13. Soils, groundwater and contamination

This chapter provides a summary of the Soil, Groundwater and Contamination Impact Assessment undertaken for the Project. A full copy of the assessment report is included in Appendix G.

13.1 Methodology

The methodologies used to identify and assess potential impacts to soils and groundwater, and to assess the impact of potentially contaminated ground on the Project included:

- A review of applicable legislation, policies and guidelines;
- A review of available soil landscape, geological and topographical maps;
- A review of bore data accessed via the DWE database of registered groundwater bores located throughout NSW;
- A limited investigation of potentially contaminated sites within the vicinity of the pipeline which included a walkover survey of the proposed pipeline route to identify potentially contaminating land uses adjacent to or within the proposed pipeline corridor and a search of the DECC database of contaminated land notices in the LGA of GMC and WSC. The limited investigation did not include physical investigations involving soil or groundwater sampling and analysis.

13.2 Existing environment

13.2.1 Soil landscapes

Topography

The 1:25,000 scale topographic maps for Moss Vale (CMA of NSW, 1985), Canyonleigh (NSW Department of Lands, 2005), Wingello (NSW Department of Lands, 2005) , Towrang (NSW Department of Lands, 1971), Bungonia (NSW Department of Lands, 1983), Kingsdale (NSW Department of Lands, 1983) and Goulburn (NSW Department of Lands, 1983) show that the pipeline route would traverse a series of hill slopes, flood plains, river valleys and low hills. Table 13.1 summarises the location of these topographical features along the pipeline route.

Table 13.1 Topography along proposed pipeline easement

Sector	General topographical feature of Sector
Glenquarry	Flood plain and rises
Werai-Moss Vale	Low hills and hills
Sutton Forest- Exeter	Low hills and hills
Paddy’s River	Hills and river valleys
Marulan	Low hills, hills and a river valley (~CH 39 km – CH 41 km)
Towrang	Low hills, rises and a flood plain (~CH 51 km to CH 58 km),
Murrays Flat	River valley and flood plain, low hills (toward Murrays Flat)

Sector	General topographical feature of Sector
Goulburn	Rises and low hills

The pipeline construction corridor would cross some steep terrain, most notably adjacent to Paddys River around Hanging Rock Road (~chainage 33.7 km and chainage 37.1 km). There are also some locally steep slopes associated with Mount Broughton. Slopes of up to 22 degrees are mapped in the hilly terrain adjacent to Paddys River. Steeper slopes may occur locally, which are not shown on the maps reviewed.

Geology

The geological maps reviewed (NSW Mineral Resources, 1999; NSW Department of Mines, 1966; NSW Department of Mines 1970; NSW Department of Primary Industries, 2008) show the proposed pipeline route would traverse a number of geological units. These units mainly comprise sedimentary formations, while igneous formations occur around Marulan and Goulburn. The expected geology in each sector of the proposed pipeline route is shown in Table 13.2.

Table 13.2 Geology along proposed pipeline route

Sector	Description of general geology in each sector
Glenquarry, Werai-Moss Vale and Sutton Forest-Exeter	Predominantly underlain by sedimentary rock formations (shales) with some intrusions of igneous rock
Paddy's River	Predominantly underlain by sedimentary rock formations (sandstone)
Marulan	Predominantly underlain by sedimentary rock formations (sandstone and siltstone) in the west portion, while the east portion is predominantly underlain by igneous rock formations
Towrang, Murrays Flat	Predominantly underlain by igneous rock formations in the west portion, but mostly underlain by sedimentary rock formations (shale, sandstone and siltstone) and alluvial sediments
Goulburn	Predominantly underlain by sedimentary rock (limestone)

The geology underlying the proposed crossings varies and is summarised in Table 13.3.

Table 13.3 Geology at crossings

Crossings	Description of general geology
Watercourses	Predominantly sedimentary rock or alluvial deposits (which are likely to be underlaid by sedimentary rock). Igneous rock (most likely underlain by minor alluvial deposits at the watercourse crossing locations) is expected to underlie the crossing at Jaormin Creek (WAT 8), Lockyersleigh Creek (WAT 9), Narambulla Creek (WAT 10) and the Wollondilly River (WAT 20). Of these crossing points underlain by igneous rock, it is proposed to horizontal direction drill the crossing of the Wollondilly River (WAT 20).
Road	The geology underlying the road crossings which are proposed to be thrust bored (Hume

Crossings	Description of general geology
	Highway, Robertson Road, Sheepwash Road) are underlain by sedimentary rock.
Railway line	The geology underlying the railway line crossings is sedimentary rock except for crossing RAIL3 (Main Southern Railway) which is underlain by igneous rock.

