24 pumping hours per day) of water from Macquarie River to Orange. This will result in a design flow of approximately 90 to 152 L/s. The system is not intended to run 24 hours per day 365 days per year. It is designed to be able to extract up to 12 ML per day when water is available in the river to a maximum of 1800 ML per year. On average the system will operate for approximately 160 days per year.

It should be noted that all sizes, materials, specifications are calculated and proposed based on the available information at this stage and are subject to finalisation in the Detailed Design stage.

5.1.2 Pipework materials

DN375 PVC pipe has been selected as the optimum pipe material and diameter. There will be a need to use a combination of pressure rating classes of PVC pipes ranging from PN12 to PN20. Steel Cement Lined (SCL) pipe is also considered in this stage for the sections of the pipeline which need to be constructed above ground due to steep slopes.

Ductile Iron Cement Lined (DICL) and/or SCL pipe is also considered for creek crossings.

5.1.3 Hydraulic considerations

The hydraulic concept is to have a main pumping station at the river off-take and 2 booster pumping stations along the pipeline.

Each section of pipeline would be hydraulically discontinuous, discharging to a 1ML tank at each site prior to being re-pumped consecutively into the next section of the pipeline. In this manner, the large overall change in system elevation over the full length of the pipeline can be reasonably managed in respect of the hydraulic and structural issues relating to the operating pressures within the pipeline.

Due to the terrain and topographical conditions, the final section of the pipeline, is considered to be a pressurised gravity main feeding to a downstream tank at Suma Park Dam Pumping Station. This tank is indicatively considered to be a 6ML concrete tank to provide a 24hr storage together with the three intermediate 1ML tanks.

An outcome of the Value and Innovations Workshop held during the concept investigation was to consider a second connection point for the transfer main. It is proposed that in the event that there are water quality issues that can be mitigated by having an increased detention time the water should be diverted to the saddle dam on the western edge of Suma Park Dam. This feature of the system should be considered during the detailed design phase of the project.

5.1.4 Structural considerations

Structural considerations relate to essentially the pipe class/wall thickness required to accommodate the anticipated maximum and minimum pressures.

The temperature range affecting the infrastructure on this project is approximately -7°C to $+42^{\circ}\text{C}$.

Freezing of water in system components such as the air valves is possible and hence the system can be damaged by these temperatures. Conversely the high temperatures can cause expansion of any above ground pipeline or cause the shutdown of electrical systems.

The detailed design must consider the impacts of a significant temperature range on the system components.

Structural considerations for different typical sections of the pipeline are dealt with and described in Appendix B.

5.1.5 Pipeline specifications

River off-take pumping station transfer main

For the river off-take pumping station transfer main (approximately the first 2-3 km), the material options are limited to steel since or ductile iron, since PVC is not available in the required pressure rating. Subject to detailed design, it is likely that the most practical and economical alternative would be to construct a steel pipeline aboveground supported on piers.

There will be a 1ML steel tank at the end of this section. Details of this section of the pipeline are presented in Appendix B.

At this Concept Design stage an air vessel has been allowed for surge mitigation pending surge investigation and analysis work during the Detailed Design stage. The total volume of the air vessel at the river pumping station site is estimated at this stage to be around 5 m^3 , i.e. approximately 4m high x 1.25m in diameter.

Transfer Mains of Booster Pumping Stations

For the transfer mains of the booster pumping stations, the material options are more varied due to the lower operating pressures on these parts of the overall system. Ductile iron and/or PVC-M (PN16 and PN20) are appropriate choices, depending on technical and economic considerations.

There will be 1ML steel tanks at the end of these sections. Details of this section of the pipeline are presented in Appendix B.

The requirement for surge mitigation equipment needs to be confirmed in Detailed Design.

Gravity main

As mentioned earlier, the last section of the pipeline can be a gravity main. uPVC PN12 pipe can be used in this sections.

There will be a 6ML steel tank at the end of this section at the site of Suma Park Dam Pumping Station. Details of this section of the pipeline are presented in Appendix B.

For any future augmentation of the pipeline for higher flow rates, this gravity section of pipeline should be upsized to at least a DN375mm pipe, depending on actual design levels and available head.

A typical Hydraulic Grade Line (HGL) of the proposed concept hydraulics is displayed in Figure 5-1.

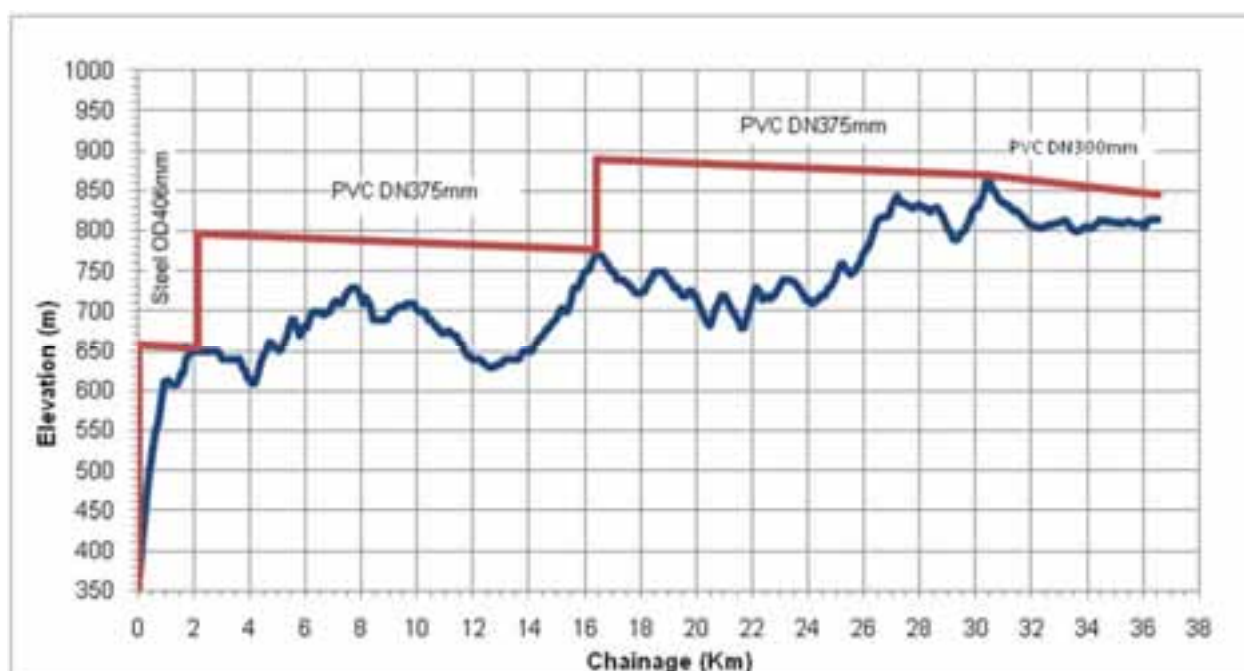


Figure 5-1: Typical HGL of the proposed concept hydraulics

Mini hydro power generation potential

As it can be seen in Figure 5-1, there may be a residual head of around 30m at the downstream end of the gravity main which may be considered as a potential for hydro power generation for carbon offset.

Considering an efficiency of 80% for the hydro power generation equipment, around 21kw of power generation capacity would be available which will result in an annual electricity generation of around 170Mwh.

Should this option be considered beneficial by Council, further investigation will be undertaken in Detailed Design stage.

5.1.6 Pumping Specifications

The design of the system is to cater for a daily demand of 7.0 to 12.0 ML based on 22 to 24 hours of operation per day (design flow of approximately 90 to 152 L/s). Once the detailed hydraulic analysis for the pipeline has been completed in the Detailed Design stage, the total developed head required for each pumping station will be determined and finalised.

It is proposed to design the system with 4 tanks located along the pipeline corridor. Tanks 1 and 2 will have an associated booster pumping station while Tank 3 will be set up to allow gravity feed into the gravity section of the pipeline. Tank 4, the last tank in the system will be located in the grounds of Suma Park Dam and act as a system balance tank and the final point for water quality control. The tanks have been considered to provide a hydraulic break with the pipeline open discharging to the tank and with water being extracted from the tank, either via booster pump or via gravity, to feed the downstream system.

More details are provided in Appendix B.

River off-take pumping station

Due to the site constraints, it is proposed to install a staged pump station at the river off-take.

A set of medium head lift pumps will be installed in a pre-fabricated “wet well”. It is proposed that these pumps be heavy duty submersible pumps designed to handle poor water quality. The water will be pumped from the submersible pumps through two filters and then into the main booster pumps. The filters will be designed to remove particles larger than 200 micron in diameter.

There will be two main booster pumps proposed in the design each delivering half of the design flow with a total dynamic head capability of around 300m. The units are proposed multistage centrifugal pumps. The pumps will alternate in their roles of “duty” and “standby” to ensure even wear between the two pumping units.

The maximum operating pressure of the pumps will be approximately 40bar and the power absorbed for the duty point of 45 L/s at around 300m TDH will be approximately 190 kW.

Each of the booster pumps will be controlled via individual Variable Frequency Drives (VFD) while the submersibles at the river will operate via Soft Starter control allowing ramping of the units on start and stop.

The pump start signal for the system will be based on the level input at Tank1 and the system demand from the Tank 3 flow meter.

The booster pumps will be located above the 100yr flood level of Macquarie River (subject to finalisation in Detailed Design) plus a minimum freeboard of 500mm to prevent inundation during flooding, the final freeboard will be determined during the detailed design.

A typical general arrangement of the river off-take pumping station is presented in Appendix A.

Booster pumping stations

Additional booster pumping stations will be located at Tanks 1 and 2. These booster stations will be similar in design with two smaller step multistage pumps and one large multistage centrifugal pump.

The Total Dynamic Head (TDH) of pumps will vary at each pump station depending on the flow requirement.

The maximum operating pressure of the pumps is 40bar and the power absorbed for a typical duty point of 90 L/s at 200m TDH is approximately 211 kW.

The larger multistage pump will be controlled via an individual soft starter. The smaller pumps will be controlled via individual VFDs to allow regulated flow based on system demand.

The flow from Tank 3 flow meter will be used to initiate operation of the system and set flowrate requirements at each of the River off-take, Tank 1 and Tank 2 sites.

5.1.7 Tanks

There are four tanks proposed for the system, three having a capacity of 1ML and the fourth located at Suma Park Dam having a capacity of approximately 6ML. Assuming that 15% of the storage would be dead storage there would be 2.5ML of useable Tank storage along the pipeline. Based on the full system flow of 90 L/s, there would be a 2.6 hour buffer within the tank system to feed the system and allow for staging of the individual river and booster pump stations.

This system buffer means that individual pump station operation can be slowed down allowing for a seamless station start up and shut down reducing surges within the system.

The tanks will always be maintained at the full level.

A typical general arrangement of the booster pumping stations and tanks is presented in Appendix A.

The tanks proposed are steel tanks designed in accordance with all relevant Australian Standards and the Building Code of Australia.



Figure 5-2: Suma Park Dam pumping station transfer main manifolds

5.1.8 Mechanical and electrical Implications

Due to the nature of the river site, it is important that the system is protected from flood inundation and also has the ability to handle varying water quality conditions. The filter design should consider sufficient capacity to handle up to 200 L/s giving the system greater security if water quality deteriorates. The filtration provides protection for the high lift pumps and prevents material from being pumped into the pipeline system, which can cause operational problems in the future.

Based on the draft system specifications, typical electrical requirements have been calculated and shown in Table 5-1. The design of each of the pump control systems will again be dependent on the detailed hydraulic analysis of the system but with the ability to slowly stage pump operation, due to the security given by the storage Tanks within the system, complicated system controls and interlinks can be avoided.

Table 5-1: Power requirements

Power consumption	No Of units	kW	Consumed kW	Total kW	Total Consumed kW	Minimum KVA requirement	Transformer KVA
River Off-take Pumping Station Lift	2	73	55	146	110		
River Off-take Pumping Station Boost	2	315	187	630	374		
Filtration	2	2	1	4	2		
Total river pumping station system				780	486	867	1000
Booster Pumping Station and Tank 1	1	315	211	315	211	450	500
	2	45	35	90	70		
	Total			405	281		
Booster Pumping Station and Tank 2	1	315	211	315	211	450	500
	2	45	35	90	70		
	Total			405	281		
Tank 3							50

More details are provided in Appendix B.

5.1.9 Interconnection to existing infrastructure

Suma Park Dam infrastructure

The pipeline will terminate at a reservoir located next to the Suma Park Dam pump station. The size of this reservoir shall be approximately 6ML in order to provide for flexibility of supply of water and pump run times along the pipeline. The exact location of the reservoir, the pipe and valve arrangements and the operating rules shall be determined during the detailed design phase.

Water quality issues have been highlighted in the risk evaluation workshops conducted during the concept investigation phase. It is possible that increased detention times may be necessary depending on the quality of water pumped from the Macquarie River. It is recommended that the transfer main also have a cross connection to a pipeline which terminates at the saddle dam located on the western side of Suma Park Dam. This will provide an option to pump directly to the dam in the event that the water treatment plant is not on line and prevailing circumstances dictate that water be transferred from the river to Orange or there is a need to hold and mix the transferred water within the larger dam reservoir.

Connection to a Managed Aquifer Recharge project

At the time of completing this report Council was conducting a feasibility study into the viability of a Managed Aquifer Recharge (MAR) project as part of its integrated water strategy to create a secure water supply for the future of the City. In the event that the feasibility study determines that an MAR project is viable it is recommended that the ability to supply water to that project from the Macquarie River via this pipeline is fully investigated.

5.2 Project Risk

As the project moves from feasibility through to concept investigation and beyond risks are being recorded for further mitigation and action. The process of managing risks is an ongoing process which requires regular review from the project team.

5.2.1 Risk Assessment

The table below describes the risks that have been identified during the concept investigation stage of this project.

Project Name: Orange Drought Relief Connection - Risk Register						Project number: A1276402			
Risk #	Risk descriptions/Construction	Likelihood	Consequence			Mitigation			Risk
			Description	Rating		Description	Rating		
1	Material handling/access	Will happen	1 Materials can't get to site	Significant effect	0.8	Construct road for 20 t truck access	Effective	0.3	0.24
2	Environmental damage	Unlikely to happen	0.3 Site works cause damage to environment	Significant effect	0.8	Proactively manage site to conform to SEMP	Effective	0.3	0.072
3	High water level in river or flash flooding	Could happen	0.5 Flood the site and damage works	Significant effect	0.8	Build significant coffer dam	Effective	0.3	0.12
4	Rock blasting causes rock slide	Could happen	0.5 Vibrations from blasting causes rock slide further up the valley	Disastrous	1	Engage geotechnical experts to advise on all rock excavations	Effective	0.3	0.15
5	Rock blasting causes fish kill	Could happen	0.5 Fish die from rock blasting at river site	Moderate effect	0.5	Net the pond and remove fish	Low effectiveness	0.7	0.175
6	Generator access/oil spill	Could happen	0.5 Gen set leaks oil during commissioning	Moderate effect	0.5	Bund all gen sets and fuel storages on work sites	Effective	0.3	0.075
7	Fire during construction	Could happen	0.5 Bush fire damages works or harm workers	Disastrous	1	Have fire fighting equipment on all work sites and train workers in fire fighting	Effective	0.3	0.15
8	Significant volumes of spoil to remove from site	Will happen	1 All excavated materials will need to be removed from the site and disposed of effectively according to best practice	Moderate effect	0.5	Involve council in rock crushing and reuse of materials	Effective	0.3	0.15
9	Potential contamination from fill	Could happen	0.5 Imported fill contains seeds from non native invasive species	Moderate effect	0.5	Control quality of imported fill material	Moderate	0.5	0.125
10	Restricted or no water supply for pressure testing and commissioning	Will probably happen	0.8 Commissioning process requires large amount of water to effectively flushing of all pipes	Significant effect	0.8	Manage all stakeholder expectations and purchase appropriate water license off river	Effective	0.3	0.192
11	Limitations on returning flush water to river	Will probably happen	0.8 Inability to return flush water to river	Minimal effect	0.3	Find alternative use for water e.g. dust suppression or establishing revegetation zones	Excellent	0.1	0.024
12	Recreational shooting damages construction or harms worker	Unlikely to happen	0.3 Damage to equipment or injury to worker from recreational shooters	Disastrous	1	Signage - community engagement	Moderate	0.5	0.15
13	Spider bite	Could happen	0.5 Spider bite	Significant effect	0.8	Keep work site clean and inspect for habitat. Train workers in first aid and have kits on site	Effective	0.3	0.12
14	Snakes bite	Could happen	0.5 Snake bite	Significant effect	0.8	Keep work site clean and inspect for habitat. Train workers in first aid and have kits on site	Effective	0.3	0.12
15	Tiger Pear injury	Will probably happen	0.8 Injury to workers from Tiger Pear cactus	Minimal effect	0.3	Train workers in identification of plants, remove all plants found train workers in first aid	Effective	0.3	0.072
16	Vehicle accident	Could happen	0.5 Traffic or construction vehicle accident	Significant effect	0.8	Diligent traffic management and maximum speed limits in all construction areas	Moderate	0.5	0.2
17	Critical health issue	Could happen	0.5 Emergency vehicles need to pass by or through construction site	Disastrous	1	have trench bridges ready to be deployed at all times	Effective	0.3	0.15
18	Project staff hit on road	Unlikely to happen	0.3 Project staff are hit by vehicle during the project	Disastrous	1	Ensure all project staff are inducted to sites, wear PEP and work in pairs at all times.	Effective	0.3	0.09
19	Discovery of mine during construction	Could happen	0.5 Earthmoving equipment falls into disused mine shaft	Disastrous	1	Complete detailed assessment of entire route to determine location of disused mine	Effective	0.3	0.15

Up to 0.050 = Low risk; 0.050 to 0.125 = Moderate risk; Greater than 0.125 = High risk
Areas of high project risk should always be discussed with the client, and these discussions documented.
It may also be desirable to discuss areas of high commercial risk with the client and document these discussions.

Figure 5-3: Risk register

The development and implementation of a risk and opportunity management framework follows the approach outlined in the Australian and New Zealand Standard for Risk Management (AS/NZS 4360:2004). This framework involves undertaking the following steps:

- Communicate, consult with and obtain agreement from stakeholders about the approach to risk;
- Establish the context for risk and opportunity management;

- Establish criteria against which risks and opportunities will be evaluated (relate to objectives and assumptions);
- Identify risks that could affect achievement of the objectives or affect assumptions and opportunities which could result in benefits realisation;
- Analyse the risks and opportunities in terms of consequences and likelihoods;
- Evaluate the risks and opportunities against the criteria;
- Decide on how the risks and opportunities will be managed and prioritised;
- Develop plans to manage or treat the risks and to ensure the realisation of priority opportunities; and
- Monitoring and review of the risk management process, including the risks and the effectiveness of risk treatment, to capture changing circumstances.

5.2.2 Risk management

Risk is defined as the chance of something happening that will have an impact on objectives. It is measured in terms of consequences and likelihood. It is important to note, that the impact can be positive or negative.

Risk assessment has five main steps:

1. Risk criteria determination – the terms of reference by which the significance of risk is assessed
2. Risk identification – a systematic recognition of hazards to achieving objectives
3. Risk analysis – a systematic process to understand the nature of and to deduce the level of risk
4. Risk evaluation – a process of comparing the level of risk against risk criteria
5. Risk mitigation – the selection and implementation of appropriate options for dealing with risk

Each of these five steps has been completed for the Orange Drought Relief Connection (ODRC) as part of a planned workshop.

