



Kiama Municipal Council

Minnamurra Waste Disposal Depot Annual Groundwater & Surface Water Monitoring Report – 2015 to 2016

Report E2W-059 (R001 v2)

21 November 2016



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Environmental & Groundwater Consulting

Client: Kiama Municipal Council

**Project: Annual Surface and Groundwater Monitoring Report Minnamurra
Waste Disposal Depot
(EPL 2015 to 2016)**

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1. INTRODUCTION

Earth2Water Pty Ltd (E2W) was engaged by Kiama Municipal Council (KMC) to provide the 2015 to 2016 annual surface and groundwater monitoring report for the Minnamurra Waste Disposal Depot (MWDD).

This report is based on information provided in field and laboratory reports provided by ALS Environmental Pty Ltd (formerly Ecowise) and previous monitoring reports by E2W (2004 - 2015), Eco-engineers Pty Ltd and Forbes Rigby Pty Ltd (pre 2004).

This monitoring report for the MWDD is based on quarterly monitoring results (3 November 2015, 15 February 2016, 30 May 2016, and 11 August 2016) and NSW EPA Environmental Protection Licence (EPL) conditions (R1.10). E2W completed the landfill closure plan (LCP in October 2005) and construction quality assurance (April 2008) for the landfill rehabilitation works completed by KMC in January 2008.

1.1 Background

KMC has owned and operated the MWDD from the 1960's until its closure in October 2006. The MWDD operated as a Solid Waste Class 1 Landfill under the EPL No. 5958. The MWDD formerly comprised a night soil depot for liquid pump out sullage, which ceased in 1998. The existing licence and amendments required the submission of a Landfill Closure Plan (LCP), which was completed by E2W in October 2005.

Since November 2012, Minnamurra Landfill has accepted mixed food and garden organics (i.e. food waste trial), together with small loads of recyclable materials. All general waste materials are diverted to the waste facility at Shellharbour (Dunmore Waste Disposal Depot).

1.2 Objectives

The objective of surface and groundwater monitoring in the 2015 to 2016 reporting period was to assess actual or potential impacts associated with the MWDD on the surrounding aquatic environment. Gas monitoring is undertaken by KMC to measure the performance of landfill rehabilitation works.

The objective of this annual report is to provide KMC and the NSW EPA with a summary of the monitoring results obtained in the 2015-2016 reporting period (i.e. EPL 5958 conditions).

2. SCOPE OF WORK

E2W was commissioned by KMC to collate and assess surface and groundwater monitoring data provided by ALS (Ecowise) during 2015 and 2016. The annual reporting period covers four quarterly monitoring events in November 2015, February 2016, May 2016 and August 2016 (Figures 1 & 2).

Each monitoring event comprised the following:

- Sampling of onsite and offsite groundwater wells MD1B, MD1A, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, and MD10B¹.
- Sampling of surface water at three locations along Rocklow Creek (Rocklow-Up, Rocklow-Middle and Rocklow-Down).

Landfill gas monitoring was conducted by KMC (G.Hardy) at gas monitoring wells, biofilter pads and inside buildings. Monitoring was conducted using a calibrated landfill gas meter (GT402).

E2W undertook the following scope of work to satisfy KMC's surface and groundwater monitoring program at MWDD:

- Provide advice to KMC (in relation to monitoring results- as required).
- Prepare this annual report for monitoring period (November 2015 to August 2016) and comply with Section R1.10 of the EPL (No. 5958). The annual report is to include the following:
 1. Tabulation of the monitoring data obtained for the period.
 2. Graphical representation of the current and previous monitoring data (minimum - last three years). Statistically significant variations or anomalies will be highlighted.
 3. Analyses and interpretation of monitoring data.
 4. Analyses and response to any complaints received.
 5. Identification of any deficiencies in the environmental performance of the MWDD, as highlighted by the monitoring data, trends and/or accidents.
 6. Recommendations to address the above identified deficiencies.
 7. Recommendations on improving the overall environmental performance of the facility.

Rehabilitation of the landfill commenced in August 2006 and was completed by KMC in January 2008. The work included reshaping, cut/fill of waste materials and capping with clays and soil/compost mix (i.e. evapotranspiration layer). The rehabilitation works may have temporarily degraded the runoff and shallow groundwater (2007) due to exposure and leaching of buried putrescible waste which was redistributed during the reshaping. In early to mid 2016, E2W and Council commenced testing of new extraction bores near MD-9C to assess yields, water quality and the potential for reducing the leachate impact (i.e. ammonia >100 mg/L) by irrigation on the mound.

Council provided the following information regarding a reportable pollution incidence at the site; *"On Wednesday 17-08-16 morning at approx. 6am we discovered a very small fire in our mulch stockpile (approx. 2 metres x 4 metres). We used a front end loader and excavator to remove this section from the stockpile and extinguish it using compaction and water from our onsite water tanker. The incident was reported to EPA after hours at approx. 6.15- 6.30 am as per our Pollution Incident Response Management Plan. The reference number for this reported incident*

¹ The shallow well was consistently dry MD4A. The two wells were dry (50%) on occasions: MD1A, MD1B

is 132523. Once it was daylight we then spread out the balance of the mulch stockpile to reduce the heat and then compacted the material to reduce any further risk of fire”.

3. ENVIRONMENTAL SETTING

The Minnamurra Waste Disposal and Recycling Depot (MWDD) is located 1 km north of the Minnamurra town ship (Figures 1 and 2). The site is located within a swamp environment, bounded to the west by the rail line and Riverside Drive (formerly a part of the Princes Highway), and to the north and east by the confluence of Rocklow Creek and Minnamurra River. The site is approximately 1 km west of Mystics (Minnamurra) Beach (Figure 1).

The MWDD covers an area of approximately 50 acres (~20 ha), while the landfill mound occupies approximately 6 ha. At present, the MWDD comprises the following features:

- An elevated landfill mound (capped) ranging from 1 to 14 m AHD. The landfill mound was rehabilitated in 2006/2007 according to the LCP submitted by E2W in October 2005,
- A weighbridge and administration office/toilet block,
- KMC truck parking area,
- KMC storage sheds,
- Dog impounding facility,
- Green waste/composting,
- Waste/recycling receival & transfer station.

3.1 Climate

The long-term mean and median rainfall values available for the Kiama Bowling Club (Latitude 344033 N and Longitude 1055103E) between 1897 and 2001 indicate that average yearly rainfall at the MWDD is 1261 mm/year. On average, the MWDD would receive approximately 1220 mm, based on rainfall records obtained from Shellharbour and Albion Park (Forbes Rigby, 1996).

The annual rainfall from August 2015 to July 2016 was 1260 mm which is similar to the previous year (August 2014 to July 2015 was 1269² mm). The annual rainfall in previous years are as follows; August 2013 to July 2014 = 873.0 mm³, 1201.8 mm = August 2012 to July 2013, 1282.8 mm = August 2011 to July 2012, 1308 mm = August 2010 to July 2011, 1054.4 mm = August 2009 to July 2010. Periods of high monthly rainfall occurred in June 2016 (328 mm) and August 2015 (260.4 mm) and are reflected in higher water levels in the following months (note: the pattern with ammonia trends is not clear or consistent).

² Bombo Headland

³ Note: data from Kiama (Bombo Headland) (Station ID 068242), ~4.5 km SSE of MWDD.

3.2 Topography

A plan of the existing site topography and surrounds is presented in Figure 1. The site is located within mangrove tidal flats, an estuarine environment associated with Rocklow Creek and Minnamurra River (Figure 7 of Appendix B).

Local relief is less than 3 m AHD around the footprint of the landfill (except southern wall), with slopes generally less than 5%. The landfill forms a mound, which reaches a maximum of 14 m AHD above the surrounding low-lying ground surface (approximately 1 m AHD).

The RL of the landfill footprint area ranges from approximately 0.6 m AHD (north-east corner) to 5.2 m AHD (southern wall). On the western side of Riverside Drive the land rises rapidly to a small east and north-east facing ridge where Dunmore House is situated (Figures 1 and 2).

3.3 Geology

The site is located within Quaternary alluvial sediments comprising sands and silts. Based on drilling investigations undertaken by Forbes Rigby in 1996 and recent investigations at the site by KMC and E2W in 2005, the geology is dominated by fine to medium sandy sediments with minimal sandy silt and sandy clays. In most places, the sand is overlain by a 0.5 m thick organic silty loam.

Drill cores by the Geological Survey of NSW in the Rocklow Creek valley predominantly consist of poorly to well-sorted very fine to medium-grained quartz lithic sands. Sand deposits typically extend to a maximum depth of 14 m, with increasing clay content below about 7 m (Forbes Rigby, 1996).

3.4 Hydrogeology and Groundwater Flow Regime

The hydrogeology at the site is dominated by a semi-confined sandy aquifer. Groundwater is encountered at depths of approx 1 m below natural ground level (~0.5 m AHD) along the west, north and east sides of the landfill mound. The depth to water along the southern wall is not well known.

The groundwater quality at the site varies from fresh to saline, with electrical conductivity ranging from 0.85 to 44.6 mS/cm (E2W, October 2005). Groundwater generally becomes more saline in the vicinity of mangroves and tidal saline water bodies (i.e. Rocklow Creek and Minnamurra River).

Recharge to the aquifer system beneath and surrounding the waste disposal facility occurs from rainfall infiltration mainly outside of the capped landfill mound. Infiltration of rainfall is moderate (~30%) around the footprint area, due to the low elevation and leakage through the organic silt layer.

Groundwater gradients in the area of the waste mound are controlled by topography, permeable sands and the nearby tidal water bodies (Rocklow Creek and Minnamurra River). The predominant groundwater flow direction at the site is considered to be north-east and towards the confluence of Rocklow Creek and Minnamurra River. The hydraulic gradient is likely to be variable, depending on the tidal regime and proximity to the river. It is interpreted that the groundwater gradient is at a maximum during low tide and potentially reverses at high tide or high rainfall.

Groundwater discharge at Rocklow Creek and Minnamurra River is influenced by the presence of a fresh groundwater/salt water interface. The interface results from the density difference between groundwater and seawater. It is a dynamic and complex region with upward hydraulic gradients, tidal fluctuations, diverse microbiological processes, surface and groundwater interaction and salinity variations. The groundwater/salt water interface is generally associated with natural attenuation processes (biodegradation, dilution, sorption etc.), which tend to reduce levels of contaminants prior to discharge to marine ecosystems. The groundwater salt water interface is interpreted to exist at the boundary of the casuarinas and mangroves at the site.

The contamination of deep and shallow groundwater arises from nutrient enrichment at the MWDD and has been reported on in previous annual monitoring reports by Ecoengineers Pty Ltd (2004) and E2W (2005, 2006 and 2007).

The leachate plume originating from the MWDD is likely to persist for many years after landfill remediation due to the age (1960s) of the waste mound. Improvements in groundwater quality is expected over the short to medium term (up to ~10 years) reflecting the rate of natural attenuation and groundwater flushing effects from rainfall recharge.

3.5 Hydrology

The hydrology of the area is dominated by Rocklow Creek and Minnamurra River. Groundwater discharge, with possible leachate from both the Minnamurra and Shellharbour landfills, may be contributing to the nutrients detected in Rocklow Creek (Figure 1).

The Minnamurra River drains a catchment of approximately 142 km². Seventy percent of the catchment is natural, mainly located on the steeper slopes of the Illawarra escarpment. The middle section of the catchment is characterised by a broad floodplain area called Terragong Swamp. This area, which comprises approximately 30% of the catchment, is used extensively for cattle grazing/dairying. The township of Jamberoo is located within this catchment. It can be expected that the Terragong Swamp farming area and Jamberoo itself are significant sources of nutrients and pollutants entering the river.

The entrance of Minnamurra River is permanently open, and the estuary is tidally influenced. The estuarine portion of the river extends approximately 7 km upstream from the mouth and has the suburb of Minnamurra on its western bank. The lower section of the river is an ecologically significant aquatic environment, comprising areas of seagrass, mangrove and salt marsh communities (Forbes Rigby, 1996).

Rocklow Creek catchment has an area of 23 km² and occupies the northern most portion of the Minnamurra River catchment. Rocklow Creek flows into the main arm of the Minnamurra River downstream of the MWDD, approximately 2 km upstream of the river entrance. Potential up-gradient sources of contamination may include the Shellharbour landfill, Princes Highway, Riverside Drive and nearby sand mining operations.

Water samples from Rocklow Creek and Minnamurra River have been collected by the DECCW in 1991 and 2005 (Denis Pascall, August 2005), as part of a water quality and landfill impact assessment for the area (Forbes Rigby, 1996).

The following opinions were offered as a result of DECCW's sampling work:

- Concentrations of most indicators (except dissolved oxygen) are considerably higher in Rocklow Creek than in Minnamurra River; and
- Concentration of nutrients (ammonia) measured at several locations along Rocklow Creek indicate that Shellharbour and Minnamurra landfills may be contributing leachate into the aquatic ecosystem.

One upstream and one downstream Rocklow Creek location are sampled as part of the quarterly MWDD water quality monitoring program. Since 2009, a third location midstream of the creek has also been sampled. Access to the downstream location has been restricted due to mangrove growth along the track (no sample for past three years). Sampling is undertaken by ALS (formerly Ecowise- the sample location was re-established in 2014 once access was available through the mangroves).

4. LICENCE CRITERIA AND RELEVANT GUIDELINES

Under the NSW EPA requirements for Licence No. 5958, the criteria for surface and groundwater quality are based on the ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

The ANZECC guidelines include risk-based trigger levels and indicative interim working levels (IIWLs). The IIWLs are used when insufficient data is available to calculate a trigger level and are of low reliability. It should be noted that the ANZECC water quality guidelines are applicable to receiving water and not groundwater. However, they form an appropriate basis for undertaking a screening level assessment of groundwater quality. Selection of the applicable guideline values are based on an assessment of potential pathways by which human or environmental exposure might take place, as well as the beneficial end use of the groundwater.

The beneficial use classification for groundwater at the site depends on the quality of the water and its potential use in the long term. Although groundwater in the shallow aquifer surrounding (upgradient) the waste disposal facility is likely to be of relatively good quality (depending on the presence of saline intrusions), there are no known groundwater extraction bores (agricultural or domestic) within the immediate vicinity of the site. Therefore, the appropriate beneficial use category of the groundwater is considered to be for the protection of aquatic marine and fresh water ecosystems in discharge zones at Rocklow Creek and Minnamurra River, the closest aquatic environmental receptors for the site.

The adopted groundwater assessment guidelines are presented with the summary analytical results (i.e. Tables GW-1, SW-1). Exceedances of the ANZECC (2000) trigger values for marine water ecosystems have been highlighted on the tables.

4.1 EPL Requirements

The Environmental Protection Licence (EPL No. 5958) details 17 monitoring points for the MWDD (two for landfill gas and fifteen for groundwater monitoring). The landfill gas monitoring points are required to be analysed for methane every 6 months (i.e. twice in the reporting period). Landfill gas monitoring was conducted on a quarterly basis by KMC (Appendix C) at gas wells and trenches, however annually for inside buildings.

The frequency of testing of the groundwater monitoring points (MD1A, MD1B, MD2A, MD2B, MD2C, MD4A, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, MD10B) is also half yearly (EPL requirement). However, KMC conducts the groundwater monitoring on a quarterly basis (November 2015, February 2016, May 2016 and August 2016 of each reporting period) to establish water quality trends post landfill rehabilitation works.

Some of the groundwater monitoring locations (i.e. MD4A, and previously MD2A, MD6A, MD9A, MD10A) are sampled on some occasions (i.e. shallow wells are commonly dry or do not have enough water for sampling). Other available wells onsite including MD3B, MD3C, MD7, MD5A/B/C and MD8 however are not part of the EPL (previously tested prior to landfill closure for characterising the local groundwater).

Table 4.1 (below) lists the analytes that are included in the groundwater testing suite.

Table 4.1: Half yearly groundwater analytical suite (as per the EPL)

Alkalinity (as CaCO ₃)	Dissolved Oxygen	Nitrate	Temperature
Ammonia	Fluoride	Potassium	Total Phenolics
Calcium	Iron	Sodium	Total Organic Carbon
Chloride	Magnesium	Standing Water Level	pH
Conductivity	Manganese	Sulphate	

Surface water monitoring is not a requirement of the EPL, however is also undertaken quarterly by KMC in conjunction with groundwater monitoring. Surface water samples are collected and analysed from an up-stream (Rocklow-Up) and mid-gradient (Rocklow-Middle) locations. An alternative sample location was established in May and August 2015 for the down-gradient location (Rocklow-Down, Figure 2).

The mid sample location was included to assess the performance of the landfill rehabilitation works and requirement for a bund wall around the landfill (i.e. access to the downstream location was impeded due to the thick vegetation and relocated in May 2015).

4.2 Previous Monitoring Results

The previous annual monitoring reports have been provided by E2W, Ecoengineers and Forbes Rigby. Groundwater ammonia results presented in these earlier reports are included in graphical form and attached in this report (Graphs -1, 2 & 3).

Ammonia is a key landfill leachate indicator based on the results obtained from monitoring wells placed around the MWDD. Landfill leachate has impacted the local groundwater system, with potential or actual impact to Rocklow Creek and Minnamurra River (Appendix B, Figure 7).

5. ENVIRONMENTAL MONITORING

Prior to May 2005, surface and groundwater monitoring was undertaken by KMC. Ecowise were (since August 2005) engaged to sample and analyse the surface and groundwater monitoring points as per the EPL and performed the November 2009 sampling round. Ecowise were acquired by ALS in November 2009, who carried out the subsequent surface and groundwater sampling in the reporting period (2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015). Quarterly sampling in the 2015 to 2016 reporting period was undertaken on the following dates:

- 3 November 2015,
- 15 February 2016,
- 30 May 2016; and
- 11 August 2016.

The procedure for sample collection, storage and handling employed by KMC and Ecowise/ALS are generally in accordance with NEPM (2013) and ANZECC (2000).

The following subsections outline the nature of the site's monitoring and analytical program, as well as conditions at the time of sample collection (from information provided by KMC).

5.1 Landfill Gas Monitoring

The landfill gas testing locations (areas where intermediate or final cover has been placed and inside all buildings within 250 m of the deposited waste) were tested by KMC (2 February 2015, 5 May 2016, and 9 September 2016) during the 2015/16 reporting period (Appendix C).

Six onsite landfill gas wells (Gas 1 to Gas 6) were installed by E2W on 2 August 2006 and gas monitoring has been performed since then as part of the landfill rehabilitation work. Landfill gas monitoring is a requirement of the EPL, but only relates to onsite buildings/sheds and the waste mound (over the capped area).

Two gas monitoring wells (i.e. Gas 5 and Gas 6) have not been monitored since November 2009 as they are located at the same location as Trench 1 (i.e. alternative gas test location, Refer to Figure 1 in Appendix C). The gas well (Gas-2) was removed end of 2014 due to construction of the CRC shed.

Monitoring data (2015/2016) from the trenches (biofilter pads, Trench 1 to Trench 7) and gas monitoring wells (Gas 1, Gas 3 & Gas 4) showed similar concentrations to previous years (i.e. 2010/2011/2012/2013/2014/2015). Methane gas readings were consistent at each sampling event through the monitoring period. The maximum methane (stable) gas reading was 490 ppm at Trench 4 (8 February 2016). The lowest readings were 100 ppm at two locations: Trench 2 & 4 in February 2016. Several gas well locations reported low concentrations (100 to 120 ppm) at Gas-3 & 4 during 2016. The highest readings at each sampling event were recorded at either Trench 4, or Trench 1. Buildings were sampled for landfill gas in 2016, with all locations recording no methane gas readings (non-detectable and compliant with EPL conditions).

E2W interpret that landfill gas is unlikely to be present in the buildings due to the previous results, landfill capping, and type of onsite buildings (i.e. well vented or air conditioned office).

5.2 Surface and Groundwater Monitoring Locations

Groundwater monitoring was undertaken from up to 16 existing groundwater wells (shallow, intermediate and deep) located on the landfill mound perimeter and surface water monitoring at two locations along Rocklow Creek (up, middle and down-gradient of the landfill mound, whilst access was re-established at Rocklow-down in May 2015). Monitoring locations are shown on Figure 2.

The wells and surface water locations sampled in the 2015 and 2016 reporting period are outlined below:

- 3 November 2015. Groundwater wells: MD2B, MD2C, MD4B, MD4C, MD6B, MD6C, MD9B, MD9C, MD10B, Surface water: Rocklow-Up, Rocklow-Middle;
- 15 February 2016. Groundwater wells: MD2B, MD2C, MD4B, MD4C, MD6B, MD6C, MD9B, MD9C, MD10A, MD10B, Surface water: Rocklow-Up, Rocklow-Middle, Rocklow-Down.
- 30 May 2016. Groundwater wells: MD1A, MD1B, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10B, Surface water: Rocklow-Up, Rocklow-Middle, Rocklow-Down;
- 11 August 2016. Groundwater wells: MD1A, MD1B, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, MD10B, Surface water: Rocklow-Up, Rocklow-Middle, & Rocklow-Down.

Out of the 16 wells that were “not” tested in the 2015 and 2016 reporting period, but are part of the EPL include:

- MD1A & MD1B. No access in 2 rounds
- MD4A. Dry/damaged well in all 4 rounds

It is noted that shallow wells tend to be dry at time of sampling. One well has been damaged and requires repair (i.e. MD4A).

The nature of saline water stratification within the local groundwater system and well network is presented in Table 5.2.1 (below) and Appendix B (Figure 7).

Table 5.2.1: Summary of Groundwater Salinity Changes with Depth

Well ID	Salinity (EC, $\mu\text{S/cm}$)	Comment
MD1B	850	Fresh- water 10 m away is saline
MD2A	25,200	surface water from high tide
MD2B	29,100	saline groundwater
MD2C	44,600	saline groundwater
MD4A	NA	Damaged well (shallow/dry)
MD4B	15,300	saline groundwater
MD4C	33,100	saline groundwater
MD6A	11,100	surface water from high tide
MD6B	2,221	fresh - brackish groundwater
MD6C	27,400	saline groundwater
MD9A	3,375	fresh - brackish groundwater
MD9B	3,207	fresh - brackish groundwater
MD9C	3,600	fresh - brackish groundwater
MD10A	40,900	saline groundwater
MD10B	2,797	fresh - brackish groundwater

Note: Electrical Conductivity data is from sampling by E2W on 29 June 2005.

Well suffix 'A' and 'B' = shallow well screen (less than 3 m into water table).

Well suffix 'C' = well screen greater than 3 m below water table (refer to Figure 7 in Appendix B).

Several of the groundwater wells (MD4A/B/C, MD6A/B/C etc.) comprise nested wells, which target various depths within the coastal sand aquifer. The sampling frequency and depth of the groundwater samples are presented in Table 5.2.2 (below).