Soils

A review of the published soil landscape maps for the Hawkesbury – Nepean Catchment (DECC, 2009b) identified 34 soil landscapes along the proposed project route. Broadly, these soil landscapes can be grouped into five separate units based on origin and/or surface processes. The five units are as follows:

Erosional:	Soil formation is affected by the removal of weathered parent material
Transferral:	Similar to alluvial soils but are considered to have undergone less transportation, and often resemble local soil and weathered materials (*e.g.* “slopewash”)
Alluvial:	Soils transported by water down creeks and rivers.
Colluvial:	Soils of colluvial origin are derived from subsurface materials that have undergone or are undergoing mass-movement down slope, primarily due to the influence of gravity
Residual:	Soils that form where weathering of parent material occurs without significant erosion over extended periods of time

A number of constraints have been identified for the soil units located along the pipeline.

The constraints are described below:

Sheet erosion hazard:	Soils susceptible to the removal of a uniform thin layer of soil by raindrop splash or water run-off.
Shallow soils:	Areas where the soil layer is thin and rock would likely be encountered at shallow depth
Sodicity:	"Sodic soil” is typically associated with agricultural soil science. Its environmental engineering implications are highly dispersive, erodible soils, that are often waterlogged.
Seasonal waterlogging:	Poorly drained soils
Salinity hazard:	Soils containing excessive salt which impacts health of vegetated ground cover, exposing soils to high erosion hazards
Steep slopes / Mass movement hazard:	Soils on steep slopes which is subject to mass movement down slope

A summary of the predominant soil constraints in each sector of the pipeline route is provided in Table 13.4.

Table 13.4 Dominant soil constraints in Pipeline Sector

Sector	Sheet erosion hazard	Shallow soils	Sodicity	Seasonal waterlogging	Salinity hazard	Steep slopes
Glenquarry and	W	L	W	W & L	-	W (minor

Sector	Sheet erosion hazard	Shallow soils	Sodicity	Seasonal waterlogging	Salinity hazard	Steep slopes
Werai - Moss Vale						extent)
Sutton Forest - Exeter	W	L	W	W & L	-	W (minor extent)
Paddy's River	W	-	W & L	-	-	W (minor extent)
Marulan	W	L	W & L	W & L	L	L
Towrang	W	L	W	L	L	-
Murrays Flat and Goulburn	W & L	-	L	W	L	-

Legend: L – Localised occurrence W – Widespread occurrence.

The expected soil landscapes and associated constraints at the crossing points are as follows:

- Watercourse crossings: The soil landscapes present at the majority of proposed watercourse crossings are either Alluvial or Transferral;
- Road crossings: The majority of road crossings would be undertaken in Erosional soils that are subject to widespread sheet erosion and sodicity; and
- Railway line crossings: The soil landscapes expected at the railway crossings include Transferral (RAIL 1 to 3), Alluvial (RAIL 4) and Erosional (RAIL 5). The soil landscapes at these locations are subject to sheet erosion hazards and sodicity. The Erosional soil landscape is also subject to localised salinity.

13.2.2 Groundwater

Reliability and use of bore data

Information on groundwater within bores located in the vicinity of the pipeline route was obtained from the NSW Office of Water's (formerly the DWE) database of registered groundwater bores located throughout NSW (DWE 2004). A review of information held in this database revealed there are approximately 350 registered groundwater bores located within 2 km from the proposed pipeline route. However, the data obtained contained a number of gaps. As such, its use in determining the local groundwater conditions beneath the proposed pipeline route has a number of limitations including the following:

- There is a lack of groundwater bore data at some crossing locations included railway crossing RAIL 3, road crossings ROAD 40 and ROAD 45, and watercourse crossings WAT 6, WAT 8, WAT 9, WAT 10 and WAT 11. With the exception of Railway line crossing RAIL 3, these crossing are all proposed to be trenched, and therefore the risk of intersecting groundwater at these crossings is significantly reduced;
- The depth of the bores has been used to indicate the depth to groundwater. This assumes that borehole drilling was terminated when a significant source of groundwater was intercepted;

- The depth to groundwater can vary with distance from the borehole. It is noted that the nearest bore to a major crossing is 150 m; and
- Some bore depths are recorded as 0 m below ground level. This may indicate a data error, or that no data was recorded. The depth of casing has been used to indicate the depth to groundwater in such cases.