5.2.3 Objectives

Risk is about understanding the impact of something in terms of achieving objectives. Hazards to achieving those objectives and the successful implementation of the servicing strategy have identified by participants during a risk workshop.

5.2.4 Determination of risk criteria

Risk criteria are used to determine the relative significance of risks. This allows risks to be prioritised and management and mitigation efforts to be tailored to reflect the relative significance. This recognises that it is important that resources are devoted to minimising the risk posed by hazards that will have a high or significant risk of impacting objectives.

5.2.5 Identification of risk

During the workshop, participants were asked to review each of the components of the ODRC project to identify hazards that may prevent the achievement of project objectives. This process was facilitated and risks were recorded into a risk register.

5.2.6 Risk analysis and evaluation

Each of the identified risks were analysed by the workshop participants. The results of this assessment are recorded in the risk register.

5.2.7 Risk mitigation

Together, workshop participants determined appropriate risk mitigation measures for all identified risks.

5.2.8 Ownership and review

The diligent management of risks requires the assignment of a champion for the cause. During the early implementation phases of the project, a preliminary assignment of potential champions for the management of each risk will be undertaken. Assignment of champions will only be confirmed following an additional project risk workshop.

Risk management is a continuous, process. Therefore, the outcomes of the workshop should be regarded as a base case for commencing the management of the risks for successfully implementing the strategy. The risk register should be regularly reviewed during the remainder of the project.

6 Project Timeline

The timeline below shows that the project scheduled to be completed in March 2013. This timeline is subject to impacts from delays in receiving project approvals from the NSW Department of Planning and its referral authorities.

Orange Drought Relief Connection Timeline																																						
	2010				2011								2012								2013																	
Task	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun				
Project Management																																						
Planning approval and land matters																																						
Stage 1																																						
Preliminary Investigations																																						
Investigation and concept design																																						
Detailed Design and Documentation																																						
Early contractor involvement																																						
Stage 2																																						
Construction management																																						
Construction																																						
Commissioning and handover																																						

7 Project opportunities

During the concept investigation phase of the project several opportunities and project legacies have been identified. The key opportunities that arise for the local community from this project are outlined below.

7.1.1 Job Creation:

The project will employ approximately 55 people during the construction phase. The construction phase will create employment for up to 20 local people in various positions for a period of between 6 and 18 months.

7.1.2 Stimulus to the local economy

The project will provide stimulus to the local economy with an estimated \$15 million being spent in the region on materials, labour and services.

7.1.3 Power supply upgrade

The project will require the installation of three phase power along the preferred corridor. This will enable residents along the corridor to access three phase power for their properties and businesses in the future.

7.1.4 Provision of fire fighting resources

The project will provide access to water for the Rural Fire Service during periods of bush fire threats in the local community. The RFS will be involved in selecting and positioning infrastructure that will support fire fighting services.

7.1.5 Road improvement

Long sections of roadways within the preferred corridor will be improved as a result of the project.

8 Operation Philosophy

8.1 Minimum river flow conditions

It is fully expected and recognised that the trigger for operating the pipeline will be a “minimum flow” condition that is established by the New South Wales Office of Water (NOW). The pumps stations will not be permitted to pump water from the river in periods of low flow. A NOW owned and operated gauging station is to be constructed near the river pump station in order to provide accurate flow data which will be used as a key parameter in allowing activation of the system.

The minimum flow condition has not been established at the time of writing this report however negotiations regarding this matter have commenced and it is expected that this will be determined as part of the permit conditions under which the construction of the project will be permitted by various NSW Government Departments.

8.2 Critical water supply levels

The full set of parameters which must be satisfied to operate the pipeline have not been established at the time of writing this report however it is expected the following items will be included in the activation decision process:

- Suma Park Dam levels
- Minimum flow conditions being established in the Macquarie River
- Indices' such as the Southern Oscillation Index indicated that there is an ongoing likelihood of reduced inflows to the catchment

8.3 Instrumentation and controls

Each of the Tank sites and the single river pump site will have individual PLC control. Each PLC unit will be Ethernet compatible and expandable. The Ethernet connection allows for direct connection of ancillary equipment such as VFD and soft starters directly to the PLC simplifying system operation and wiring. This unit would be directly connected to the telemetry system via the Ethernet connection.

At each site there will also be an industrial PC HMI. The unit comes with inbuilt Ethernet connection allowing the units to be integrated directly into the system.

The degree of Citect SCADA connection and requirement will be decided upon once final system logic is determined and in consultation with the Council.

Citect SCADA comes with some powerful features including:

- Graphical process visualisation
- Superior alarm management
- Advanced clustering options for control when and where you want
- Historical and real-time trending
- Built-in reporting
- Statistical Process Control
- Multi-threaded CitectVBA and Cicode programming languages
- Powerful analysis tools

Magnetic flow meters will be installed on the discharge points of each of the tanks. Due to the high operating pressure at the river off-take pumping station and the inaccessibility of the site, the main system water meter will be located prior to the fill point at Tank 1. Insert meters will be used to monitor river off-take pumping station flows to allow for flow protection and system monitoring. These will be installed on the filter discharges.

The VFD and Soft starters will be suitable for Ethernet connection to the PLC. Once final design is completed, it will be necessary to look at cooling requirements for the electrical system. It is envisaged at this stage that the electrical control equipment will be housed separately within the common pump shed. This control room will be vermin proof and will be climate controlled as required.

8.4 Telemetry

The telemetry system is proposed to be Trio Datacom J-series Spread Spectrum Ethernet radio or equivalent. This radio will operate in the licensee free 900 MHz and 2.4GHz ISM band. It will be necessary during the detail design phase to carry out a full radio survey to determine exact aerial position and aerial design. It is possible to achieve significant distances with line of site (up to 40km).

The telemetry units will be powered by a DC power backup system so in the case of loss of power at one site, system communication is not affected. The system will be designed to maintain communication for at least 24 hours in the case of a power failure.

A watchdog system will be programmed into each of the PLC units so that in the event of a prolonged communication fault between the units the system will enter emergency shut down and all pumps and valves will be closed.

8.5 Integration into Council's existing systems

The pipeline control systems will be integrated into the existing Council SCADA system and a central control point located within the Works Depot.

8.6 Water quality

The pipeline is supplying water which will be treated and distributed for potable use around the City of Orange. Consequently the water quality will be subject to regulatory requirements. In order to proactively manage the water quality the pipeline system controls will include real-time monitoring and reporting of; TDS, BOD, EC and pH. Testing in accordance with water quality management standards will also be conducted and results managed as part of the normal operating procedures for the system.

9 Considerations for detailed design

9.1 Pipeline

As mentioned before, the feasibility study recommended a design flow of 7.0 ML per day and a nominal pipe diameter of 375mm for delivery of around 90 L/s over 22 pumping hours.

Detailed Design should consider the possibility of transferring 7.6ML per day with the same infrastructure and over 24 pumping hours and 12.0 ML per day over 22 pumping hours with an increased pumping head. It should be noted that this will increase the unit headlosses (m/km) by around 2.8 times in which case, the unit headlosses will be above the recommended figures for an economic design. Higher headlosses will result in higher pumping heads and in some section of the pipeline, there may be a need to change the material and/or pressure rating to cope with the increased pressures.

Detailed Design should also consider the flow range of the pump operation scenarios as the extraction from the river could vary from 7.0 to 12.0 ML per day. With a variable flow range the first 2.1 km section of the pipeline (the above-ground steel pipe section) could be designed as 2 parallel pipes with smaller diameter to provide more flexibility in all operation scenarios. The rest of the pipeline can be operated with the design flow but less pumping hours. The option of 2 parallel pipes in the first section will also have a benefit of easier installation of the pipes due to lighter weight, but it will increase the capital cost.

9.2 Materials

Use of SCL, PVC and DICL pipe materials in different sections of the pipeline should be carefully investigated and considered in the Detailed Design stage.

9.3 Pipe Class

In Detailed Design and when a detailed survey of the pipeline corridor is available, there may be an opportunity to refine the pipe pressure rating classes according to exact pressures in various sections of the pipeline.

9.4 Installation

9.4.1 Early contractor involvement

The movement, handling and storage of materials during construction will be challenging particularly at the river site. Detailed design and project planning should involve the contractor responsible for construction. It is highly recommended that an Early Contractor Involvement (ECI) procurement model be implemented for the remainder of the project to ensure that all constructability issues are addressed and that contingency risk particularly with respect to rock is minimised. Once selected the successful contractor must be involved in the detailed design process and be involved in design reviews and innovation workshops as a minimum.

9.4.2 Below or above ground installation

With the assistance of the contractor a cost model for the installation of pipes below or above ground, subject to the type and hardness of rock, should be established in order to inform decisions about the exact details of pipe installations in particular sections of the pipe corridor. It is the intention of the project to install pipes below ground where ever practical however it is realised that in some locations the cost of excavating rock may be prohibitive and the use of explosives undesirable. The detailed design process will determine the best outcome and consider landholder opinions at the same time.

9.4.3 Spoil and imported fill

All unused trench spoil is to be removed from the pipe corridor and stored for reuse by Council's engineering department.

All fill must be certified to be free of seeds, organic matter and disease. The detailed design must specify the details of fill and the QA process which imported fill material must be subjected to, to ensure that it does not become the source of weeds or disease.

9.5 Corrosion protection

Corrosion protection of SCL and DICL sections of the pipeline by suitable external coating and/or cathodic protection should be investigated and considered in Detailed Design stage.

9.6 Overhead power lines

Low and high voltage power lines intersect with the preferred pipe corridor in several locations. The detail design must consider all potential impacts from these powerlines including but not limited to:

- Power easement sharing restrictions
- Pipe materials allowed under powerlines
- Installation risks under powerlines
- Potential for induced current under powerlines
- Maintenance restrictions in power easements
- Minimum specifications for installations in power easement
- Signage requirements around power easement

9.7 Lightning protection

The impact of a lightning strike on any of the pipeline components must be considered and particularly the potential for a lightning strike on the pipework to affect electronic sensors and electrical components.

9.8 Ancillary items

9.8.1 Air, scour and isolation valves and control equipment

All pipeline ancillary items must be designed and specified for installation so as to create no ongoing effect on the landholders existing management practices on farms. Where at all possible all air, scour air and isolation valves and pipeline control equipment shall be located adjacent to fences or within road reserves along the entire corridor.

Innovative design and installation features should be investigated through-out the detailed design phase to ensure all opportunities to minimise impact are implemented.

9.8.2 Signage and markers

Detailed design must consider all standards and regulatory requirements for the marking and signing of all aspects of the pipeline installation.

9.9 Hydraulic transients

In Detailed Design, a full surge analysis needs to be undertaken to determine the likely pressures more accurately and the need for surge mitigation measures. This would involve the use of a proprietary surge analysis computer programme to simulate the pressures that would occur in the pipelines during different operation scenarios.

These pressures would then be assessed against the safe head for the various pipeline materials and classes available to determine whether or not any surge mitigation is required. Final determination of the magnitude of surge, and any surge mitigation that may be required, is therefore an output from the Detailed Design.

9.10 Water management during operation

The detailed design must consider the issues of water management during operation. The pipeline is part of the integrated water strategy of Council and has a primary function of providing water to the City of Orange in order to mitigate the effect of low inflows into Suma Park Dam. It is important to ensure that the normal operation of the pipeline does not require unreasonable amounts of water to be flushed from the pipeline for maintenance purposes. If water is required to be purged from the pipeline then effective containment and reuse infrastructure must be incorporated into the design.

9.11 Tanks

9.11.1 Location and land issues

Tanks must be located at points that allow the pipeline to operate within defined hydraulic parameters and conditions. Where possible the detailed design should give consideration to the location of these tanks to ensure that they do not disrupt the ongoing day to day management of properties upon which they may be sited.

It will be necessary for any land, upon which pump and tank infrastructure is located, to be purchased as freehold land from the existing owners. Subsequently the location of the land should be as close to a public road reserve as possible in order to reduce the need for permission or entry. The size of the land should also be such that it allows for all operational needs.

9.11.2 Size and dimensions

The exact size and final dimensions of the tanks will be the subject of a water balance and operational model developed in the detail design phase. The potential aesthetic impact of the tanks will need to be considered in conjunction with landholder's views and feedback during detailed design.

9.11.3 Aesthetics and revegetation

The detailed design of the tank installations should provide for full revegetation of the tank sites. Where possible the sites should have no visual impact to passing traffic or the view from landowners existing homes.

One objective of landscaping and re-vegetation should be to minimise vandalism or impact of recreational shooting.

The impact of recreational shooting should be considered for all infrastructure along the pipe corridor during the detailed design phase.

9.12 Seismic analysis

Seismology of the area especially for the first 2.1km of the pipeline which will comprise of aboveground SCL pipe in a very steep terrain should be carefully considered in the Detailed Design stage and required measures for protection of the pipeline from potential land slide or falling rocks and boulders should be considered.

9.13 Pipework and ancillary items

The detailed design of pipework and ancillary items around the tanks should ensure that all infrastructure is easily accessed and maintained and at the same time be difficult to vandalise. Consideration should be given to the potential impact of recreational shooting.

9.14 Rural fire service access

The detailed design of all tank pipework should incorporate the needs of the local Rural Fire Service (RFS). The legacy of this pipeline will be an improved access to water for the RFS in the region. Quick access to tank sites and the water they contain must be a fundamental requirement of the detail design phase. The type, size, location and accessibility of quick connection fittings shall be specified and signed off by the Local RFS Brigade Captain. At Tank 1 and Tank 2 pressurized water will be available from the pump discharge manifold.

9.15 Access and maintenance

Access to tank sites for maintenance purposes shall be via public roads where ever possible so as not to impact on the operation of properties that surround them.

The purging of tanks and cleaning of silt shall have no impact on surrounding properties. The detailed design shall ensure that all management of the tank sites can be fully contained on the site upon which it is situated.

All water purged from tanks should be captured, treated and reused for beneficial purposes where ever possible.

It is proposed that access to the tanks will be via a caged ladder and platform and locked manhole cover.

9.16 Instrumentation and controls

Each tank should be fitted with an external level indicator. In addition to this, during installation a pressure transducer should be installed at the base of each tank. This pressure transducer will be used to monitor tank level and through the Programmable Logic Control (PLC) and radio communication system initiate pumps starts and stop.

Access to the PLC will be via a touch screen HMI (Human Machine Interface). Connection between the sites will be via radio telemetry utilising Ethernet connection. Remote access to each site via GPRS is still to be considered.

In addition to the level transducer, a mechanical sensor should be connected directly to the PLC. In the case of the mechanical sensor tripping an alarm SMS message will be sent out and an automatic system shut down initiated through the PLC system.

Each tank outlet is to be fitted with a magnetic flow meter.

9.16.1 Control Logic

The delivery from each of the tanks should be metered by a Magnetic Flowmeter and monitored via the local PLC at the tank. This flow information in conjunction with the level information from the transducer mounted inside the tank will allow the initiation of a filling cycle.

The amount of flow being taken out of the tank and the current level of the tank will be used to initiate the pump call to the preceding tank or river system. The tank will continue to fill after water ceases to be taken from the tank so that the tanks always remain full.

9.16.2 Water quality

Sampling and testing

The detail design shall consider all instrumentation and infrastructure required to implement a comprehensive raw water monitoring program. Real time sensors monitoring water quality parameters such as TDS, BOD, EC and pH should be incorporated into the design of sensors and data management systems at the tanks. Points for sampling water should be incorporated into the pipe and valve details up and downstream of the tanks.

Chemical injection and water treatment

Equipment required for the injection chemicals such as Chlorine and acid shall be incorporated into the infrastructure at the tanks. The tank sites should be capable of being used for the overall management of water quality within the supply system.

Primary filtration of the water will occur at the river with two screen filters (filtering to 200 micron). The manifolds at each of the tank sites will be fitted with pigging points to allow future system maintenance. In addition to this, each site should be fitted with an injection system to allow for the injection of either chlorine or hydrogen peroxide into the supply water.

9.17 Pumping stations

9.17.1 Land issues

All pumps with the exception of the river pumps will be located adjacent to online storage tanks and therefore are subject to the same location and land considerations as the tanks.

9.17.2 Pump selection

Primary River Pumps

The proposed site does not allow for conventional pump station design. Due to the geology of the area and the river gradient, it is essential that the pump station design allows for security in operation while catering for variability in water level and quality.

The primary pumps suggested are heavy duty submersible sewerage pumps. These pumps have a free flow channel impeller design and are made of resistant materials such as cast iron and stainless steel and are capable of delivering 60lps at 50m TDH. These pumps are suggested as they have the capacity to handle poor quality water and have high operating efficiency.

The units have been considered with a double mechanical shaft seal and water tight cable entries to allow for full submersion of the units in the case of a high river.

The pumps are also proposed to be fitted with a water cooling jacket to allow for safe operation under all flow s within the pumps operational range. This feature also minimizes motor noise under general operation.

The motors should be fitted with moisture protection and seal condition monitoring via water in oil sensor.

The pumps should be designed with a smart trim impeller system that allows for onsite adjustment of the impeller and bowl trim settings without pump disassembly. This allows for easy maintenance of system performance and efficiency.

River Lift pumps

The recommended pumps are multistage pumps. 6 stage centrifugal pumps capable of delivering 45lps at 300m TDH have been reviewed. These pumps are operating at an efficiency of 70.6%. Detailed design will finalise the pump selection.

Boost Pumps

The boost pump stations incorporate twin small boost pumps capable of 15lps per pump and a single main boost pump capable of supplying 90lps.

These pumping units should have:

- Carbon graphite vs. Silicon carbide mechanical seal on a renewable sleeve
- Cast iron casings volute and diffusers
- Bronze CC480K-GS Impellers Tempered steel shaft
- Grease lubricated drive end bearing
- Product lubricated suction bearing
- Certified performance testing to ISO 9906 grade 2

9.17.3 Motor selection

The selected motors should be of the highest efficiency possible and have low noise emissions. Locally available spare parts are essential.

9.17.4 Electrical components

As described previously, system control will be via PLC installations at each of the tank and river sites. All electrical equipment will be supplied and installed according to relevant Australian Standards. Protection for installed equipment will be provided by:

- All pumps will be fitted with flow and pressure sensors to protect against loss of prime or no flow
- Level sensors will be installed in
 - Wet sump at the river
 - Tanks 1,2 and 3
- Mainline pressures downstream of pump stations will be monitored and recorded
- Flow totalisation and system water accounting, via tank level monitoring, will be used to confirm system integrity. Any flow discrepancies will initiate remote alarms and system shut down.
- Security at all pump stations will be monitored via the PLC system

9.17.5 Controls and data management

All flow and water level data will be monitored and recorded utilising the PLC units and computers. This data will be available via download and for viewing on the electrical cabinet control screen.

The units will also monitor:

- Pump faults
- Pump station temperature
- Electrical cabinet temperature
- Motor faults
- communication faults

- Pump run times
- Maintenance records
- Power consumed vs. water delivered

9.17.6 Corrosion protection

Corrosion protection of pipe and valve arrangements of the pumping stations by suitable external coating and/or cathodic protection should be investigated and considered in the Detailed Design stage.

9.17.7 Standby power generation

The detail design should ensure that all pump sets within the overall scheme are able to be operated under power generated by standby diesel generators fitted with silent packs in the event that the power supply is damaged and inoperable for extended periods.

Local generator hire companies should be consulted to ensure that appropriate generator units complete with silent packs are available for hire during the commissioning and early operational phases of the project. Specific consideration should be given to the interaction of such systems with variable speed drives and other electrical controls and power conditioning requirements. Connection wiring and isolation switches should be incorporated into the detailed design of electrical systems.