Table 5.2.2: Monitoring Summary for the 2015 to 2016 Reporting Period

Sample ID	Screen Interval (m AHD) - or Sample Location	Nov 2015	Feb 2016	May 2016	Aug 2016
(MD1A)	0.5 to -0.5	No Access/dry	No Access/dry	X	X
MD1B	-4.7 to -5.7	No Access/dry	No Access/dry	X	X
MD2A	0.525 to -0.475	X	X	X	X
MD2B	-2.93 to -3.93	X	X	X	X
MD2C	-5.2 to -6.2	X	X	X	X
(MD3B)	-3.22 to -4.22*				
(MD3C)	-5.55 to -6.55*				
MD4A	1.2 to 0.2	Dry	Dry	Dry	Dry
MD4B	-3.22 to -4.22	X	X	X	X
MD4C	-5.55 to -6.55	X	X	X	X
MD6A	0.71 to -0.30	X	X	X	X
MD6B	-1.05 to -2.05	X	X	X	X
MD6C	-8.8 to -9.8	X	X	X	X
(MD7)	0.5 to -0.5 *				
(MD8)	0.5 to -0.5*				
MD9A	0.58 to -0.42	X	X	X	X
MD9B	-2.3 to -3.3	X	X	X	X
MD9C	-4.75 to -5.75	X	X	X	X
MD10A	0.68 to -0.32	X	X	X	X
MD10B	-2.85 to -3.85	X	X	X	X
Rocklow-Up	Upstream of landfill	X	X	X	X
Rocklow-Middle	Midstream of landfill	X	X	X	X
Rocklow-Down	Downstream and opposite landfill	X (new location)	X (new location)	X (new location)	X (new location)

*Note: *= to be confirmed (logs not available). X = Sample collected.*

(MD7), well in brackets = well is not an EPL requirement. Blank space = not sampled.

= Not enough water for sampling

The groundwater monitoring wells and sampling depths for each event are summarised in Table 5.2 (above) and Table 5.3 (rear of report). The sampling labels for the nested wells ('A' to 'C') are attached to each of the depths associated with these wells (e.g. MD1A, MD1B, MD1C).

6. MONITORING RESULTS

All surface and groundwater analytical results for the 2015/16 reporting period are presented in Tables GW-1, and SW-1, SW-2, and SW-3. The ALS field records and laboratory reports are presented in Appendix A.

A summary of all groundwater monitoring data (1999 to 2016) for ammonia (mg/L) is presented in Graph-1, Graph-2 and Graph-3. The graphs highlight ammonia groundwater quality trends over the past ~ 15 years (January 1999 to August 2016). Ammonia is considered to be a key landfill leachate indicator for the site.

A summary of previous ammonia surface water results for Rocklow Creek is presented in Table SW-2. Ammonia is considered as the key landfill leachate indicator in surface water, however other sources of ammonia exist in the same catchment (i.e. fertiliser use in paddocks and Dunmore landfill on the opposite side of Rocklow Creek).

6.1 Groundwater Data

Groundwater for the 2015/16 reporting period was collected from a network of seventeen monitoring wells (mostly downgradient locations) at the MWDD (Figure 2). The results of the groundwater testing are summarised in Table GW-1, Graphs-1 to 3, Figure 2 and in the following subsections.

6.1.1 Groundwater Depth

The depth to groundwater was measured prior to each sampling event using a water level probe. Depth to the groundwater below top of casing and relative to a common reference (i.e. Australian Height Datum, m AHD) is presented in Table GW-1. The inferred radial groundwater flow direction for the site is presented in Figure 2. Given the proximity to Rocklow Creek, the groundwater flow direction and gradients would be influenced by tides.

The groundwater levels recorded from the 2015/16 reporting period are similar to previous years and reflect changes in rainfall and tide levels.

The reduced groundwater levels (m AHD) from the 16 wells sampled in 2015/16⁴ indicate a relatively low water table elevation (<1 m AHD), which is characteristic of the swamp/estuarine environment. The annual rainfall from August 2015 to July 2016 was 1260 mm (Albion Park Airport), which is similar to the previous year.

Recharge to the aquifer system beneath and surrounding the waste disposal facility mainly occurs from rainfall infiltration and storm water runoff around the footprint. Minor recharge may occur through the landfill mound (e.g. <5% of annual rainfall). The infiltration of rainfall is interpreted to be moderate/high around the footprint area (uncapped areas) due to the sandy soils, low elevation and run-off.

⁴ Note: MD2A, MD4A, MD10A, MD10B have no RL measurement.

6.1.2 Field Parameters

The field parameters measured during groundwater sampling are indicative only, due to the low purge volumes (ALS sampling) and dominant reduced/anaerobic condition of the groundwater (Table GW-1).

Insitu measurements (within borehole) are likely to provide a more accurate rendition of the field chemistry, especially with respect to dissolved oxygen (parameters are not considered critical for the quarterly monitoring).

6.1.2.1 Field pH

The pH from the 15 wells (MD1A, MD1B, MD2A, MD2B, MD2C, MD4B, MD4C, MD6A, MD6B, MD6C, MD9A, MD9B, MD9C, MD10A, MD10B) ranged from pH 6.5 to 7.6 (MD10A and MD1A, respectively) in the 2015-16 reporting period, indicating relatively neutral groundwater.

Fluctuation (minor) in pH is likely to relate to a combination of factors including leachate quality, acid sulphate soils, tidal influences (together with a rise in electrical conductivity) and surface water quality.

E2W considers that field pH measurements may be more reliable than laboratory, as the pH of waters can change once out of equilibrium with the natural environment and stored within containers (holding time for pH is less than 4 hrs).

6.1.2.2 Electrical Conductivity (EC)

The EC in groundwater collected from the site ranged from approximately 533 to 43,500 uS/cm in the 2015/16 reporting period (MD1B and MD2C, respectively). The salinity reflects the transgression/regression of fresh and marine groundwater and presence of saline groundwater at depth (Figure 2 & Appendix B).

The distribution of EC indicates fresh water is located under the landfill mound and close to the landfill footprint, with sharp salinity increases near Rocklow Creek and Minnamurra River (Figure 7, Appendix B). The saline water correlated with the fresh/salt water interface and presence of mangroves/sedges (tidal area).

6.1.2.3 Dissolved Oxygen (DO)

The 15 wells recorded field dissolved oxygen (DO) concentrations ranging between 0.26 to 4.69 mg/L in the 2015/16 reporting period (MD1A and MD10A, respectively). The concentrations of dissolved oxygen were similar to those reported in previous annual monitoring reports.

It is likely the concentrations of DO would be lower if measured insitu, as opposed to during the purging and sampling process. Wells with low purge volumes (& sampling via a bailer) are unlikely to provide representative groundwater DO concentrations.

Landfill leachate and the organic rich sediments (estuary) are likely to deplete DO in the groundwater (e.g. MD9C). This phenomenon is seen on many landfill sites, where organic carbon and nutrients provide surplus electron acceptors, which react with and consume the available DO in groundwater.

6.1.3 Nutrients (groundwater)

6.1.3.1 Nitrogen-based compounds

Groundwater collected from the MWDD monitoring wells were analysed for ammonia and nitrate in the 2015/16 reporting period (note: Total nitrogen is not an EPL requirement).

Six (MD1A, MD1B, MD2A, MD2C, MD6A, MD10B) out of the 15 wells reported one or more samples with nitrate concentrations above the ANZECC (2000) trigger value for fresh water ecosystems (0.7 mg/L, at 95% protection level). In 2015/2016 concentrations ranged from <0.01 (non-detected/below LOR) to 8.5 mg/L (MD-10B), which is higher than previous years.

Nitrate has been detected in more wells in the 2013/2014 monitoring round (nine wells above ANZECC 2000) in comparison to the 2012/2013 monitoring round (eight wells above ANZECC 2000). The majority of nitrate concentrations in groundwater in 2015/2016 are generally very low (except 4 wells, below ANZECC 2000) relative to the ammonia concentrations. Occasional elevated nitrate results are from shallow wells (e.g. MD1A, MD1B, MD10B, MD2C, Figure 2B).

Nitrogen species in the groundwater is predominantly ammonia, and indicative of a reducing groundwater environment. Thus, potential impact to the aquatic environment is interpreted to arise from ammonia, and to a lesser extent, the oxidised nitrogen form (nitrate).

The guidelines (ammonia) for the protection of freshwater and marine ecosystems vary according to pH and temperature. Given the range of pH and temperature measured across the site and in Rocklow Creek, the guideline values have been calculated as 1.88 and 2.84 mg/L for fresh and marine waters, respectively (at pH of 7.3).

Fourteen (14) out of 15 wells (excluding MD10A) reported ammonia concentrations in excess of the ANZECC (2000) trigger value for marine ecosystems (2.84 mg/L, based on a pH of 7.3) in either of the 4 rounds of sampling.

Groundwater from the wells MD1A, MD2A, MD4B, MD4C, MD6A, MD6B, MD6C, MD9B, MD9C and MD10B, located on the north and eastern landfill perimeters (plume centreline path) reported the highest concentrations of ammonia (Figure 2). Well (**MD9C**) reported the maximum ammonia of **162** mg/L (November 2015), which is similar to November 2014 (170 mg/L), and higher than the maximum in 2012/13 (ammonia=122 mg/L) and in 2010/2011 (ammonia= 118 mg/L). Ammonia trends are presented in the time series Graphs 1 to 3. Highest ammonia correlates with the main downgradient area (plume centreline) of the waste mound and above average rainfall conditions. The 11 August 2016 results from MD9C (107 mg/L) may indicate a beginning of a potential decreasing trend.

It is noted that rehabilitation works were completed in early 2008, and the 2008/09 and 2009/10 ammonia concentrations have generally decreased since then at most well locations. Well locations MD2B, MD2C and MD9B have decreased in maximum ammonia concentrations in 2012/13 in comparison to the previous 2011/12 period. Well (MD10B) has a variable to rising trend, however has significantly decreased in the past two monitoring events (Note: further monitoring is required to verify the 2016 change to a possible declining ammonia trend).

6.1.4 Ammonia Trends

The groundwater ammonia trends from 1999 to 2016 are presented in Graphs-1, Graph-2 and Graph-3. The data indicates ammonia in most monitoring wells exceed the ANZECC (2000) marine water trigger value. A summary the ammonia trends are presented in Table 6.1.4.

Table 6.1.4 Summary of Ammonia Trends in Groundwater (1999 to 2016)

South-east of Landfill (Across-gradient)		North of Landfill (Down-gradient, plume centreline)	
Well ID	Trend	Well ID	Trend
MD1B	Overall Decreasing, but variable	MD4B	Variable with possible rising trend
MD2B	Overall Decreasing	MD4C	Overall Decreasing
MD2C	Overall Decreasing	MD9B	Variable and Overall Decreasing
MD6B	Variable trend	MD9C	Rising trend & peaks in late 2011, late 2012, mid & late 2014 and 2015, with a possible decreasing trend from Aug 2016.
MD6C	Overall Decreasing, & recently stable	MD10B	Variable trend- 2015 & 2016 (possible recent decreasing trend)

Note: "B" and "C" denote shallow and deep wells, respectively.

The ammonia trends are generally variable over time; however most locations show a downward or stable trend. The ammonia from the quarterly monitoring events may reflect a combination of seasonal rainfall, tidal fluctuations and the landfill rehabilitation works.

Monitoring reports (e.g. E2W, 2008-09, 2009-10, 2010-11, 2011-12, 2012-13, 2013-2014, 2014-2015) have identified spikes in ammonia concentrations that are interpreted to result from high rainfall in preceding months. For example, in February 2008, high rainfall (169.2 mm, 5 February) was followed by a rise in ammonia in early to mid 2008. In October 2009, 187.8 mm of rainfall, which was the highest monthly rainfall recorded for the 2009 calendar year (next highest December 2009, 106.2 mm). During the 2010-11 monitoring period, 22 March 2011 (163.8 mm rainfall) was followed by a rise in ammonia (May 2011, Graphs 1-3)⁵. Over the 2011/12 period, a combined 176.2mm rainfall from 20 to 23 July was followed by an increase in ammonia (November 2011, Graph 1-3). Rainfall of 289 mm in February and 213.2mm in March 2012 (502.2mm combined in 2 months) was followed by rises in ammonia (May 2012, Graph 1-3)⁷.

⁵ Rainfall data taken from the Kiama (Bombo Headland) Weather Station, (Station ID 068242)

During the 2012/13 period, high rainfall was experienced in January 2013 (170.8 mm) and February 2013 (153.2 mm) resulting in elevated ammonia during the February monitoring. In addition, high rainfall in April 2013 (183.6 mm) was followed by a rise in ammonia in May 2013. This occurred again in the 2013/14 period with high rainfall in November 2013 followed by a rise in Ammonia in the November 2013 samples and high rainfall again in March and April 2014 followed by an increase in Ammonia in the May 2014 samples. The ammonia peak in November 2014 (170 mg/L) and November 2015 are interpreted to be associated with high recharge rainfall events. The reduced ammonia in August 2016 (107 mg/L) indicates a potential beginning from a decreasing trend even though high rainfall occurred in preceding months (June 2016 rainfall =328 mm).

Rainfall events before or on the dates of sampling may contribute to rising ammonia concentrations in the groundwater due to flushing effects (e.g. leachate migration/generation and/or rising water table).

During 2014 to 2016 ammonia concentrations are generally variable at MD9C (hotspot area). In 2016, ammonia continues to decrease (variably) in wells compared with previous monitoring periods, but with continued variability (Graph-1 to Graph-3) likely to be reflecting rainfall spikes. Two wells with elevated concentrations of ammonia show variable and increasing trends (MD9C and MD4B). Recent results (August 2016) indicate possible reversal of the increasing ammonia trend at MD9C.

Review of aerial photographs taken of the landfill in late 2007 shows that the NE corner (where most of the wells are situated) was the last to be reshaped, capped and vegetated (& increase the potential for leachate generation and migration, as would have disturbance of soil and waste in that area). Continued monitoring of ammonia concentrations and climate is required to establish seasonal trends.

The amount of landfill leachate generated would decline following the closure of the landfill and completion of rehabilitation works. The groundwater quality is likely to take years (5+) to show improvements due to the scale of the mound, flat hydraulic gradients (in estuary) and tidal movements (some reversal of gradient a high tide) around the landfill footprint. Some remedial works may be required to speed up the groundwater quality improvements.

Results from 2012 to 2016 monitoring periods show cyclical seasonal trends (i.e. a variable, but generally decreasing ammonia trend). Future monitoring is required to assess ammonia trends and characteristics (nature of trends and variations), especially at MD9C, MD10B, and MD4B well locations, representing the centreline and core of leachate plume.

6.1.4.1 Total Phosphorus (TP, groundwater)

The total phosphorus (TP) is not an EPL requirement, and was not sampled during the 2015-2016 monitoring period. In the 2007/08 monitoring period the majority of TP results from twelve wells exceeded the ANZECC (2000) trigger values for the protection of marine ecosystems.

6.1.5 Hydrogeochemical Indicators

Concentrations of major ions (chloride, sulphate, calcium, magnesium, sodium and potassium) in the groundwater at the site are presented in Table GW-1. The concentrations of major ions in all monitoring wells are within previously reported ranges and generally dominated by one cation (sodium) and anion (chloride). In wells with freshwater, (MD6B and MD10B) calcium concentrations are similar to, and sometimes greater than sodium concentrations.

The landfill leachate may be contributing concentrations of ions including calcium, potassium and magnesium. Contribution of sodium and chloride is difficult to ascertain as these ions are typically associated with marine environments (e.g. salt spray, tidal influence).

6.1.6 Inorganic Contaminants (Iron, Manganese and Fluoride)

Total iron (filtered at the laboratory) ranges from the 0.05 mg/L at MD1B to 17 mg/L (MD6C). With the exception of MD6B, MD1A, MD1B all the groundwater wells reported ANZECC (2000) exceedances (freshwater ecosystems, 0.3 mg/L) in at least one in of the four sampling rounds.

It is noted that the ANZECC (2000) guideline for iron is an indicative interim working level (IIWL) and is of low reliability. No guideline is available for iron in marine water, which has a higher relevance to Rocklow Creek and receiving water bodies.

Concentrations of manganese ranged from 0.012 mg/L (MD9A/MD1B) to 0.562 mg/L (MD10A). The ANZECC (2000) guideline for manganese in fresh water is 1.9 mg/L. All results were reported below the ANZECC fresh water guidelines.

The levels of filterable iron and manganese are similar to those reported in previous reporting periods.

Concentrations of fluoride ranged from 0.1 mg/L (MD1A/1B) to 1.7 mg/L (MD2A). No recommended reliable ANZECC (2000) guidelines exist for fluoride in fresh or marine waters. The data ranges between the minimum and maximum values are similar to previous levels. The results indicate that fluoride levels are generally associated with landfill leachate.

6.1.7 Organic Contaminants (DOC, TOC and Phenols- Groundwater)

Concentrations of dissolved organic carbon (DOC) ranged from 4 to 404 mg/L in the 2015/16 reporting period (MD2C & MD9A, respectively). Concentrations of total organic carbon (TOC) ranged from 6 mg/L (MD1B) to 404 mg/L (MD9A) in the 2015/16 reporting period. ANZECC (2000) guidelines do not exist for DOC or TOC. The DOC/TOC may relate to landfill leachate and/or naturally occurring organic matter/content associated with lowland/estuary.

Concentrations of phenols were below LOR (0.05 mg/L) to 0.6 mg/L (MD9A). The single result from MD9A (15 Feb 2016 of 0.6 mg/L) exceeded the marine water trigger values (ANZECC

2000, 0.4 mg/L), all other results were reported below the guidelines. The results from MD9A is atypical of the phenol concentrations from the location (typically phenol is ND).

6.2 Surface Water

Surface water sampling was undertaken quarterly during the 2015/16 reporting period (EPL requirement is only six-monthly sampling). Samples were collected from two locations along the estuarine reach of Rocklow Creek on November 2014, whilst three locations (including Rocklow down) were tested on November 2015, and February, May and August 2016 (Figure 2).

The three surface water locations provide a general indication of water quality impacts from the MWDD (Figure 2). Impacts to Rocklow Creek water quality may be occurring from Shellharbour Waste Disposal Depot, which is situated on the northern side of Rocklow Creek and runoff from agricultural and residential land in the catchment.

The three surface water locations are not sampled according to tidal levels (i.e. Rocklow Creek has marine water influences which is a mixture of groundwater discharge and tidal water), therefore nutrients concentrations are likely to vary according to tidal water influence (dilution effects).

The surface water monitoring data is variable and possibly reflecting a combination of tide sampling regimes and influence from the broader catchment area. Timing of the samples should be coordinated with the tide so that creek samples are collected during a run-out tide when the maximum amount of groundwater discharges into the creek.

6.2.1 Physical Parameters

6.2.1.1 pH

The pH in Rocklow Creek at the middle and upstream location is generally neutral (7.0 to 7.6) in 2015/16, and has not changed significantly from previous reporting periods.

6.2.1.2 TDS (and EC)

The conductivity (EC, mS/cm) of waters at the upstream location are generally lower than those recorded downstream (Rocklow-Middle), reflecting the tidal range and groundwater discharge from the catchment area.

Water collected from Rocklow Creek is fresh to brackish (0.833 to 44.53 mS/cm). Sampling at low tide would result in decreased salinity due to an increased baseflow (fresh groundwater) contribution.

6.2.1.3 Dissolved Oxygen (DO)

The DO of waters ranged from 2.83 to 8.70 mg/L. Higher DO values are associated with upstream section of Rocklow Creek.

6.2.2 Nutrients (surface water)

6.2.2.1 Nitrogen

Rocklow Creek surface water samples collected in the 2015/16 reporting period reported ammonia below the ANZECC (2000) guidelines for marine and fresh water ecosystems (2.84 and 1.88 mg/L, respectively, Tables SW-1 and SW-2). Concentrations of nitrate were all at or below 0.07 mg/L (ANZECC (2000), lower than the trigger value for fresh water ecosystems (0.7 mg/L, at 95% protection level). Nitrate analyses were not included in the 3 Rocklow Creek samples in May and August 2016.

Water samples collected from Rocklow Creek during 2015/16 reporting period generally show an increase (of up to 2.3 mg/L) in ammonia in the midstream sample compared to the upstream sample (15 February 2016). The ammonia increments between the upper, mid and down stream samples are presented in Table SW-2 and Graph-4 (note: mid-stream location is downgradient to MD-9C, MD4B and MD-10B which have elevated and irregular ammonia trends).

Ammonia concentrations in Rocklow Creek (2015/16) are generally comparable to previous results (2014/2015, 2013/2014, 2012/13 and 2011/12, Table SW-2). However, a slight rise in ammonia increments and variability in the Rocklow-Mid and Rocklow-Low is evident in 2016, which may relate to the rising ammonia trends in local groundwater (MD9C).

Increases in ammonia from upstream to downstream of the landfill have been observed over previous monitoring periods (Graph-4). While these increases could be attributable to the discharge of groundwater impacted by ammonia from the MWDD, other sources of nitrogen input such as polluted runoff from the catchment (Shellharbour Landfill, agricultural areas) and nutrients bound in sediments cannot be discounted.

Graph-4 shows the ammonia increments in all monitoring periods since 1999 and illustrates a decreasing difference between upstream and downstream ammonia concentrations. Ammonia concentrations at Rocklow-Up have remained relatively stable over time while ammonia concentrations at Rocklow-Down show a variable trend.

The ammonia contribution from the MWDD into Rocklow Creek is complicated by the sampling regime (i.e. sampling at various tides level with dilution from tidal water) and other potential sources of nitrogen in the area (Dunmore Landfill and nutrients from upstream agricultural areas). Surface water results should be interpreted as indicative only due to the dynamic nature of the catchment and multiple nutrient sources.

6.2.2.2 Total Phosphorous (surface water)

Total phosphorus (TP) is not an EPL requirement and were not analysed during the 2015/16 monitoring period.

Monitoring from previous years indicate that TP concentrations decrease from up to downstream of the landfill (except in August 2008), implying there is nutrient contribution from other (agricultural) sources in the catchment area.

6.2.3 Organic Contaminants (TOC/DOC, Phenols & Fluoride)

Concentrations of total & dissolved organic carbon (TOC/DOC) ranged from 7 to 24 mg/L, and 7 to 11 mg/L, respectively in the 2015/16 reporting period. No recommended ANZECC (2000) guidelines exist for DOC (concentrations could be related to natural waters or leachate).

Concentrations of phenols were reported all below LOR (0.05 mg/L) in all other surface water samples in all monitoring rounds. Concentrations of fluoride ranged from 0.2 mg/L to 1 mg/L, with concentrations showing an increase in the Rocklow-Mid & Rocklow-Low sampling locations relative to the upstream sample.

7. CHEMICALS OF CONCERN AND CONTAMINANT PLUMES

The results of 2015/16 monitoring have been assessed to determine the surface and groundwater conditions with respect to the relevant guidelines which serve to protect aquatic ecosystems (both fresh and marine), as this is considered to be the dominant beneficial (environmental) use of local groundwater.

The primary landfill leachate indicator at the site is ammonia. Ammonia represents the analyte which exceeds ANZECC (2000) guidelines in the majority of monitoring wells. The landfill is also a source of dissolved salts, metals (i.e. iron, which was generally above interim guidelines) and potentially organics. The dissolved salts, metals and organics are associated with the dissolution of ions from various types of waste material.

Results of the sampling (1999 to 2016) confirm that ammonia concentrations are elevated above background levels. Improvement in groundwater quality (i.e. a decreasing ammonia trend) is evident in several wells (MD2B, MD2C, MD4C, MD6C) since landfill rehabilitation works commenced (2006).