Despite these above limitations the data obtained is considered sufficient to provide a general overview of the likely groundwater conditions beneath the proposed pipeline route.

Groundwater depth

The DWE 2004 data shows that most of the boreholes within 2 km of the proposed pipeline easement have a depth of greater that 20 m below ground level. If it is assumed that the boreholes were terminated at the depth where a significant groundwater source was intercepted, then it could be concluded that significant aquifers beneath the proposed pipeline easement are at depths typically greater than 20 m below ground level.

The data also indicates that there are eight bores within 2 km of the pipeline route that may contain shallow groundwater (< 10m BGL). Data on these bores is provided in Table 13.5.

Table 13.5 Location of boreholes in shallow groundwater

Sector	Bore ID	Depth of borehole (m)	Depth of casing (m BGL**)	Standing water level (SWL) (m BGL)	Approximate distance from pipeline route (m)
Glenquarry	GW065891	0*	6.0	No data	1180
Sutton Forrest - Exeter	GW034245	0*	3.9	No data	1800
	GW035156	3	No data	No data	230
	GW044058	9	No data	No data	850
	GW066775	0*	6.0	No data	850
Paddy's River	GW034230	3	No data	No data	470
Murrays Flat	GW104582	3	No data	No data	380
	GW104585	7	No data	No data	400
Goulburn	GW105020	9	No data	3.5	950

*Where the depth of the borehole has been listed as 0 m, the depth of casing has been used to indicate the possible depth of the borehole and the depth to groundwater.

** Below ground level.

It is expected that deeper confined aquifers would exist in the fractured bedrock (basalts, granites, sandstones, shales), while shallow unconfined aquifers may exist in Transferral or Alluvial deposits, which are typically present adjacent to watercourse. As such, a permanently higher watertable could be expected in alluvial deposits located within the watercourse's flood plains. Therefore, the interception of significant aquifers (expected to be at depths of 20 m below ground level or more) is not expected during construction trenching or pit excavations. Shallow or perched unconfined aquifers may be encountered during excavations at watercourse crossings or in lower lying flood plains.

Since trenching and excavations would not likely be undertaken to depths over 3 m below ground level, the risk of encountering a significant groundwater resource or a groundwater resource used by nearby landholders is low.

A review of the data of bores located within 1 km of the crossing locations shows the depths to groundwater vary considerably as would be expected. Table 13.6 provides a summary of this data.

Table 13.6 Groundwater bore data summary for crossings (Source: DWE, 2004)

Crossing Type	No. of bores (within 1 km of crossing point)	Range of bore depth (m BGL)	Range of SWL (m BGL)
Railway Crossings	14	50 – 150	23 - 94
Highway Crossings	11	18 – 156	13 – 41.6
Road Crossings	109	3 – 175	3.2 - 94
Watercourse Crossings	83	3 – 156	3.5 - 94

The information provided in Table 13.6 shows that, in general, the depths to significant groundwater are likely to be between 18 m and 175 m below ground level, but could be as shallow as 3 m below ground level near road and watercourse crossings.

The road and watercourse crossings that would have shallow bores (<10 m depth BGL) located within 1 km are listed in Table 13.7.