9.17.8 Ancillary items

Due to the high head at the river, PN40 control valves and check valves have been allowed for. Where pressures allow along the pipeline, valves and associated fittings will be of lower pressure ratings. All valves and fittings on the low pressure side of the river lift pump and on the tank side of the booster pumps will be PN16.

All of the low pressure manifolds are proposed to be protected with quick acting pressure relief valves in the case of failure of the check valves on the system allowing “seeping” of pressure back from the high pressure discharge manifold. These pressures will be monitored via the PLC and will alarm if the low pressure within the suction manifolds exceed 10bar.

9.17.9 Noise attenuation

The level of noise emitted from all components and pump sheds must be minimised through innovative design. Landholders have expressed their concern about noise during the early part of the consultation process. Council is committed to mitigating noise pollution and the impact of noise on any Landholders.

9.17.10 Safety in design

The detailed design process should embrace a “safety in design” process described in the graphic displayed in Figure 9-1.

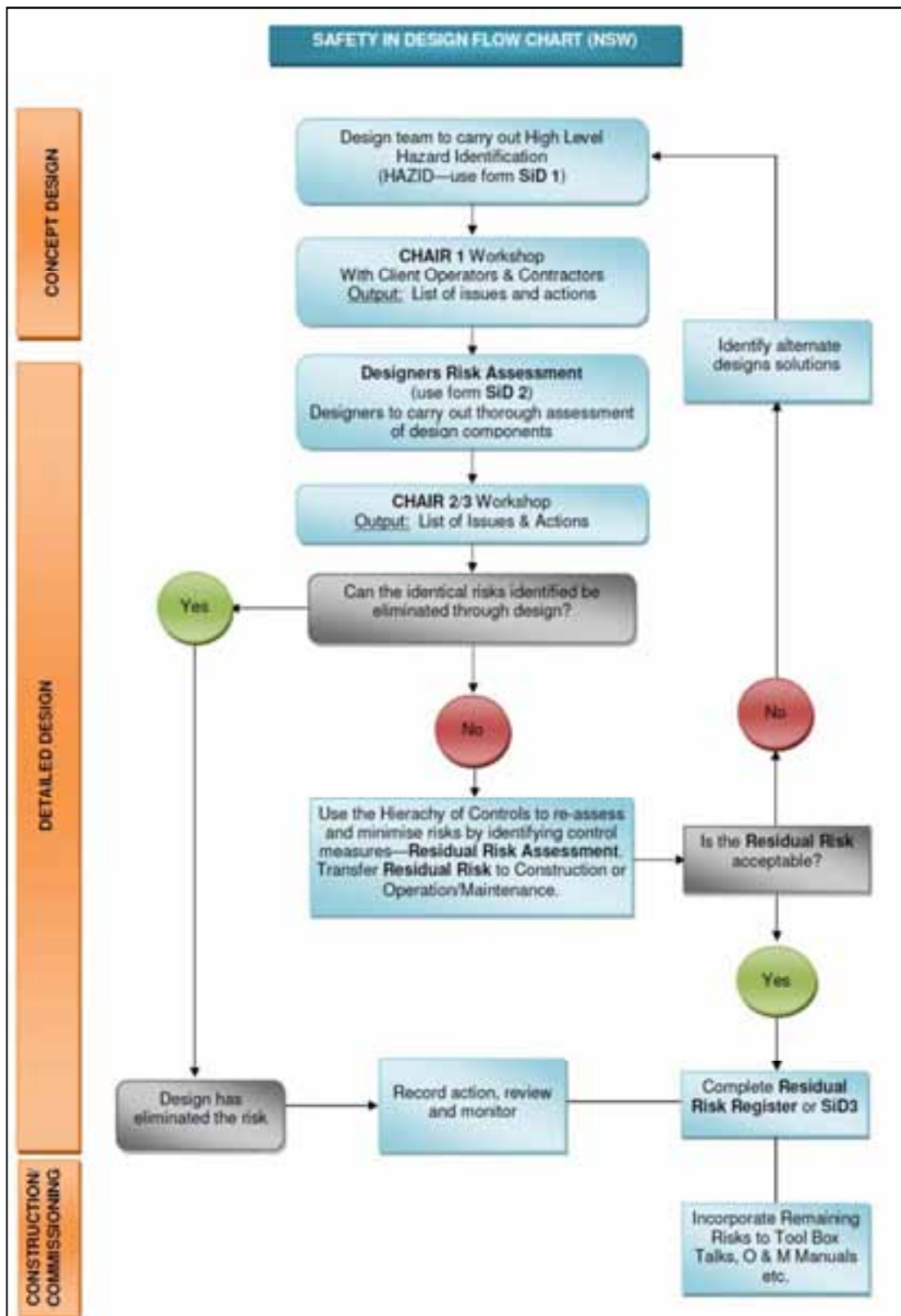


Figure 9-1: Safety in design process

9.17.11 Building design

The detail design should ensure that all pump station buildings comply with local building codes and safety in design standards and consider the following issues.

Architectural features

The design of the pump buildings should be in keeping with the local environment and have little or no visual impact.

Site preparation

Site preparation shall avoid the removal of any native vegetation and have no impact on landholder management practices.

Fire protection

The building shall be designed in such a way as to be unaffected by local bushfires.

Gantry

The building should contain a gantry system to lift and move all heavy components contained within.

Vandalism

The building should be designed to be vandal resistant in its features.

Recreational shooting

Consideration should be given to preventing the impact of recreational shooting.

Revegetation

The project will require revegetation along various sections of the corridor in accordance with permit conditions.

9.17.12 Standards and reference documents

The following list represents the many of the standards and codes that should be adopted during the detailed design phase of the project.

WSA-03	Water Supply Code of Australia
BCA-2010	Building Code of Australia
AS 1281	Cement mortar lining for steel pipes and fittings
AS 1289	Methods for testing soils for engineering purposes
AS 1379	Specification for supply of concrete
AS 1579	Arc welded steel pipes and fittings for water and wastewater
AS 2200	Design charts for water supply and sewerage
AS 2638	Gate valves for waterworks purposes
AS 3600	Concrete structures
AS 3610	Formwork for concrete
AS 3680	Polyethylene sleeving for ductile iron pipelines
AS 3735	Water retaining structures code
AS 3996	Metal access covers, road grates and frames
AS 4087	Metallic flanges for waterworks purposes
AS 4321	Fusion bonded medium density polyethylene coating and lining for pipes and fittings
AS/NZS 1477	PVC pipes and fittings for pressure applications
AS/NZS 1554	Structural steel welding
AS/NZS 2280	Ductile iron pressure pipes and fittings
AS/NZS 2566	Buried flexible pipelines
AS/NZS 2832	Cathodic protection of metals
AS/NZS 3679	Structural steel
AS/NZS 4020	Testing of products for use in contact with drinking water
AS/NZS 4360	Risk management
AS 4536	Life cycle costing – an application guide
AS/NZS 4081	Occupational health and safety management systems – specification with guidance for use
AS/NZS4853	Electrical hazards on metallic pipelines
ISO 9000	Quality management and quality assurance standards
ISO 9001	Quality systems – model for quality assurance in design, development, production, installation and servicing
ISO 9002	Quality systems – model for quality assurance in production, installation and servicing
ISO 14001	Environmental management systems - specification with guidance for use

9.18 River access and construction

9.18.1 Access road

The design of an access road suitable for delivering components of the pump station including a 1000kw transformer, pumps, electrical motors and building materials should be incorporated into the scope of the detail design. The road design should consider variable weather conditions and the prevailing geotechnical constraints. The road design will need to consider the requirements and conditions of the existing landowner.

Fencing as gates or cattle grids should be incorporated into the full design.

9.18.2 Environmental sensitivity

The land adjacent to the Macquarie River is highly sensitive and contains ecosystems that must be preserved. Many of the local landholders enjoy residency in a quiet and secluded location. Where ever possible infrastructure design and construction methodologies should be mindful of this fact. Where ever possible the use of large earthmoving equipment and explosives should be minimised.

9.18.3 River diversion

The required strategy for river diversion during the construction of the River Off-take Pumping Station should be carefully considered in the Detailed Design stage and a suitable detailed design should be undertaken. The river diversion will likely comprise of a protective coffer dam around the construction site and pipes to divert the river flow from the construction site. Since sizes and levels of the diversion structures depend on the duration of construction, these will be determined during the Detailed Design stage based on the construction plan of the project.

9.18.4 Spoil and fill

All unused trench and footing spoil is to be removed from the pipe corridor and stored for reuse by Council's engineering departments.

All fill must be certified to be free of seeds, organic matter and disease. The detailed design must specify the details of fill and the QA process which imported fill material must be subjected to, to ensure that it does not become the source of weeds or disease.

9.19 OH&S and safety in design

Occupational Health and Safety will have the highest priority in all project phases. Stringent risk evaluation and mitigation process will be adopted at all times and the engineering design must adopt a safety in design process that is followed.

9.20 Geotechnical considerations

The preliminary Geotechnical investigation has highlighted the following potential hazards and risks that must be considered in depth during the detail design.

- Potential rock slides or boulder movement
- Erosion and ground instability
- Type and hardness of rock
- Excavation techniques

When reviewing the project budgets during detailed design the cost benefit of having an above ground pipe installation in high strength rock areas must be considered.

9.21 Previous mining activities

The region around this project has a long history of mining, much of which was undertaken before records were kept. There is a chance that a disused mine may exist on the proposed corridor. The detailed geotechnical investigation must determine the location of any disused mine shafts along the corridor.

It has been confirmed with NSW Mine Subsidence Board that there is no Mine Subsidence zones within the area.

9.22 Landowners

All stakeholders and particularly existing landowners must be proactively consulted during all phases of the project and every effort made to accommodate their requirements.

10 Summary and Recommendations

The concept investigation has determined that Corridor 1 is the most appropriate location for a pipeline which will transfer 1800 mega litres per annum at a rate of between 7 and 12 mega litres per day to the City of Orange under certain conditions.

There is still a considerable amount of work to finalise the alignment of the pipeline and document the engineering details of the project.

Stakeholder negotiations have commenced and need to progress in order for the project to continue.

10.1 Report recommendations

- Adopt Corridor 1 as the preferred corridor to undergo Detailed Design
- Complete detailed geological drilling, laboratory testing and analysis to assist in finalising alignment and development of construction methodologies.
- Complete detailed title survey to assist in finalising alignment and design details.
- Continue with detailed Landholder negotiations to assist in finalising pipe alignment within the corridor and procurement of easements and freehold land packets where necessary.
- Adopt an Early Contractor Involvement (ECI) model of procurement to minimise risks and potential costs to the project and ensure that all constructability issues are managed throughout the design process.

10.2 Detailed Design

Key considerations for the detailed design phase are:

- Careful appraisal of the river site and conditions will be required before final design of the river pump station
- Consideration should be given to using multiple smaller pumps at the booster sites to give added system flexibility but this may increase the cost of the system.
- Pipeline design considerations:
 - Potential for surge in different operation scenarios.
 - Location of isolation valves along pipeline to allow for servicing. These valves need to be sluice type to allow for pigging of mainline.
 - The use of lower class pipe in the higher sections of the pipeline.
- Pumping stations design needs to incorporate additional safety features:
 - Protection against over pressurization of suction manifolds.
 - Individual pump vibration sensors.
 - Pump station leak detection – sump with level sensor.
 - Heat sensors within the electrical cabinets.
- When locating purge, surge anticipation and quick acting pressure relief valves consideration needs to be given to:
 - Where and how will discharge water be disposed of
 - The PLC system will need to monitor operation of these valves in case one valve does not shut. Simple flow sensor on downstream side of valve

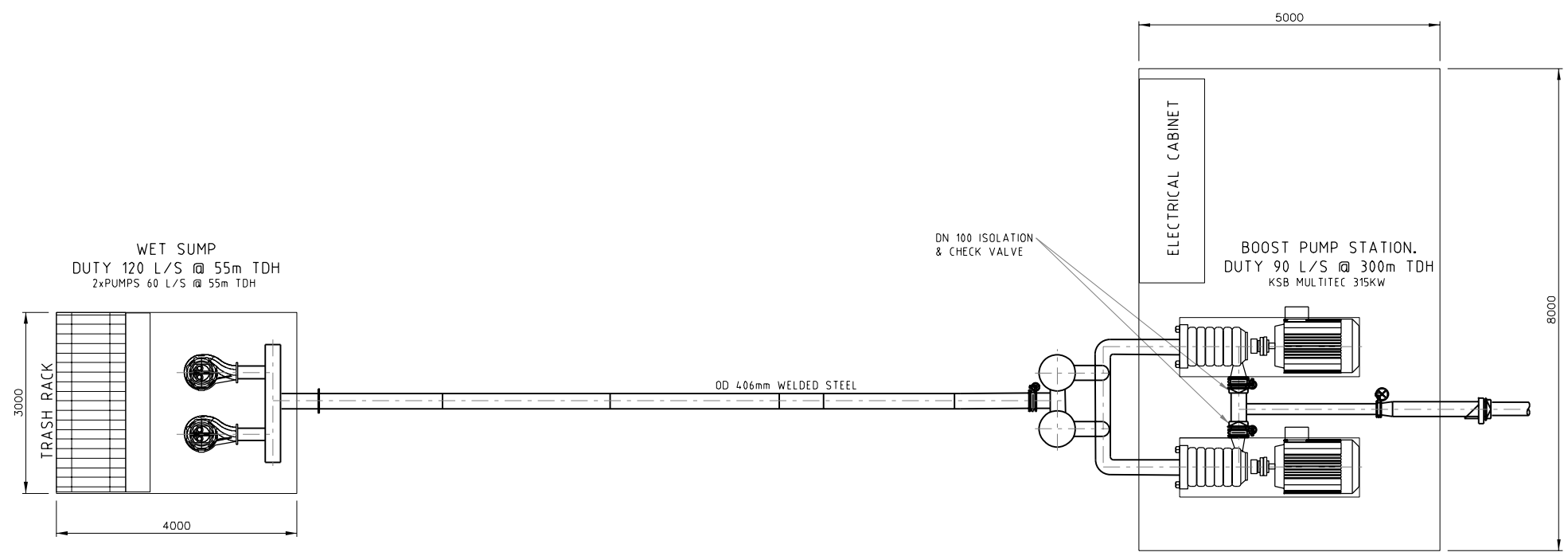
10.3 System maintenance

Key system maintenance considerations that should be incorporated into the detailed design phase are:

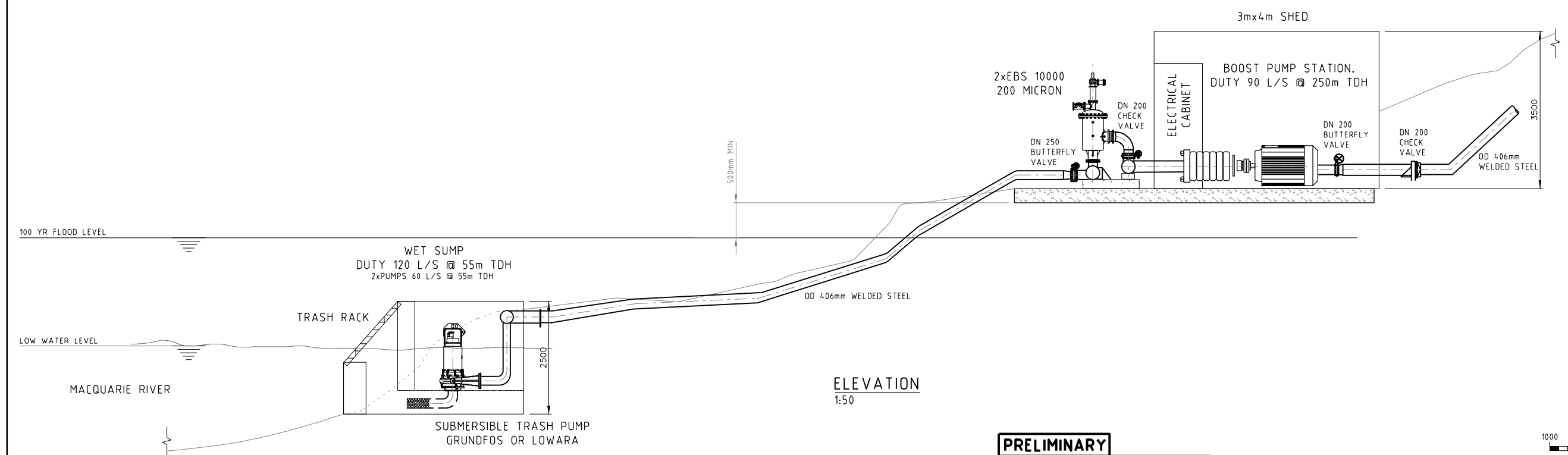
- Mainline maintenance air valves and associated protection equipment like surge valves and quick acting pressure relief valves.
- Mainline pigging program needs to be evaluated including:
 - Pre treat the system prior to pigging e.g. H_2O_2
 - What to do with discharge water from pigging.
 - Re establishing flow after pigging – there is always residual material within the system.

- Pump station servicing and motor greasing – involves testing all protection systems, electrical servicing, tank servicing.

Appendix A Maps and Drawings

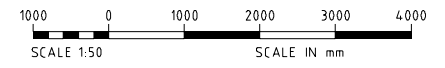


PLAN
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ELEVATION
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PRELIMINARY
NOT FOR CONSTRUCTION



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DESIGN CHECK			
PROJ. MANAGER			

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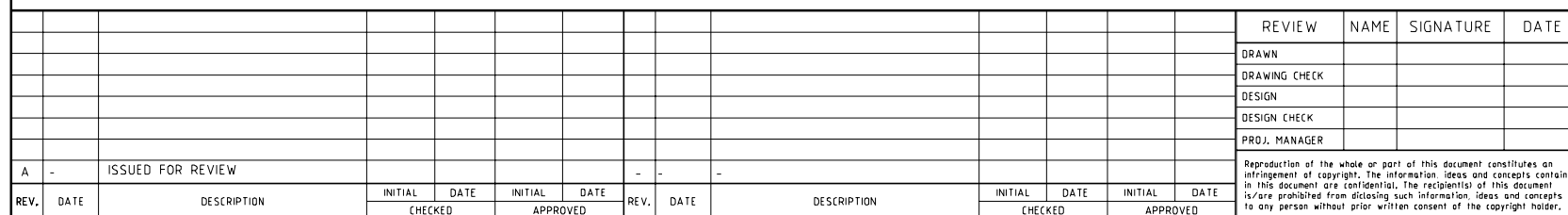
ORANGE
Sustainable Infrastructure

CLIENT :

PROJECT: **ORANGE DROUGHT RELIEF CONNECTION**

TITLE: **RIVER OFF-TAKE PUMPING STATION GENERAL ARRANGEMENT**

SIZE: A1	SCALE:	DRAWING No.: A1267402-00-G001	REV. A
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ORANGE
Auditor's Office

PROJECT:			
ORANGE DROUGHT RELIEF CONNECTION			
TITLE:			
BOOSTER PUMPING STATIONS & TANKS GENERAL ARRANGEMENT			
SIZE:	SCALE:	DRAWING No.:	REV.
A1		A1267402-00-G002	A

Appendix B Concept Investigations and Considerations

B1. Field Assessments

B1.1 Environmental and heritage assessment

B1.1.1 Previous studies

In July 2010, MWH completed an 'Emergency Water Supply Feasibility Assessment' to determine the key environmental constraints and opportunities associated with various options to supply raw water to Orange. The assessment focussed on strategic issues rather than detailed corridors which would have the greatest influence on the selection of a preferred option for the emergency pipeline corridor.