High rainfall periods since landfill rehabilitation completion are interpreted to have resulted in periodic ammonia increases (e.g. February 2008, March 2011, July 2011, February/March 2012, January/February 2013, April 2013, November 2013 and March-April 2014 and late 2014, August 2015 and June 2016). Some wells (MD-6B, MD-10B) show variable trends, whilst two wells show an increasing trend (MD-9C, MD-4B) in 2015/2016.

It is likely the leachate plume arising from the landfill mound would migrate radially (local system) with (regional) flow mainly directed towards the north-east and east (MD9 centreline). It is likely that landfill leachate infiltrates the underlying sandy aquifer and consequently migrates under the predominant groundwater flow regime towards Rocklow Creek and Minnamurra River.

The extent of natural attenuation and degradation of the nutrient plume prior to discharge is not well known, however the groundwater/saltwater interface and mangrove environment are likely to enhance attenuation and de-nitrification of the ammonia plume (Appendix B, Figure 7).

7.1 Ecological Issues

Groundwater migrating from under the landfill mound to Rocklow Creek and Minnamurra River will be diluted by the dynamic and tidal nature of the environment. Contaminants contained within this discharge will be diluted and dispersed via biological, chemical and physical processes which occur at the groundwater/salt water interface. Uptake of the nutrients by plants (mangroves, sedges) dependent on groundwater will also occur at the creek and river.

The adverse effects arising from landfill leachate on the Rocklow Creek and Minnamurra River aquatic environments is unclear and difficult to ascertain, given the multiple sources of nutrients present and disturbance in the catchment area. No obvious evidence of degradation is evident in the water bodies or surrounding vegetation (Note; some trees were damaged/removed during landfill rehabilitation works in 2007/2008).

Discharges of landfill leachate to Rocklow Creek would be at a maximum when the tide is low and groundwater gradients are steeper. The net increment of ammonia in the midstream sample (Rocklow-Middle) averaged ~0.05 mg/L in the 2014/15, and ~0.96 mg/L the 2015/16 reporting period (Table SW-2). This net increment in 2015-2016 is also dependant on tidal regime during sampling.

The ammonia in groundwater (MD-9C, MD-10B, MD-4B) during 2015/16 may be contributing to the minor nutrient concentrations in the surface water (Rocklow-Middle & Down), however this is not confirmed due to the other potential sources (Dunmore landfill). Downstream ammonia concentrations have generally declined, but show significant variability since monitoring commenced in 1999 (Graph-4).

While it is likely that some nitrogen-impacted groundwater may discharge into Rocklow Creek and Minnamurra River, it is unclear as to the extent of attenuation of the nitrogen plume prior to discharge. Attenuation is likely to occur through a combination of dilution, through mixing of groundwater from north of the creek, by flows and tidal movements within the creek and estuary itself, oxidation of the ammonia to nitrate, and finally as conversion to nitrogen gas.

Since early 2016, Council and E2W have investigated groundwater near MD9C and installed test bores in order to evaluate groundwater remedial options. Potential leachate management may include extraction of groundwater at MD9C and irrigation of the landfill mound (work is in progress with Council, E2W, and the DPI, NSW EPA).

Ammonia and nitrate concentrations in all surface water samples collected in the 2015/16 reporting period were below ANZECC (2000) trigger values for fresh and marine water ecosystems.

8. CONCLUSIONS

Surface and groundwater monitoring was undertaken at the Minnamurra Waste Disposal Facility by ALS on a quarterly basis⁶ from November 2015 to August 2016 (EPL reporting period). Monitoring data collected during the 2015/2016 period was assessed by E2W to determine the impact of the landfill facility on local groundwater and aquatic ecosystems.

Based on the environmental data reviewed and assessed, E2W offer the following conclusions:

- Elevated concentrations of nutrients, in particular ammonia, continue to be detected in groundwater at the former landfill site. Ammonia levels reported by the laboratory exceed the ANZECC (2000) guidelines for the protection of fresh and marine water ecosystems in 14 out of 15 monitoring wells sampled (i.e. MD-4A dry, MD10A ammonia below guidelines).
- The impacted wells are located on the footprint (downgradient) of the landfill mound, indicating contaminant migration towards Rocklow Creek and Minnamurra River (north-east and east).
- Elevated ammonia concentrations (above ANZECC 2000) were reported at several wells including; MD1A (43.4 mg/L), MD2B (12 mg/L), MD4B (38.86 mg/L), MD4C (3.43 mg/L), MD6B (38.2 mg/L), MD6C (37.3 mg/L), MD9B (34.3 mg/L), MD10B (78.8 mg/L) and the maximum at MD9C (162 mg/L). Elevated ammonia in the groundwater is located on the north and eastern landfill perimeters coinciding with the predominant groundwater flow direction.
- Nitrate concentrations in groundwater during the 2015/16 reporting period ranged from not detected to 8.5 mg/L (MD10B). Six (6) out of 15 wells reported one or more samples with nitrate concentrations above the ANZECC (2000) trigger value for fresh water ecosystems (0.7 mg/L, at 95% protection level). Nitrate concentrations are comparable or lower in 2015/2016 with those previously reported in 2014/2015.
- Ammonia concentrations in the 2015/16 monitoring period continue to be elevated and variable, however show an overall decreasing trend. Some exceptions include MD10B/MD-6B (variable trend), and MD9C, and MD4B (lesser degree) have rising trends. Recent August (2016) results at MD9C (ammonia =107 mg/L) may indicate the beginning of a decreasing trend. Variations in ammonia are inferred to reflect seasonal trends (high rainfall resulting in increased concentrations) and decreased leachate generation due to the landfill rehabilitation works.
- During the 2015/16 monitoring period Rocklow-Down (downstream) was sampled three times in 2016 due to sample relocation (previously un-accessible). Generally low concentrations of ammonia and nitrate (i.e. below ANZECC 2000 trigger values) were reported from the upstream, mid and down stream locations on Rocklow Creek during the 2015/16 reporting period. A general increase in ammonia is evident in the downstream or Rocklow-Mid surface water locations relative to upstream. The net increment of ammonia between upstream, mid stream and downstream concentrations is variable since 1999, however a slight increase is evident in the 2015/2016 results (Graph 4).
- The net increment of ammonia in the midstream sample (Rocklow-Middle) averaged ~0.05 mg/L in 2014/15, and ~0.96 mg/L in the 2015/16 reporting (Table SW-2) period. This "net

⁶ Council has conducted additional monitoring at the site as the EPL only requires 6 monthly sampling.

incremental average" is higher than previous years mainly due to high ammonia reported in February 2016 (2.49 mg/L). The 2012/13 averaged net incremental increase = 0.315 and 2011/12 averaged net incremental increase = 0.91 mg/L. The elevated ammonia in nearby groundwater (MD-9C, MD-10B) may be contributing to the ammonia detected in the surface water (Rocklow-Mid/downstream). Further monitoring is required to verify this interpretation, as multiple sources are situated around the creek (e.g. Dunmore landfill).

- While downstream ammonia concentration increases could be attributable to the discharge of groundwater impacted by ammonia from the MWDD, contribution from other sources of nitrogen input such as polluted runoff from the catchment (Dunmore Landfill, agricultural areas) is not discounted.
- All other water quality indicators were consistent with the results of previous monitoring periods.
- The testing of the gas monitoring wells (Gas 1, Gas 3, Gas 4) and trenches (Trench 1 to Trench 7 -the biofilter pads) indicated that gas levels are comparable with previous years. All buildings sampled (within 250 m of the deposited waste) recorded no detectable landfill gas readings on February 2016, May 2016 and September 2016 (annual monitoring). KMC (& E2W) are unaware of any complaints from the community arising from rehabilitation works at the MWDD during the 2015/16 reporting period. Council provided the following information regarding a reportable pollution incidence at the site; *"On Wednesday 17-08-16 morning at approx. 6am we discovered a very small fire in our mulch stockpile (approx. 2 m x 4 m). A front end loader and excavator to remove this section from the stockpile and extinguish it using compaction and water from onsite water tanker. The incident was reported to EPA after hours at approx. 6.15- 6.30 am as per our Pollution Incident Response Management Plan. The reference number for this reported incident is 132523"*.

The nutrients in the local surface and groundwater are likely to decrease over time due to the landfill closure and rehabilitation works. Given that the landfill capping commenced in August 2006 and completed in January 2008 the leachate generation has substantially decreased. Monitoring data in 2015/16 supports this interpretation and improvement in the local water quality.

The elevated ammonia concentrations reported at MD-9C and MD-10B is interpreted to relate to the remnant deeper centre/core plume migrating from under the landfill mound to the site boundary (other area are showing a decrease in leachate strength associated with landfill closure works).

Monitoring over the next few years will continue to provide the relevant environmental data to assess the effectiveness and performance of the landfill rehabilitation (& remedial works- as necessary). The landfill closure and capping of the landfill mound would improve the local surface water and groundwater quality.

Close monitoring of the elevated ammonia at wells (MD-9C, MD-10B, MD04B at centreline of plume) and Rocklow Creek (mid-downstream creek) is recommended to address timing of the remedial requirements (e.g. groundwater extraction and irrigation of the mound). E2W consider that ongoing monitoring (re-sampling with ammonia spikes/increasing trends over 100 mg/L) to assess ammonia trends and any remedial actions (MD-9C/MD-10B) to minimise impact to the creek (*note: the down stream samples at Mid & low indicate potential measurable impacts from*

the ammonia in the groundwater). The scale of the landfill mound (6 ha) and generally slow movement of the deeper groundwater is likely to be influencing results at MD-9C (i.e. the residual core leachate plume is still migrating slowly under the capped part of the mound).

Since early to late 2016, Council and E2W have investigated the groundwater conditions near MD9C and installed test bores in order to evaluate groundwater remedial options. Potential leachate management may include extraction of impacted groundwater at the new test bores (near MD9C) to irrigate the landfill mound (work is in progress with Council, E2W, and the DPI, NSW EPA).

E2W interpret that additional time (5 + years) and groundwater extraction at MD9C area is required to show a more consistent and widespread improvement in the water quality trends (eg. ammonia). This interpretation takes in consideration the dilution effects of rainfall recharge, clean water runoff from the mound and subsequent attenuation of the landfill leachate around the landfill footprint. It is noted that the majority of the monitoring wells are situated immediately outside the landfill footprint perimeter.

8.1 Recommendations

E2W offer the following recommendations regarding the monitoring at the Minnamurra Waste Disposal Depot:

- Continued water monitoring and assessment of the ammonia is required to assess trends in relation to the landfill rehabilitation works.

E2W have initiated groundwater investigation works to address the rising ammonia trend identified at well (MD-9C). Currently, extraction wells (EMW 1& 2) have been installed in mid 2016 and are proposed to facilitate extraction of impacted groundwater, and for irrigation works to reduce the hotspot ammonia area and address the rising trends. Groundwater remedial works are recommended if ammonia concentrations continue to exceed 100 mg/L in successive monitoring rounds in 2016 and 2017 (i.e. MD-9C or MD-10B).

Nitrate analysis is recommended for all sampling in Rocklow Creek (*Note: no nitrate analysis was conducted in the 3 Rocklow Creek samples in May and August 2016*).

Sampling Procedures:

- Recording of groundwater purge volumes and any observations (odour, sheen, turbidity) during sampling of monitoring wells,
- Use of calibrated field instruments for measuring field chemistry (pH, EC, DO, Eh, T) prior to sampling (documentation required),
- Sampling of surface water to be timed with a **low ‘run out’ tide**, and documenting tidal and climatic conditions (i.e. sampling at different tides dilutes the groundwater plume).
- Details regarding the well conditions (eg. damaged). Any damaged wells should be replaced or substituted with nearby wells.

The recommended groundwater monitoring program for the prescribed well locations (i.e. EPL conditions) is summarised in Table 8.1. E2W acknowledge that the EPL recommends a half yearly sampling frequency, whilst KMC have continued with quarterly groundwater monitoring and also include surface water sampling (three locations). Increased monitoring frequency facilitates earlier detection of rising trends and decisions regarding potential remedial works.

E2W recommend the current surface water monitoring program is continued on a quarterly basis for the 2015/16 reporting period (exceeds EPL requirements). Frequent review of results from the Rocklow-Mid/Down stream sampling locations is required to address ecosystem risks associated with the elevated ammonia concentrations at well (MD-9C).

Continued monitoring of landfill gas at the gas monitoring wells, trenches (biofilter pads) and buildings (6 monthly) is recommended to comply with the EPL.

Table 8.1 - Recommended Groundwater Analytical Program for MWDD (2015/16)

Analytes	Detection Limit	Sampling Frequency	Method Reference
Alkalinity	0.5 mg/L	6 monthly	APHA 2320B
pH/Eh	0.01 pH unit	3 monthly	pH meter and probe/APHA4500-HB
Electrical Conductivity	0.01 mS/cm	3 monthly	Conductivity meter and probe
Dissolved Oxygen	0.01 %	6 monthly	DO meter and probe
Temperature	1 deg	6 monthly	Temperature meter and probe
Ammonia-nitrogen	0.01 mg/L	3 monthly	FIA
Nitrate-nitrogen	10 µg/L	3 monthly	FIA
Calcium	1 mg/L	6 monthly	USEPA 6010 A
Chloride	0.5 mg/L	6 monthly	Titrated with mercuric nitrate using diphenol-carbazone/xylene cyanol FF indicator
Fluoride	0.1 mg/L	6 monthly	APHA4500-FC
Magnesium	0.02 mg/L	6 monthly	USEPA 6010 A
Sulphate	1 mg/L	6 monthly	ICID/MS
Sodium	0.05 mg/L	6 monthly	USEPA 6010 A
Total Alkalinity	0.5 mg/L	6 monthly	APHA 2340C
Potassium	0.05 mg/L	6 monthly	USEPA 6010 A
Dissolved Organic Carbon	0.50 mg/L	6 monthly	APHA 531 OC
Iron	1 µg/L	6 monthly	USEPA 6010 A
Manganese	1 µg/L	6 monthly	USEPA 6010
Phenols	1 µg/L	6 monthly	APHA 5530D
Standing Water Level	m AHD	6 monthly	Water level Probe

Notes: The key landfill indicator (ammonia/nitrate) is proposed on a quarterly basis in groundwater/surface water locations
 ICP - Inductively Coupled Plasma µg/L - micrograms per litre
 FIA - Flow Injection Analyser mg/L - milligrams per litre
 MS - Mass Spectrometry APHA - American Public Health Association
 FC - Client Filtered USEPA - United States Environment Protection Agency
 µS/cm - micro Siemens per centimetre

9. LIMITATIONS

Earth2Water Pty Ltd has prepared this report for the use of Kiama Municipal Council in accordance with the standard terms and conditions of the consulting profession. This report is prepared in accordance with the agreed scope of work. The methodology adopted and sources of information used by E2W are outlined in this report.

This report was prepared during October/November 2016 and is based on the information reviewed at the time of preparation. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented by Ecowise and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, E2W should be notified of any such findings and be provided with an opportunity to review our content and recommendations.

10. REFERENCES

Hazelton (1992). *Soil Landscapes of the Kiama 1:1,000,000 Sheet, Department of Conservation and Land Management.*

NSW EPA (1996). *Environmental Guidelines: Solid Waste Landfills.*

DUAP (1996). *EIS Practise Guideline: Landfilling*

NSW EPA (1999). *Environmental Guidelines: Assessment, Classification & Management of Liquid & Non-Liquid Wastes.* May 1999.

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Earth2Water Pty Ltd (October, 2005). *Landfill Closure Plan for the Minnamurra Waste Disposal Facility.*

Tables

Table 5.3: Groundwater and Surface Water Monitoring (2015 to 2016)

Analytes	Groundwater				Surface Water (Rocklow Creek)				Detection Limits	Method Reference
	3/11/15	15/2/16	30/5/16	11/8/16	3/11/15	15/2/16	30/5/16	11/8/16		
Physical Properties										
pH	X	X	X	X	X	X	X	X	0.01 pH unit	pH meter and probe/ APHA4500-HB
Electrical Conductivity	X	X	X	X	X	X	X	X	0.01 mS/cm	Conductivity meter and probe
Dissolved Oxygen	X	X	X	X	X	X	X	X	0.0001	DO meter and probe
Redox (Orp)									1 mV	Platinum electrode probe - NA
Temperature	X	X	X	X	X	X	X	X	1 °C	Temperature meter and probe
Turbidity									1 NTU	APHA2540D
Nutrients										
Nitrate	X	X	X	X	X	X			0.01 mg/L	FIA
Ammonia-nitrogen	X	X	X	X	X	X	X	X	0.01 mg/L	FIA
Total Nitrogen										
Total Phosphorus									2 µg/L	FIA
Hydrochemical										
Calcium	X	X	X	X	X	X	X	X	0.5 mg/L	USEPA 6010 A
Chloride	X	X	X	X	X	X	X	X	0.5 mg/L	diphenol-carbazonel/xylene cyanol FF indicator
Fluoride	X	X	X	X	X	X	X	X	0.1 mg/L	APHA4500-FC
Magnesium	X	X	X	X	X	X	X	X	0.02 mg/L	USEPA 6010 A
Sulphate	X	X	X	X	X	X	X	X	1 mg/L	ICID/MS
Sodium	X	X	X	X	X	X	X	X	0.05 mg/L	USEPA 6010 A
Bicarbonate/Alkalinity	X	X	X	X	X	X	X	X	0.5 mg/L	APHA2340C - "Hardness done by error"
Potassium	X	X	X	X	X	X	X	X	0.05 mg/L	USEPA 6010 A
Organic Contaminants										
Dissolved Organic Carbon	X	X	X	X	X	X	X	X	0.50 mg/L	APHA 5310C
Total Organic Carbon	X	X	X	X	X	X	X	X	0.1 mg/L	APHA 5310C
Inorganic Contaminants										
Iron	X	X	X	X	X	X	X	X	1 µg/L	USEPA 6010 A
Manganese	X	X	X	X	X	X	X	X	1 µg/L	USEPA 6010
Total Phenolics	X	X	X	X	X	X	X	X	1 µg/L	APHA 5530D

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD 1A	MD 1A	No. Samples	MD 1B	MD 1B	No. Samples	MD2A	MD2A	MD2A	MD2A	No. Samples	Min	Mean	Max	MD 2B	MD 2B	MD 2B	MD 2B	No. Sample	Min	Mean	Max
Field Measurements	Freshwater	Marine	30/5/16	11/8/16		30/5/16	11/8/16		3/11/15	15/2/16	30/5/16	11/8/16					3/11/15	15/2/16	30/5/16	11/8/16				
RL (mAHD at TOC)			NM	NM		2.11	2.11		1.17	1.17	1.17	1.17					1.17	1.17	1.17	1.17				
Standing water level (mTOC)			1.43	1.35	2	1.44	1.33	2	0.48	0.46	0.31	0.45	4	0.31	0.43	0.48	0.74	0.63	0.58	0.76	4	0.58	0.68	0.76
Reduced SWL (mAHD)						0.67	0.78		0.69	0.71	0.86	0.72	4	0.69	0.74	0.86	0.43	0.54	0.59	0.41	4	0.41	0.49	0.59
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.60	7.40	2	7.40	7.10	2	7.20	6.90	7.00	7.40	4	6.9	7.1	7.4	7.10	7.00	6.90	7.10	4	6.9	7.0	7.1
Temperature			20.30	17.90	2	19.70	18.60	2	17.10	22.50	19.00	16.90	4	16.9	18.9	22.5	16.80	19.50	20.00	17.40	4	16.8	18.4	20.0
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		618	1610	2	543	533	2	15900	11900	12400	16600	4	11900	14200	16600	24200	23400	26900	18300	4	18300	23200	26900
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	2.34	0.26	2	1.41	1.33	2	2.51	2.00	2.08	1.60	4	1.60	2.05	2.51	1.46	2.50	1.57	1.15	4	1.15	1.67	2.50
Laboratory Analyses (mg/L)																								
Sodium (ICP)			36	110	2	32	30	2	2860	1850	2070	3190	4	1850	2493	3190	4090	4420	4700	3570	4	3570	4195	4700
Potassium (ICP)			7	14	2	13	13	2	152	138	141	180	4	138	153	180	175	190	191	161	4	161	179	191
Calcium (ICP)			70	116	2	52	50	2	210	190	211	258	4	190	217	258	344	353	358	320	4	320	344	358
Magnesium (ICP)			13	23	2	8	8	2	381	276	305	445	4	276	352	445	523	575	603	470	4	470	543	603
Chloride			36	202	2	35	40	2	5380	3610	3640	7020	4	3610	4913	7020	7580	8050	8210	6780	4	6780	7655	8210
Sulphate (SO4)			36	<1	2	32	26	2	808	451	433	690	4	433	596	808	1110	1240	1340	862	4	862	1138	1340
Water Parameters (mg/L)																								
Alkalinity (as CaCO3)			208	482	2	163	142	2	804	539	968	826	4	539	784	968	655	727	727	672	4	655	695	727
Fluoride			1.1	0.8	2.0	0.1	0.1	2.0	0.8	1.7	0.8	0.8	4.0	0.8	1.0	1.7	0.7	0.8	0.8	0.7	4	0.7	0.8	0.8
Phenols		0.40	<0.05	0.13	2.00	<0.05	<0.05	2.00	<0.05	<0.05	<0.05	<0.05	4.00	ND	ND	ND	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND
Metals (mg/L)																								
Iron (ICP)	0.3 (1)		<0.05	0.09	2	<0.05	0.05	2	0.83	3.33	6.28	0.35	4	0.35	2.70	6.28	0.69	1.18	1.07	0.66	4	0.66	0.90	1.18
Manganese (ICP)	1.90		0.056	0.192	2	0.012	0.016	2	0.045	0.032	0.038	0.048	4	0.032	0.041	0.048	0.082	0.086	0.094	0.07	4	0.070	0.083	0.094
Nutrients (mg/L)																								
Nitrate (NO3 as N)	0.7 (7)		0.90	<0.01	2	3.54	5.60	2	0.74	0.26	0.5	2.57	4	0.26	1.02	2.57	0.07	0.04	0.09	0.06	4	0.04	0.07	0.09
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	0.12	43.40	2	4.40	6.92	2	18.00	26.00	31.60	19.60	4	18.00	23.80	31.60	9.19	9.63	9.87	12.00	4	9.19	10.17	12.00
Total Nitrogen	0.5 (3)	0.12 (4)																						
Dissolved Organic Carbon (DOC)			9	51	2	6	6	2	29	46	36	45	4	29	39	46	25	24	45	30	4	24	31	45
Total Organic Carbon (TOC)			10	118	2	12	6	2	84	39	72	46	4	39	60	84	61	23	44	30	4	23	40	61
Total Phosphorus (TP)	0.05 (5)	0.025 (6)																						

Notes:

1. Trigger value is an indicative interim working level only (IIWL).
 2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
 3. Trigger value for total nitrogen for lowland rivers in SE Australia.
 4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
 5. Trigger value for total phosphorus in lowland rivers in NSW.
 6. Trigger value for total phosphorus in marine ecosystems in NSW.
 7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsourced well on EPL
Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD 2C	MD 2C	MD 2C	MD 2C	No. Samples	Min	Mean	Max	MD4A	MD4A	MD4A	MD4A	No. of Samples
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16					3/11/15	15/2/16	30/5/16	11/8/16	
RL (mAHD at TOC)			1.165	1.165	1.165	1.165					Dry	Dry	Dry	Dry	0
Standing water level (mTOC)			0.80	0.70	0.64	0.80	4	0.64	0.74	0.80	-	-	-	-	0
Reduced SWL (mAHD)			0.37	0.47	0.53	0.37	4	0.37	0.43	0.53	-	-	-	-	0
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.20	7.10	7.00	7.20	4	7.0	7.1	7.2	-	-	-	-	0
Temperature			16.90	19.30	19.20	17.40	4	16.9	18.2	19.3	-	-	-	-	0
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		43500	39100	43100	41200	4	39100	41725	43500	-	-	-	-	0
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	1.23	2.80	1.34	1.38	4	1.23	1.69	2.80	-	-	-	-	0
Laboratory Analyses (mg/L)															
Sodium (ICP)			7660	8890	7300	8400	4	7300	8063	8890	-	-	-	-	0
Potassium (ICP)			313	292	278	311	4	278	299	313	-	-	-	-	0
Calcium (ICP)			474	485	420	486	4	420	466	486	-	-	-	-	0
Magnesium (ICP)			958	1120	912	986	4	912	994	1120	-	-	-	-	0
Chloride			14000	13400	13500	14000	4	13400	13725	14000	-	-	-	-	0
Sulphate (SO4)			2110	2260	2280	1810	4	1810	2115	2280	-	-	-	-	0
Water Parameters (mg/L)															
Total Suspended Solids (TSS)											-	-	-	-	0
Alkalinity (as CaCO3)			508	578	552	538	4	508	544	578	-	-	-	-	0
Fluoride			1	1	1	1	4	0.6	0.7	0.8	-	-	-	-	0
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND	-	-	-	-	0
Metals (mg/L)															
Iron (ICP)	0.3 (1)		0.11	3.14	1.46	1.09	4	0.11	1.45	3.14	-	-	-	-	0
Manganese (ICP)	1.90		0.126	0.207	0.107	0.166	4	<0.01	0.152	0.207	-	-	-	-	0
Nutrients (mg/L)															
Nitrate (NO3 as N)	0.7 (7)		0.81	<0.01	0.24	0.03	4	0.03	0.36	0.81	-	-	-	-	0
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	0.45	5.06	4.01	4.14	4	0.45	3.42	5.06	-	-	-	-	0
Total Nitrogen	0.5 (3)	0.12 (4)													
Dissolved Organic Carbon (DOC)			5	20	4	21	4	4	13	21	-	-	-	-	0
Total Organic Carbon (TOC)			50	21	28	21	4	21	30	50	-	-	-	-	0
Total Phosphorus (TP)	0.05 (5)	0.025 (6)									-	-	-	-	0
Notes:															

1. Trigger value is an indicative interim working level only (IIWL).
 2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
 3. Trigger value for total nitrogen for lowland rivers in SE Australia.
 4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
 5. Trigger value for total phosphorus in lowland rivers in NSW.
 6. Trigger value for total phosphorus in marine ecosystems in NSW.
 7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsampled well on EPL

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD 4B	MD 4B	MD 4B	MD 4B	No. Samples	Min	Mean	Max	MD 4C	MD 4C	MD 4C	MD 4C	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16					3/11/15	15/2/16	30/5/16	11/8/16				
RL (mAHD at TOC)			1.63	1.63	1.63	1.63					1.59	1.59	1.59	1.59				
Standing water level (mTOC)			1.20	1.05	1.06	1.20	4	1.05	1.13	1.20	1.22	1.11	1.08	1.22	4	1.08	1.16	1.22
Reduced SWL (mAHD)			0.43	0.58	0.57	0.43	4	0.43	0.50	0.58	0.37	0.48	0.51	0.37	4	0.37	0.43	0.51
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.10	7.00	6.90	7.10	4	6.9	7.0	7.1	7.00	6.90	6.90	6.90	4	6.9	6.9	7.0
Temperature			16.4	20.3	16.9	18.0	4	16.4	17.9	20.3	16.4	19.3	16.6	18.3	4	16.4	17.7	19.3
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		8370	11200	14200	7270	4	7270	10260	14200	36000	34600	39900	36300	4	34600	36700	39900
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	1.25	2.5	2.66	1.2	4	1.20	1.90	2.66	2.03	2.5	1.28	1.08	4	1.08	1.72	2.50
Laboratory Analyses (mg/L)																		
Sodium (ICP)			1270	1780	2280	1130	4	1130	1615	2280	6160	7500	7280	6580	4	6160	6880	7500
Potassium (ICP)			106	124	137	101	4	101	117	137	257	253	275	280	4	253	266	280
Calcium (ICP)			297	348	367	279	4	279	323	367	410	446	452	458	4	410	442	458
Magnesium (ICP)			172	228	297	164	4	164	215	297	786	982	918	875	4	786	890	982
Chloride			2450	3650	4280	2410	4	2410	3198	4280	11500	11900	12200	12000	4	11500	11900	12200
Sulphate (SO4)			277	379	533	206	4	206	349	533	1760	1840	2000	1550	4	1550	1788	2000
Water Parameters (mg/L)																		
Alkalinity (as CaCO3)			894	931	893	920	4	893	910	931	668	744	707	724	4	668	711	744
Fluoride			0.5	0.6	0.6	0.5	4	0.5	0.6	0.6	0.7	0.8	0.9	0.8	4	0.7	0.8	0.9
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND
Metals (mg/L)																		
Iron (ICP)	0.3 (1)		1.52	1.66	1.77	1.09	4	1.09	1.51	1.77	1.01	1.72	1.59	1.45	4	1.01	1.44	1.72
Manganese (ICP)	1.90		0.07	0.08	0.10	0.07	4	0.071	0.08	0.10	0.22	0.18	0.17	0.19	4	0.174	0.192	0.221
Nutrients (mg/L)																		
Nitrate (NO3 as N)	0.7 (7)		0.01	<0.01	<0.01	<0.01	4	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	4	0.00	NA	0.00
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	43.40	45.50	38.80	43.70	4	38.80	42.85	45.50	1.91	2.56	2.34	3.43	4	1.91	2.56	3.43
Total Nitrogen	0.5 (3)	0.12 (4)																
Dissolved Organic Carbon (DOC)			19	36	38	22	4	4	24	38	23	22	36	32	4	22	28	36
Total Organic Carbon (TOC)			70	37	39	44	4	37	48	70	48	21	41	29	4	21	35	48
Total Phosphorus (TP)	0.05 (5)	0.025 (6)																

Notes:

1. Trigger value is an indicative interim working level only (IIWL).
 2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
 3. Trigger value for total nitrogen for lowland rivers in SE Australia.
 4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
 5. Trigger value for total phosphorus in lowland rivers in NSW.
 6. Trigger value for total phosphorus in marine ecosystems in NSW.
 7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsampled well on EPL
Exceeds ANZECC (2000) marine trigger value

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD6A	MD6A	MD6A	MD6A	No. Samples	Min	Mean	Max	MD 6B	MD 6B	MD 6B	MD 6B	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16					17/11/14	26/2/15	27/5/15	10/8/15				
RL (mAHD at TOC)			1.85	1.85	1.85	1.85					1.85	1.85	1.85	1.85				
Standing water level (mTOC)			1.27	1.27	1.15	1.25	4	1.15	1.24	1.27	1.31	1.25	1.23	1.26	4	1.23	1.26	1.31
Reduced SWL (mAHD)			0.58	0.58	0.70	0.60	4	0.58	0.62	0.70	0.54	0.60	0.62	0.59	4	0.54	0.59	0.62
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.20	6.80	7.10	7.00	4	6.8	7.0	7.2	7.10	6.90	7.00	7.00	4	6.9	7.0	7.1
Temperature			17.8	20.8	21.2	18.0	4	17.8	19.5	21.2	18.0	20.9	21.2	18.1	4	18.0	19.6	21.2
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		4560	5570	4930	6360	4	4560	5355	6360	1700	1520	1780	1560	4	1520	1640	1780
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	4.04	2.5	1.7	1.82	4	1.70	2.52	4.04	1.48	4.3	1.32	1.19	4	1.19	2.07	4.30
Laboratory Analyses (mg/L)																		
Sodium (ICP)			564	735	667	901	4	564	717	901	100	93	131	94	4	93	105	131
Potassium (ICP)			120	106	101	139	4	101	117	139	38	38	42	39	4	38	39	42
Calcium (ICP)			198	275	192	289	4	192	239	289	140	141	152	134	4	134	142	152
Magnesium (ICP)			136	147	115	158	4	115	139	158	43	36	43	34	4	34	39	43
Chloride			916	1200	943	1520	4	916	1145	1520	131	103	116	103	4	103	113	131
Sulphate (SO4)			410	537	393	522	4	393	466	537	106	84	46	63	4	46	75	106
Water Parameters (mg/L)																		
Alkalinity (as CaCO3)			760	796	768	735	4	735	765	796	660	638	744	570	4	570	653	744
Fluoride			0.8	0.7	0.8	0.7	4	0.7	0.8	0.8	0.6	0.6	0.6	0.5	4	0.5	0.6	0.6
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	0.05	0.05	0.05	<0.05	<0.05	<0.05	<0.05	4	0.05	0.05	0.05
Metals (mg/L)																		
Iron (ICP)	0.3 (1)		0.54	2.56	0.76	0.46	4	0.46	1.08	2.56	0.17	0.16	0.19	0.15	4	0.15	0.17	0.19
Manganese (ICP)	1.90		0.094	0.102	0.077	0.112	4	0.077	0.096	0.112	0.103	0.092	0.108	0.093	4	0.092	0.099	0.108
Nutrients (mg/L)																		
Nitrate (NO3 as N)	0.7 (7)		0.59	0.67	0.69	2.75	4	0.59	1.18	2.75	0.11	<0.01	0.36	0.14	4	0.11	0.20	0.36
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	15.50	26.30	19.60	17.60	4	15.50	19.75	26.30	32.40	38.20	34.60	33.00	4	32.40	34.55	38.20
Total Nitrogen	0.5 (3)	0.12 (4)																
Dissolved Organic Carbon (DOC)			30	48	59	61	4	30	50	61	27	22	49	26	4	22	31	49
Total Organic Carbon (TOC)			86	46	56	63	4	46	63	86	56	19	49	26	4	19	38	56
Total Phosphorus (TP)	0.05 (5)	0.025 (6)																
Notes:																		

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
 - a. Reference only, not directly applicable to groundwater.

Unsamped well on EPL
Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD 6C	MD 6C	MD 6C	MD 6C	No. Samples	Min	Mean	Max	MD9A	MD9A	MD9A	MD9A	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16					3/11/15	15/2/16	30/5/16	11/8/16				
RL (mAHD at TOC)			1.86	1.86	1.86	1.86					1.35	1.35	1.35	1.35				
Standing water level (mTOC)			1.48	1.39	1.35	1.32	4	1.32	1.39	1.48	0.60	0.60	0.45	0.72	4	0.45	0.59	0.72
Reduced SWL (mAHD)			0.4	0.5	0.5	0.5	4	0.38	0.47	0.54	0.8	0.8	0.9	0.6	4	0.63	0.76	0.90
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.1	7.2	7.1	7.3	4	7.1	7.2	7.3	6.6	6.5	7.2	6.9	4	6.5	6.8	7.2
Temperature			18	20	20	18	4	17.9	19.1	20.2	16	21	18	16	4	15.6	17.6	21.0
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		25100	21900	24200	25400	4	21900	24150	25400	4590	2880	2080	2150	4	2080	2925	4590
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	1.23	2.40	0.81	0.99	4	0.81	1.36	2.40	1.42	2.50	1.89	2.68	4	1.42	2.12	2.68
Laboratory Analyses (mg/L)																		
Sodium (ICP)			4110	4030	4110	4360	4	4030	4153	4360	814	547	368	402	4	368	533	814
Potassium (ICP)			146	148	145	162	4	145	150	162	38	31	35	31	4	31	34	38
Calcium (ICP)			356	354	354	359	4	354	356	359	39	32	23	33	4	23	32	39
Magnesium (ICP)			510	521	518	572	4	510	530	572	85	54	39	42	4	39	55	85
Chloride			7800	7710	7460	9400	4	7460	8093	9400	1220	814	485	596	4	485	779	1220
Sulphate (SO4)			1140	1170	1200	1080	4	1080	1148	1200	<100	15	8	89	4	8	37	89
Water Parameters (mg/L)																		
Alkalinity (as CaCO3)			420	415	417	407	4	407	415	420	219	252	255	219	4	219	236	255
Fluoride			0.4	0.4	0.4	0.4	4	0.4	0.4	0.4	0.2	0.2	0.2	0.2	4	0.2	0.2	0.2
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	0.00	0.00	0.00	<0.05	0.60	<0.05	0.33	4	0.00	0.00	0.00
Metals (mg/L)																		
Iron (ICP)	0.3 (1)		0.06	8.04	12.70	17.00	4	0.06	9.45	17.00	0.53	0.38	0.08	0.70	4	0.08	0.42	0.70
Manganese (ICP)	1.90		0.064	0.085	0.080	0.065	4	0.064	0.074	0.085	0.023	0.016	0.012	0.025	4	0.012	0.019	0.025
Nutrients (mg/L)																		
Nitrate (NO3 as N)	0.7 (7)		0.02	<0.01	<0.01	0.03	4	0.02	0.03	0.03	<0.10	<0.10	0.04	1.51	4	0.04	0.78	1.51
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	36.70	34.00	36.10	37.30	4	34.00	36.03	37.30	0.76	3.30	5.28	1.69	4	0.76	2.76	5.28
Total Nitrogen	0.5 (3)	0.12 (4)																
Dissolved Organic Carbon (DOC)			8	<1	22	9	4	8	13	22	404	274	40	230	4	40	237	404
Total Organic Carbon (TOC)			31	7	23	16	4	7	19	31	404	276	45	229	4	45	239	404
Total Phosphorus (TP)	0.05 (5)	0.025 (6)																
Notes:																		

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
5. Trigger value for total phosphorus in lowland rivers in NSW.
6. Trigger value for total phosphorus in marine ecosystems in NSW.
7. Trigger value for 95% protection level
 - a. Reference only, not directly applicable to groundwater.

Unsamped well on EPL

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD 9B	MD 9B	MD 9B	MD 9B	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16				
RL (mAHD at TOC)			1.35	1.35	1.35	1.35				
Standing water level (mTOC)			0.89	0.75	0.69	0.88	4	0.69	0.80	0.89
Reduced SWL (mAHD)			0.5	0.6	0.7	0.5	4	0.46	0.55	0.66
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.0	6.9	6.8	7.0	4	6.8	6.9	7.0
Temperature			17	20	19	17	4	17.2	18.4	20.4
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		2810	2870	3130	2980	4	2810	2948	3130
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	1.07	2.80	1.09	1.78	4	1.07	1.69	2.80
Laboratory Analyses (mg/L)										
Sodium (ICP)			277	276	289	272	4	272	279	289
Potassium (ICP)			67	77	84	82	4	67	78	84
Calcium (ICP)			170	196	194	195	4	170	189	196
Magnesium (ICP)			89	97	98	100	4	89	96	100
Chloride			375	398	382	418	4	375	393	418
Sulphate (SO4)			73	3	<10	<10	4	3	38	73
Water Parameters (mg/L)										
Alkalinity (as CaCO3)			1080	1100	1140	1060	4	1060	1095	1140
Fluoride			0.7	0.7	0.6	0.5	4	0.5	0.6	0.7
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	0.00	0.00	0.00
Metals (mg/L)										
Iron (ICP)	0.3 (1)		4.86	9.61	4.26	2.96	4	2.96	5.42	9.61
Manganese (ICP)	1.90		0.254	0.261	0.256	0.395	4	0.254	0.292	0.395
Nutrients (mg/L)										
Nitrate (NO3 as N)	0.7 (7)		0.07	<0.01	<0.01	<0.01	4	0.07	0.07	0.07
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	28.80	27.70	34.30	33.10	4	27.70	30.98	34.30
Total Nitrogen	0.5 (3)	0.12 (4)								
Dissolved Organic Carbon (DOC)			32	53	59	55	4	32	50	59
Total Organic Carbon (TOC)			32	48	61	57	4	32	50	61
Total Phosphorus (TP)	0.05 (5)	0.025 (6)								

Notes:

1. Trigger value is an indicative interim working level only (IIWL).
 2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
 3. Trigger value for total nitrogen for lowland rivers in SE Australia.
 4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
 5. Trigger value for total phosphorus in lowland rivers in NSW.
 6. Trigger value for total phosphorus in marine ecosystems in NSW.
 7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsamped well on EPL
Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD 9C	MD 9C	MD 9C	MD 9C	No. Samples	Min	Mean	Max
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16				
RL (mAHD at TOC)			1.40	1.40	1.40	1.40				
Standing water level (mTOC)			0.90	0.80	0.80	0.91	4	0.80	0.85	0.91
Reduced SWL (mAHD)			0.50	0.60	0.60	0.49	4	0.49	0.55	0.60
pH (field)	6.5-8.0 (a)	8-8.4 (a)	7.20	7.00	7.00	7.00	4	7.00	7.05	7.20
Temperature			17.5	19.7	19	18.4	4	17.50	18.65	19.70
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		3890	3480	3700	3600	4	3480	3668	3890
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	0.99	3.8	0.65	0.97	4	0.65	1.60	3.80
Laboratory Analyses (mg/L)										
Sodium (ICP)			311	307	340	313	4	307	318	340
Potassium (ICP)			147	158	150	145	4	145	150	158
Calcium (ICP)			117	132	132	130	4	117	128	132
Magnesium (ICP)			58	61	63	64	4	58	62	64
Chloride			517	490	534	508	4	490	512	534
Sulphate (SO4)			<10	<10	<10	<1	4	0	0	0
Water Parameters (mg/L)										
Alkalinity (as CaCO3)			1360	1300	1260	1180	4	1180	1275	1360
Fluoride			0.5	0.5	0.5	0.4	4	0.40	0.48	0.50
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND
Metals (mg/L)										
Iron (ICP)	0.3 (1)		5.91	8.08	8.15	6.96	4	5.91	7.28	8.15
Manganese (ICP)	1.90		0.186	0.181	0.177	0.194	4	0.18	0.18	0.19
Nutrients (mg/L)										
Nitrate (NO3 as N)	0.7 (7)		0.09	<0.01	0.04	<0.01	4	0.04	0.07	0.09
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	162.00	156.00	158.00	107.00	4	107	146	162
Total Nitrogen	0.5 (3)	0.12 (4)								
Dissolved Organic Carbon (DOC)			118	82	50	90	4	50	85	118
Total Organic Carbon (TOC)			137	84	56	93	4	56	93	137
Total Phosphorus (TP)	0.05 (5)	0.025 (6)								
Notes:										

1. Trigger value is an indicative interim working level only (IIWL).
 2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
 3. Trigger value for total nitrogen for lowland rivers in SE Australia.
 4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
 5. Trigger value for total phosphorus in lowland rivers in NSW.
 6. Trigger value for total phosphorus in marine ecosystems in NSW.
 7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsampled well on EPL
Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table GW-1: Summary 2015/16 Analytical Results - Minnamurra Waste Disposal Depot

Minnamurra Waste Disposal Depot

Sample ID	ANZECC, 2000		MD10A	MD10A	MD10A	MD10A	No. Samples	Min	Mean	Max	MD 10B	MD 10B	MD 10B	MD 10B	No. Sample	Min	Mean	Max
Field Measurements	Freshwater	Marine	3/11/15	15/2/16	30/5/16	11/8/16					3/11/15	15/2/16	30/5/16	11/8/16				
RL (mAHD at TOC)			NM	NM	NM	NM					NM	NM	NM	NM				
Standing water level (mTOC)			0.83	0.76	0.5	0.53	4	0.50	0.66	0.83	0.66	0.61	0.48	0.68	4	0.48	0.61	0.68
Reduced SWL (mAHD)																		
pH (field)	6.5-8.0 (a)	8-8.4 (a)	6.8	6.5	6.9	6.8	4	6.5	6.8	6.9	7.5	7.3	7.4	7.4	4	7.3	7.4	7.5
Temperature			18.4	23.2	16.9	15.8	4	15.8	18.6	23.2	18.9	23.7	18.4	16.5	4	16.5	19.4	23.7
Electrical Conductivity (uS/cm)	0.125-2.2 (a)		35100	37000	39800	39400	4	35100	37825	39800	2350	2010	2110	2250	4	2010	2180	2350
Dissolved Oxygen (mg/L)	8.5-11.0 (a)	9.0-10.0 (a)	2.01	2.9	4.69	2.48	4	2.01	3.02	4.69	1.91	2.2	1.25	2.15	4	1.25	1.88	2.20
Laboratory Analyses (mg/L)																		
Sodium (ICP)			5860	6760	7100	7540	4	5860	6815	7540	161	154	146	134	4	134	149	161
Potassium (ICP)			138	128	145	139	4	128	138	145	79	84	81	78	4	78	81	84
Calcium (ICP)			626	560	575	589	4	560	588	626	108	114	110	109	4	108	110	114
Magnesium (ICP)			805	939	976	1140	4	805	965	1140	46	43	42	38	4	38	42	46
Chloride			11200	11900	12500	13400	4	11200	12250	13400	208	216	208	272	4	208	226	272
Sulphate (SO4)			1750	2060	2170	1820	4	1750	1950	2170	<10	<10	<10	<10	4	0	0	0
Water Parameters (mg/L)																		
Alkalinity (as CaCO3)			319	310	319	419	4	310	342	419	815	811	782	741	4	741	787	815
Fluoride			0.4	0.6	0.6	0.6	4	0.4	0.6	0.6	0.8	0.8	0.8	0.7	4	0.7	0.8	0.8
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND	<0.05	<0.05	<0.05	<0.05	4	ND	ND	ND
Metals (mg/L)																		
Iron (ICP)	0.3 (1)		1.49	3.96	0.42	3.99	4	0.42	2.47	3.99	0.93	0.88	0.68	0.74	4	0.68	0.81	0.93
Manganese (ICP)	1.90		0.359	0.466	0.199	0.562	4	0.199	0.397	0.562	0.388	0.358	0.409	0.409	4	0.358	0.391	0.409
Nutrients (mg/L)																		
Nitrate (NO3 as N)	0.7 (7)		0.02	<0.01	0.11	<0.01	4	0.02	0.07	0.11	0.06	8.50	<0.01	0.04	4	0.04	2.87	8.50
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	0.43	0.72	0.10	0.60	4	0.10	0.46	0.72	78.80	59.40	65.00	65.00	4	59.40	67.05	78.80
Total Nitrogen	0.5 (3)	0.12 (4)																
Dissolved Organic Carbon (DOC)			45	61	67	70	4	45	61	70	57	50	56	50	4	50	53	57
Total Organic Carbon (TOC)			68	60	66	85	4	60	70	85	87	50	63	50	4	50	63	87
Total Phosphorus (TP)	0.05 (5)	0.025 (6)																
Notes:																		

1. Trigger value is an indicative interim working level only (IIWL).
 2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
 3. Trigger value for total nitrogen for lowland rivers in SE Australia.
 4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.
 5. Trigger value for total phosphorus in lowland rivers in NSW.
 6. Trigger value for total phosphorus in marine ecosystems in NSW.
 7. Trigger value for 95% protection level
- a. Reference only, not directly applicable to groundwater.