Table 13.7 Shallow bores located near road and watercourse crossings

Crossing ref no.	Crossing name	Proposed construction method	Bore ID	Approx distance from crossing (m)	Depth of Bore (m BGL)
ROAD 11	Bibbys Lane	Trenched	GW035156	400	3
ROAD 12	Mount Broughton Road	Trenched	GW035156	400	3
ROAD 68	Taralga Road	Trenched	GW104582	450	3
			GW104585	600	7
W119	Wollondilly River	HDD	GW104585	800	7
			GW104582	850	3
WAT 16	Kenmore Creek	Trenched	GW104585	850	7
			GW104582	900	3
WAT 17	Kenmore Creek	Trenched	GW104585	600	7
			GW104582	500	3
WAT 18	Kenmore Creek	Trenched	GW104585	700	7
			GW104582	600	3

Crossing ref no.	Crossing name	Proposed construction method	Bore ID	Approx distance from crossing (m)	Depth of Bore (m BGL)
WAT 19	Kenmore Creek	Trenched	GW104585	800	7
			GW104582	700	3
W131	Wollondilly River	HDD	GW105020	900	9

Table 13.7 shows that the shallow bores are located between 400 m and 900 m from the crossing points. Therefore there use in identifying shallow groundwater in the vicinity of the crossing points is limited. However, most of the crossings in Table 13.7 are proposed to be constructed by trenching, which would not involve excavations to significant depths. This reduces the likelihood of intersecting shallow groundwater at these locations.

Groundwater quality

Groundwater salinity data for bores located within 2 km of the proposed pipeline route was reviewed. However this data was incomplete. No other indicator of groundwater quality was available in the data obtained.

Salinity data is recorded as either a qualitative (*e.g.*, 'good', 'fair', 'salty' etc) or quantitative *(e.g.,* 1001 - 3000 ppm) measure. Most of the recorded measures of salinity indicate that groundwater with relatively low salt concentrations would be expected to exist beneath the majority of the proposed pipeline route.

A particularly sensitive groundwater resource exists in the area around Lot 122 / DP 802050 (Paddys River sector) which is located approximately 5 km west-south west of Sallys Corner. Lot 122 / DP 802050 contains seven bores from which groundwater is extracted and bottled for drinking water. Bore data for the seven bores that exist on this block are provided in Table 13.8.

Table 13.8 Bore data (Lot 122 / DP 802050)

Bore ID	Date completed	Bore depth (m BGL)	SWL (m BGL)	Salinity
GW053995	1/11/1982	31	No data	Good
GW101583	14/12/1994	30	7.6	No data
GW102066	14/12/1994	34	7.1	No data
GW107520	7/08/2006	15	12.5	No data
GW107521	8/08/2006	35	16.5	No data
GW107522	9/08/2006	42	30.4	No data
GW107556	24/10/2006	No data	No data	No data

The information in Table 13.8 shows the shallowest groundwater bore is 15 m below ground level (GW 107520). This may suggest the shallowest groundwater resource beneath this block is also approximately 15 m below ground level and well below the maximum expected trenching depth of 2 m below ground level.

Of the bores located within 2 km of the pipeline route, poor quality groundwater (recorded as 'bad', 'stock', `1001-3000 ppm', 'hard' or 'salty') was recorded in thirteen bores. These bores have depths of 18 m below ground level or greater. The nearest bore containing poor quality groundwater would be 640 m from the proposed pipeline easement. It is considered that 'Poor' quality groundwater is not likely to be present at the depth and location of the proposed pipeline route.

Groundwater flow direction

In general, groundwater is understood to flow from topographically higher areas toward topographically lower areas. Groundwater may also discharge into watercourses, providing the watercourse with a baseline flow of water. This is typically the case in hilly and undulating areas such as is typical of the topography in the Project area.

Localised groundwater flow directions beneath the proposed pipeline route are likely to vary between the Wingecarribee Reservoir and Goulburn, and would be generally expected to flow toward the nearest major watercourse. Table 13.9 describes the expected direction of groundwater flow in each of the sectors of the pipeline route.