The key environmental issues identified were:

- Threatened communities, populations and species, particularly patches of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland which are present along potential pipeline corridors;
- Clearing of native vegetation particularly on road corridors and reserves administered by Cabonne Council, Department of Lands and DECCW;
- Hydrology and water quality impacts from creek's and water extraction from the Macquarie River;
- Erosion and additional sediment deposition associated with construction of pipelines; and
- Aboriginal and non-Aboriginal heritage.

This report provides a preliminary assessment of the key issues associated with the proposal and outlines broad methodologies for subsequent detailed environmental assessment.

The key environmental issues identified included:

- The presence and proximity of threatened flora and fauna adjacent to and within the proposed pipeline and power corridors;
- Potential changes to the hydrology and aquatic habitat value of the Macquarie River in proximity to and as a result of the proposed new off-take structure and associated water extraction;
- Listed and potentially previously unidentified indigenous and non-indigenous heritage items located within and adjacent to the existing pipeline and power corridors;
- Social impacts associated with the acquisition of land and visual amenity of the pipeline and power structures;
- Disturbance of soil during bulk earthworks and clearing and potential for erosion and sedimentation of adjacent watercourses; and
- The creation of waste products during construction.

B1.1.2 Desktop investigations

State and Commonwealth database searches were undertaken for the project area to identify records or potential occurrences of environmental constraints and/or opportunities which may apply. For the

purposes of heritage and ecology investigations, searches of the following databases were undertaken, and gaps identified to be gathered during the field investigations.

Table B-1 : Desktop searches and gap analysis for heritage and ecological investigations

Issue	Data	Source
Heritage		
Aboriginal heritage	Location of known Aboriginal sites.	Aboriginal Heritage Information Management System (AHIMS) database Local Environmental Plans (LEPs). State Heritage Register.
	Potential Aboriginal sites	Field assessment
	Native Title Claims	Native Title Tribunal website.
Non-Aboriginal heritage	Locally listed heritage sites	LEPs
	State listed heritage sites	State Heritage Register database
	Federally listed heritage sites	Commonwealth Register of the National Estate (RNE)
	World heritage sites	Environment Australia website
Ecology		
Vegetation clearing	Vegetation patches around pipeline corridors.	Department of Lands vegetation mapping (1:50 000 map sheet) Vegetation layer derived from aerial imagery (produced by MWH)
Threatened flora and fauna	Threatened flora, fauna and endangered ecological communities (NSW)	Department of Environment, Conservation, Climate Change and Water – Threatened Species, Populations and Communities of NSW
	Threatened flora, fauna and recorded locations (NSW)	National Parks and Wildlife Service Threatened Species Sites Register
	Threatened flora, fauna and threatened ecological communities (Aust)	EPBC Act Database: Protected Matters Search Tool
	Habitat value for threatened flora and fauna	Field assessment
Conservation significance	Vegetation communities, condition, habitat suitability and conservation significance	Field assessment
Mitigation potential	Width, slope and surrounding topography of pipeline corridors	Field assessment

B1.1.3 Field investigations

A field assessment was undertaken during November of 2010 by two specialists from Ozark Environment, Heritage and Management to identify likely environmental constraints. The field assessment was sufficient to identify likely major issues associated with each of the corridors inspected.

B1.1.4 Assumptions and constraints

The constraints and assumptions that apply to this assessment include:

- There has been no assessment of water quality or hydrological impacts from water extraction from the Macquarie River as this issue is common to all options and therefore does not differentiate between options.
- The assessment is part of the planning stage to determine the preferred option. As a result, the level of detail is less than is required to undertake a formal Part 3A Environmental Assessment (EA) and should not be relied upon for input into an EA without further investigation.
- Environmental issues relating to creek or watercourse crossings, soils, ground subsidence, bushfire risk, property access is discussed elsewhere in this report.

B1.1.5 Assessment criteria

Assessment criteria relevant to this study were developed based on issues typically addressed in EA. The following table outlines the heritage and ecology assessment criteria and how they are measured in this assessment.

Table B-2 : Heritage and Ecology Assessment Criteria

Assessment Criteria	Type	Performance Measures
Heritage		
Aboriginal sites	Qualitative	Potential for Aboriginal sites (known and unknown)
Non-Aboriginal sites	Qualitative	Potential impact to non-Aboriginal sites (known and unknown)
Ecology		
Vegetation clearing	Quantitative	Area of vegetation clearing required
Threatened species	Qualitative	Habitat value for threatened flora and fauna
Conservation significance	Qualitative	Conservation significance of vegetation patches (based on size, vegetation type and condition)
Mitigation potential	Qualitative	Ability to avoid or minimise impacts in design and construction phases e.g. relocation of pipe

B1.1.6 Heritage

Aboriginal Sites

The Study Area is highly likely to have significant importance to the social, economic and ceremonial life of the Wiradjuri people. Throughout the region, sites of Aboriginal heritage significance are associated with major creek lines, foothills and high points of ridge lines. Travel corridors often followed watercourses, it is likely that Summer Hill Creek, Ophir Creek and the Macquarie River were part of a travel corridor from west and north-west to Mount Canobolas.

An Aboriginal Heritage Information Management System (AHIMS) search was undertaken to identify recorded sites within a 15-kilometre radius of the proposed corridors. A total of 162 sites were listed. Of these, the majority (106) were sites associated with artefacts or isolated artefact finds. Of the remainder, seventeen were stone quarries, fifteen were modified (carved or scarred) trees, five were burial sites, three were stone arrangements, two were hearths, two were Aboriginal Ceremony or Dreaming sites, two were earth mounds, one was art (pigment or engraved) and one was a habitation structure.

The number of AHIMS sites potentially affected was assessed by examining AHIMS sites within a 1 km corridor along each of the pipeline corridors. The following sites were located in the vicinity of the corridors:

Table B-3 : AHIMS sites located in the vicinity (1km) of pipeline corridors

Item	Site Type/Name	Description
Corridor 1-MR4		
54	Artefact	Oaky Creek 2
55	Artefact	Oaky Creek 1
158	Artefact	Quartz Site
Corridor 1-MR5a		
54	Artefact	Oaky Creek 2
55	Artefact	Oaky Creek 1
158	Artefact	Quartz Site
Corridor 1-MR5b		
54	Artefact	Oaky Creek 2
55	Artefact	Oaky Creek 1
83	Artefact	-
158	Artefact	Quartz Site
Corridor 2-MR6		
14	Modified tree carved or scarred	Gowan

It is important to note that much of the area around the pipeline corridors is under-represented in surveys for Aboriginal sites. This is a key caveat with measuring AHIMS sites, as their occurrence is highly correlated to areas where significant levels of development has occurred or is planned. As a result a field assessment was undertaken to determine sensitivity or areas with the highest potential for Aboriginal sites.

The results of the field assessment indicate that the offtake point at MR5b has greater likelihood of Aboriginal sites than MR4 or MR5a. During the field investigation a new artifact site (occupation area) was recorded at MR5b on a flat sandy terrace adjacent to the Macquarie River. Any impact to this landform would potentially affect the artifact as the site extends along the river for approximately 150m. MR-4 has greater potential for an Aboriginal site to be recorded than MR5a, owing to the width of the sandy terrace and accessibility to the river.

Areas of very high ecological sensitivity are found along Oaky Lane; around tributaries to Emu Creek and within the Oaky Lane road corridor, where large remnant trees are present. There are nine Aboriginal sites associated with analogous landforms around Oaky Lane indicating high sensitivity. The remaining corridor along Ophir Road, Banjo Patterson Way and Rossi Drive had generally low archaeological sensitivity, increasing to moderate around waterways.

Corridor 2 traverses a series of landforms that have high sensitivity. Occupation sites are likely around creek's and spurs overlooking drainage features. The potential off-take point at MR6 is located at the confluence of the Macquarie and Turon rivers which has the highest potential of all landforms assessed to possess a significant Aboriginal heritage sites. Such areas were often used as occupation or meeting areas and carry special cultural significance.

The results of the desktop and field investigations indicate that Corridor 1 shows the least archaeological sensitivity on the basis of landform and known sites.

Non-Aboriginal sites

OCC has undertaken a heritage search of Orange and Cabonne LEPs, which revealed a large number of heritage items:

Orange LGA:

- 51 local heritage items;
- 23 State listed heritage items; and
- 16 places on the Register of the National Estate.

Cabonne LGA:

- 42 local heritage items;
- 5 State listed heritage items; and
- 17 places on the Register of the National Estate.

As a result, a preliminary desktop investigation of non-Aboriginal sites was undertaken; focusing on the location of known heritage places or items within a 200m envelope either side of the proposed corridor. The results of the assessment are shown below:

Table B-4 : Results of desktop investigation of non-Aboriginal sites

Name	Location	Description	Significance
Narrambla	Corridor 1-MR4 and Ophir Road	Banjo Patterson Memorial Homestead	Not within 200m of pipeline corridor
Suma Park	Ophir Road	Homestead	Not within 200m of pipeline corridor
Rosedale	Ophir Road	Homestead	Not within 200m of pipeline corridor

During the field investigation, observations of potentially significant non-Aboriginal heritage sites were also recorded. The results of this investigation are shown below:

Table B-5: Results of field investigation of non-Aboriginal sites

Name	Location	Description	Significance
Phone exchange	All except Corridor 2-MR6 (Long Point Rd)	Historic phone exchange	Further assessment to contextualize. Can be avoided
Chinamen's Bend	Corridor 1-MR5a	River bank	Further assessment to contextualize. Can be avoided
Fence	Corridor 2-MR6 (Corridor Hog Fire Trail)	Wooden fence	Potential heritage item. Further investigation required. Can be avoided
Chinese Water races	Corridor 2-MR6 (Corridor Hog Fire Trail)	Dry stone wall - former mining infrastructure.	Further investigation required to contextualize. Statement of heritage impact may be required. Avoidance may be difficult

The results of the desktop and field investigations indicate that Corridor 2 has the greatest potential for non-Aboriginal heritage impact due to historic gold mining operations along this corridor. This corridor,

extending up to Ophir was once an important gold mining area during the 1850s. Heritage items along other corridors are less abundant and more easily avoided

B1.1.7 Ecology

Vegetation clearing

A quantitative assessment of remnant vegetation and regrowth has been undertaken. As no vegetation mapping was available for the study area at a detailed enough scale, MWH created a GIS based vegetation map using aerial imagery. This vegetation map was created by drawing polygons around patches of vegetation using the definition of 'woodland' or 'open woodland' (up to one crown width apart) for a 200m wide corridor either side of the four corridors.

Given the exact location of the pipeline alignment has not yet been determined; MWH has adopted a conservative approach to assess vegetation impacts. This approach assumes that any vegetation within a 40m wide area of the corridor centreline may be cleared or impacted to facilitate the construction of the pipeline. In reality, the final pipeline alignments are determined during detailed design would greatly lessen the clearing required. The precise area cleared would largely depend on outcomes of discussions with landowners adjacent to the corridors.

It should be noted that any calculations regarding vegetation or habitat clearing provided in this section do not include any areas for stockpiling or lay down of equipment as it is assumed this would only be done in previously cleared areas.

Threatened Flora and Fauna

MWH has undertaken a flora and fauna search to identify threatened species present or likely to occur in the project study area. The results indicate that the White Box /Yellow Box /Blakely's Red Gum Woodland (Box-Gum Woodland) is present throughout the study area. Box-Gum woodland is listed as an Endangered Ecological Community (EEC) under the Threatened Species Conservation Act (TSC) and a Critically EEC under the Environment Protection and Biodiversity Conservation Act (EPBC).

There are 73 Threatened species classified under various State and Federal Legislation which are known or likely to occur in the study area. A likely occurrence assessment of these species should be performed during EA. Threatened species predicted to occur in the Reserves include:

- Southern Bell Frog *Litoria raniformis*
- Koala *Phascolarctos cinereus*
- Brush-tailed Possum *Phascogale tapoatafa*
- Eastern Pygmy-possum *Cercartetus nanus*
- Spotted-tailed Quoll *Dasyurus maculatus*
- Squirrel Glider *Petaurus norfolcensis*
- Barking Owl *Ninox connivens*
- Freckled Duck *Stictonetta naevosa*
- Powerful Owl *Ninox strenua*
- Pink Robin *Petroica rodinogaster*
- Square-tailed Kite *Lophoictinia isura*
- Painted Honeyeater *Grantiella picta*
- Glossy Black-Cockatoo *Calyptorhynchus lathami*

In terms of habitat for threatened species, the offtake point and beginning sections of Corridor 1-MR5b is likely to provide better habitat than either MR4 or MR5a. In the vicinity of MR5b there are records of regent honeyeater (a listed species under the TSC Act and EPBC Act) and likely koala habitat. During the field assessment a sighting of two brown-treecreepers (also listed under TSC Act) was recorded along Corridor 1-MR5b. The fragmented nature of the vegetation along Corridor 1 means that this pipeline corridor is unlikely to affect any threatened species, populations or communities.

Oaky Lane along Corridor 1 provides significant hollows and habitat for the regions threatened biota. There is strong evidence that there is a resident Koala (listed under the TSC Act) population utilising the road corridor in Oaky Lane and records from the New South Wales National Parks and Wildlife Service (NPWS) Wildlife Atlas show previous records of Spotted-tail Quoll (also listed under TSC and EPBC Acts) both in the Mullion Range Nature Reserve adjacent to Oaky Lane and in the road corridor itself. It was noted that there is high potential for Squirrel Gliders (listed under the TSC Act) to be found in this area.

Given the diversity of vegetation and structural complexity, many of the patches of vegetation along Corridor 2 are likely to have high habitat value for a variety of threatened species. In particular the area around Lower Lewis Ponds has recorded sightings of koala, and likely to provide habitat for squirrel gliders and quolls.

The results of the desktop and field investigations indicate that Corridor 1 is preferred as its habitat value is not as high as along Corridor 2. Corridor 2 contains high value habitat with several large areas of vegetation providing ideal habitat for resource dependent threatened species.

Conservation significance

There was no background data available on the conservation significance of any of the areas of vegetation along the corridors. As a result, the field assessment focused on identifying the presence of endangered ecological communities.

The results indicate that the off-take point around MR4 or MR5a is preferred to that of MR5b. The vegetation around MR4 largely consists of scattered trees, which are not as important from a conservation perspective as larger areas with high connectivity to other patches. The area closest to the Macquarie River (first 500m) crosses through a large consolidated patch of remnant vegetation, with high conservation significance, however, it is easily avoided using the alignment of an existing track.

The area around MR5a largely consists of regrowth of the Box-Gum Woodland which has lesser conservation significance than remnant Box-Gum woodland around MR4 or MR5b. There are areas of vegetation within corridor 1 which is classified as Box-Gum Woodland (which is classified as an Endangered Ecological Community (EEC) under the TSC Act and a Critically Endangered Ecological Community (CEEC) under the EPBC Act.

Along Long Point Road the vegetation has been cleared and is disturbed which reduces its ecological sensitivity, although some isolated stands of Box-Gum woodland and potential grasslands with high conservation value are present.

The vegetation along Oaky Lane is comprised of Box-Gum Woodland (EEC and CEEC) of high quality and structural complexity. This corridor is considered a rare example of the particular Box-Gum Woodland variant in the Cabonne LGA. Its significance is increased due to its proximity to the Mullion Range Nature Reserve and the absence of vegetation in adjacent farmland.

Along Ophir Road there are areas of Box-Gum Woodland (EEC and CEEC) and occasional large remnant tress with hollows. Although the connectivity between the patches of vegetation is poor, the corridor would still provide important resource requirements for winter flowering dependant migratory species. The remaining corridor along Ophir Road, Banjo Patterson Way and Rossi Drive is unlikely to have any major ecological issues.

The off-take point at MR6 is located at the confluence of the Macquarie and Turon rivers. This area is dominated by a regionally important example of Box-gum Woodland with a large patch size (approximately 4 km²), which is extremely rare in central west catchment. In particularly the understorey has high species diversity and contains a variety of herbs and grasses. From the off-take to Root Hog Fire Trail and the beginning of Fremantle Road the vegetation is generally cleared. Along Gowan Road the vegetation resembles a dry sclerophyll forest dominated by stringybarks and scribbly gums, which is of lower conservation significance. Corridor 2 traverses dense areas of vegetation along Gowan Road, with the area around Lower Lewis Ponds being of higher ecological value.

Mitigation potential

Mitigation potential was assessed during the field study to determine which corridor has the greatest flexibility in terms of pipeline corridors to avoid major impacts. Corridor 1 has the most flexibility in terms of being able to move the pipeline to different sides of the road corridor and into private property as appropriate. Oaky Lane is a key area which should be avoided, through landowner consultation. Corridor 2 has very little flexibility to avoid impacts, due to the steep slopes, road cuttings and narrow corridors along much of the corridors.

B1.1.8 Recommendations

A ranking approach has been used to determine the extent to which each of the four off-take options meets the assessment criteria. The ranking system ranges from 1 (low impact), represented by the colour green, to three (high impact), indicated by the red colour. It should be noted that more than one option can be awarded the same ranking should assessment against the assessment criteria be equal or comparative.

Table B-6 : Assessment results for pipeline corridors

Assessment Criteria	Corridor 1			Corridor 2	Justification
	MR4	MR5a	MR5b	MR6	
Aboriginal sites	2	1	3	3	MR5a area shows least archaeological sensitivity based on landform and known sites. There is some potential for at the offtake of MR4. The other two options traverse through archaeologically rich landscapes.
Non-Aboriginal sites	2	2	2	3	Corridor 2 traverses along historic gold mining corridor to Ophir, adjacent to a number of potential heritage sites. By comparison, heritage items on Corridor 1 are less abundant and more easily avoided.
Vegetation clearing	1	2	2	3	MR4 area requires the least vegetation clearing. Corridor 2 has greater potential for vegetation clearing to facilitate the construction. Further investigation required following landowner discussions.
Threatened Species	1	1	2	3	MR4 and MR5a off-take areas are the best as habitat value is not as high as MR5b. Corridor 2 provides the best habitat and critical resources for threatened species and is subsequently the highest value.
Conservation significance	1	1	2	3	Potential off-take areas around MR4 and MR5a are preferred as habitat value and conservation significance not as high as the area around MR5b. All corridors contain State and Commonwealth listed communities.
Mitigation potential	2	2	2	3	Corridor 1 allows the most flexibility to adjust the alignment. Corridor 2 has very little flexibility to avoid impacts, due to terrain constraints.

A range of assessment criteria which relate to ecology and heritage were identified and then each corridor and off-take point was assessed against these criteria, incorporating expert judgement from specialists.

The results of the field and desktop assessment indicate that Corridor 1 is the best option from a heritage and ecology perspective. Within this corridor MR4 is the preferred off-take area as it:

- requires the least amount of potential vegetation clearing
- provides important habitat to support threatened species, albeit less than the area around MR5b and MR6; and
- is largely comprised of scattered trees, which have poor connectivity to other patches and are more common in these landscapes than larger patches.

There is high potential for heritage impacts at the off-take point around MR5b and hence this option should be avoided. Similarly, the potential for ecological and heritage impacts in Corridor 2 is relatively high because of large, patches of high quality vegetation and a number of important heritage areas.

Overall Corridor 1 is considered to provide the lowest impact to ecological and heritage values and the best outcome for the proposed pipeline corridor.