Unsourced well on EPL

Exceeds ANZECC (2000) marine trigger value

Exceedance of IIWL values or fresh water not highlighted.

Table SW-1 Minnamurra Waste Disposal Depot (Rocklow Creek)

Sample ID	ANZECC, 2000		Rocklow Up	Rocklow Middle	Rocklow Down	Rocklow Up	Rocklow Middle	Rocklow Down	Rocklow Up	Rocklow Middle	Rocklow Down	Rocklow Up	Rocklow Middle	Rocklow Down
Field Measurements	Freshwater	Marine	3/11/15	3/11/15	3/11/15	15/02/16	15/02/16	15/02/16	30/05/16	30/05/16	30/05/16	11/08/16	11/08/16	11/08/16
pH (field)	6.5-8.0	8-8.4	7.4	7	7.1	7.5	7.3	7.2	7.5	7.2	7.3	7.2	7.6	7.3
Temperature			19.7	19.5	19.4	24.8	23.4	25	11.3	12.2	12.6	14	14.1	16.9
Electrical Conductivity (mS/cm)	0.125-2.2		4740	32100	32900	7100	23000	29700	44500	42600	42300	833	2880	5040
Dissolved Oxygen (mg/L)	8.5-11.0	9.0-10.0	5.78	2.83	3.41	6.30	6.50	6.70	8.78	6.96	7.86	8.49	8.21	8.63
Turbidity (NTU)	6-50 (a)	0.5-10												
Laboratory Analyses (mg/L)														
Sodium (ICP)			804	5720	6820	1160	4490	5520	8420	8660	8620	101	455	884
Potassium (ICP)			32	217	256	48	184	231	313	329	325	6	19	34
Calcium (ICP)			72	252	284	87	214	250	390	392	389	30	48	66
Magnesium (ICP)			113	640	736	153	461	562	1030	1060	1040	19	57	112
Chloride			1330	10200	10400	1720	7410	9480	13400	13600	14100	163	728	1430
Sulphate (SO4)			230	1440	1690	279	1140	1400	1680	1670	1980	36	122	204
Water Parameters (mg/L)														
Hardness (as CaCO3)			183	228	230	216	216	202	160	170	162	116	136	148
Fluoride			0.4	1	1	0.4	1	1	0.9	1	1	<0.1	0.2	0.3
Phenols		0.40	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Metals (mg/L)														
Iron (ICP)	0.3 (1)		0.32	0.59	0.26	0.58	0.43	0.36	0.19	0.20	0.37	1.33	1.28	1.14
Manganese (ICP)	1.90		0.15	0.24	0.15	0.18	0.24	0.22	0.04	0.09	0.06	0.06	0.05	0.06
Nutrients (mg/L)														
Total Phosphorus (TP)	0.05 (5)	0.025 (6)												
Total Nitrogen	0.5 (3)	0.12 (4)												
Nitrate (NO3 as N)	0.7 (7)		0.06	0.07	0.03	0.04	0.04	0.03	----	----	----	----	----	----
Ammonia (NH3 as N)	1.88 (2)	2.84 (2)	0.12	1.08	2.09	0.19	2.49	0.58	0.17	0.67	0.68	0.06	0.17	0.23
Ammonia Increment (Upper to Mid Rocklow)				0.96			2.30			0.50			0.11	
Ammonia Increment (Mid to lower Rocklow)					1.01		-1.91				0.01			0.06
Dissolved Organic Carbon (DOC)			<1	11	<1	10	9	7	8	10	9	8	9	9
Total Organic Carbon (TOC)			7	24	9	12	10	8	7	8	9	9	10	10

Notes:

1. Trigger value is an indicative interim working level only (IIWL).
2. Ammonia trigger value at pH = 8.0, 95% PL, corrected to pH = 7.3.
3. Trigger value for total nitrogen for lowland rivers in SE Australia.
4. Trigger value for oxides of nitrogen (NOx) for marine ecosystems, NSW.

Table SW-2: Rocklow Creek - Historical Ammonia Concentrations (1999 - 2016)

Sample ID	6/05/1999	17/08/1999	2/12/2000	28/02/2000	11/05/2000	10/08/2000	21/11/2000	15/02/2001	17/05/2001	16/08/2001	13/11/2001	22/02/2002	8/04/2002	19/08/2002	14/11/2002	11/02/2003	12/06/2003	22/08/2003	20/11/2003	17/02/2004	12/05/2004	11/08/2004	7/12/2004	2/02/2005	4/05/2005	16/08/2005
Upper Rocklow (mg/L)	0.16	<0.02	0.10	0.16	0.03	0.06	0.04	0.10	0.22	0.35	0.18	0.10	0.07	0.13	0.06	0.01	0.11	0.14	0.03	0.17	0.28	0.03	0.22	<0.02	<0.02	0.06
Middle Rocklow (mg/L)																										
Lower Rocklow (mg/L)	1.00	0.65	2.07	1.74	0.57	1.34	0.26	0.56	0.69	0.42	0.24	0.64	1.11	2.00	1.60	0.51	0.13	1.40	1.70	0.38	0.55	0.65	0.92	<0.02	0.31	1.40
Net Increment (mg/L)	0.84	0.64	1.97	1.58	0.54	1.28	0.22	0.46	0.47	0.07	0.06	0.54	1.04	1.87	1.54	0.50	0.02	1.26	1.67	0.21	0.27	0.62	0.70	NA	0.30	1.34

Sample ID	9/11/2005	28/02/2006	30/05/2006	30/08/2006	27/11/2006	26/02/2007	22/05/2007	21/08/2007	20/11/2007	21/02/2008	28/05/2008	26/08/2008	25/11/2008	16/02/2009	18/05/2009	28/08/2009	27/11/2009	26/02/2010	20/05/2010	17/08/2010	29/11/2010	25/02/2011	23/05/2011	23/08/2011	2/11/2011	2/02/2012
Upper Rocklow (mg/L)	<0.02	<0.02	0.22	0.09	0.39	0.66	0.41	0.32	0.39	<0.1	0.27	0.12	<0.1	0.56	0.12	0.15	0.10	0.20	<0.1	0.05	0.30	<0.1	0.01	0.05	0.03	0.14
Middle Rocklow (mg/L)														0.56	0.61	0.38	0.80	<0.1	<0.1	0.27	0.33	5.65	0.56	0.20	0.31	0.58
Lower Rocklow (mg/L)	<0.02	<0.02	0.64	0.90	1.20	0.32	0.62	0.48	1.60	NM	1.60	1.20	0.16	0.66	0.30	0.21	0.60	<0.1	<0.1	0.42	NM	NM	NM	NM	NM	NM
Net Increment (mg/L)	NA	NA	0.42	0.81	0.81	(0.34)	0.21	0.16	1.21	NA	1.33	1.08	NA	0.10	0.18	0.06	0.50	NA	NA	0.37	0.03	5.55	0.55	0.15	0.28	0.44

Sample ID	30/05/2012	9/08/2012	20/11/2012	18/02/2013	30/05/2013	29/08/2013	26/11/2013	6/02/2014	6/05/2014	18/08/2014	17/11/2014	26/02/2015	27/05/2015	10/08/2015	3/11/2015	15/02/2016	30/05/2016	1/08/2016
Upper Rocklow (mg/L)	<0.01	0.04	0.10	0.10	0.12	0.16	0.09	0.16	0.39	0.14	0.14	0.14	0.06	0.09	0.12	0.19	0.17	0.06
Middle Rocklow (mg/L)	1.06	1.91	0.44	0.71	0.19	0.40	0.18	1.60	0.29	0.14	0.24	0.13	0.29	0.23	1.08	2.49	0.67	0.17
Lower Rocklow (mg/L)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	0.09	0.28	0.19	2.09	0.58	0.68	0.23
Net Increment (mg/L) Middle- Lower	1.06	1.87	0.34	0.61	0.07	0.24	0.09	1.44	(0.10)	0.00	0.10	(0.05)	0.01	0.04	(1.01)	1.91	(0.01)	(0.06)

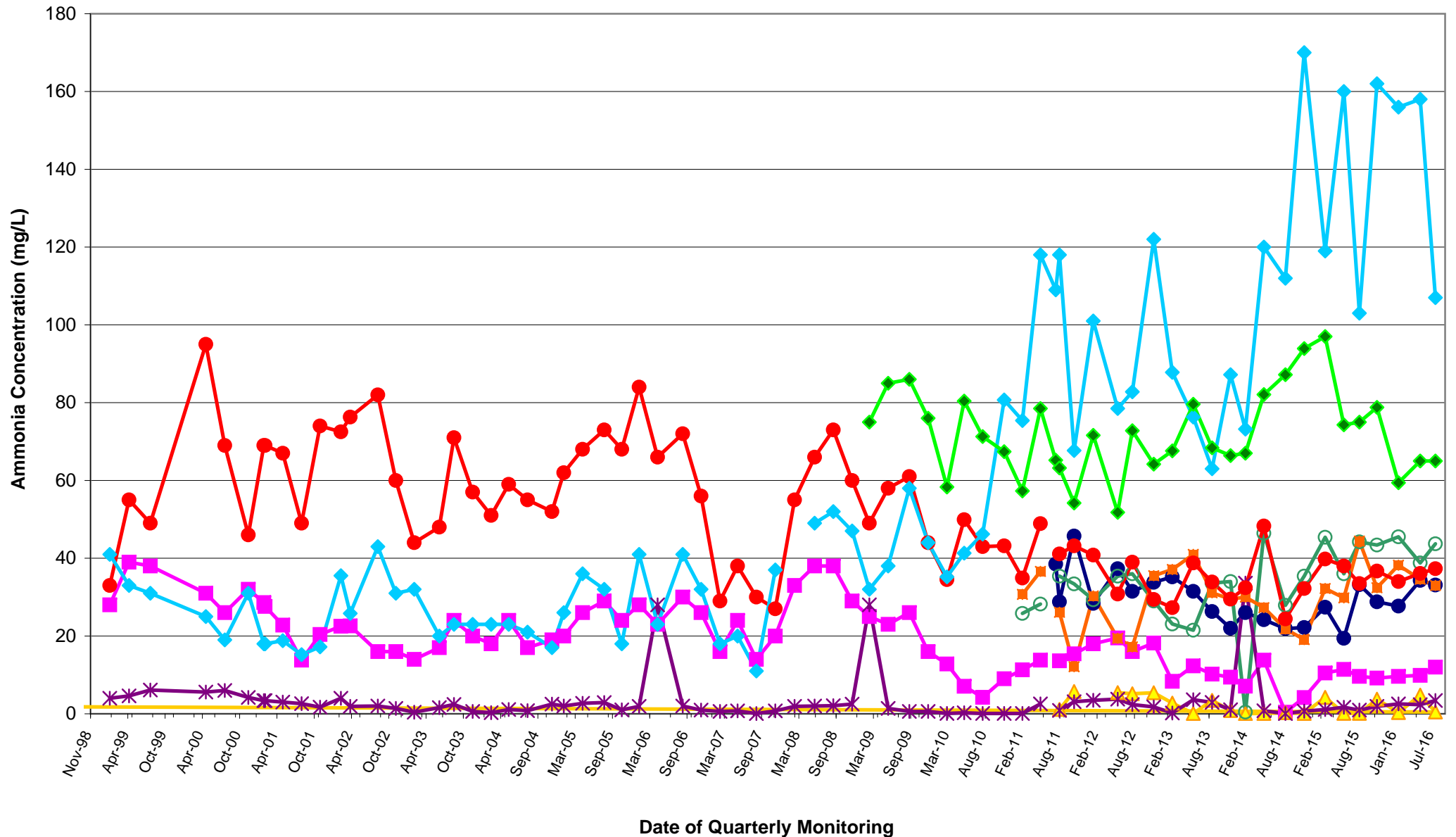
Legend

NA = Not Analysed NM= Not measured

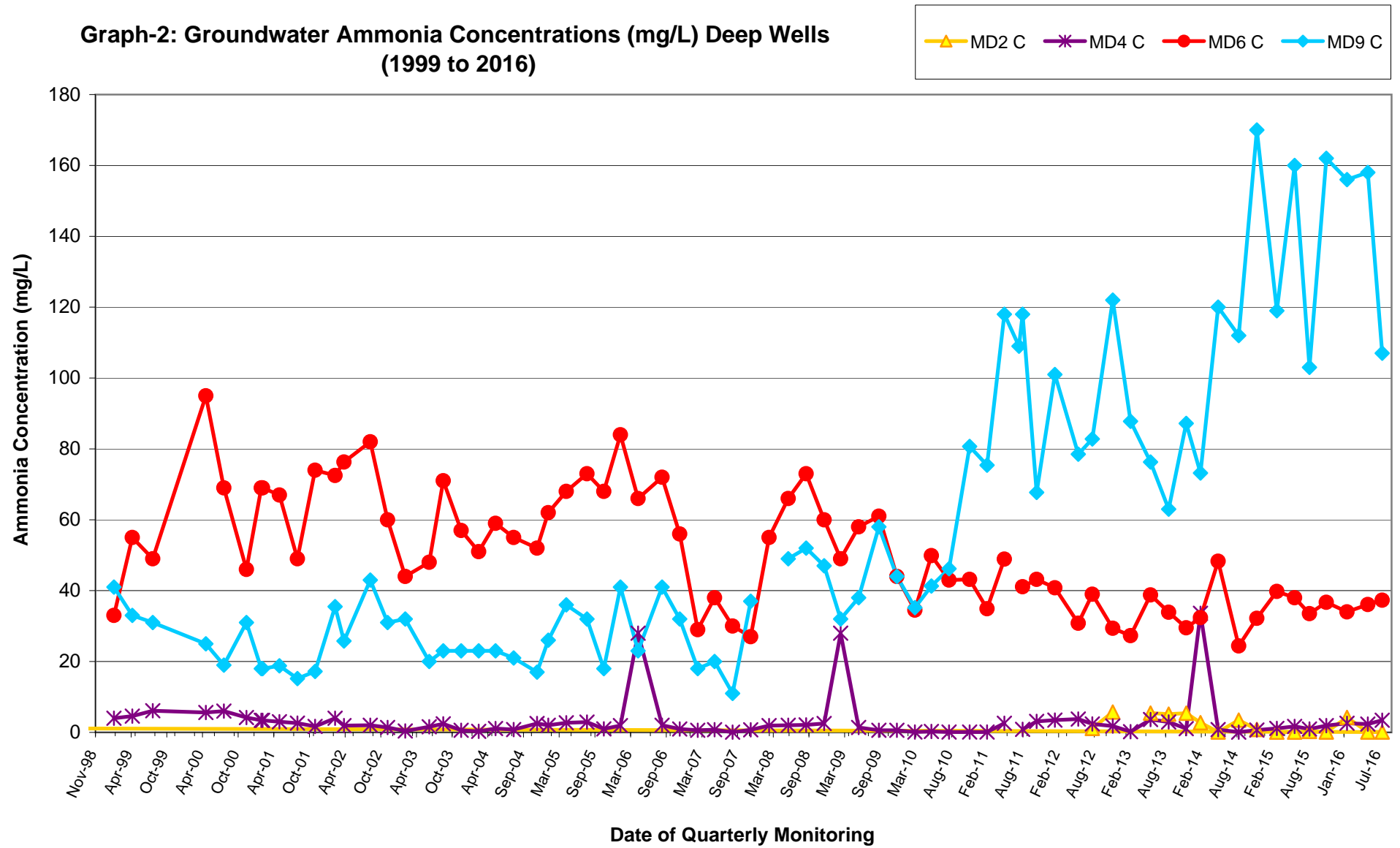
Note: Rocklow Down was inaccessible during the 2010-2014 monitoring periods

Graphs

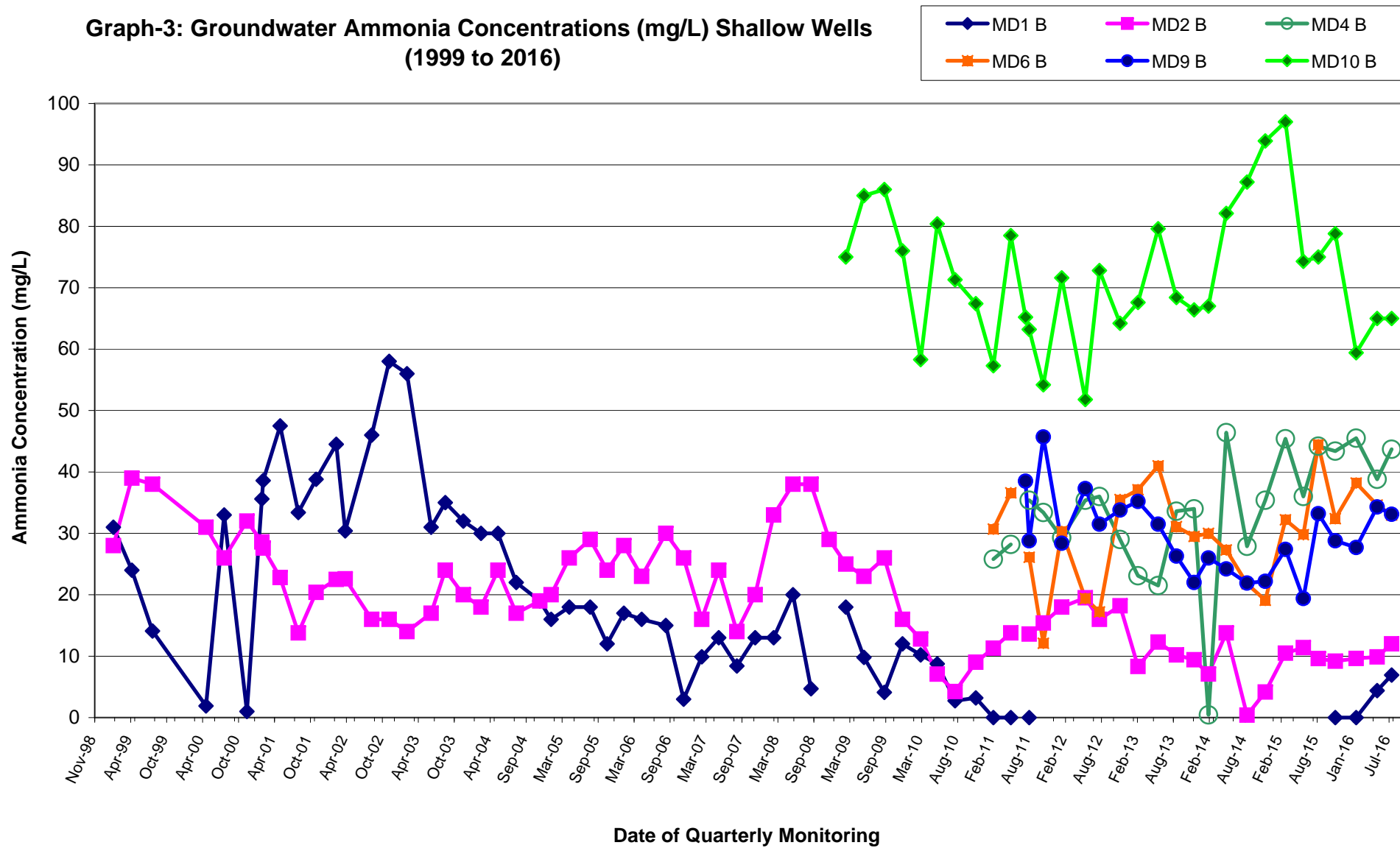
**Graph-1: Groundwater Ammonia Concentrations (mg/L) All Wells
(1999 to 2016)**



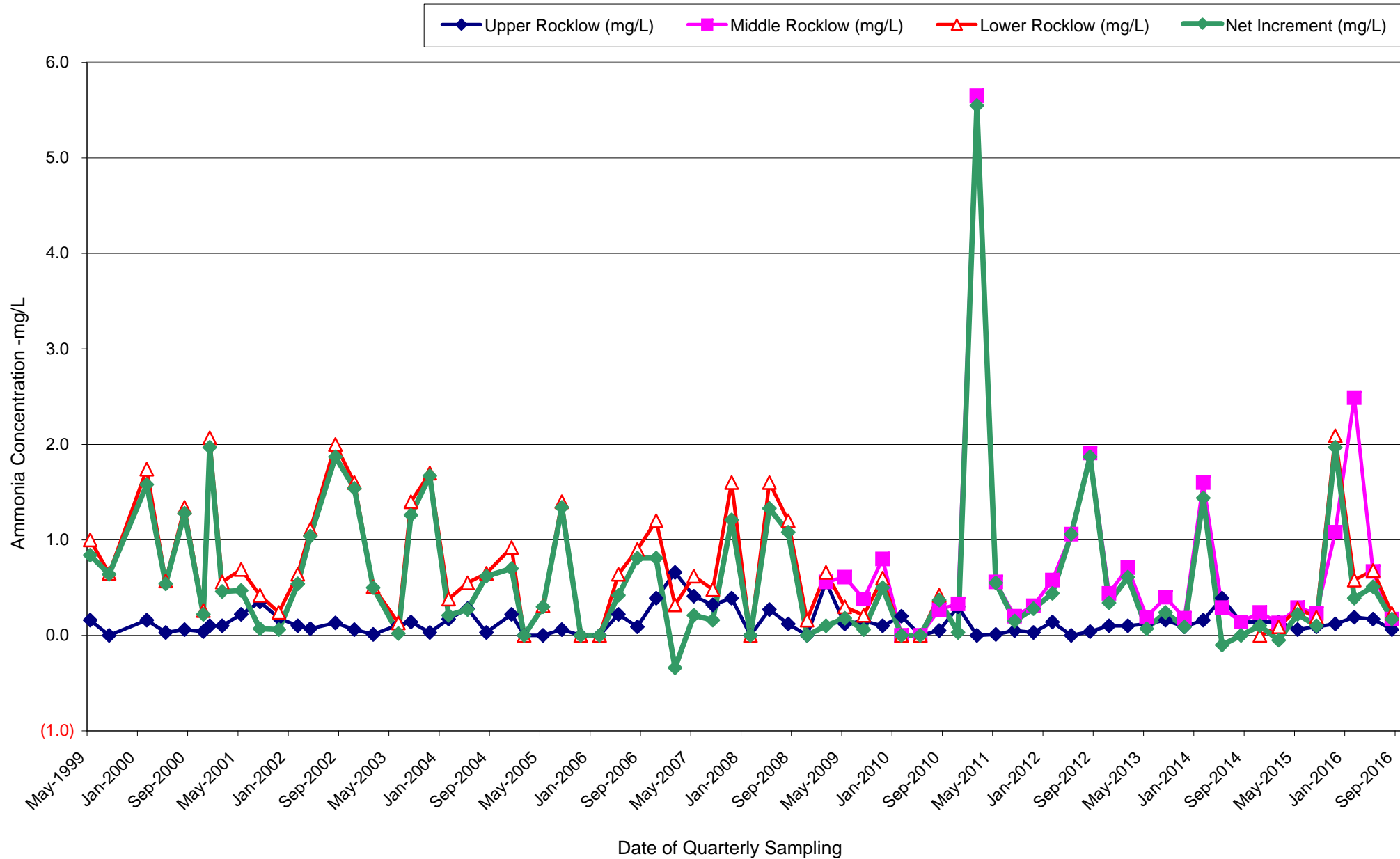
**Graph-2: Groundwater Ammonia Concentrations (mg/L) Deep Wells
(1999 to 2016)**