Table 13.9 Expected groundwater flow directions

Sectors	Expected groundwater flow direction in each Sector from the proposed pipeline easement
Glenquarry	Groundwater flow is likely to be northeast from the centre of the sector (~CH2.5 km) toward Wingecarribee River. From the western side of the sector the groundwater flow is also expected to be northeast from the topographically higher point (~CH5.6 km) towards Kelly's Creek.
Werai - Moss Vale	From the topographically high point (~CH12.5 km) groundwater is expected to flow either north and northeast, or southwest toward Medway Rivulet
Sutton Forest - Exeter	The groundwater flow direction would vary with the undulating topography. In the eastern portion of the sector the groundwater flow direction may be trending to the north, while in the western portion of the sector groundwater flows are likely to trend from topographically higher points toward Long Swamp Creek and Black Bobs Creek (typically northeast or southwest from high points)
Paddy's River	Again the groundwater flow direction would likely be highly variable with the undulating topography. In the eastern portion of the sector from ~CH35 km, the flow direction would likely trend in a northerly direction. In the western portion of the sector the groundwater flow direction would likely be toward Paddy's River.
Marulan	In the eastern portion of the sector (from ~CH44 km) the groundwater flow direction is likely to be in an easterly direction toward Uringalla Creek. In the western portion of the sector the groundwater flow would likely be toward Jaormin Creek (typically northeast or southwest from high points)
Towrang	The groundwater flow would likely be in a north easterly direction toward the Wollondilly River (~CH52 km – CH60 km)
Murrays Flat	The groundwater flow would likely be in a northerly direction toward the Wollondilly River (~CH65 km – CH70 km). . From the elevated Murrays Flat area the groundwater flow is likely to be in a north easterly direction toward Boxes Creek
Goulburn	The groundwater flow direction is likely to be in a southerly direction toward the Wollondilly River (~CH72 km – CH78 km).

13.2.3 Contaminated land

Areas of potential concern

Five 'areas of potential concern' (being areas where potentially contaminating activities have or may have taken place) were observed adjacent to or within the proposed pipeline construction corridor. The areas are described in Table 13.10 together with an assessment of the likelihood of significant ground contamination occurring at the location.

Table 13.10 Locations of areas of potential concern

Pipeline Route Sector	Location (Lot No./DP)	Contaminants of concern	Likelihood of significant ground contamination occurring
Paddy's River	137 / 751298	Material stockpiles: Piles of scrap metal	Unlikely: Stockpiled material is not likely to be a source of ground contamination.
Sutton Forest – Exeter	10 / 811912	Old Drums. Potential for ground chemical or fuel contamination associated with drums	Unlikely: Area does not appear to be an actual former drum storage location and therefore the drums do not appear to be a source of significant contamination.
Towrang	122 / 750050	Stockyard: Potential for chemical contamination from drenching of livestock.	Unlikely: Past activities undertaken at this location are not likely to be a source of significant ground contamination. (Note: significant contamination could occur if the location contains a sheep dip)
Murray's Flat	102 / 791867	Stockyard: Potential for chemical contamination from drenching of livestock.	Unlikely: Past activities undertaken at this location are not likely to be a source of significant ground contamination. (Note: significant contamination could occur if the location contains a sheep dip)
Goulburn	1/1126788 2/1126788	Area of effluent irrigation: Potential for heavy metals, pesticides, thermo tolerant coliforms, oil and grease, pH.	Likely: Current effluent irrigation may have caused elevated concentrations of contaminants in soil

No other areas of potential concern were observed during the site visits to determine the pipeline route alignment.

Australia and New Zealand Environment and Conservation Council and the National Health Environment and Medical Research Council's *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC & NHMRC 1992) lists 'railway yards' as a potentially contaminated activity. Furthermore, weed management on railway lines often included the spraying of weedicides and herbicides onto the tracks. As such, excavations adjacent to, and boring beneath, the railway line may encounter contaminated soil.

Orders made under Part 3 of the* NSW *Contaminated Land Management Act 1997

A search of a database of orders made under Part 3 of the CLM Act was undertaken. Part 3 of the CLM Act provides for DECCW to order a site investigation to be undertaken at a site due to the risks posed by existing contamination on the site. The results of the searches show that four sites, all located in the Wingecarribee LGA had or formerly had notices imposed under the CLM Act. These sites are at least

4 km from the proposed pipeline construction corridor and are not expected to impact the soils located within the proposed alignment.

13.3 Impact assessment

13.3.1 Risk assessment

A risk assessment was conducted to assess the risk of particular events occurring during the construction and operational phases of the Project. Should these events occur, the outcome would be an impact to the existing environment (with respect to soils, groundwater and contamination). The risk assessment considered the likelihood and consequence of each event occurring.

The consideration of the likelihood and consequence of the events occurring took account of the standard (construction and operational) management practices and techniques that would be implemented to control the particular events. Project environmental controls are described in Chapter 6 and would be implemented to address the following issues:

- Soil erosion and sedimentation;
- Management of in-stream works;
- Rehabilitation and maintenance of disturbed areas;
- Management of spoil;
- Management of groundwater;
- Management of acid sulphate soils;
- Management of saline soils;
- Education of the construction work teams with respect to their responsibilities and legislated requirements to prevent surface water and groundwater contamination;
- Management of contaminated soil; and
- Management of scour water.