B1.2 Geological inspections

Field geological inspections have been undertaken by Douglas & Partners. The Geological Inspection Report is presented in Appendix C.

Technical considerations

B2.3.1 Flow and pressure

As a result of the multi-criteria analysis, Corridor 1-MR4 option is selected as the preferred corridor. Hence, the Concept Investigations have been carried out for this option as described below.

It should be noted that all sizes, materials, specifications are calculated and proposed based on the available information at this stage and are subject to finalisation in the Detailed Design stage.

Based on the design parameters and assumptions of the Feasibility Study, the pipeline and pumping stations are designed to transfer 7.0 ML of water from Macquarie River to Orange over 22 pumping hours per day. This will result in a design flow of approximately 90 L/s.

There is a possibility to transfer 7.6ML per day with the same infrastructure and 24 pumping hours.

The operational pressures (steady state pump pressures plus an allowance for surge) are kept within the range of pressure rating of the pipes.

The water Supply Code of Australia (WSA 03-2002) has been considered as the technical compliance document for the Concept Development of Orange Drought Relief Connection.

B2.3.2 Pipework materials

In feasibility studies of this pipeline, MWH carried out a Net Present Value (NPV) analysis to determine the optimum pipe material and diameter considering PVC, PE and DICL as the material options. Based on the studies, DN375 PVC pipe was selected as the optimum pipe material and diameter.

Steel Cement Lined (SCL) pipe is also considered in this stage for the sections of the pipeline which need to be constructed above ground due to steep slopes.

The general advantages of plastic pipe material and specifically PVC are listed below:

- Relatively cheaper than metallic (DICL and SCL) pipes
- Corrosion resistant and suitable for conveying soft water
- Easy to cut

- Easier for manhandling of much longer length and larger sizes than thermosetting plastic (GRP) and metallic pipes and fittings
- Rubber Ring Jointed (RRJ) pipes are easily jointed and tolerate some deflection

B2.2.3 Hydraulic considerations

Assessment of the longitudinal ground profile along Corridor 1-MR4 (Figure 3-1) has led to the selection of three pumping station sites along the proposed pipeline at Chainage (CH) 0+000 (river off-take), CH 2+120 and CH 16+400. Each section of pipeline would be hydraulically discontinuous, discharging to a tank at each site prior to being re-pumped consecutively into the next section of the pipeline. In this manner, the large overall change in system elevation over the full length of the pipeline can be reasonably managed in respect of the hydraulic and structural issues relating to the operating pressures within the pipeline.

The final section of the pipeline, from CH 30+450 to CH 36+513 is proposed to be a pressurised gravity main feeding to a downstream tank at Suma Park Dam Pumping Station. This tank is indicatively considered to be a 7.0ML concrete tank to provide a 24hr storage together with the three intermediate 1ML tanks.

An outcome of the Value and Innovations Workshop held during the concept investigation was to consider a second connection point for the transfer main. It is proposed that in the event that there are water quality issues that can be mitigated by having an increased detention time the water should be diverted to the saddle dam on the western edge of Suma Park Dam. This feature of the system should be considered during the detailed design phase of the project.

Friction losses along the transfer main have been calculated using the Darcy-Weisbach Equation to determine the friction loss.

As mentioned above, DN375 PVC pipe was selected as the optimum pipe material and diameter during the feasibility studies and we have employed the same results here in more detail. Selected pipe materials and diameters (as described below) can also be confirmed with WSA 03-2002 suggesting a headloss of less than 3 m/km for pipes larger than DN200 and a velocity in the range of 0.8 m/sec to 1.4 m/sec to achieve an economic design.

In addition, a contingency allowance of 5% has been applied to account for minor losses along the individual reaches of the pipelines. The total dynamic head (TDH) is therefore determined by the summation of the static head for each pipeline reach, the friction loss and the minor losses due to pipe fittings and ancillaries. The duty points for the proposed pumping stations at the design flow rate of 7ML/d, i.e. approximately 90 L/s over 22 h/day pumping are therefore calculated as follows:.

- | | |
|---|-------------------|
| 1) River Off-take Pump Station @ CH 0+000 | 90L/s at 288m TDH |
| 2) Booster Pump Station #1 @ CH 2+120 | 90L/s at 150m TDH |
| 3) Booster Pump Station #2 @ CH 16+400 | 90L/s at 120m TDH |

For the above duty points, allowance has also been made for water hammer pressures resulting from hydraulic transients during pumping operations, e.g. due to sudden loss of power at a pumping station. A preliminary assessment of potential surge pressures resulting from such a condition is estimated in Table B-7.

For the purposes of this report, minimum and maximum anticipated surge pressures have been allowed for in determining the likely class of the pipes required for each pipeline reach between pumping stations. These pressure allowances have been based on the Joukowsky Equation for rapid system shutdown, typically for example, as would happen in the case of a sudden power failure to any of the pumping stations

The surge allowances shown in Table B-7 are based on a flow velocity of 0.82 m/s and a wave celerity of 500m/s for PVC and a pipeline celerity of 1000 m/s for both steel and ductile iron pipeline materials. The surge allowance has been added to the steady state TDH to predict anticipated maximum pressures in the pipeline during operation. A minimum pipeline pressure up to full vacuum (- 10m water head) has also been anticipated for pipeline structural considerations. The surge pressure allowances shown above are subject to a further investigation and determination during the Detailed Design stage.

In Detailed Design, a full surge analysis needs to be undertaken to determine the likely pressures more accurately and the need for surge mitigation measures. This would involve the use of a proprietary surge analysis computer programme to simulate the pressures that would occur in the pipelines during different operation scenarios. Initially, the computer model would be run with appropriate input data relating to the pipeline flow, pipeline material and profile, and the mechanical characteristics of the selected pumps. The output from this analysis would provide the likely maximum and minimum pressures in the pipeline during hydraulic transient scenarios.

These pressures would then be assessed against the safe head for the various pipeline materials and classes available to determine whether or not any surge mitigation is required. For each of the pipelines as proposed herein, the most likely surge mitigation alternatives are the use of air vessels (accumulators), bypass pipe and valve arrangements around the pump stations, check valves in the pipelines or a combination of any of these options. The air valves provided on the pipeline for air management should not be considered as a primary means of surge mitigation due to issues relating to long term reliability, maintenance, vandalism, etc.

Final determination of the magnitude of surge, and any surge mitigation that may be required, is therefore an output from the Detailed Design, however, preliminary recommendations have been made herein for inclusion into initial cost estimates at a concept level.

Table B-7 Maximum operating pressures in different pipeline sections with different pipe materials

Pump Station & Transfer Main Material Selection	Static Head (m)	Total Dynamic Head (TDH) (m)	Maximum Dynamic Head along the pipe (m)	Surge Allowance* (m)	Maximum Operating Pressure including Surge (m)
River Off-take Pumping Station PVC Transfer Main	280	288	288	40	328
River Off-take Pumping Station Steel Transfer Main	280	288	288	84	372
River Off-take Pumping Station Steel Transfer Main	280	288	288	72	360
Pump Station #1 : PVC Transfer Main	122	150	184	40	224
Pump Station #1 : DICT Transfer Main	122	150	184	72	256
Pump Station #2 :PVC Transfer Main	93	120	203	40	243
Pump Station #2 : DICT Transfer Main	93	120	203	72	275
Gravity Main: PVC	-	-	59	40	99
Gravity Main: DICT	-	-	59	72	131

B2.3.4 Structural considerations

Structural considerations relate to essentially the pipe class/wall thickness required to accommodate the anticipated maximum and minimum pressures. For the maximum and minimum operating pressures (including surge), the required pipe pressure class/wall thickness for pipeline materials are detailed in Table B-8.

Table B-8 Specification of pipe material in different sections

Pump Station & Transfer Main Material Selection	Maximum anticipated pressure (m)	Minimum anticipated pressure (m)	Pipe Specifications	Comments
River Off-take Pumping Station PVC Transfer Main	328	-10	PVC not available for max pressure	Max PN class available is PN20
River Off-take Pumping Station Steel Transfer Main	372	-10	OD406 x 6mm SCL with rated pressure of 651m	Wall thickness based on circumferential hoop stress ~ maximum 50% of yield stress
River Off-take Pumping Station DICI Transfer Main	360	-10	DICI not available for max pressure	PN35 minimum required to comply with AS2566 "loads on buried pipes". PN35 OK to a test pressure of 1.25 PN rating = 438m.
Pump Station #1 : PVC Transfer Main	224	-10	DN375 PVC-M PN20	Fatigue derating not applicable to continuous pumping with limited pressure cycles
Pump Station #1 : DICI Transfer Main	256	-10	DN375 PN35	PN35 minimum required to comply with AS2566 "loads on buried pipes". PN35 OK to a test pressure of 1.25 PN rating = 438m.
Pump Station #2 : PVC Transfer Main	243	-10	DN375 PVC-M PN20 for sections with pressures up to 180 m, use DICI DN375 PN 35 for other sections	Fatigue derating not applicable to continuous pumping with limited pressure cycles
Pump Station #2 : DICI Transfer Main	275	-10	DN375 PN35	PN35 required to comply with AS2566 "loads on buried pipes".
Last Section : PVC Gravity Main	99	-10	DN375 uPVC PN12	PN12 minimum required to comply with AS2566 "loads on buried pipes".
Last Section : DICI Gravity Main	131	-10	DN375 DICI PN35	PN35 required to comply with AS2566 "loads on buried pipes".

Structural considerations for different sections of the pipeline are described below.

B2.3.5 Transfer main specifications

River off-take pumping station transfer main

For the river off-take pumping station transfer main (approximate length 2.1 km), the material options are limited to steel since or ductile iron, since PVC is not available in the required pressure rating. Subject to detailed design, it is likely that the most practical and economical alternative would be to construct a steel pipeline aboveground supported on piers.

A preliminary concept design for the river pumping station transfer main includes:

- OD406 x 6mm welded Steel Cement Lined (SCL) pipeline with epoxy painted external coating
- 18m continuous spans over piered supports to rock foundation (6m or 12m lengths of steel pipe string welded together for up to 90m between expansion joints). In Detailed Design, consideration should be given to the pipe manufacturer specifications for maximum spacing between piers to avoid pipe deflection.
- Pipeline would be either fixed or sliding over piered supports (depending on pipe layout and location of expansion joints)
- Expansion joints every 90m (rated to PN40)
- Thrust blocks/anchors at changes in direction, rated up to 400m pressure
- 1ML steel tank at the downstream end
- Pipeline ancillaries including air valves at high points, scour valves at low points, isolation valves (if required at nominated spacings), pigging insertion and retrieval points, flow metering and surge mitigation pipework connections

At this Concept Design stage an air vessel has been allowed for surge mitigation pending surge investigation and analysis work during the Detailed Design stage. The total volume of the air vessel at the river pumping station site is estimated at this stage to be around 5 m³, i.e. approximately 4m high x 1.25m in diameter. The installation will need to be provided with an appropriate piping, valving and compressed air supply. In Detailed Design, other means of surge control may be found to be either more appropriate or more economic.

Pump Station #1 & #2 Transfer Mains

For the remaining two pumping stations, the material options are more varied due to the lower operating pressures on these parts of the overall system. Ductile iron and/or PVC-M are appropriate choices, depending on technical and economic considerations.

The requirement for surge mitigation equipment needs to be confirmed in Detailed Design.

Pump Station #1 Transfer Main

A preliminary concept design for this transfer main includes:

- DN375 PN20 PVC-M RRJ pipeline (approximate length 14.3 km) with some sections of DICL/SCL at creek Bs where applicable
- Buried pipeline in trench, minimum 600mm cover (creek Bs may be aboveground on piers or attached to existing bridges where feasible)
- Thrust blocks at changes in direction, rated up to 230m and 260m pressure for PVC-M and DICL sections, respectively
- 1ML steel tank at the downstream end
- Pipeline ancillaries including air valves at high points, scour valves at low points, isolation valves (if required at nominated spacings), pigging insertion and retrieval points, flowmeter and pipe connections for chlorine dosing.

Pump Station #2 Transfer Main

A preliminary concept design for this transfer main includes:

- DN375 PN20 PVC-M RRJ pipeline for around 11km and DN375 DICL PN35 for around 3km where pipeline pressures at low points are greater than 200m and with some sections of

DICL/SCL at creek Bs where applicable. Alternatively, DN375 PN35 DICL RRJ pipeline may be constructed for the full length of this pipeline reach

- Buried pipeline in trench, minimum 600mm cover (creek Bs may be aboveground on piers or attached to existing bridges where feasible)
- Thrust blocks at changes in direction, rated up to 250m and 280m pressure for PVC-M and DICL sections, respectively
- 1ML steel tank at the downstream end
- Pipeline ancillaries including air valves at high points, scour valves at low points, isolation valves (if required at nominated spacings), pigging insertion and retrieval points, flowmeter.

Gravity main

A preliminary concept design for this transfer main includes:

- DN300 PN12 uPVC RRJ pipeline (approximate length 6 km) with some sections of DICL/SCL at creek Bs where applicable
- Buried pipeline in trench, minimum 600mm cover
- 7ML concrete tank at the downstream end
- Thrust blocks at changes in direction, rated up to 100m and 130m pressure for uPVC and DICL sections, respectively
- Pipeline ancillaries including air valves at high points, scour valves at low points, isolation valves (if required at nominated spacings), pressure sustaining/flow control valve at downstream end of gravity main (inlet to reservoir).

Note that for any future augmentation of the pipeline for higher flowrates, this gravity section of pipeline should be upsized to at least a DN375mm pipe, depending on actual design levels and available head.

Hydraulic Grade Line (HGL) of the proposed concept design is displayed in Figure B-10-1.

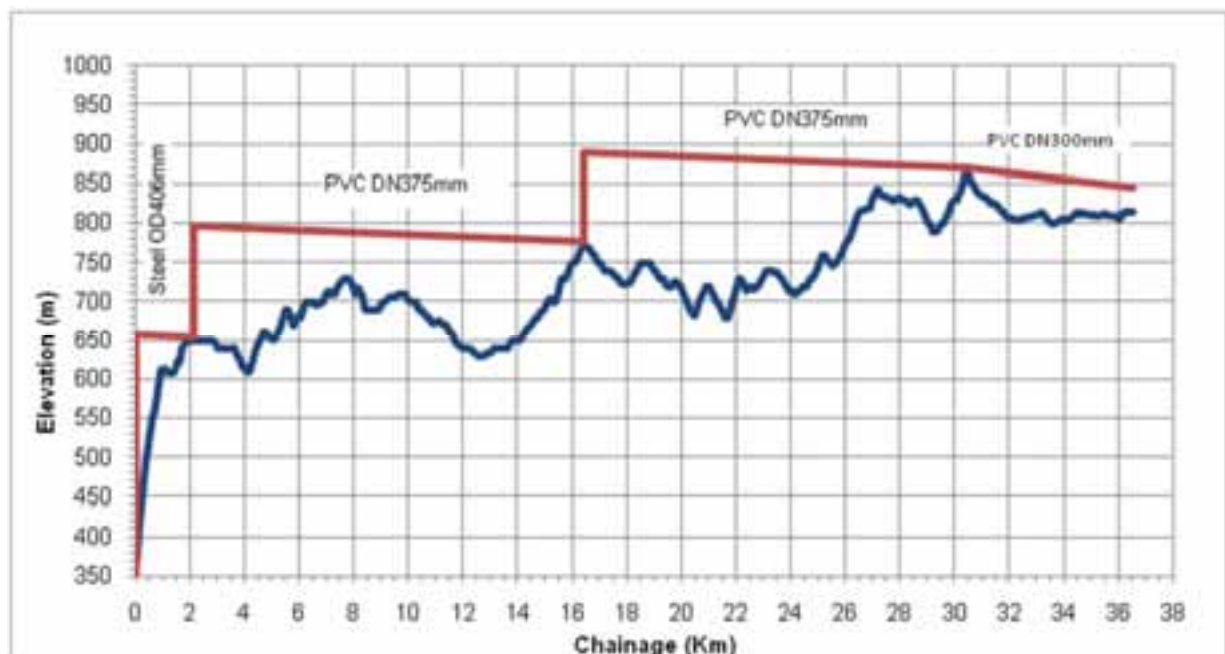


Figure B-10-1: Typical HGL of the proposed concept hydraulics

Temperature effects

The temperature range affecting the infrastructure on this project is approximately -7°C to $+42^{\circ}\text{C}$.

Freezing of water in system components such as the air valves is possible and hence the system can be damaged by these temperatures. Conversely the high temperatures can cause expansion of any above ground pipeline or cause the shutdown of electrical systems.

The detailed design must consider the impacts of a significant temperature range on the system components.

Mini hydro power generation potential

As it can be seen in Figure B-10-1, there is a residual head of around 30m at the downstream end of the gravity main which may be considered as a potential for hydro power generation for carbon offset.

Considering an efficiency of 80% for the hydro power generation equipment, around 21kw of power generation capacity would be available which could result in an annual electricity generation of around 170Mwh.

There is a lot of detail required to ensure that a mini hydro power generation scheme is viable as connection costs and revenue tariffs have not been determined at this stage. The detail design process should present a full BCA of this proposal.

B2.3.6 Pumping Specifications

The design of the system is for a daily demand of 7.0ML based on 22 hours of operation per day (design flow of approximately 88 L/s). The system design for the pump stations has been based on the ability to supply 90 L/s. Once the detailed hydraulic analysis for the pipeline has been completed in the Detailed Design stage, the total developed head required for each pumping station will be reviewed and finalised.

The system has been designed with 4 tanks located along the pipeline corridor. Tanks 1 and 2 will have an associated booster pumping station while Tank 3 will be set up to allow gravity feed into the gravity section of the pipeline. The tanks have been considered to provide a hydraulic break with the pipeline open discharging to the tank and with water being extracted from the tank, either via booster pump or via gravity, to feed the downstream system.

River off-take pumping station

Due to the site constraints, it is proposed to install a staged pump station at the river off-take.

A set of medium head lift pumps will be installed in a pre-fabricated "wet well". It is proposed that these pumps be heavy duty submersible pumps designed to handle poor water quality. The pumps will each be fitted with a cooling jacket to enable efficient cooling of the motor and also to minimize any motor noise. These pumps will have a 100mm internal free passage and are made of resistant material such as cast iron and stainless steel. Similar units have been used extensively in wastewater and sewerage systems in a wide range of municipal and private industrial applications.

The maximum pressure from such pumps is approximately 66m, within the limit for the casing for the booster pumps (nominally 160m).

Screen filtration prior to the lift pumps is recommended (200micron screen). The free passage size for the booster pump impellers is approximately 22 mm. The filters will operate on a pressure differential across the screen and when required will backflush automatically.

There will be two main booster pumps proposed in the design each delivering 45 L/s with a total dynamic head capability of 300m. The units are proposed multistage centrifugal pumps. Each unit would be coupled directly to a high efficiency 315kw 4 pole (1450rpm) motor which will be fitted with a low noise fan.

The maximum operating pressure of the pumps will be approximately 40bar and the power absorbed for the duty point of 45 L/s at around 300m TDH will be approximately 190 kW.

Each of the booster pumps will be controlled via individual Variable Frequency Drives (VFD) while the submersibles at the river will operate via Soft Starter control allowing ramping of the units on start and stop.

The pump start signal for the system will be based on the level input at Tank1 and the system demand from the Tank 3 flow meter.

The PLC system will analyse all system flows to predict if there are imbalances between inflows and outflows to any of the tanks so as to determine potential for pipeline surcharge.

The booster pumps will be located above the 100yr flood level of Macquarie River (subject to finalisation in Detailed Design) plus a freeboard of at least 500mm to prevent inundation during flooding.