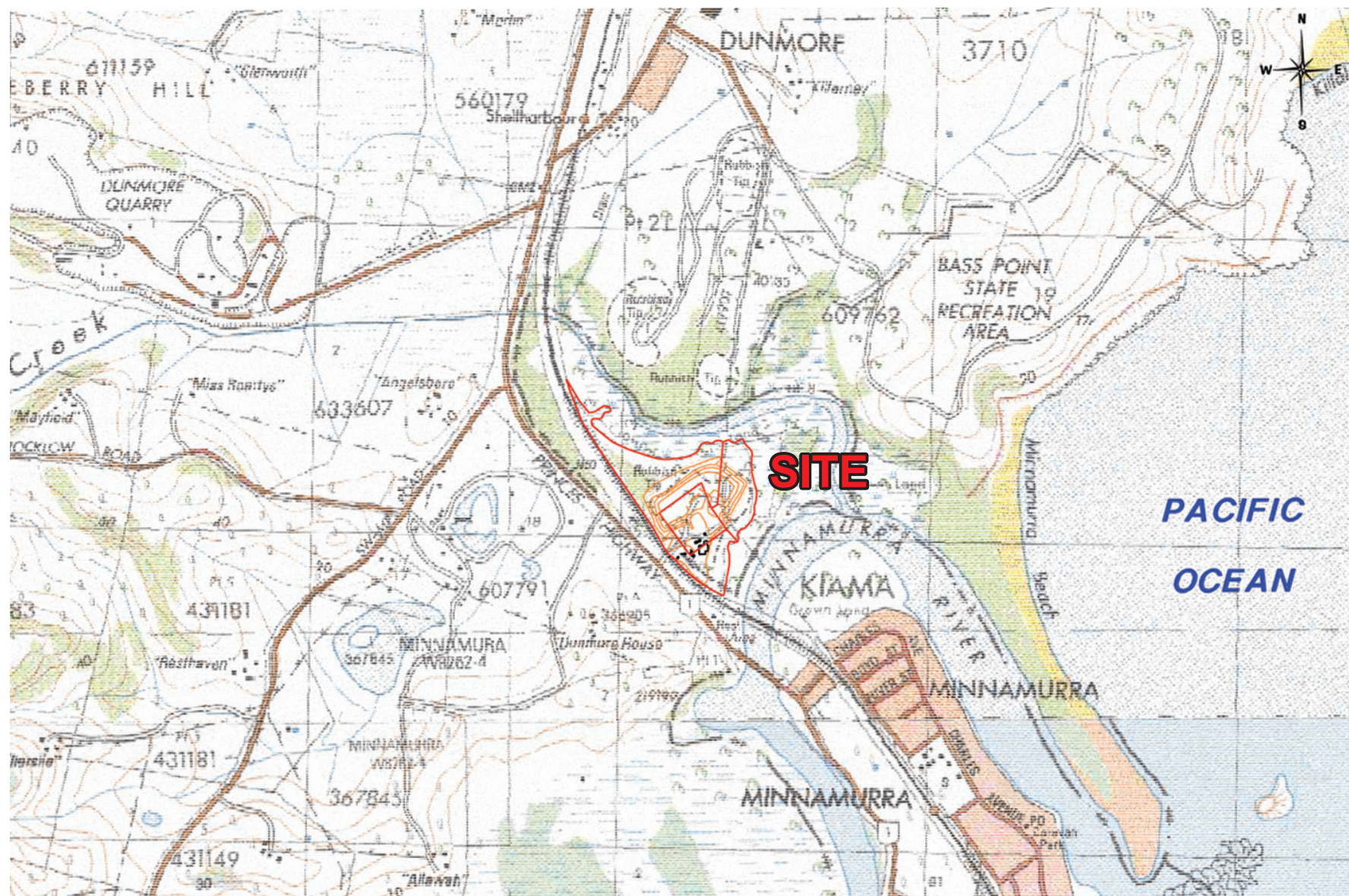
**Graph-3: Groundwater Ammonia Concentrations (mg/L) Shallow Wells
(1999 to 2016)**



Graph-04: Net Increments of Ammonia Between Up and Down Stream Samples (1999 to 2016)











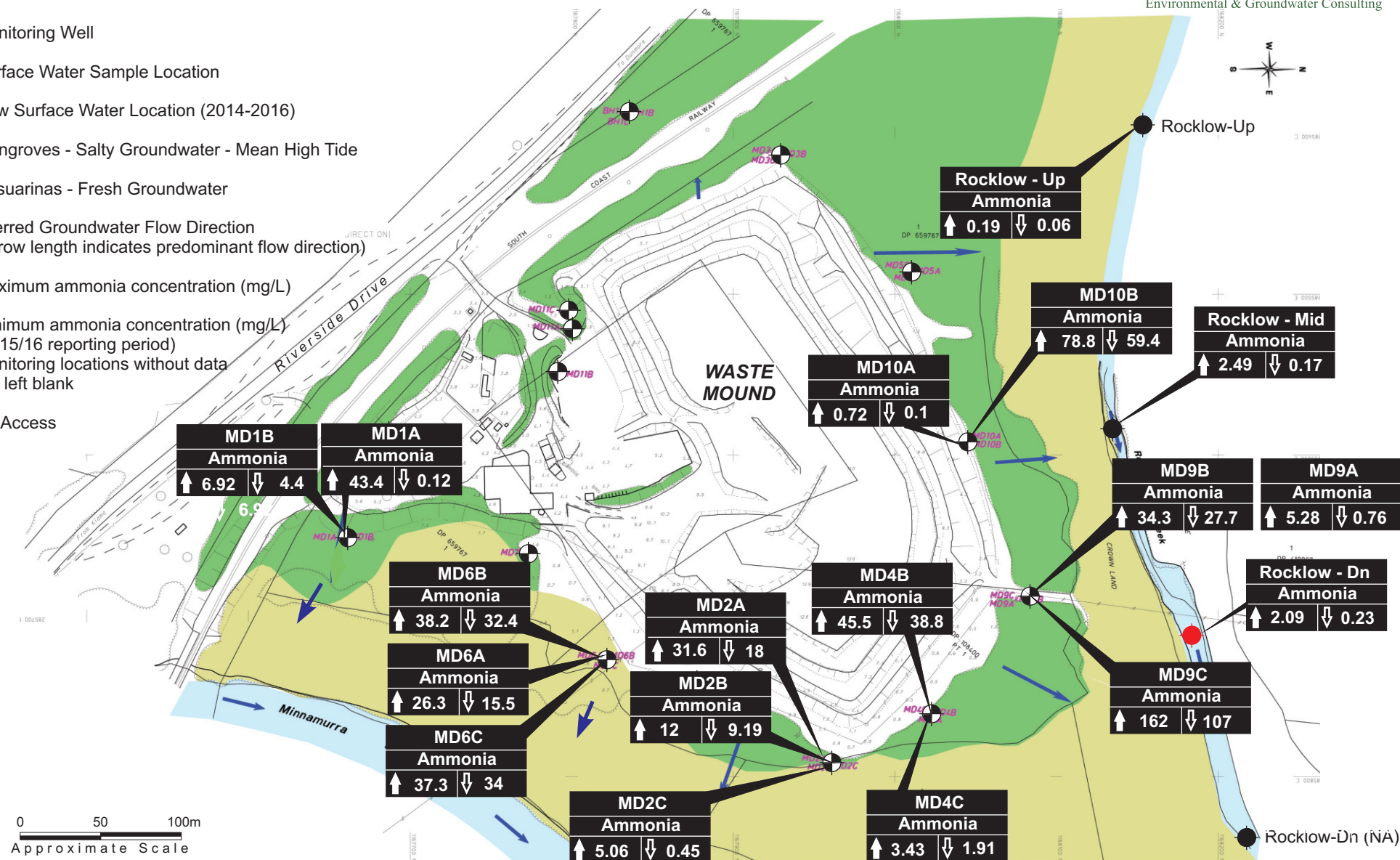
Figures



SITE LOCATION

LEGEND

-  Monitoring Well
-  Surface Water Sample Location
-  New Surface Water Location (2014-2016)
-  Mangroves - Salty Groundwater - Mean High Tide
-  Casuarinas - Fresh Groundwater
-  Inferred Groundwater Flow Direction
(Arrow length indicates predominant flow direction)
-  **↑ 3.2** Maximum ammonia concentration (mg/L)
-  **↓ 0.4** Minimum ammonia concentration (mg/L)
(2015/16 reporting period)
Monitoring locations without data are left blank
- NA** No Access



Source: Neil Charters Pty Ltd

MONITORING WELL LOCATIONS & MAXIMUM & MINIMUM AMMONIA CONCENTRATIONS (2015-2016)

Date: October 2016

KIAMA COUNCIL - MINNAMURRA ANNUAL MONITORING REPORT (2015-2016)

Reference: E2W_059_04.cdr

Figure 2

Appendix A



CHAIN OF CUSTODY

ALS Laboratory, please tick →

- ☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176
Ph: 02 8784 8655 E: samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warahook NSW 2304
Ph: 02 4968 9433 E: samples.newcastle@alsenviro.com
- ☐ Brisbane: 32 Sheard St, Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818
Ph: 07 4726 0800 E: townsville@alsenviro.com
- ☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171
Ph: 03 8649 9800 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Porirua SA 5095
Ph: 08 8330 0880 E: adelaide@alsenviro.com
- ☐ Perth: 10 Hot Way, Malaga WA 6060
Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: Kiama Municipal Council

OFFICE: PO Box 75 Kiama NSW 2533

PROJECT: Minnamurra Landfill

ORDER NUMBER: 87886

PROJECT MANAGER: Paul Czulowski

SAMPLER: Craig Wilson

COC emailed to ALS? (YES / NO)

Email Reports to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

Email Invoice to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS : ☐ Standard TAT (list due date): ☐ Non Standard or urgent TAT (list due date):

(Standard TAT may be longer for some tests e.g. Ultra Trace Organics)

ALS QUOTE NO.: SY-146-10

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EOD FORMAT (or default):

RELINQUISHED BY: Craig

DATE/TIME: 3/11/15 15:55

RECEIVED BY: Angela

DATE/TIME: 3/11/15 15:00

RELINQUISHED BY:

DATE/TIME:

FOR LABORATORY

Control Seal Intact?

Freezer / frozen ice block received?

Random Sample Temp?

Other comments:

Environmental Division

Wollongong

Work Order Reference

EW1512379



Telephone : 02 42263125

Additional Information

Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.

YSI (Field Results)
pH, Temp, EC, Sal, DO, Depth

LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	ANALYSIS REQUIRED INCLUDING SUITES (NB, Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (filtered bottle required).							Additional Information
						NT-02A (Alkalinity, Cl, SO4 & Fluoride)	Nitrate, Ammonia, Total Phenolics	DOC (Filtered)	TOC	(Dissolved Filtered) Fe, Mn, NT-01 (Mg, Ca, Na, K)	(Total) Fe, Mn, Mg, Ca, Na, K		
1	MD 1B	3/11 1320	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓	Not Found.		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
2	MD 2A	1050	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
3	MD 2B	1105	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
4	MD 2C	1115	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
5	MD 4A	1130	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓	dry		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
6	MD 4B	1135	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
7	MD 4C	1145	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
8	MD 6A	1005	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
9	MD 6B	1015	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
10	MD 6C	6/11 1025	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
11	MD 9A	1250 1200	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
12	MD 9B	1300	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓			YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
TOTAL													

Water Container Codes: P = Unpreserved Plastic, N = Nitric Preserved Plastic, ORC = Nitric Preserved ORC, SH = Sodium Hydroxide/Cr Preserved, S = Sodium Hydroxide Preserved Plastic, AG = Amber Glass Unpreserved, AP = Airfreight Unpreserved Plastic, V = VOA Vial HCl Preserved, VB = VOA Vial Sodium Bisulfate Preserved, VS = VOA Vial Sulfuric Preserved, Vial SG = Sulfuric Preserved Amber Glass, H = HCl Preserved Plastic, HS = HCl Preserved Speciation bottle, SP = Sulfuric Preserved Plastic, F = Formaldehyde Preserved Glass, Z = Zinc Acetate Preserved Bottle, E = EDTA Preserved Bottles, ST = Sterile Bottle, ASS = Plastic Bag for Acid Sulphate Soils, B = Unpreserved Bag.

CERTIFICATE OF ANALYSIS

Work Order : **EW1512379**
Client : **KIAMA COUNCIL**
Contact : **MR PAUL CZULOWSKI**
Address : **11 MANNING STREET**
KIAMA NSW, AUSTRALIA 2533

E-mail : **paulc@kiama.nsw.gov.au**
Telephone : **+61 02 4232 0444**
Facsimile : **+61 02 4232 0555**
Project : **Minnamurra Landfill**
Order number : **87896**
C-O-C number : **----**
Sampler : **Craig Wilson**
Site : **----**

Quote number : **----**

Page : 1 of 10
Laboratory : Environmental Division NSW South Coast
Contact : Glenn Davies
Address : 1/19 Ralph Black Dr, North Wollongong 2500
4/13 Geary Pl, North Nowra 2541
Australia
E-mail : glenn.davies@alsglobal.com
Telephone : 02 42253125
Facsimile : W 02 42253128 N 02 44232083
QC Level : NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Date Samples Received : 03-Nov-2015 15:00
Date Analysis Commenced : 03-Nov-2015
Issue Date : 10-Nov-2015 14:32

No. of samples received : 19
No. of samples analysed : 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Dian Dao		Sydney Inorganics
Glenn Davies	Environmental Services Representative	Laboratory - Wollongong
Shobhna Chandra	Metals Coordinator	Sydney Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

- EK059G-EK058G: LOR raised for NOx- Nitrate on sample 11 due to sample matrix.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time				03-Nov-2015 13:20	03-Nov-2015 10:50	03-Nov-2015 11:05	03-Nov-2015 11:15	03-Nov-2015 11:30
Compound	CAS Number	LOR	Unit	EW1512379-001	EW1512379-002	EW1512379-003	EW1512379-004	EW1512379-005
				Result	Result	Result	Result	Result
EA005FD: Field pH								
pH	----	0.1	pH Unit	----	7.2	7.1	7.2	----
EA010FD: Field Conductivity								
Electrical Conductivity (Non Compensated)	----	1	µS/cm	----	15900	24200	43500	----
EA020FD: Field Salinity								
Salinity	----	0.2	g/L	----	11.1	17.8	33.9	----
EA116: Temperature								
Temperature	----	0.1	°C	----	17.1	16.8	16.9	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	----	<1	<1	<1	----
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	----	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	----	804	655	508	----
Total Alkalinity as CaCO ₃	----	1	mg/L	----	804	655	508	----
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	----	808	1110	2110	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	----	5380	7580	14000	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	----	210	344	474	----
Magnesium	7439-95-4	1	mg/L	----	381	523	958	----
Sodium	7440-23-5	1	mg/L	----	2860	4090	7660	----
Potassium	7440-09-7	1	mg/L	----	152	175	313	----
ED093T: Total Major Cations								
Calcium	7440-70-2	1	mg/L	----	----	----	----	----
Magnesium	7439-95-4	1	mg/L	----	----	----	----	----
Sodium	7440-23-5	1	mg/L	----	----	----	----	----
Potassium	7440-09-7	1	mg/L	----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	----	0.045	0.082	0.126	----
Iron	7439-89-6	0.05	mg/L	----	0.83	0.69	0.11	----
EG020T: Total Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	----	----	----	----	----
Iron	7439-89-6	0.05	mg/L	----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time					03-Nov-2015 13:20	03-Nov-2015 10:50	03-Nov-2015 11:05	03-Nov-2015 11:15	03-Nov-2015 11:30
Compound	CAS Number	LOR	Unit		EW1512379-001	EW1512379-002	EW1512379-003	EW1512379-004	EW1512379-005
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		----	0.8	0.7	0.6	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		----	18.0	9.19	0.45	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	0.02	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	0.74	0.07	0.81	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	0.76	0.07	0.81	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	185	250	449	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	170	242	444	----
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		----	4.11	1.52	0.61	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		NOT FOUND	----	----	----	DRY
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		----	29	25	5	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		----	84	61	50	----
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		----	2.51	1.46	1.23	----
Dissolved Oxygen - % Saturation	----	0.1	% saturation		----	26.2	15.0	12.8	----
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		----	<0.05	<0.05	<0.05	----
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		----	0.48	0.74	0.80	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					03-Nov-2015 11:35	03-Nov-2015 11:45	03-Nov-2015 10:05	03-Nov-2015 10:15	03-Nov-2015 10:25
Compound	CAS Number	LOR	Unit		EW1512379-006	EW1512379-007	EW1512379-008	EW1512379-009	EW1512379-010
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.1	7.0	7.2	7.1	7.1
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		8370	36000	4560	1700	25100
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		5.7	27.8	2.9	1.0	17.9
EA116: Temperature									
Temperature	----	0.1	°C		16.4	16.4	17.8	18.0	18.1
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		894	668	760	660	420
Total Alkalinity as CaCO3	----	1	mg/L		894	668	760	660	420
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		277	1760	410	106	1140
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		2450	11500	916	131	7800
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		297	410	198	140	356
Magnesium	7439-95-4	1	mg/L		172	786	136	43	510
Sodium	7440-23-5	1	mg/L		1270	6160	564	100	4110
Potassium	7440-09-7	1	mg/L		106	257	120	38	146
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.073	0.221	0.094	0.103	0.064
Iron	7439-89-6	0.05	mg/L		1.52	1.01	0.54	0.17	0.06
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					03-Nov-2015 11:35	03-Nov-2015 11:45	03-Nov-2015 10:05	03-Nov-2015 10:15	03-Nov-2015 10:25
Compound	CAS Number	LOR	Unit		EW1512379-006	EW1512379-007	EW1512379-008	EW1512379-009	EW1512379-010
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.5	0.7	0.8	0.6	0.4
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		43.4	1.91	15.5	32.4	36.7
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	0.11	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		0.01	<0.01	0.59	0.11	0.02
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		0.01	<0.01	0.70	0.11	0.02
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		92.7	374	49.6	19.1	252
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		86.9	360	48.7	15.8	242
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		3.24	2.02	0.90	9.27	2.02
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		19	23	30	27	8
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		70	48	86	56	31
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		1.25	2.03	4.04	1.48	1.23
Dissolved Oxygen - % Saturation	----	0.1	% saturation		13.0	17.6	42.9	15.7	13.1
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		1.20	1.22	1.27	1.31	1.48



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					03-Nov-2015 12:50	03-Nov-2015 13:00	03-Nov-2015 13:10	03-Nov-2015 12:00	03-Nov-2015 12:15
Compound	CAS Number	LOR	Unit		EW1512379-011	EW1512379-012	EW1512379-013	EW1512379-014	EW1512379-015
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		6.6	7.0	7.2	6.8	7.5
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		4590	2810	3890	35100	2350
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		3.0	1.7	2.4	25.7	1.4
EA116: Temperature									
Temperature	----	0.1	°C		15.6	17.2	17.5	18.4	18.9
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		219	1080	1360	319	815
Total Alkalinity as CaCO3	----	1	mg/L		219	1080	1360	319	815
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		<100	73	<10	1750	<10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		1220	375	517	11200	208
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		39	170	117	626	108
Magnesium	7439-95-4	1	mg/L		85	89	58	805	46
Sodium	7440-23-5	1	mg/L		814	277	311	5860	161
Potassium	7440-09-7	1	mg/L		38	67	147	138	79
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.023	0.254	0.186	0.359	0.388
Iron	7439-89-6	0.05	mg/L		0.53	4.86	5.91	1.49	0.93
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time				03-Nov-2015 12:50	03-Nov-2015 13:00	03-Nov-2015 13:10	03-Nov-2015 12:00	03-Nov-2015 12:15
Compound	CAS Number	LOR	Unit	EW1512379-011	EW1512379-012	EW1512379-013	EW1512379-014	EW1512379-015
				Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	0.2	0.7	0.5	0.4	0.8
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.76	28.8	162	0.43	78.8
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	0.07	<0.01	<0.01	<0.01	0.76
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.10	0.07	0.09	0.02	0.06
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.10	0.07	0.09	0.02	0.82
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	38.8	33.7	41.8	359	22.2
Total Cations	----	0.01	meq/L	----	----	39.5	----	----
Total Cations	----	0.01	meq/L	45.3	29.6	----	356	18.2
Ionic Balance	----	0.01	%	----	----	2.86	----	----
Ionic Balance	----	0.01	%	7.75	6.50	----	0.40	9.80
EN67 PK: Field Tests								
Field Observations	----	0.01	--	----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	404	32	118	45	57
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	404	32	137	68	87
EP025FD: Field Dissolved Oxygen								
Dissolved Oxygen	----	0.01	mg/L	1.42	1.07	0.99	2.01	1.91
Dissolved Oxygen - % Saturation	----	0.1	% saturation	14.7	11.2	10.3	21.4	20.5
EP035G: Total Phenol by Discrete Analyser								
Phenols (Total)	----	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth								
Depth	----	0.01	m	0.60	0.89	0.90	0.83	0.66



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	----
Client sampling date / time					03-Nov-2015 09:00	03-Nov-2015 12:35	03-Nov-2015 09:40	03-Nov-2015 11:40	----
Compound	CAS Number	LOR	Unit		EW1512379-016	EW1512379-017	EW1512379-018	EW1512379-019	-----
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.1	7.0	7.4	----	----
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		32900	32100	4740	----	----
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		23.4	22.7	2.8	----	----
EA116: Temperature									
Temperature	----	0.1	°C		19.4	19.5	19.7	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		230	228	183	----	----
Total Alkalinity as CaCO3	----	1	mg/L		230	228	183	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		1690	1440	230	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		10400	10200	1330	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	<1	----
Magnesium	7439-95-4	1	mg/L		----	----	----	<1	----
Sodium	7440-23-5	1	mg/L		----	----	----	<1	----
Potassium	7440-09-7	1	mg/L		----	----	----	<1	----
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		284	252	72	----	----
Magnesium	7439-95-4	1	mg/L		736	640	113	----	----
Sodium	7440-23-5	1	mg/L		6820	5720	804	----	----
Potassium	7440-09-7	1	mg/L		256	217	32	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	<0.001	----
Iron	7439-89-6	0.05	mg/L		----	----	----	<0.05	----
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.153	0.244	0.146	----	----
Iron	7439-89-6	0.05	mg/L		0.26	0.59	0.32	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	----
Client sampling date / time					03-Nov-2015 09:00	03-Nov-2015 12:35	03-Nov-2015 09:40	03-Nov-2015 11:40	----
Compound	CAS Number	LOR	Unit		EW1512379-016	EW1512379-017	EW1512379-018	EW1512379-019	-----
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		1.0	1.0	0.4	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		2.09	1.08	0.12	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		0.01	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		0.03	0.07	0.06	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		0.04	0.07	0.06	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		----	----	----	----	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		<1	11	<1	<1	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		9	24	7	----	----
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		3.41	2.83	5.78	----	----
Dissolved Oxygen - % Saturation	----	0.1	% saturation		37.2	30.6	63.8	----	----
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	----	----
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		----	----	----	----	----



CHAIN OF CUSTODY

ALS Laboratory, please tick →

☐ Sydney 277 Woodpark Rd, Smithfield NSW 2176
Ph 02 8784 8555 E samples.syd@alsenviro.com
☐ Newcastle 5 Rosegum Rd, Warabrook NSW 2204
Ph 02 4968 9433 E samples.newcastle@alsenviro.com
☐ Brisbane 32 Sharn St, Sturford QLD 4053
Ph 07 3243 7122 E samples.brisbane@alsenviro.com
☐ Townsville 14-15 Darna Ct, Bole QLD 4818
Ph 07 4796 0600 E townsville.environmental@alsenviro.com
☐ Melbourne 2-4 Westall Rd, Springvale VIC 3177
Ph 03 8549 9000 E samples.melbourne@alsenviro.com
☐ Adelaide 2-1 Burna Rd, Portaka SA 5095
Ph 08 8359 0890 E adelaide@alsenviro.com
☐ Perth 10 Hrd W ay, Malaga WA 6060
Ph 08 9209 7055 E samples.perth@alsenviro.com
☐ Launceston 27 Wellington St, Launceston TAS 7250
Ph 03 6331 2158 E launceston@alsenviro.com

CLIENT: Kiama Municipal Council

OFFICE: PO Box 75 Kiama NSW 2533

PROJECT: Mammurra Landfill

ORDER NUMBER: 87896

PROJECT MANAGER: Paul Czulkowski

SAMPLER: Craig Wilson

COC emailed to ALS? (YES / NO)

Email Reports to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

Email Invoice to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS: ☐ Standard TAT (list due date):

(Standard TAT may be longer for some tests e.g. Ultra Trace Organics)

ALS QUOTE NO.: SY-146-10

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EDD FORMAT (or default):

RELINQUISHED BY: Craig

DATE/TIME: 15/2/16 15:25

RECEIVED BY: Aneta

DATE/TIME: 15-2-16 15:25

FOR LABORATORY USE ONLY (circle)

Seal line

Free ice / frozen

Random Sample

Other comment

RELINQUISHED BY

DATE/TIME:

DATE/TIME:

DATE/TIME:

DATE/TIME:

DATE/TIME:

DATE/TIME:

DATE/TIME:

DATE/TIME:

DATE/TIME:

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DATE/TIME:

Telephone : 02 42263126



Environmental Division
Wollongong
Work Order Reference
EW1600608

Unlaminated or samples requiring specific OC analysis etc.