It is anticipated that these procedures and control would form part of a construction environmental management plan (CEMP) and an operational environmental management plan (OEMP). The implementation of the CEMP would be audited by a third party to ensure the practices and controls are maintained and continually improved throughout the construction phase.

The Project environmental controls are described in Chapter 6.

13.3.2 Potential construction impacts

Potential impacts that could occur during the construction phase of the Project are generally the result of the following:

- Soil erosion and land degradation, and the associated degradation of surface water quality generated by sediment laden stormwater;
- Degradation of groundwater quality and the reduction in groundwater availability;
- Dust generation;

- Instability of excavations;
- Ground subsidence; and
- The contamination of soil.

Events that would lead to the above soils and groundwater impacts were considered in the risk assessment. These events included:

- Disturbance of soils during earthworks at the Wingecarribee WTP site associated with the construction of the proposed pumping station;
- Disturbance of soils by construction traffic along the construction corridor and at points along the access routes to the construction corridor;
- Disturbance of highly erosive, shallow, sodic, saline, contaminated or acid sulfate soils within the construction corridor leading to sedimentation and erosion of soils and / or dust generation;
- Disturbance of soils on steep slopes;
- Disturbance of riparian zones;
- Stability of excavations in colluvial soils;
- Interception of groundwater during trenching and / or pit excavations associated with crossing construction by HDD or thrust boring;
- Management of groundwater seepage into excavations;
- Management and use of drilling fluids, fuels and chemicals during construction;
- Subsidence of backfilled excavations; and
- ‘Frac outs’ (fractures or cave ins) occurring during thrust boring.

13.3.3 Potential operational impacts

The potential impacts that could occur during the operational phase of the Project are generally the result of the following:

- Soil erosion;
- Infiltration of groundwater to trench;
- The contamination of soil; and
- Degradation of groundwater quality

The following operational events that would potentially lead to impacts to soils and / or groundwater were assessed in the risk assessment:

- Release of scour water; and
- Use of fuels and chemicals.

13.4 Summary of results

The assessment of the risks (likelihood and consequence) of construction and operational related events occurring (which would lead to impacts to soils, groundwater and contamination) concluded the following:

- The risk of most events occurring is ‘negligible’ or ‘low’. This is primarily due to the construction techniques that would be adopted and the extensive Project controls that would be implemented. Negligible or low risks are considered acceptable in the context of the Project; and
- The risk of encountering contaminated soil on effluent irrigated land near Goulburn is considered to be ‘medium’. There is the potential that disturbance of contaminated land on effluent irrigated land has the potential to cause health impacts to construction works and impacts to surface water quality. Mitigation measures to prevent these impacts are provided.

13.5 Mitigation measures

Additional mitigation measures to those already described in the project environmental controls that would be included in the CEMP are described below.

Investigate potentially contaminated soil in effluent irrigation area

Prior to construction, a contaminated soil investigation should be undertaken in the effluent irrigation area on Lots 1 and 2 / DP 1126788.

The investigations should be undertaken in accordance with guidelines approved by the NSW DECC&W under Section 105 of the CLM Act including:

3. Australia and New Zealand Environment and Conservation Council and the National Health Environment and Medical Research Council (ANZECC & NHMRC), 1992 *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites;* and
4. National Environment Protection Council (NEPC).1999. *National Environment Protection (Assessment of Site Contamination) Measure 1999*.

Based on the results of the proposed investigation, plans for protecting the health of constructions workers and for managing and re-using excavated spoil should be prepared and included in the CEMP. This could include remediation of any significantly contaminated soil. Any waste spoil generated should be managed in accordance with the *Waste Classification Guidelines*, DECCW 2008.

Prevent infiltration of groundwater to trench

Groundwater infiltrating the trench can cause tunnel erosion in the trench after it has been constructed. Backfill compaction can help prevent this but on steeper sections of pipe an additional mitigation measure would be used. Seepage controls such as sandbags the height of the trench would be installed at regular intervals along the pipeline trench as appropriate (Refer Appendix G).