A typical general arrangement of the river off-take pumping station is presented in Appendix A.

The development of a sustainable alternative energy supply such as a mini hydro system or a solar array will provide offsets to the cost of power and the carbon footprint for the project. The control system for either of these two alternative energy supplies would be independent of the operation of the pumping systems. Any alternative power generation system would export power to the grid and not directly to any of the pumping infrastructure within the project.

Booster pump stations

Additional booster pumping stations will be located at Tanks 1 and 2. These booster stations will be similar in design with two smaller stet multistage pumps each capable of delivering 15 L/s and one large multistage centrifugal pump capable of delivering 90 L/s. The TDH will vary at each pump station depending on the flow requirement.

The maximum operating pressure of the pumps is 40bar and the power absorbed for the duty point of 90 L/s at 200m TDH is approximately 211 kW. The free passage size for the large impellers is 28.5 mm.

The larger multistage pump will be controlled via an individual soft starter. The smaller pumps will be controlled via individual VFDs to allow regulated flow based on system demand.

The flow from Tank 3 flow meter will be used to initiate operation of the system and set flowrate requirements at each of the River off-take, Tank 1 and Tank 2 sites.

Tanks

There are three tanks proposed for the system each has the capacity of holding 1ML. Assuming that 15% of the storage would be dead storage there would be 2.5ML of useable Tank storage along the pipeline. Based on the full system flow of 90 L/s, there would be a 2.6 hour buffer within the tank system to feed the system and allow for staging of the individual river and booster pump stations.

This system buffer means that individual pump station operation can be slowed down allowing for a seamless station start up and shut down reducing surges within the system.

The Tanks will always be maintained at the full level.

A typical general arrangement of the booster pumping stations and tanks is presented in Appendix A.

The tanks proposed are steel tanks. These tanks are designed in accordance with all relevant Australian Standards and the Building Code of Australia. The tanks include a heavy duty corrugated tank roof with HDG Roof Trusses. The tanks will be lined with a reinforced Food Grade Metallocene coated liner. These liners are to be UV stabilized.

Each of the tanks requires the construction of a concrete ring beam footing. Specification of this footing can be completed once soil tests are carried out on the selected sites.

The final material composition of the tanks needs to be decided in the detailed design phase and it is quite important that the potential impact of recreational shooting on the tank design be considered.

B2.3.7 Mechanical and electrical Implications

Due to the nature of the river site, it is important that the system is protected from flood inundation and also has the ability to handle varying water quality conditions. The filter design has sufficient capacity to handle up to 200 L/s giving the system greater security if water quality deteriorates. The filtration provides protection for the high lift pumps and prevents material from being pumped into the pipeline system, which can cause operational problems in the future.

Based on the draft system specifications, the electrical requirements have been calculated and shown in Table B-9: Power requirements. The design of each of the pump control systems will again be dependent on the detailed hydraulic analysis of the system but with the ability to slowly stage pump operation, due to the security given by the storage Tanks within the system, complicated system controls and interlinks can be avoided.

The largest single power requirement is at the river station. Consideration to the Power authority's requirement in relation to the allowable amount of Total Harmonic Distortion Variation (THDV) needs to be established to allow final design of the electrical system. Information required will be:

- Allowable THD as a percentage
- Point of Common Coupling (PCC).
- Short Circuit Power at the PCC
- The supply transformer Impedance
- Degree of existing background harmonics

Table B-9: Power requirements

Power consumption	No Of units	kW	Consumed kW	Total kW	Total Consumed kW	Minimum KVA requirement	Transformer KVA
River Off-take Pumping Station Lift	2	73	55	146	110		
River Off-take Pumping Station Boost	2	315	187	630	374		
Filtration	2	2	1	4	2		
Total river pumping station system				780	486	867	1000
Booster Pumping Station and Tank 1	1	315	211	315	211	450	500
	2	45	35	90	70		
	Total			405	281		
Booster Pumping Station and Tank 2	1	315	211	315	211	450	500
	2	45	35	90	70		
	Total			405	281		
Tank 3							50

B2.3.8 Interconnection to existing infrastructure

Suma Park Dam infrastructure

The pipeline will terminate at a reservoir located next to the Suma Park Dam pump station. The size of this reservoir shall be at least 6 megalitres in order to provide for flexibility of supply of water and pump run times along the pipeline. The exact location of the reservoir, the pipe and valve arrangements and the operating rules shall be determined during the detailed design phase.

Water quality issues have been highlighted in the risk evaluation workshops conducted during the concept investigation phase. It is possible that increased detention times may be necessary depending on the quality of water pumped from the Macquarie River. It is recommended that the transfer main also have a cross connection to a pipeline which terminates at the saddle dam located on the western side of Suma Park Dam. This will provide an option to pump directly to the dam in the event that the water treatment plant is not on line and prevailing circumstances dictate that water be transferred from the river to Orange or there is a need to hold and mix the transferred water within the larger dam reservoir.

Connection to a Managed Aquifer Recharge project

At the time of completing this report Council was conducting a feasibility study into the viability of a Managed Aquifer Recharge (MAR) project as part of its integrated water strategy to create a secure water supply for the future of the City. In the event that the feasibility study determines that an MAR project is viable it is recommended that the ability to supply water to that project from the Macquarie River via this pipeline is fully investigated.

Appendix C Geological Inspection Report

Report on
Geological Inspection
Orange Drought Relief Connection
Orange, NSW

Prepared for
MWH Australia Pty Ltd

Project 72151.00
November 2010

Integrated Practical Solutions



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Report on Geological Inspection of Orange Drought Relief Connection Corridors Orange, NSW

1. Introduction

This report presents the results of a geological inspection and associated desk study by Douglas Partners Pty Ltd (DP) of the two investigated pipeline corridors from the Macquarie River to the City of Orange, NSW (refer to Section 3 of the main report for more information on the investigated corridors). The proposed Orange Drought Relief Connection will include the construction of an approximately 40 km long, 375 mm pipeline, with associated new pumping stations, from the Macquarie River to the existing Suma Park Dam Pumping Station with a provision for connection to Suma Park Dam reservoir. The work was commissioned by MWH Australia Pty Ltd (MWH) and was undertaken in liaison with Orange City Council (OCC) and in accordance with DP's proposal dated 12 November 2010.

Information supplied by MWH and OCC indicates that the Orange Drought Relief Connection will comprise one of two investigated corridors with proposed river off-take points of MR4, MR5a, MR5b and MR6. The eastern corridor (Corridor 2), from the confluence of the Macquarie and Turon River, is common with Corridor 1 only over a short section adjacent to the Suma Park Dam Pumping Station.

The aim of this study is to provide a preliminary assessment of regional and engineering geology, with particular emphasis on:

- rock types and strengths and the probability of intersection of the rock profile by pipeline trenches up to 3 m in depth;
- soil characteristics including susceptibility to erosion;
- influence of previous mining; and
- potential constructability issues.

2. Site Description

The project area lies within the Central Tablelands area of NSW where plateaux areas crest at approximately RL 900 relative to Australian Height Datum (AHD). The plateaux have been entrenched by the meandering, northwesterly-trending course of the Macquarie River and its associated northward-trending drainage systems, particularly those of Summer Hill Creek, Oaky Creek, Lewis Pond Creek, Emu Swamp Creek and Coolumbala Creek. Site levels at the proposed Macquarie River pumping station sites range between approximately RL 400 and RL 450.

It is anticipated that the corridor selected for construction will lie mostly within existing road easements and will deviate into adjacent property where surface conditions (e.g. vegetation, excessive slopes) or access from roads to the Macquarie River is required. The roads along the investigated corridors are

mostly unsealed with the exception of the southern sections of Ophir Road and Lewis Creek Road. Properties adjacent to the roads are mostly used for grazing purposes or are part of public reserves.

Details of topography, drainage systems and land use are included in Maps 1 – 9 (Drawings 2 -10 in Appendix A) which include extracts of 1:25 000 topographic mapping sheets.

The project area lies within Climatic Zone 10A described by Edwards (in Soil Landscapes of the Bathurst 1:250 000 Sheet). The warm temperate climate of the Orange area has an average rainfall of approximately 810 mm; rainfall is at a maximum between June and August (monthly average of approximately 70 mm to 80 mm) and February and March are the driest (monthly average of approximately 40 mm).

3. Regional Geology and Soils

The study area lies within the Hill End Trough Geological Zone of the Central and Southern Highlands Fold Belt of NSW. The fold belt is characterised by north-trending bands of folded and faulted, metamorphosed strata of Ordovician, Silurian and Devonian ages which have been locally intruded by granitic rocks of Carboniferous age. These rocks are locally mantled by basalt and gravel deposits of Tertiary age and by recent alluvium along the creek and gully lines.

The distribution of lithological units (after the Orange 1:100 000 Geological Series Sheet), within an approximately 2 km wide corridor centred on the investigated corridors, are shown on Maps 1 – 9. A summary of lithologies and lithological unit identifiers of the various units shown in Maps 1 – 9 are given in Table 1 (refer following page).

The Soils Landscapes of the Bathurst 1:250 000 Sheet indicates that the bedrock geology is the major factor controlling the distribution of soils within the mapped area. The Silurian and Devonian rocks of the Hill End Trough are characterised by the development of yellow solodic soils, red podzolic soils and shallow soils which are grouped into the Mookerawa (mk), Mullion Creek (mu) and Burrendong (bd) Soil Landscapes. The Ordovician rocks within or adjacent to the proposed pipeline corridors are included within the North Orange (no) Soil Landscape. The soils developed on the Tertiary basalts overlying the older rocks are grouped in the Panorama (pa) Soil Landscape.

Two soil groups, the Macquarie (mq) Soil Landscape and the Lachlan (lh) Soil Landscape, are also locally developed on alluvium associated with Summer Hill Creek and Emu Swamp Creek. It is noted that additional alluvial deposits have also been observed along streams during the current study.

Table 1: Summary of lithological units

Lithological Unit	Unit Identifier	Lithologies
-	Qa *	Gravel, sand, silt, clay
-	Tg	Gravel
-	Tb *	Pyroxene olivine plagioclase basalt, alkali basalt, trachybasalt, trachyandesite
Bruinbun Granite	Crga	Biotite granite
Turondale and Waterbeach Formations (undifferentiated)	Dc *	Feldspathic volcanoclastics, greywacke, slate
Bay Formation	Dcb *	Feldspathic sandstone, siltstone
Cookman Formation	Dcc *	Quartz sandstone, minor siltstone, shale, silicified tuff
Merrions Formation	Dcm *	Massive quartzo-feldspathic sandstone, lithic sandstone, rhyodacite, conglomerate, siltstone
Cunningham Formation	Dn *	Slate, laminated siltstone, lithic sandstone
	Dns *	Muddy lithic sandstone, polymictic conglomerate
Anson Formation	Sma *	Carbonaceous pyritic siltstone, felsic volcanics, volcanic sandstone, limestone
	Smac *	Conglomerate, sandstone, siltstone
	Smal *	Calcareous siltstone, massive limestone
Barnby Hills Shale	Smb *	Feldspathic, micaceous and carbonaceous siltstone and shale, fine grained sandstone
Mullions Range Volcanics	Smu *	Rhyolite, tuffaceous mudstone, rhyolite breccia, volcanic conglomerate, dacite, limestone
Chesleigh Formation	Ss	Lithic sandstone, slate, tuff, mudstone
	Ssv	Dark grey, thinly interbedded crystal and vitric tuff, fine grained tuffaceous sediments
Oakdale Formation	Oco *	Mafic volcanic sandstone, basalt, siltstone, black shale, chert, breccia, conglomerate
-	Om	Monzonite, monzogabbro, quartz monzonite
-	Ou *	Ultramafic cumulates and lava

* Intersected by proposed pipeline corridors

The distributions of the mapped soil landscapes are shown in relation to the investigated pipeline corridors on Figure 1.

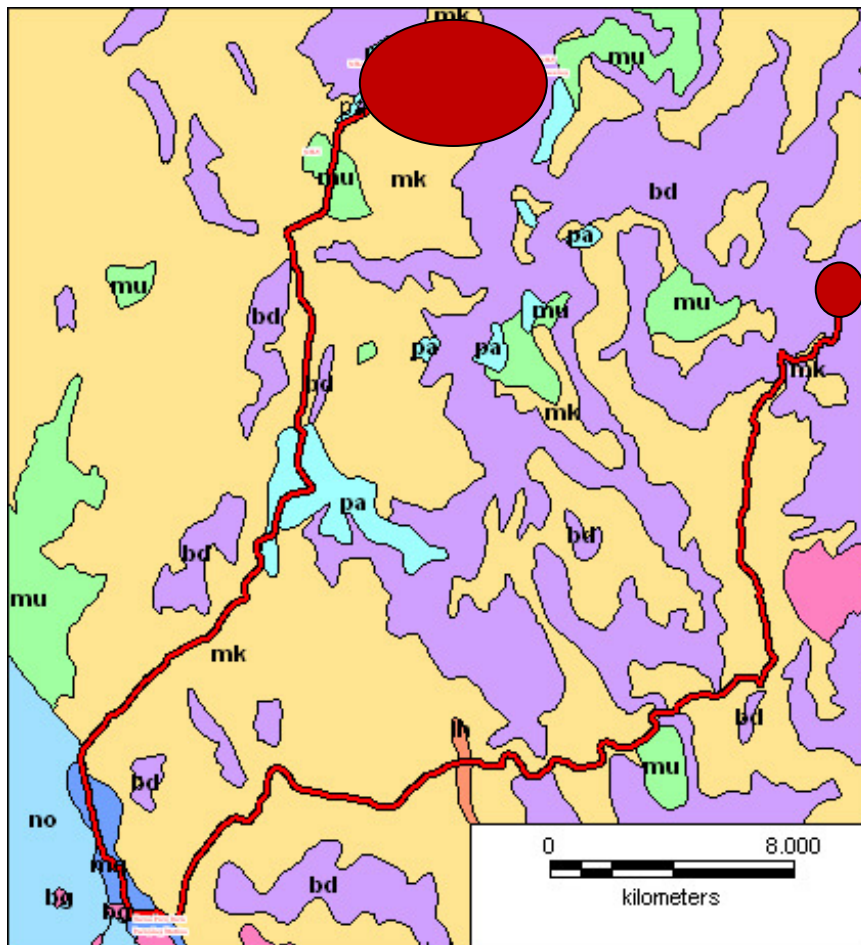


Figure 1: Distribution of mapped soil landscapes

4. Previous Mining Activity

The rocks of the Hill End Trough and alluvium derived from these include locally developed mineral deposits. Mining activity in the study area dates from the mid 1800s with underground mining of gold, silver copper, zinc and lead being carried out. Alluvial workings for gold have also been carried out within the bed of the Macquarie River and Turon River.

The locations (shown ▲) of previous mining activities recorded on the data base provided by MWH are shown in Figure 2 (following page); an extract of the Bathurst 1:250 000 Metallogenic Map which also shows previous mining locations. The closest previous mining to a corridor (Corridor 2) is the Dead Horse Gully Mine (mine reference No. 42, Figure 2) where the 1:25 000 topographic mapping sheets (refer Map 6, Drawing 7) indicates an “abandoned mine shaft”.

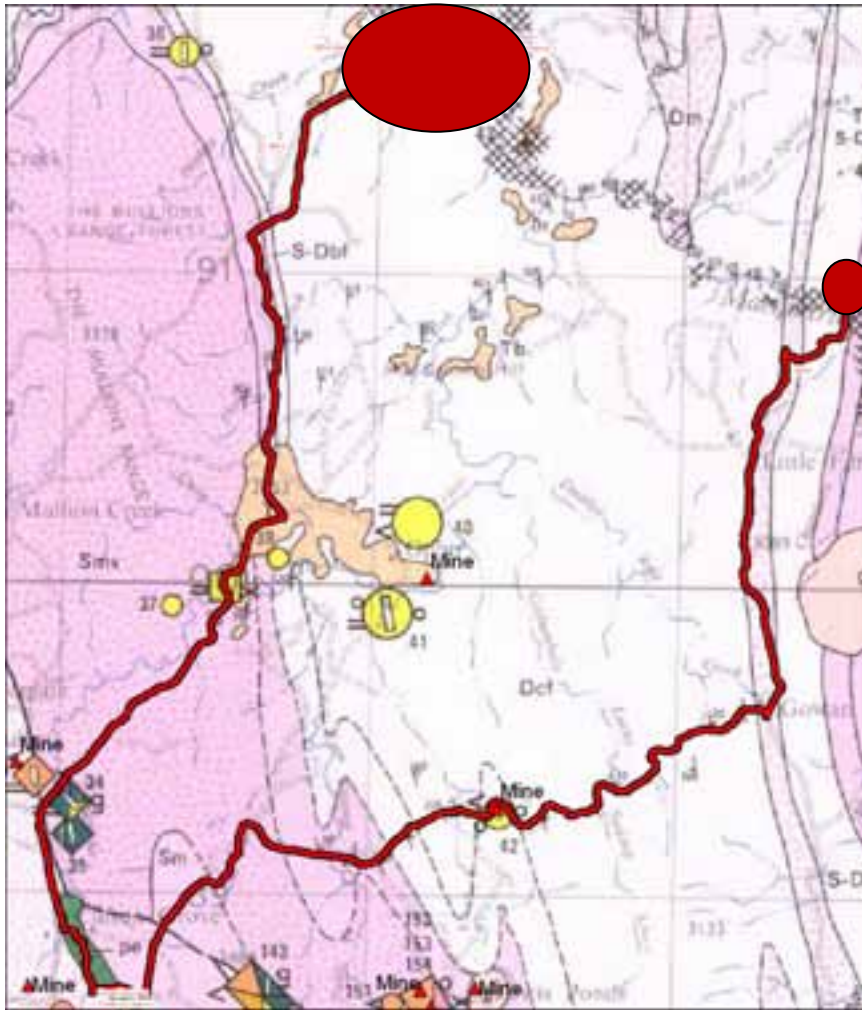


Figure 2: Mine locations (extract from Bathurst 1:250 000 Metallogenic Map)

The 1:25 000 topographic mapping sheets also indicate the presence of “numerous abandoned mines” in the vicinity of Summer Hill Creek 4th Crossing (refer Maps 2 and 3, Drawings 3 and 4). These correspond to mine reference No. 38 of Figure 2. Additional “old gold digging” are also shown along Lewis Ponds Creek adjacent to MR-6 (refer Map 6, Drawing 7).

5. Field Work

The field work comprised inspection of the corridors by a Principal Engineering Geologist during November 2010. The locations of items of note were determined by either reference to features shown on 1:25 000 topographic mapping sheets or by measurement to MGA Zone 55 co-ordinates by a hand held GPS receiver.

The main items of note are described on Maps 1 – 9 and selected items are additionally shown in Photos 1 – 20 (refer Plates 1 – 6 in Appendix A). Notes describing classification methods and descriptive terms are also included in Appendix A.

5.1 Corridor 1, section around MR4 river off-take towards Long Point Road

The geological conditions of this section (Figure 3) are described below.