YSI (Field Results)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
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YSI (Field Tests)
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YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airflight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulfate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airflight Unpreserved Vial SQ = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass.
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Solids; B = Unpreserved Bag.



CHAIN OF CUSTODY

ALS Laboratory, please tick →

☐ Sydney 277 Woodpark Rd. Smithfield NSW 2176
Ph: 02 8784 8555 E: samples.syd@alsenviro.com
☐ Newcastle 5 Rosegum Rd. Warbrook NSW 2304
Ph: 02 4568 9433 E: samples.newcastle@alsenviro.com

☐ Brisbane 32 Sharn St. Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsenviro.com
☐ Townsville 14-15 Desma Ct. Bohle QLD 4818
Ph: 07 4796 0800 E: townsville.environmental@alsenviro.com

☐ Melbourne 2-4 Westall Rd. Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide 2-1 Burma Rd. Pooraka SA 5095
Ph: 08 8359 0880 E: adelaide@alsenviro.com

☐ Perth 10 Hed Way, Malaga WA 6060
Ph: 08 9209 7055 E: samples.perth@alsenviro.com
☐ Launceston 27 Wellington St. Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: Kiama Municipal Council

OFFICE: PO Box 75 Kiama NSW 2533

PROJECT: Minnamurra Landfill

ORDER NUMBER:

PROJECT MANAGER: Paul Czulowski

SAMPLER: Craig Wilson

COC emailed to ALS? (YES / NO)

Email Reports to (will default to PM if no other addresses are listed):

Email Invoice to (will default to PM if no other addresses are listed):

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS: ☐ Standard TAT (list due date):

(Standard TAT may be longer for some tests e.g.: Ultra Trace Organics) ☐ Non Standard or urgent TAT (list due date):

ALS QUOTE NO.: SY-146-10

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EDD FORMAT (or default):

RELINQUISHED BY: Craig

DATE/TIME: 15/2/11

FOR LABORATORY USE ONLY (Circle)

Quesby Seal intact? Yes No N/A

Freeze / frozen ice bricks present upon receipt? Yes No N/A

Random Sample temperature on Receipt: °C

Other comment:

RECEIVED BY:

DATE/TIME:

LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	ANALYSIS REQUIRED including SUITES (NB: Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).						Additional Information
						NT-02A (Alkalinity, Cl, SO4 & Fluoride)	Nitrate, Ammonia, Total Phenolics	DOC (Filtered)	TOC	(Dissolved Filtered) Fe, Mn, NT-01 (Mg, Ca, Na, K)	(Total) Fe, Mn, Mg, Ca, Na, K	

13	MD 9C	15/2 1134	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
14	MD 10A	1102	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
15	MD 10B	1102	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
16	Rocklow Down	935	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
17	Rocklow Middle	1054	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
18	Rocklow Up	943	W	500mL, SP, 2 X VS, N	5	✓	✓	✓	✓	✓		YSI (Field Tests) pH, Temp, EC, Sal, DO, Depth
19	Blank	956	W	VS, N	2			✓		✓		

TOTAL												
Water Container Codes: P = Unpreserved Plastic, N = Nitric Preserved Plastic, ORC = Nitric Preserved ORC, SH = Sodium Hydroxide/Cd Preserved, S = Sodium Hydroxide Preserved Plastic, AG = Amber Glass Unpreserved AP = Airfreight Unpreserved Plastic V = VOA Vial HCl Preserved, VB = VOA Vial Sodium Bisulphate Preserved, VS = VOA Vial Sulfuric Unpreserved Vial SG = Sulfuric Preserved Amber Glass, H = HCl preserved Plastic, HS = HCl preserved Speciation bottle, SP = Sulfuric Z = Zinc Acetate Preserved Bottle, E = EDTA Preserved Bottles, ST = Sterile Bottle, ASS = Plastic Bag for Acid Sulphate Solids, B = Unpreserved Bag.												

CERTIFICATE OF ANALYSIS

Work Order	: EW1600608	Page	: 1 of 10
Amendment	: 1		
Client	: KIAMA COUNCIL	Laboratory	: Environmental Division NSW South Coast
Contact	: MR PAUL CZULOWSKI	Contact	: Glenn Davies
Address	: 11 MANNING STREET	Address	: 1/19 Ralph Black Dr, North Wollongong 2500
	KIAMA NSW, AUSTRALIA 2533		4/13 Geary Pl, North Nowra 2541
			Australia
Telephone	: +61 02 4232 0444	Telephone	: 02 42253125
Project	: Minnamurra Landfill	Date Samples Received	: 15-Feb-2016 15:25
Order number	: 87896	Date Analysis Commenced	: 15-Feb-2016
C-O-C number	: ----	Issue Date	: 02-Nov-2016 13:08
Sampler	: Craig Wilson		
Site	: ----		
Quote number	: ----		
No. of samples received	: 19		
No. of samples analysed	: 19		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Glenn Davies	Environmental Services Representative	Laboratory - Wollongong



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EK040P: Poor spike recovery for FLUORIDE due to matrix interferences(confirmed by re-analysis).
- EK059G: LOR raised for NOx on samle 11 due to sample matrix.
- EK058G: LOR raised for Nitrate on sample 11 due to sample matrix.
- ED041G: LOR raised for Sulfate analysis on a few samples due to matrix interferences.
- EP002: It has been noted that DOC is greater than TOC, however this difference is within the limits of experimental variation.
- Amendment (2/11/2016): This report has been amended and re-released to allow additional certificates to be added to the report. All analysis results are as per the previous report.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time					15-Feb-2016 13:05	15-Feb-2016 12:24	15-Feb-2016 12:32	15-Feb-2016 12:43	15-Feb-2016 11:55
Compound	CAS Number	LOR	Unit		EW1600608-001	EW1600608-002	EW1600608-003	EW1600608-004	EW1600608-005
				Result	Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit	----	6.9	7.0	7.1	----	----
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm	----	11900	23400	39100	----	----
EA020FD: Field Salinity									
Salinity	----	0.2	g/L	----	7.2	16.0	28.3	----	----
EA116: Temperature									
Temperature	----	0.1	°C	----	22.5	19.5	19.3	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	----	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	----	2	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	----	536	727	578	578	----
Total Alkalinity as CaCO3	----	1	mg/L	----	539	727	578	578	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	451	1240	2260	2260	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L	----	3610	8050	13400	13400	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	----	190	353	485	485	----
Magnesium	7439-95-4	1	mg/L	----	276	575	1120	1120	----
Sodium	7440-23-5	1	mg/L	----	1850	4420	8890	8890	----
Potassium	7440-09-7	1	mg/L	----	138	190	292	292	----
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L	----	----	----	----	----	----
Magnesium	7439-95-4	1	mg/L	----	----	----	----	----	----
Sodium	7440-23-5	1	mg/L	----	----	----	----	----	----
Potassium	7440-09-7	1	mg/L	----	----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	----	0.032	0.086	0.207	0.207	----
Iron	7439-89-6	0.05	mg/L	----	3.33	1.18	3.14	3.14	----
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L	----	----	----	----	----	----
Iron	7439-89-6	0.05	mg/L	----	----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time					15-Feb-2016 13:05	15-Feb-2016 12:24	15-Feb-2016 12:32	15-Feb-2016 12:43	15-Feb-2016 11:55
Compound	CAS Number	LOR	Unit		EW1600608-001	EW1600608-002	EW1600608-003	EW1600608-004	EW1600608-005
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		----	1.7	0.8	0.8	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		----	26.0	9.63	5.06	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	0.02	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	0.26	0.04	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	0.28	0.04	<0.01	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	122	267	436	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	116	262	510	----
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		----	2.44	1.03	7.79	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		NOT FOUND	----	----	----	DRY
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		----	46	24	20	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		----	39	23	21	----
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		----	2.00	2.50	2.80	----
Dissolved Oxygen - % Saturation	----	0.1	% saturation		----	24.1	30.4	35.6	----
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		----	<0.05	<0.05	<0.05	----
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		----	0.46	0.63	0.70	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					15-Feb-2016 11:58	15-Feb-2016 12:07	15-Feb-2016 10:15	15-Feb-2016 10:07	15-Feb-2016 10:23
Compound	CAS Number	LOR	Unit		EW1600608-006	EW1600608-007	EW1600608-008	EW1600608-009	EW1600608-010
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.0	6.9	6.8	6.9	7.2
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		11200	34600	5570	1520	21900
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		7.1	24.8	3.3	0.8	14.7
EA116: Temperature									
Temperature	----	0.1	°C		20.3	19.3	20.8	20.9	20.1
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		931	744	796	638	415
Total Alkalinity as CaCO ₃	----	1	mg/L		931	744	796	638	415
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		379	1840	537	84	1170
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		3650	11900	1200	103	7710
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		348	446	275	141	354
Magnesium	7439-95-4	1	mg/L		228	982	147	36	521
Sodium	7440-23-5	1	mg/L		1780	7500	735	93	4030
Potassium	7440-09-7	1	mg/L		124	253	106	38	148
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.083	0.182	0.102	0.092	0.085
Iron	7439-89-6	0.05	mg/L		1.66	1.72	2.56	0.16	8.04
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					15-Feb-2016 11:58	15-Feb-2016 12:07	15-Feb-2016 10:15	15-Feb-2016 10:07	15-Feb-2016 10:23
Compound	CAS Number	LOR	Unit		EW1600608-006	EW1600608-007	EW1600608-008	EW1600608-009	EW1600608-010
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.6	0.8	0.7	0.6	0.4
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		45.5	2.56	26.3	38.2	34.0
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	0.07	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	0.67	<0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	0.74	<0.01	<0.01
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		129	389	60.9	17.4	250
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		117	436	60.5	15.0	240
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		5.17	5.68	0.36	7.35	2.16
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		36	22	48	22	<1
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		37	21	46	19	7
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		2.50	2.50	2.50	4.30	2.40
Dissolved Oxygen - % Saturation	----	0.1	% saturation		28.5	31.1	28.7	48.0	29.4
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		1.05	1.11	1.27	1.25	1.39



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					15-Feb-2016 11:40	15-Feb-2016 11:28	15-Feb-2016 11:34	15-Feb-2016 11:02	15-Feb-2016 11:09
Compound	CAS Number	LOR	Unit		EW1600608-011	EW1600608-012	EW1600608-013	EW1600608-014	EW1600608-015
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		6.5	6.9	7.0	6.5	7.3
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		2880	2870	3480	37000	2010
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		1.6	1.7	2.1	24.4	1.1
EA116: Temperature									
Temperature	----	0.1	°C		21.0	20.4	19.7	23.2	23.7
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		252	1100	1300	310	811
Total Alkalinity as CaCO3	----	1	mg/L		252	1100	1300	310	811
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		15	3	<10	2060	<10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		814	398	490	11900	216
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		32	196	132	560	114
Magnesium	7439-95-4	1	mg/L		54	97	61	939	43
Sodium	7440-23-5	1	mg/L		547	276	307	6760	154
Potassium	7440-09-7	1	mg/L		31	77	158	128	84
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.016	0.261	0.181	0.466	0.358
Iron	7439-89-6	0.05	mg/L		0.38	9.61	8.08	3.96	0.88
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					15-Feb-2016 11:40	15-Feb-2016 11:28	15-Feb-2016 11:34	15-Feb-2016 11:02	15-Feb-2016 11:09
Compound	CAS Number	LOR	Unit		EW1600608-011	EW1600608-012	EW1600608-013	EW1600608-014	EW1600608-015
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.2	0.7	0.5	0.6	0.8
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		3.30	27.7	156	0.72	59.4
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		0.03	<0.01	<0.01	<0.01	0.04
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.10	<0.01	<0.01	<0.01	8.50
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.10	<0.01	<0.01	<0.01	8.54
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		28.3	33.3	39.8	385	22.3
Total Cations	----	0.01	meq/L		----	----	40.2	----	22.3
Total Cations	----	0.01	meq/L		30.6	31.7	----	402	----
Ionic Balance	----	0.01	%		----	----	0.40	----	0.01
Ionic Balance	----	0.01	%		3.92	2.35	----	2.24	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		274	53	82	61	50
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		276	48	84	60	50
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		2.50	2.80	3.80	2.90	2.20
Dissolved Oxygen - % Saturation	----	0.1	% saturation		28.6	31.7	42.4	38.9	26.7
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		0.60	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		0.60	0.75	0.80	0.76	0.61



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	----
Client sampling date / time					15-Feb-2016 09:35	15-Feb-2016 10:54	15-Feb-2016 09:43	15-Feb-2016 09:56	----
Compound	CAS Number	LOR	Unit		EW1600608-016	EW1600608-017	EW1600608-018	EW1600608-019	-----
				Result	Result	Result	Result	Result	----
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.2	7.3	7.5	----	----
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		29700	23000	7100	----	----
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		18.4	14.4	3.9	----	----
EA116: Temperature									
Temperature	----	0.1	°C		25.0	23.4	24.8	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		202	216	216	----	----
Total Alkalinity as CaCO3	----	1	mg/L		202	216	216	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		1400	1140	279	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		9480	7410	1720	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	<1	----
Magnesium	7439-95-4	1	mg/L		----	----	----	<1	----
Sodium	7440-23-5	1	mg/L		----	----	----	<1	----
Potassium	7440-09-7	1	mg/L		----	----	----	<1	----
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		250	214	87	----	----
Magnesium	7439-95-4	1	mg/L		562	461	153	----	----
Sodium	7440-23-5	1	mg/L		5520	4490	1160	----	----
Potassium	7440-09-7	1	mg/L		231	184	48	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	<0.001	----
Iron	7439-89-6	0.05	mg/L		----	----	----	<0.05	----
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.224	0.240	0.183	----	----
Iron	7439-89-6	0.05	mg/L		0.36	0.43	0.58	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	----
Client sampling date / time					15-Feb-2016 09:35	15-Feb-2016 10:54	15-Feb-2016 09:43	15-Feb-2016 09:56	----
Compound	CAS Number	LOR	Unit		EW1600608-016	EW1600608-017	EW1600608-018	EW1600608-019	-----
					Result	Result	Result	Result	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		1.0	1.0	0.4	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.58	2.49	0.19	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		0.03	0.04	0.04	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		0.03	0.05	0.04	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		----	----	----	----	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		7	9	10	<1	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		8	10	12	----	----
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		6.70	6.50	6.30	----	----
Dissolved Oxygen - % Saturation	----	0.1	% saturation		89.6	82.6	77.8	----	----
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	----	----
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		----	----	----	----	----

CHAIN OF CUSTODY

ALS Laboratory please tick ->

☐ Sydney 227 Macquarie Rd, Smithfield NSW 2176
Ph 02 8786 8555 E samples@alsenviro.com
☐ Newcastle 5 Rosegum Rd, Warabrook NSW 2304
Ph 02 4969 9433 E samples@alsenviro.com

☐ Brisbane 32 Stand St, Stretford QLD 4053
Ph 07 3243 7222 E samples@alsenviro.com
☐ Townsville 14-15 Dania Ct, Bohle QLD 4818
Ph 07 4796 0000 E samples@alsenviro.com

☐ Melbourne 2-4 Westall Rd, Springvale VIC 3171
Ph 03 8949 9000 E samples@alsenviro.com
☐ Adelaide 2-1 Burns Rd, Pineside SA 5095
Ph 08 8359 0950 E samples@alsenviro.com

☐ Perth 10 Hot Way, Malaga WA 6090
Ph 08 9209 7655 E samples@alsenviro.com
☐ Launceston 27 Wellington St, Launceston TAS 7250
Ph 03 6331 2150 E samples@alsenviro.com

Kiama Municipal Council

OFFICE: PO Box 75 Kiama NSW 2533

PROJECT: Minnamurra Landfill

ORDER NUMBER: 87886

PROJECT MANAGER: Paul Czulowski

SAMPLER: Craig Wilson

COC emailed to ALS? (YES / NO)

Email Reports to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

Email Invoice to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNDOWN REQUIREMENTS: ☐ Standard TAT (list due date): ☐ Non Standard or urgent TAT (list due date):

(Standard TAT may be longer for some tests e.g. Ultra Trace Organics)

ALS QUOTE NO: 3444-10

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EDD FORMAT (or default):

RELINQUISHED BY: Craig

DATE/TIME: 30/5/16 15:15

RECEIVED BY: Andrew

DATE/TIME: 30-5-16 15:15

RELINQUISHED

ANALYSIS REQUIRED INCLUDING SUITES (NB. Suite Codes must be list Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (filtered)

Telephone : 02 42263125

21

Environmental Division

Wollongong

Work Order Reference

EW1602021



Comments on likely contaminant levels, dilutions, or samples requiring specific OC analysis etc.

YSI (Field Results)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
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YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth



CHAIN OF CUSTODY

ALS Laboratory, please tick →

☐ Sydney 277 Wycombe Rd, Smithfield NSW 2176
Ph: 02 8784 8655 E: samples@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2204
Ph: 02 4968 9433 E: samples.newcastle@alsenviro.com

☐ Brisbane 32 Shand St, Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Deana Ct, Bohle QLD 4818
Ph: 07 4796 0960 E: samples.townsville@alsenviro.com

☐ Melbourne 2-4 Westall Rd, Springvale VIC 3171
Ph: 03 9549 9801 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burnt Rd, Para Hills SA 5095
Ph: 08 8330 0380 E: samples.adelaide@alsenviro.com

☐ Perth 10 Hord Way, Midvale WA 6009
Ph: 08 9209 7665 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: Kiama Municipal Council

OFFICE: PO Box 75 Kiama NSW 2533

PROJECT: Minnamurra Landfill

ORDER NUMBER:

PROJECT MANAGER: Paul Czujowski

SAMPLER: Craig Wilson

COC emailed to ALS? (YES / NO)

Email Reports to (will default to PM if no other addresses are listed):

Email Invoice to (will default to PM if no other addresses are listed):

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS: ☐ Standard TAT (List due date):
e.g.: Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EDD FORMAT (or default):

RELINQUISHED BY:

DATE/TIME:

3/5/16

COC SEQUENCE NUMBER (Circle)

1 2 3 4 5 6 7

OFF: 1 2 3 4 5 6 7

RECEIVED BY:

DATE/TIME:

DATE/TIME:

DATE/TIME:

FOR LABORATORY USE ONLY (Circle)

Client Seal Here

Seal Here (Do Not Reuse)

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CERTIFICATE OF ANALYSIS

Work Order	: EW1602021	Page	: 1 of 10
Amendment	: 1		
Client	: KIAMA COUNCIL	Laboratory	: Environmental Division NSW South Coast
Contact	: MR PAUL CZULOWSKI	Contact	: Glenn Davies
Address	: 11 MANNING STREET	Address	: 1/19 Ralph Black Dr, North Wollongong 2500
	KIAMA NSW, AUSTRALIA 2533		4/13 Geary Pl, North Nowra 2541
			Australia
Telephone	: +61 02 4232 0444	Telephone	: 02 42253125
Project	: Minnamurra Landfill	Date Samples Received	: 30-May-2016 15:15
Order number	: 87896	Date Analysis Commenced	: 30-May-2016
C-O-C number	: ----	Issue Date	: 02-Nov-2016 13:09
Sampler	: Craig Wilson		
Site	: ----		
Quote number	: ----		
No. of samples received	: 20		
No. of samples analysed	: 20		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Dian Dao		Sydney Inorganics, Smithfield, NSW
Kristy Boje	Laboratory Supervisor	Laboratory - Wollongong