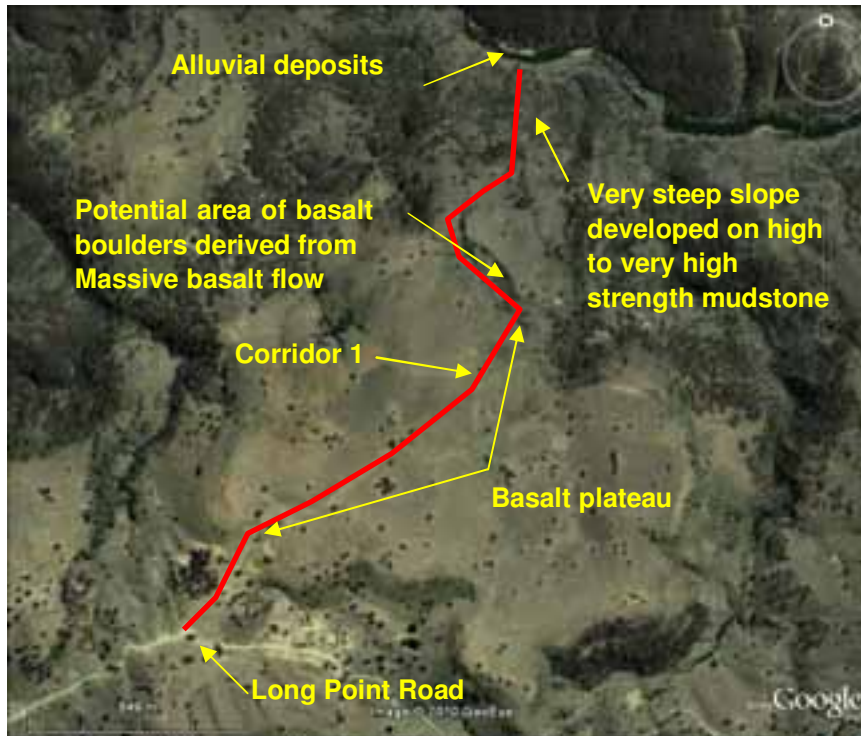


Figure 3: Inferred conditions of Corridor 1 around MR4 river off-take towards Long Point Road

It is inferred that the main geological features significant to pipeline installation in this area are:

- Potential for instability of basalt boulders from cliff lines formed about the perimeter of the basalt capped plateau.
- Probable shallow depth to High or Very high strength basalt on the plateau and in foliated mudstone, but with some interbedded sandstone, underlying steep ($18^{\circ} - 27^{\circ}$) to very steep ($27^{\circ} - 45^{\circ}$) slopes below the base of the basalt at approximately RL 600.
- Sand and gravel deposits within the base and banks of the Macquarie River.

5.2 Corridor 1, section from around MR5a river off-take towards Long Point Road

The area of Corridor 1 from around MR5a river off-take towards Long Point Road (refer Map 5, Drawing 6) is characterised by:

- Predominantly underlain at shallow depth (< 1 m) by foliated mudstone with some interbedded sandstone.
- Numerous Medium or greater strength outcrops, particularly in steep or very steep hillside sections.

- Shallow (0.5 m to 1.5 m) road cuttings exposing Extremely Low to Very Low strength mudstone with included high strength bands between areas of outcrop.
- Shallow, narrow bands of alluvium infilling the base of several minor gullies.
- A High strength rock bar within the stream bed controlling ponding within the river section (refer Photos 1 and 2, Plate 1) and apparently extending upslope (approximately 8 m above current water levels) below river alluvium (refer Photo 3, Plate 1).

5.3 Corridor 1, section from around MR5b river off-take towards Long Point Road

The conditions of this area are as described below:

- A current bed load comprising sand and gravel and high level alluvium, also including gravel bands, extending approximately 15 m to 20 m above the current water level.
- Open jointing and some fragmentation of High to Very High strength foliated mudstone at the downstream of the two possible off-take sites (refer Photo 5).
- A relatively moderate grade along the existing access track (refer Photo 6, Plate 3) which intersects, open jointed, Medium to High strength mudstone outcrops.
- Cut to fill sections of Long Point Road crossing steep side slopes (refer Photo 7, Plate 2) with spalling of 3 m high cut faces and poorly placed filling on the downslope side.
- Cleared surface conditions (refer Photo 8, Plate 2) along Long Point Road

5.4 Corridor 1, section from Long Point Road to Suma Park Dam Pumping Station

This section (refer Maps 1 – 5, Drawings 2 – 6) is characterised by:

- Road cuts, ranging from approximately 0.5 m to 8 m deep, exposing profiles with soil profiles ranging from less than 0.3 m to approximately 1.5 m deep underlain by mostly foliated mudstone, siltstones and sandstone. The cuttings include many Medium or greater strength rock bands with variously tight to open jointing.
- Basaltic profiles with rounded corestones of Medium or greater strength within extremely to highly weathered matrix (refer Photo 9, Plate 3) in cuttings of Lookout Road near the intersection with Ophir Road and also in cuttings of Ophir Road (refer Maps 2 and 3, Drawings 3 and 4). A southeasterly extension of a mapped basalt-capped ridge extends to Ophir Road (refer Map 2, Drawing 3) and is also characterised by corestones (tors) to approximately 0.2 m diameter.
- High to Very High strength rock bars within the beds and banks of Summer Hill Creek 3rd and 4th Crossings (refer Photos 10 – 12, Plate 4).
- Alluvium infilling the bases of many gullies and creeks. The section of Lookout Road extending approximately 1 km to 6 km south of its intersection with Long Point Road is crossed by many gullies of Oaky Creek where the alluvium is subject to water logging or erosion by flood events. Recent alluvium also mantles much of the Oakdale Formation for approximately 2 km north of the Lewis Ponds Creek intersection.
- An alluvial flood plain about Summer Hill Creek (refer Photo 13, Plate 4).

- A probable cover of older, high level alluvium or colluvial soils overlying the gently sloping footslopes within the Clifton Grove subdivisional area.
- Colluvial soils including joint blocks derived from the steep hill located immediately west of the pumping station.

5.5 Corridor 2

This section (refer Maps 1, 6 - 9, Drawings 2, 7 - 10) is characterised by:

- An alluvial flood plain about Summer Hill Creek.
- A probable cover of older, high level alluvium or colluvial soils overlying the gently sloping footslopes within the Clifton Grove subdivisional area and extending approximately 2 km east of Ophir Road.
- Many alluvium infilled gullies and creek beds and extending over continuous corridor lengths of up to 1100 m. Gully erosion of the alluvium is present to depths in excess of 2 m in some locations.
- Alluvium forming a flood plain along the banks of the Macquarie River at and south of the intersection with the Turon River (refer Photo 14, Plate 5).
- Very steep hillslopes, about the course of the entrenched Macquarie River (refer Photo 14, Plate 5), with rock outcrops and joint blocks which may evidence previous slope instability.
- Road cuts of Lewis Ponds Road, Gowan Road and Root Hog Fire Trail, mostly ranging from approximately 0.5 m to 3 m deep, exposing profiles with soil profiles ranging from less than 0.5 m deep underlain by mostly foliated mudstone, siltstones and sandstone, conglomeratic in part. The cuttings and adjacent outcrops include many Medium or greater strength rock bands with variously tight to open jointing (refer Photos 15 – 17, Plates 5 and 6). A previously unmapped granite exposure (refer Photo 20, Plate 6) is also noted in a cutting of the Lewis Ponds Road adjacent to the intersection with White Hill Lane.
- The steep hillside (refer Photo 16, Plate 5), crossed by the Root Hog Fire Trail approximately 1 km to 2 km west of the Macquarie River, includes massive outcrops, tors or boulders, many of which appear to have been transported as the result of previous slope instability.
- The stream bed of Emu Swamp Creek includes rock bars both downstream and upstream of the Lewis Creek Road bridge (refer Photos 18 and 19, Plate 6).

6. Proposed Development

The concept design for the proposed Orange Drought Relief Connection includes an approximately 40 km long, 375 mm diameter pipeline, with associated new pumping stations, from the Macquarie River to the existing Suma Park Dam Pumping Station with provision to connect to Suma park Dam reservoir. Upgrading of existing roads or tracks or the construction of new roads will be required for the installation and operation of the new structures.

It is understood that OCC may have a preference for a ductile pipeline and that the depth of burial will probably range from 1 m to 3 m. Some above ground, suspended sections may be required in the initial run of rising main from the main pumping station at the river bank.

The selection of the final corridor from the currently investigated corridors (including river off-take options) will be informed by this and other engineering and environmental studies.

7. Comments

7.1 Slope Instability

Previous slope instability is noted in several natural slopes adjacent to or at the investigated pipeline corridors. Steep slopes, at the periphery of a basalt covered plateau crossed by Corridor 1 at MR4 river off-take, include scattered fallen joint blocks to in excess of 3 m greatest dimension. The eastern rising section of Corridor 2, which crosses steep to very steep slopes, is also characterised by rocky terrain including large tors and/or boulders resting on the slope. Construction of access roads or pipeline trench excavation across these areas will need to ensure that fallen blocks or open jointed exposures from which the blocks have been derived are not inadvertently disturbed as there is potential for additional slope instability.

Existing road cuttings, particularly in foliated rocks, are subject to on-going fretting and (at least) small wedge failures (e.g. in the cuttings of Long Point Road, refer Photo 7, Plate 3) controlled by foliation, jointing and often steeply inclined bedding. Construction of access roads, pumping station platforms or pipeline trench excavations will need to ensure that cut batters are selected on a site specific basis to ensure long-term amenity and construction period safety.

7.2 Excavatability

The depths of cuttings and soil depths observed during the field work are shown on Drawings 2 – 10. At the current level of field assessment, no attempt has been made to determine the proportion of soil to rock within likely trenching depth.

Along most of the lengths of the corridors, bedrock is present at shallow depth (typically <0.3 m to 1 m) below colluvial or residual soils. Shallow deposits of often erratically distributed alluvium also mantle gully and creek floors which may have eroded down onto high or very high strength rock.

Overburden alluvial, colluvial and residual soils, Very Low, Low and Medium strength rocks may be expected to be readily excavated by heavy bulldozers (e.g. D9 class or larger) in open excavations for access roads and construction platforms. Significantly reduced (potentially uneconomic) productivity may be expected in High and Very High strength rocks and may require blasting or heavy rock breaker use. The use of these excavation techniques may result in additional fracturing of the rock mass in the batters and a consequent need for surface treatment.

In detailed excavations for the pipeline trench, footings for pumping stations and drainage/services lines, allowance should be made for use of hydraulic rock hammers for breakage of Medium or greater strength rocks. Blasting may also be required where jointing is widely spaced in the higher strength materials.

Excavations in alluvium (particularly granular material) subject to water logging have the potential for rapid caving. The use of trench boxes may be required in these areas to facilitate placement of pipes and to provide safe working conditions.

It is anticipated that the high quartz content of some of the quartz sandstones, volcanic bands and granitic materials will result in relatively high abrasion rates for the earthworks equipment.

7.3 Site Preparation

Relevant general earthworks guidelines for the cut to fill operations for access roads and pumping station platforms proposed for the project:

- unsupported cuts in soil should not exceed 1.5 m height and should be battered at no steeper than 2H:1V.
- the growth of vegetation on soil covered slopes should be encouraged and assisted by hydro-mulching where required.
- where cuts in soil are to be steeper than 2H:1V and deeper than described above, the slope should be supported by engineer-designed retaining walls.
- cuts in rock should be constructed at batters between 1.5H:1V to 0.25H:1V. The final batter slopes will depend on the strength and intensity of fracturing of the rock and should be determined by a combination of site specific investigation and excavation monitoring.
- all rock cuts should be thoroughly cleaned of loose debris prior to final inspection to determine requirements for any additional face support works (e.g. shotcrete or rock bolting) for prevention of block fall or water scour of erodible materials.
- prior to placement of filling, the subgrade should be inspected during proof rolling carried out after the removal of topsoil and any deleterious soft, loose or compressible material.
- where the ground slopes are steeper than 8H:1V, each layer should be placed and compacted horizontally in a cut and benched formation in accordance with AS3798 – 2007.

- filling materials should generally be restricted in size to less than 75 mm unless specifically selected for erosion protection or other specific purposes of limited areal extent. It should be noted that where there are open joints in the rock mass, it is likely that excavation of the high or greater strength material may result in large blocks which may not break down under compaction. These blocks should not be utilised in filling but may be used as slope protection.
- all filling materials should be approved and placed under engineering control (to Level 1 criteria in accordance with AS3798 - 2007).
- filling should be battered at no steeper than 2H:1V, unless supported by engineer-designed retaining walls. Flatter slopes and intermediate berms with drains are suggested to minimise erosion when slope lengths are in excess of 15 m.
- retaining walls should include free draining backfill over the full height for a width of at least 0.3 m behind the face to reduce the risk of water pressure build-up. Drainage should be facilitated by an ag drain at the base of the granular fill and by a lined surface drain at the crest. The collected water should be discharged to the site stormwater system.
- subsoil drainage lines should include flexible couplings and adequate inspection points for maintenance purposes.

7.4 Erodibility

Gully erosion has been noted within alluvial deposits along several minor streams. Within the confines of the Macquarie River, the gravel and sand deposits should be considered to be erodible and mobile during flood flows.

The Soils Landscapes of the Bathurst 1:250 000 Sheet provides an assessment (refer Table 2, following page) of the soil erodibility (the susceptibility of a soil to detachment and transport by water and wind) of dominant soil types of most of the soil landscapes within the study area. The Burrendong Soil Landscape is assessed as having a slight potential for sheet erosion.

7.5 Influence of Previous Mining on the Proposed Development

It is likely that previous mine working will lie adjacent to very short sections of the investigated corridors. At the current level of available detail, it is anticipated that pipeline corridors within or immediately adjacent to the existing road easements should not be affected by the previous mining activities. It will, however, be appropriate to carry out walk-over inspections of the selected corridor to confirm this assessment by searching for previously un-recorded workings.

Table 2: Summary of Ranking of Soil Erodibility

Soil Landscape	Dominant Soil	Topsoil Erodibility	Subsoil Erodibility
Lachlan	Alluvial soil (sandy)	Medium	Low
	Alluvial soil (loamy)	Low	Medium to High
	Prairie soil	Medium	Medium to High
Macquarie	Alluvial soil (sandy)	Medium	Low
	Alluvial soil (loamy)	Low	Medium to High
	Prairie soil	Medium	Medium to High
	Black Earth	Medium	Low
Panorama	Krasnozern	Medium	Medium
	Wiesenboden	Low	Medium to High
Mookerawa	Brown podzolic soil	Medium	Low
	Yellow podzolic soil	Medium	Medium
Mullion Creek	Soloth	High	High
North Orange	Red Earth	Medium	Medium
	Yellow podzolic soil	High	High
	Wiesenboden	Low	Medium to High
	Yellow Earth	Medium	High

7.6 Constructability Aspects

The site observations indicate that the main geological and geotechnical constraints related to constructability of the proposed pipeline are:

- The steep hillslope (with possible cliff line sections) crossing the margins of the basalt capped plateau on Corridor 1 around MR4 river off-take where there is potential for disturbance to trigger slope instability within massive joint blocks and boulders.
- The steep and very steep hillslope section from river terrace level to the Root Hog Fire Trail on Corridor 2 where construction plant access will be extremely limited and will probably require significant disturbance of the slope and vegetation cover. Such disturbance has the potential to trigger erosion or slope instability.
- The steep hillslope section along the Root Hog Fire Trail on Corridor 2 where there is potential for disturbance to trigger erosion or slope instability within massive joint blocks and boulders.
- The presence of numerous high to very high strength rock bars at surface or within the expected depth of pipeline trench excavation in both corridors. The requirement for heavy rock hammer use or blasting to excavate the trench will be governed by the intensity and intactness of jointing and the orientation of the dominant rock mass defects (typically bedding and foliation) to the trench alignment.

- The likely coarse sized, rocky nature of much of the materials excavated from pipeline trenches with potential for resulting unsuitability for use as compacted trench backfilling.
- Water logging of alluvial sections, particularly on Corridor 1 between Long Point Road and Ophir Road, with resultant potential for poor trafficability and collapse of trench excavations.
- Likely high conductivity in alluvial materials subject to long-term saturation with resulting potential for corrosive conditions in ductile materials.

7.7 Further Investigation

It is suggested that further investigation after the pegging of the preferred pipeline corridor include:

- A walk-over geological survey of the entire preferred corridor by a senior engineering geologist to assess soil and rock distribution and potential for instability or erosion.
- Selection of test pit locations for investigation of excavatability and sampling of materials for laboratory assessment of suitability for use as trench backfilling and access road construction. It is suggested that an initial phase of test pitting be carried out using a tractor mounted backhoe to enable rapid movement along the preferred corridor. A second phase of test pit excavation is suggested and would employ a larger (say 20 – 22 tonne) excavator with rock bucket and hydraulic hammer attachments to investigate areas of difficult excavation conditions assessed during the site walk-over and initial phase of test pitting.
- In situ electrical resistivity testing, using the Wenner method, within areas of potential high conductivity and corrosion potential.
- A program of laboratory testing including classification tests, compaction parameters, California bearing ratio for assessment of access roads and pavements associated with new pumping stations, together with soil aggressivity for assessment of corrosion of buried concrete and steel elements.

8. References

1. Kovac, M. and Lawrie, J.A. (1990), *Soil Landscapes of the Bathurst 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.
2. Raymond, O.L., Pogson, D.J., Wyborn, D., Chan, R.A., Hawley, S.P., Henderson, G.A.M., Krynen, J.P., Meakin, S., Moffitt, R.S., Morgan, E.J., Scott, M.M., Spackman, J.M., Stuart-Smith, P., Wallace, D.A., Warren, A.Y.E., Watkins, J.J., Glen, R.A., 1997, *Bathurst SI5508 (Orange 1:100 000) Digital Geology Data Package*, Australian Geological Survey Organisation, Canberra / New South Wales Department of Mineral Resources, Sydney
3. Geological Survey of NSW, Department of Mines (1979), *Bathurst Metallogenic Map Sheet SI 55-8*.
4. Standards Association of Australia, Australian Standard AS 3798-2007: *Guidelines on Earthworks for Commercial and Residential Developments*.

9. Limitations

Douglas Partners (DP) has prepared this report for MWH Australia Pty Ltd in accordance with DP's proposal dated 12 November 2010 and acceptance received from MWH Australia Pty Ltd on 17 November 2010. The report is provided for the exclusive use of MWH Australia Pty Ltd for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of anthropogenic influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

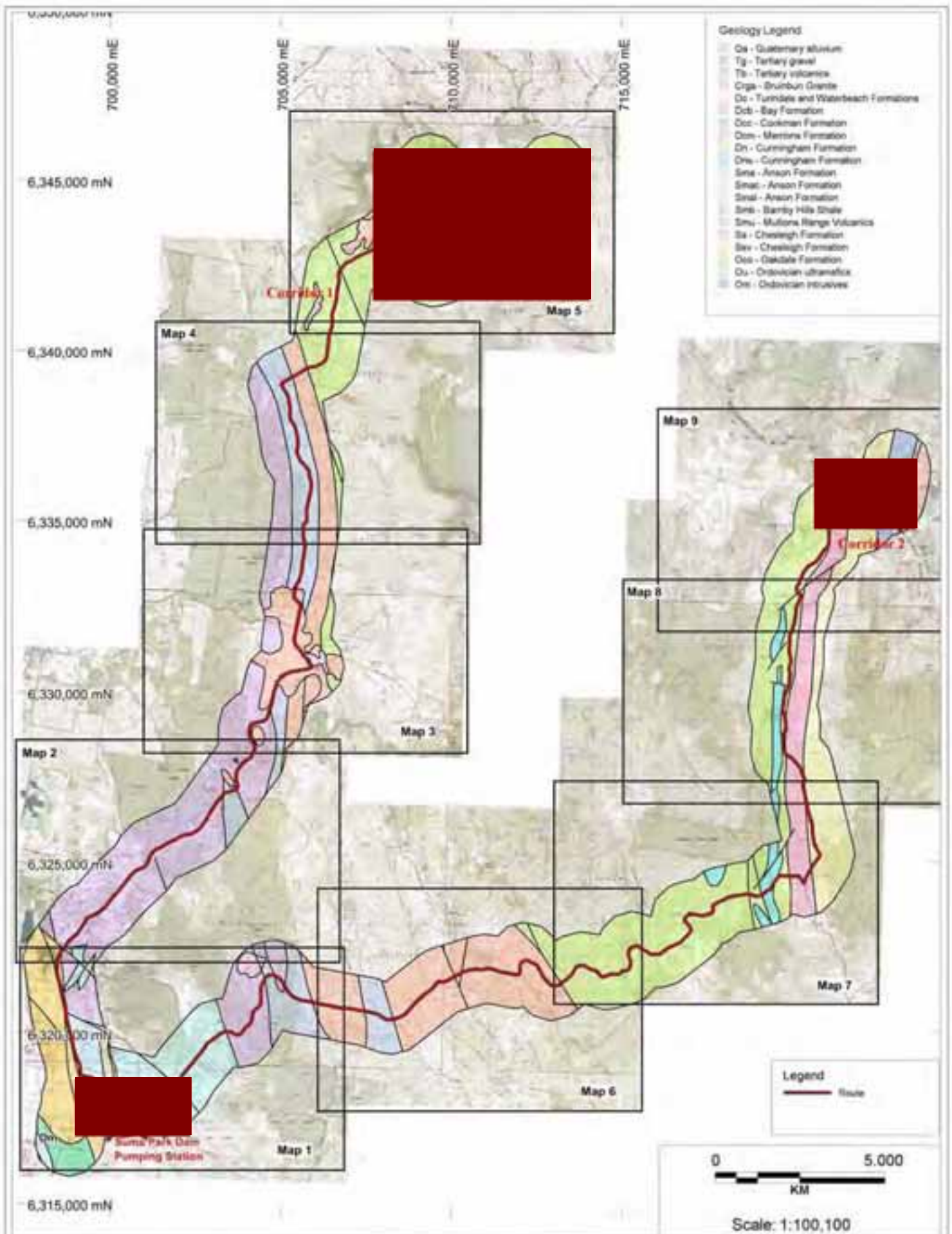
This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

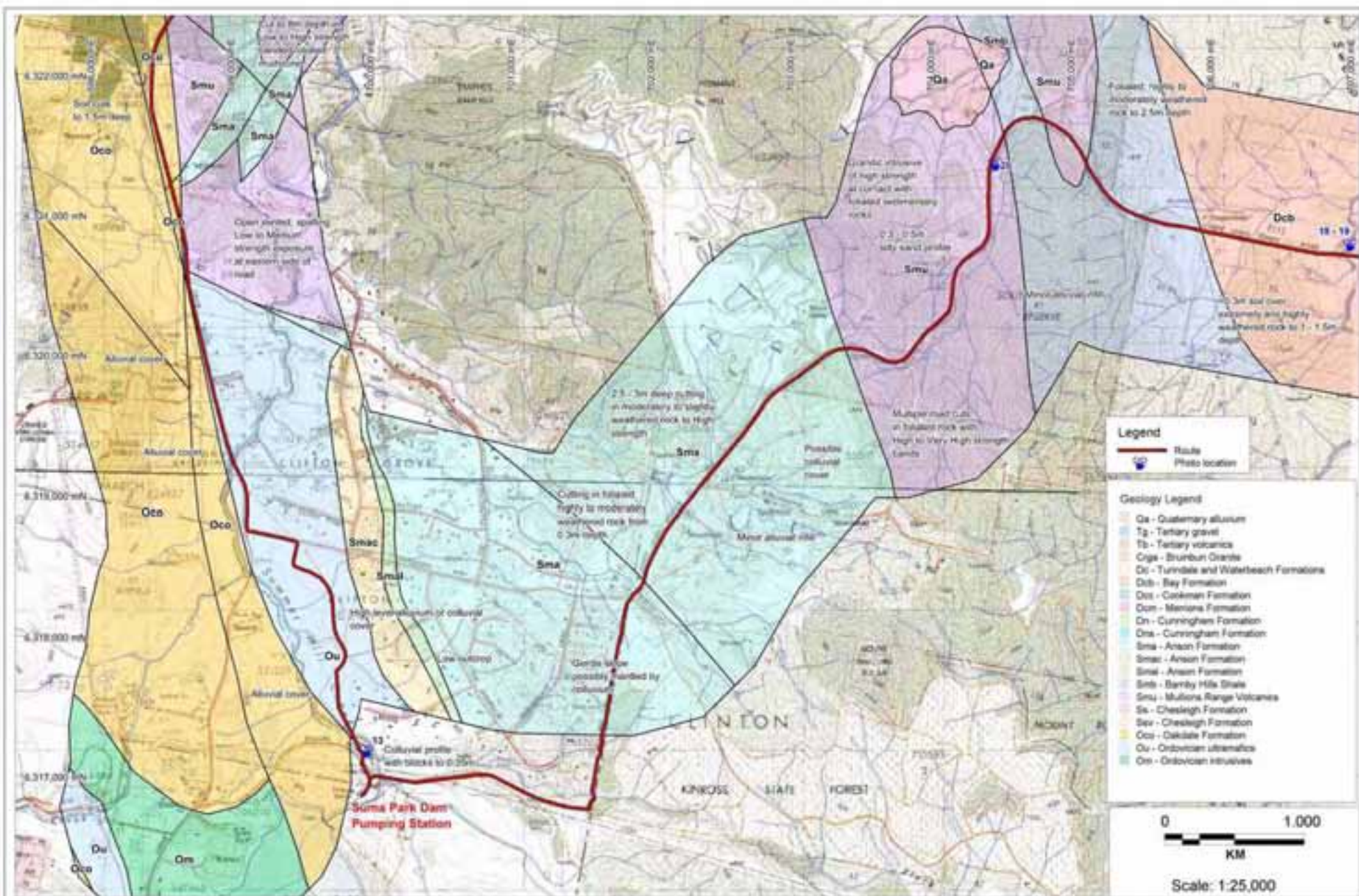
This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

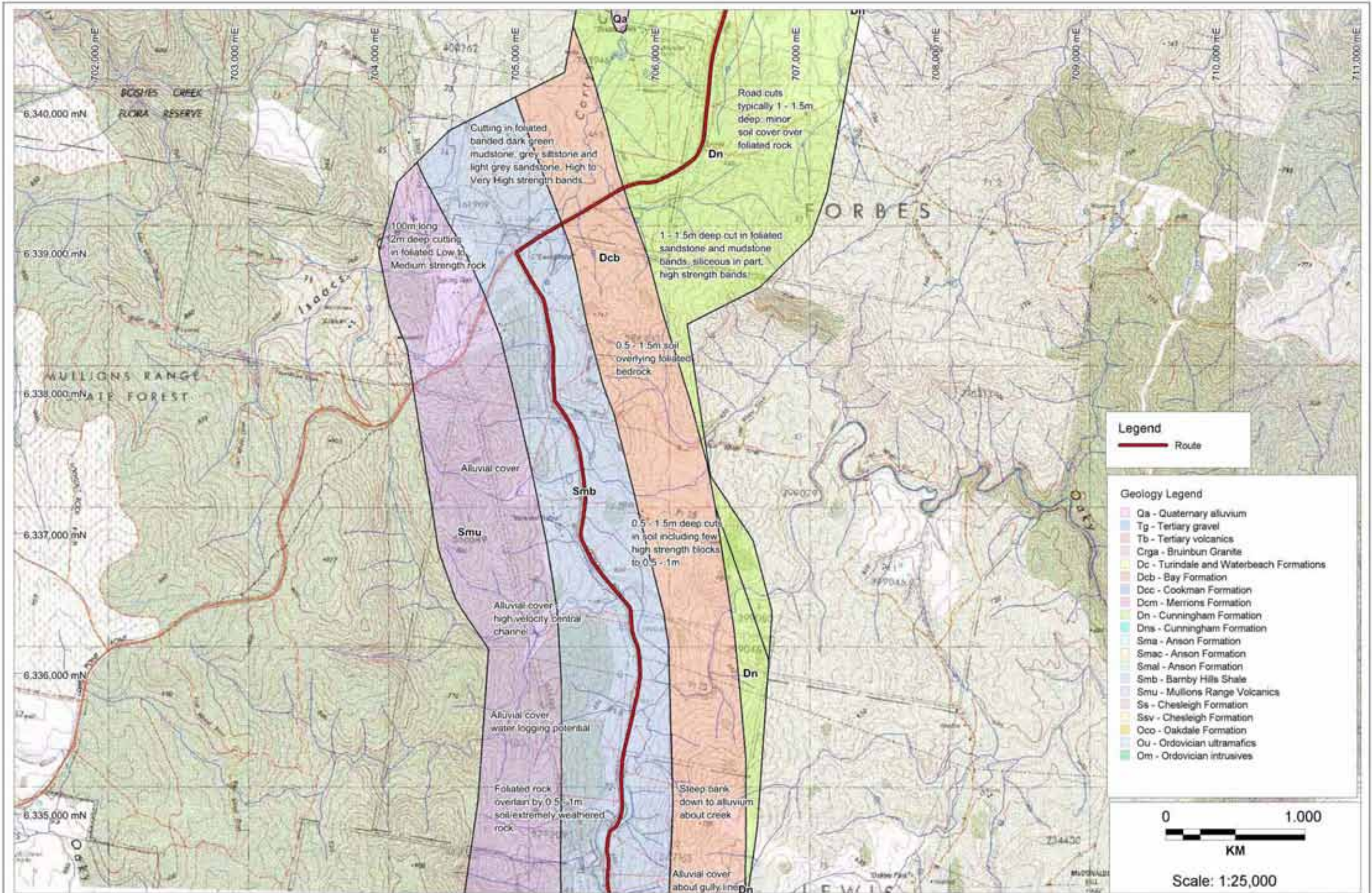
Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings 1 – 10
Plates 1 - 6







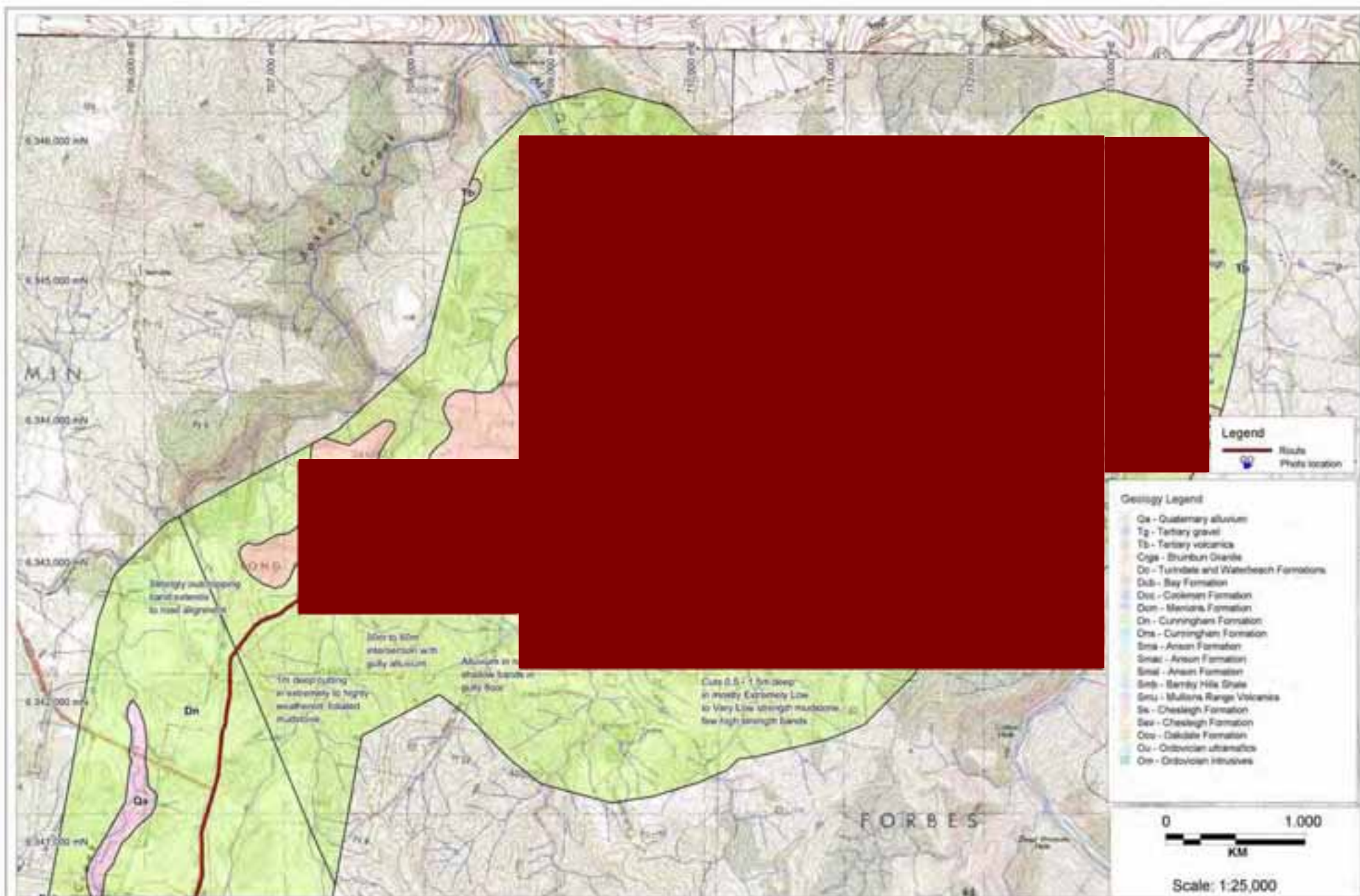




Photo 1: High strength rock bar controlling level of ponded area



Photo 2: Ponded area upstream of rock bar in Photo 1

Rock bar from river bed
(refer Photo 1) appears
to extend below
alluvium



Photo 3: View looking eastward

Approximate flood level

For locations of photos refer Map 5.

Ponded area above gravel bar

Sand and gravel from current stream deposition

High level alluvium overlies continuation of rock bars from river level (refer Photo 5)



Photo 4: Looking northward to upstream

Rock bar has fragmented into blocks in this area

High to Very High strength foliated mudstone, open jointed, rock bar



Photo 5: Looking south over downstream

For locations of photos refer Map 5.



Medium to High strength
mudstone outcrops

Photo 6: View looking north along access track from Long Point Road



Photo 7: Foliated mudstones in side cut of Long Point Road



Long Point Road

Photo 8: View looking north along Long Point Road



Rounded corestones in lower strength matrix

Photo 9: 2m cutting in basalt in Lookout Road near the intersection with Ophir Road.

For location of photos refer Maps 3 - 5.



Photo 10: High to Very High strength rock bars downstream (east) of the bridge over Summer Hill Creek 4th Crossing.



Photo 11: Alluvium in creek banks upstream (west) of the bridge over Summer Hill Creek 4th Crossing.



Photo 12: Rock bars in gully sides and base downstream (east) of the bridge over Summer Hill Creek 3rd Crossing.

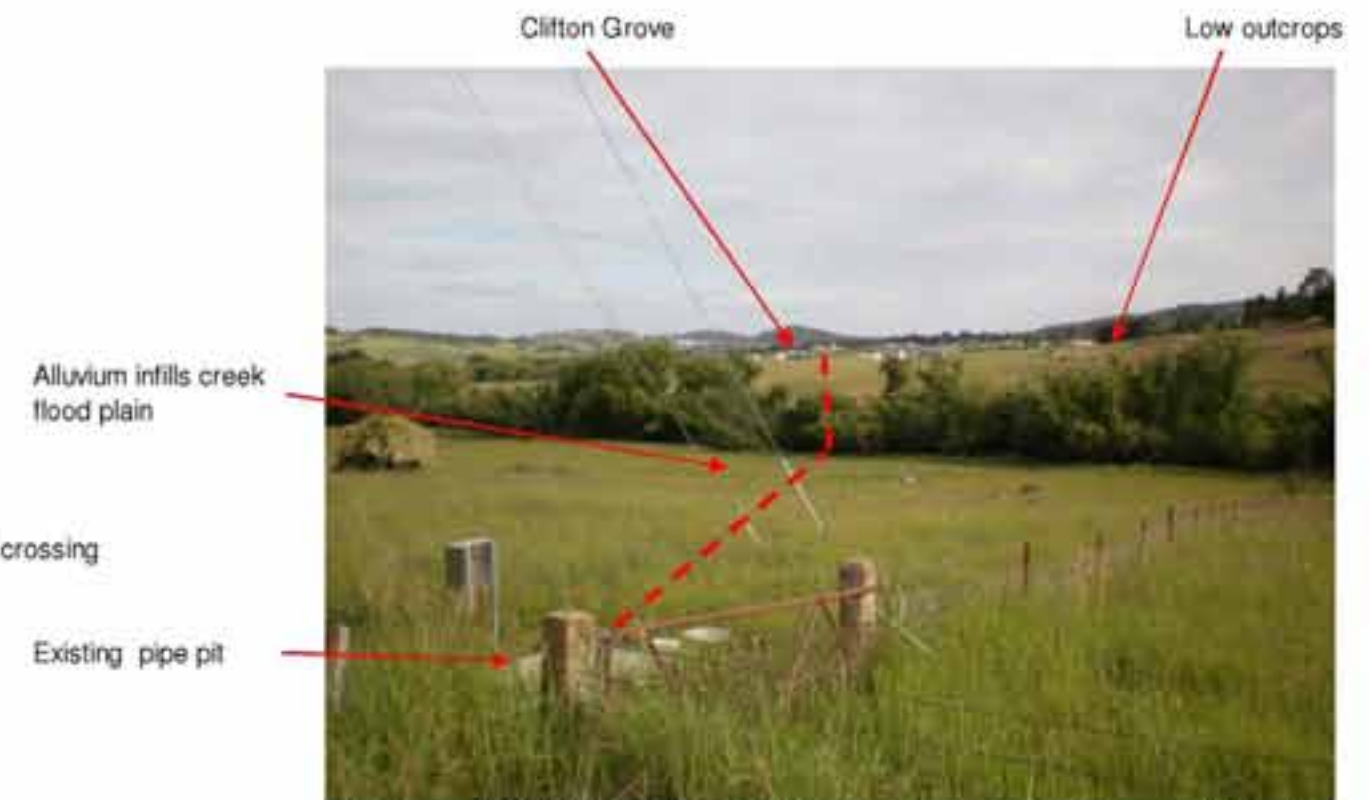


Photo 13: View looking north from Bulgas Road over course of Summer Hill Creek towards Clifton Grove.

For locations of photos refer Maps 1 - 3.



Photo 14: View looking north along Macquarie River to confluence with the Turon River.



Photo 15: Outcrop and road bed of Root Hog Fire Trail

Massive outcrops and large talus boulders above and below fire trail.



Photo 16: Climbing section of Corridor 2 along Root Hog Fire Trail.

For locations of Photos refer Map 9.



Photo 17: Foliated mudstone in cut of Gowan Road.



Photo 18: Stream bed of Emu Swamp Creek immediately downstream of Lewis Ponds Road.



Photo 19: Rock bars in stream bed of Emu Swamp Creek immediately upstream of Lewis Ponds Road.



Photo 20: Granitic exposure in cut of Lewis Ponds Road.

Note: For locations of photos refer Maps 6 - 9