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Ep002: It has been noted that DOC is greater than TOC, however this difference is within the limits of experimental variation.
- It has been noted that Nitrite is greater than NOx for sample 15, however this difference is within the limits of experimental variation.
- Amendment (2/11/2016): This report has been amended and re-released to allow additional certificates to be added. All analysis results are as per the previous report.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time				30-May-2016 14:30	30-May-2016 12:45	30-May-2016 12:55	30-May-2016 13:10	30-May-2016 12:10
Compound	CAS Number	LOR	Unit	EW1602021-001	EW1602021-002	EW1602021-003	EW1602021-004	EW1602021-005
				Result	Result	Result	Result	Result
EA005FD: Field pH								
pH	----	0.1	pH Unit	7.4	7.0	6.9	7.0	----
EA010FD: Field Conductivity								
Electrical Conductivity (Non Compensated)	----	1	µS/cm	543	12400	26900	43100	----
EA020FD: Field Salinity								
Salinity	----	0.2	g/L	0.3	8.2	18.5	31.7	----
EA116: Temperature								
Temperature	----	0.1	°C	19.7	19.0	20.0	19.2	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	163	968	727	552	----
Total Alkalinity as CaCO ₃	----	1	mg/L	163	968	727	552	----
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	32	433	1340	2280	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	35	3640	8210	13500	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	52	211	358	420	----
Magnesium	7439-95-4	1	mg/L	8	305	603	912	----
Sodium	7440-23-5	1	mg/L	32	2070	4700	7300	----
Potassium	7440-09-7	1	mg/L	13	141	191	278	----
ED093T: Total Major Cations								
Calcium	7440-70-2	1	mg/L	----	----	----	----	----
Magnesium	7439-95-4	1	mg/L	----	----	----	----	----
Sodium	7440-23-5	1	mg/L	----	----	----	----	----
Potassium	7440-09-7	1	mg/L	----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	0.012	0.038	0.094	0.107	----
Iron	7439-89-6	0.05	mg/L	<0.05	6.28	1.07	1.46	----
EG020T: Total Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	----	----	----	----	----
Iron	7439-89-6	0.05	mg/L	----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time					30-May-2016 14:30	30-May-2016 12:45	30-May-2016 12:55	30-May-2016 13:10	30-May-2016 12:10
Compound	CAS Number	LOR	Unit		EW1602021-001	EW1602021-002	EW1602021-003	EW1602021-004	EW1602021-005
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.1	0.8	0.8	0.8	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		4.40	31.6	9.87	4.01	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		0.03	0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		3.54	0.50	0.09	0.24	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		3.57	0.51	0.09	0.24	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		4.91	131	274	439	----
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		4.98	129	277	421	----
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		0.70	0.69	0.49	2.18	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	DRY
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		6	36	45	4	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		12	72	44	28	----
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		1.41	2.08	1.57	1.34	----
Dissolved Oxygen - % Saturation	----	0.1	% saturation		15.4	22.3	17.1	14.6	----
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		1.44	0.31	0.58	0.64	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					30-May-2016 12:15	30-May-2016 12:30	30-May-2016 13:25	30-May-2016 13:35	30-May-2016 13:45
Compound	CAS Number	LOR	Unit		EW1602021-006	EW1602021-007	EW1602021-008	EW1602021-009	EW1602021-010
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		6.9	6.9	7.1	7.0	7.1
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		14200	39900	4930	1780	24200
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		9.9	30.8	2.9	1.0	16.4
EA116: Temperature									
Temperature	----	0.1	°C		16.9	16.6	21.2	21.2	20.2
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		893	707	768	744	417
Total Alkalinity as CaCO ₃	----	1	mg/L		893	707	768	744	417
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		533	2000	393	46	1200
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		4280	12200	943	116	7460
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		367	452	192	152	354
Magnesium	7439-95-4	1	mg/L		297	918	115	43	518
Sodium	7440-23-5	1	mg/L		2280	7280	667	131	4110
Potassium	7440-09-7	1	mg/L		137	275	101	42	145
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.103	0.174	0.077	0.108	0.080
Iron	7439-89-6	0.05	mg/L		1.77	1.59	0.76	0.19	12.7
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					30-May-2016 12:15	30-May-2016 12:30	30-May-2016 13:25	30-May-2016 13:35	30-May-2016 13:45
Compound	CAS Number	LOR	Unit		EW1602021-006	EW1602021-007	EW1602021-008	EW1602021-009	EW1602021-010
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.6	0.9	0.8	0.6	0.4
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		38.8	2.34	19.6	34.6	36.1
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	0.69	0.36	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	0.70	0.36	<0.01
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		150	400	50.1	19.1	244
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		145	422	50.6	17.9	243
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		1.44	2.65	0.50	3.24	0.21
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		38	36	59	49	22
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		39	41	56	49	23
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		2.66	1.28	1.70	1.32	0.81
Dissolved Oxygen - % Saturation	----	0.1	% saturation		27.7	13.1	18.8	14.4	8.7
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		1.06	1.08	1.15	1.23	1.35



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					30-May-2016 11:20	30-May-2016 11:35	30-May-2016 11:50	30-May-2016 10:45	30-May-2016 11:00
Compound	CAS Number	LOR	Unit		EW1602021-011	EW1602021-012	EW1602021-013	EW1602021-014	EW1602021-015
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.2	6.8	7.0	6.9	7.4
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		2080	3130	3700	39800	2110
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		1.2	1.9	2.2	30.7	1.2
EA116: Temperature									
Temperature	----	0.1	°C		17.6	18.8	19.0	16.9	18.4
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		255	1140	1260	319	782
Total Alkalinity as CaCO3	----	1	mg/L		255	1140	1260	319	782
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		8	<10	<10	2170	<10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		485	382	534	12500	208
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		23	194	132	575	110
Magnesium	7439-95-4	1	mg/L		39	98	63	976	42
Sodium	7440-23-5	1	mg/L		368	289	340	7100	146
Potassium	7440-09-7	1	mg/L		35	84	150	145	81
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.012	0.256	0.177	0.199	0.409
Iron	7439-89-6	0.05	mg/L		0.08	4.26	8.15	0.42	0.68
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					30-May-2016 11:20	30-May-2016 11:35	30-May-2016 11:50	30-May-2016 10:45	30-May-2016 11:00
Compound	CAS Number	LOR	Unit		EW1602021-011	EW1602021-012	EW1602021-013	EW1602021-014	EW1602021-015
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.2	0.6	0.5	0.6	0.8
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		5.28	34.3	158	0.10	65.0
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	0.02
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		0.04	<0.01	0.04	0.11	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		0.04	<0.01	0.04	0.11	<0.01
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		18.9	33.6	40.2	404	21.5
Total Cations	----	0.01	meq/L		----	----	38.9	----	22.0
Total Cations	----	0.01	meq/L		21.2	32.5	----	422	----
Ionic Balance	----	0.01	%		----	----	1.74	----	1.16
Ionic Balance	----	0.01	%		5.74	1.65	----	2.09	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		40	59	50	67	56
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		45	61	56	66	63
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		1.89	1.09	0.65	4.69	1.25
Dissolved Oxygen - % Saturation	----	0.1	% saturation		19.5	11.5	6.9	47.7	13.1
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		0.45	0.69	0.80	0.50	0.48



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	MD1A
Client sampling date / time					30-May-2016 09:40	30-May-2016 10:30	30-May-2016 10:05	30-May-2016 12:00	30-May-2016 14:20
Compound	CAS Number	LOR	Unit		EW1602021-016	EW1602021-017	EW1602021-018	EW1602021-019	EW1602021-020
				Result	Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.3	7.2	7.5	----	7.6
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		42300	42600	44500	----	618
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		36.7	37.4	40.2	----	0.3
EA116: Temperature									
Temperature	----	0.1	°C		12.6	12.2	11.3	----	20.3
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	----	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	----	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		162	170	160	----	208
Total Alkalinity as CaCO ₃	----	1	mg/L		162	170	160	----	208
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		1980	1670	1680	----	36
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		14100	13600	13400	----	36
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	70
Magnesium	7439-95-4	1	mg/L		----	----	----	----	13
Sodium	7440-23-5	1	mg/L		----	----	----	----	36
Potassium	7440-09-7	1	mg/L		----	----	----	----	7
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		389	392	390	----	----
Magnesium	7439-95-4	1	mg/L		1040	1060	1030	----	----
Sodium	7440-23-5	1	mg/L		8620	8660	8420	----	----
Potassium	7440-09-7	1	mg/L		325	329	313	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	<0.001	0.056
Iron	7439-89-6	0.05	mg/L		----	----	----	<0.05	<0.05
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.060	0.092	0.043	----	----
Iron	7439-89-6	0.05	mg/L		0.37	0.20	0.19	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	MD1A
Client sampling date / time					30-May-2016 09:40	30-May-2016 10:30	30-May-2016 10:05	30-May-2016 12:00	30-May-2016 14:20
Compound	CAS Number	LOR	Unit		EW1602021-016	EW1602021-017	EW1602021-018	EW1602021-019	EW1602021-020
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		1.0	1.0	0.9	----	1.1
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.68	0.67	0.17	----	0.12
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	----	----	----	0.09
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	----	----	----	0.90
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	----	----	----	0.99
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	----	----	----	5.92
Total Cations	----	0.01	meq/L		----	----	----	----	----
Total Cations	----	0.01	meq/L		----	----	----	----	6.31
Ionic Balance	----	0.01	%		----	----	----	----	----
Ionic Balance	----	0.01	%		----	----	----	----	3.18
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		9	10	8	<1	9
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		9	8	7	----	10
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		7.86	6.96	8.78	----	2.34
Dissolved Oxygen - % Saturation	----	0.1	% saturation		73.3	64.8	80.3	----	25.9
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	----	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		----	----	----	----	1.43



CHAIN OF CUSTODY

ALS Laboratory, please tick →

1 Sydney 277 Mt Sutherland Rd, Sutherland NSW 22176
Ph 02 9791 3900 E als@als.com.au
2 Melbourne 3 Rodd Rd, Werribee VIC 3039
Ph 02 4688 5433 E als@als.com.au

3 Brisbane 39 Sharn St, Stafford QLD 4055
Ph 07 3213 7222 E als@als.com.au
4 Townsville 13-15 Deane Ct, Bowen QLD 4810
Ph 07 4786 9800 E als@als.com.au

5 Adelaide 241 Burra Rd, Adelaide SA 5006
Ph 08 8230 0200 E als@als.com.au

6 Perth 19 Hordley Way, Midland WA 0500
Ph 08 9403 7155 E als@als.com.au
7 Launceston 27 Wallington St, Launceston TAS 7250
Ph 03 6331 2100 E als@als.com.au

CLIENT: Kiama Municipal Council

OFFICE: PO Box 75 Kiama NSW 2533

PROJECT: Minnamurra Landfill

ORDER NUMBER: 87896

PROJECT MANAGER: Paul Czulowski

SAMPLER: Craig Wilson

COC emailed to ALS? (YES / NO)

Email Reports to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

Email Invoice to (will default to PM if no other addresses are listed): paulc@kiama.nsw.gov.au, juliem@kiama.nsw.gov.au

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS: ☐ Standard TAT (List due date):

(Standard TAT may be longer for some tests e.g. Ultra Trace Organics)

ALS QUOTE NO.: SY-146-10

CONTACT PH: 4232 0418

SAMPLER MOBILE: 0408 251 560

EDD FORMAT (or default):

RELINQUISHED BY: Craig

DATE/TIME: 11/6/16 1725

FOR LABORATORY: Custody Seal (if required) Random Sample

COC SEQUENCE NUMBER (Circle)

1 2 3 4 5 6 7

RECEIVED BY: [Signature]

DATE/TIME: 11.8.16 1725

RELINQUISHED BY: [Signature]

DATE/TIME: 11.8.16 1725

Telephone : 02 42253125



Environmental Division
Wollongong
Work Order Reference
EW1603036

SAMPLE DETAILS
MATRIX: Solid(S) Water(W)

CONTAINER INFORMATION

ANALYSIS REQUIRED INCLUDING SUITES (NB. Suite Codes must be listed to allow correct analysis)

Additional Information

Comments on likely contaminant levels, dilutions, or samples requiring specific CC analysis etc.

LAB ID

SAMPLE ID

DATE / TIME

MATRIX

TYPE & PRESERVATIVE
(refer to codes below)

TOTAL BOTTLES

NT-02A (Alkalinity, Cl, SO4 & Fluoride)

Nitrate, Ammonia, Total Phenolics

DOC (Filtered)

TOC

(Dissolved Filtered) Fe, Mn, NT-01 (Mg, Ca, Na, K)

(Total) Fe, Mn, Mg, Ca, Na, K

YSI (Field Results)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
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YSI (Field Tests)
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YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

YSI (Field Tests)
pH, Temp, EC, Sal, DO, Depth

ENR 204

ALS Laboratory: please tick →

1 Perth 1714-1799 at harpis.wa.gov.au
Ph 08 9220 7291 E samples@harpis.wa.gov.au
2 Launceston 2714 atington St Launceston T 35 7251
Ph 03 6231 1158 E launceston@elsample.com

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL[illegible]

Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag

CERTIFICATE OF ANALYSIS

Work Order	: EW1603036	Page	: 1 of 10
Amendment	: 1		
Client	: KIAMA COUNCIL	Laboratory	: Environmental Division NSW South Coast
Contact	: MR PAUL CZULOWSKI	Contact	: Glenn Davies
Address	: 11 MANNING STREET	Address	: 1/19 Ralph Black Dr, North Wollongong 2500
	KIAMA NSW, AUSTRALIA 2533		4/13 Geary Pl, North Nowra 2541
			Australia
Telephone	: +61 02 4232 0444	Telephone	: 02 42253125
Project	: Minnamurra Landfill	Date Samples Received	: 11-Aug-2016 17:25
Order number	: 87896	Date Analysis Commenced	: 11-Aug-2016
C-O-C number	: ----	Issue Date	: 02-Nov-2016 13:10
Sampler	: Craig Wilson		
Site	: ----		
Quote number	: ----		
No. of samples received	: 20		
No. of samples analysed	: 20		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Robert DaLio	Sampler	Laboratory - Wollongong



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED041G: LOR raised for Sulfate analysis on a few samples, due to matrix interferences.
- EP002: It has been noted that DOC is greater than TOC for samples 7 and 11, however this difference is within the limits of experimental variation.
- Amendment (2/11/2016): This report has been amended and re-released to allow additional certificates to be added to the report. All analysis results are as per the previous report.
- Sampling and sample data supplied by ALS Wollongong.
- Sampling completed as per FWI-EN001 Groundwater Sampling.
- Sampling completed as per FWI-EN002 Surface Water Sampling.
- Field tests completed on day of sampling/receipt.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time					11-Aug-2016 16:30	11-Aug-2016 15:05	11-Aug-2016 15:15	11-Aug-2016 15:25	11-Aug-2016 14:15
Compound	CAS Number	LOR	Unit		EW1603036-001	EW1603036-002	EW1603036-003	EW1603036-004	EW1603036-005
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.1	7.4	7.1	7.2	----
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		533	16600	18300	41200	----
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		0.3	11.8	12.9	31.5	----
EA116: Temperature									
Temperature	----	0.1	°C		18.6	16.9	17.4	17.4	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		142	826	672	538	----
Total Alkalinity as CaCO3	----	1	mg/L		142	826	672	538	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		26	690	862	1810	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		40	7020	6780	14000	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		50	258	320	486	----
Magnesium	7439-95-4	1	mg/L		8	445	470	986	----
Sodium	7440-23-5	1	mg/L		30	3190	3570	8400	----
Potassium	7440-09-7	1	mg/L		13	180	161	311	----
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.016	0.048	0.070	0.166	----
Iron	7439-89-6	0.05	mg/L		0.05	0.35	0.66	1.09	----
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD1B	MD2A	MD2B	MD2C	MD4A
Client sampling date / time					11-Aug-2016 16:30	11-Aug-2016 15:05	11-Aug-2016 15:15	11-Aug-2016 15:25	11-Aug-2016 14:15
Compound	CAS Number	LOR	Unit		EW1603036-001	EW1603036-002	EW1603036-003	EW1603036-004	EW1603036-005
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.1	0.8	0.7	0.7	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		6.92	19.6	12.0	4.14	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		5.60	2.57	0.06	0.03	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		5.60	2.57	0.06	0.03	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		4.51	229	223	443	----
Total Cations	----	0.01	meq/L		4.79	193	214	479	----
Ionic Balance	----	0.01	%		3.07	8.56	1.98	3.82	----
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	DRY
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		6	45	30	21	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		6	46	30	21	----
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		1.33	1.60	1.15	1.38	----
Dissolved Oxygen - % Saturation	----	0.1	% saturation		14.3	16.6	11.9	14.3	----
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		1.33	0.45	0.76	0.80	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					11-Aug-2016 14:20	11-Aug-2016 14:35	11-Aug-2016 15:40	11-Aug-2016 15:50	11-Aug-2016 16:00
Compound	CAS Number	LOR	Unit		EW1603036-006	EW1603036-007	EW1603036-008	EW1603036-009	EW1603036-010
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.1	6.9	7.0	7.0	7.3
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		7270	36300	6360	1560	25400
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		4.7	26.8	4.1	0.9	18.2
EA116: Temperature									
Temperature	----	0.1	°C		18.0	18.3	18.0	18.1	17.9
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		920	724	735	570	407
Total Alkalinity as CaCO ₃	----	1	mg/L		920	724	735	570	407
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		206	1550	522	63	1080
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		2410	12000	1520	103	9400
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		279	458	289	134	359
Magnesium	7439-95-4	1	mg/L		164	875	158	34	572
Sodium	7440-23-5	1	mg/L		1130	6580	901	94	4360
Potassium	7440-09-7	1	mg/L		101	280	139	39	162
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.071	0.190	0.112	0.093	0.065
Iron	7439-89-6	0.05	mg/L		1.09	1.45	0.46	0.15	17.0
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD4B	MD4C	MD6A	MD6B	MD6C
Client sampling date / time					11-Aug-2016 14:20	11-Aug-2016 14:35	11-Aug-2016 15:40	11-Aug-2016 15:50	11-Aug-2016 16:00
Compound	CAS Number	LOR	Unit		EW1603036-006	EW1603036-007	EW1603036-008	EW1603036-009	EW1603036-010
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.5	0.8	0.7	0.5	0.4
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		43.7	3.43	17.6	33.0	37.3
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	0.04	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	2.75	0.14	0.03
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	2.79	0.14	0.03
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		90.6	385	68.4	15.6	296
Total Cations	----	0.01	meq/L		79.2	388	70.2	14.6	259
Ionic Balance	----	0.01	%		6.77	0.38	1.25	3.42	6.68
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		22	32	61	26	9
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		44	29	63	26	16
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		1.20	1.08	1.82	1.19	0.99
Dissolved Oxygen - % Saturation	----	0.1	% saturation		12.6	11.3	19.2	12.6	10.5
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		1.20	1.22	1.25	1.26	1.32



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					11-Aug-2016 13:40	11-Aug-2016 13:50	11-Aug-2016 14:05	11-Aug-2016 12:55	11-Aug-2016 13:05
Compound	CAS Number	LOR	Unit		EW1603036-011	EW1603036-012	EW1603036-013	EW1603036-014	EW1603036-015
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		6.9	7.0	7.0	6.8	7.4
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		2150	2980	3600	39400	2250
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		1.4	1.8	2.2	31.2	1.4
EA116: Temperature									
Temperature	----	0.1	°C		16.0	17.3	18.4	15.8	16.5
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		219	1060	1180	419	741
Total Alkalinity as CaCO3	----	1	mg/L		219	1060	1180	419	741
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		89	<10	<1	1820	<10
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		596	418	508	13400	272
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		33	195	130	589	109
Magnesium	7439-95-4	1	mg/L		42	100	64	1140	38
Sodium	7440-23-5	1	mg/L		402	272	313	7540	134
Potassium	7440-09-7	1	mg/L		31	82	145	139	78
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	----
Magnesium	7439-95-4	1	mg/L		----	----	----	----	----
Sodium	7440-23-5	1	mg/L		----	----	----	----	----
Potassium	7440-09-7	1	mg/L		----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.025	0.395	0.194	0.562	0.409
Iron	7439-89-6	0.05	mg/L		0.70	2.96	6.96	3.99	0.74
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	----	----
Iron	7439-89-6	0.05	mg/L		----	----	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MD9A	MD9B	MD9C	MD10A	MD10B
Client sampling date / time					11-Aug-2016 13:40	11-Aug-2016 13:50	11-Aug-2016 14:05	11-Aug-2016 12:55	11-Aug-2016 13:05
Compound	CAS Number	LOR	Unit		EW1603036-011	EW1603036-012	EW1603036-013	EW1603036-014	EW1603036-015
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.2	0.5	0.4	0.6	0.7
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		1.69	33.1	107	0.60	65.0
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		1.51	<0.01	<0.01	<0.01	0.04
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		1.51	<0.01	<0.01	<0.01	0.05
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		23.0	33.0	37.9	424	22.5
Total Cations	----	0.01	meq/L		23.4	31.9	29.1	455	16.4
Ionic Balance	----	0.01	%		0.72	1.67	13.2	3.46	15.6
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		230	55	90	70	50
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		229	57	93	85	50
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		2.68	1.78	0.97	2.48	2.15
Dissolved Oxygen - % Saturation	----	0.1	% saturation		27.1	18.6	10.3	25.3	21.9
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		0.33	<0.05	<0.05	<0.05	<0.05
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		0.72	0.88	0.91	0.53	0.68



Analytical Results

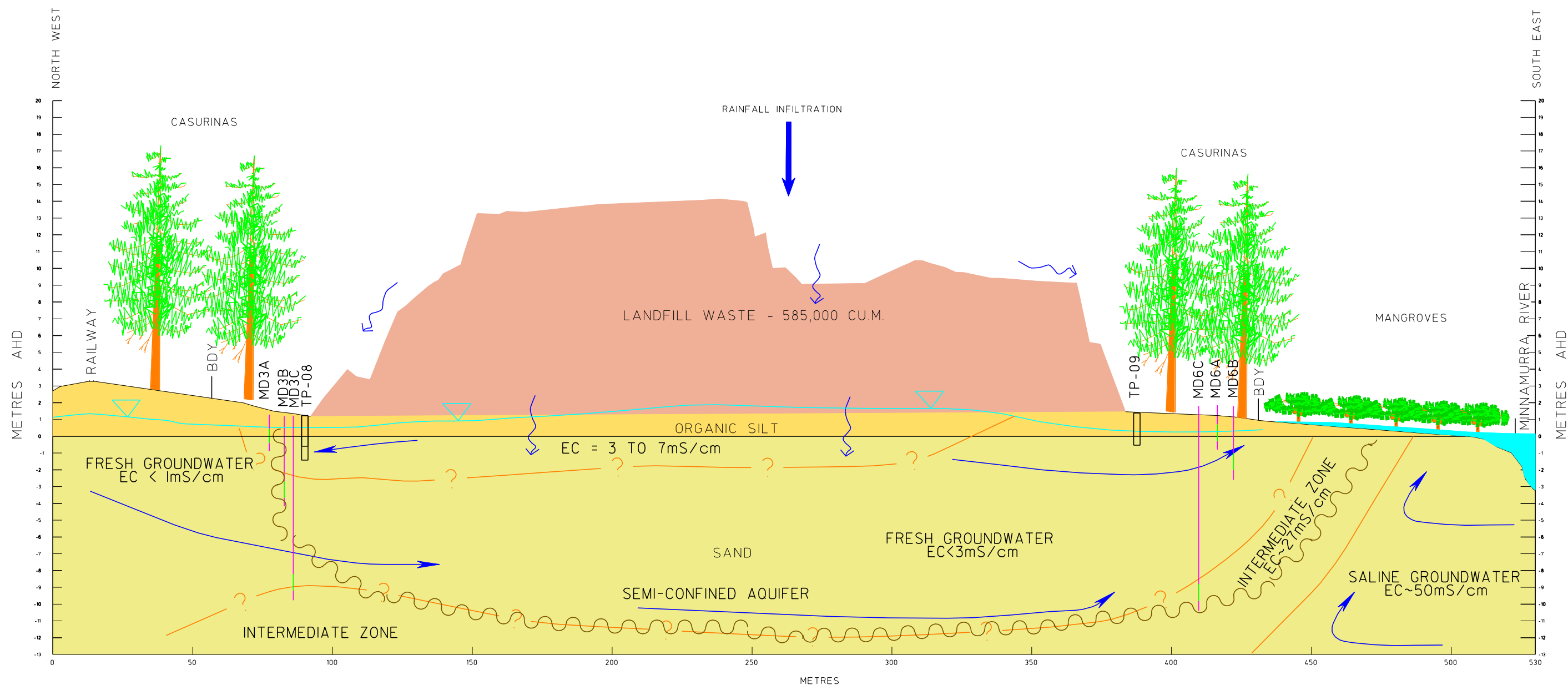
Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	MD1A
Client sampling date / time					11-Aug-2016 12:15	11-Aug-2016 13:15	11-Aug-2016 12:30	11-Aug-2016 13:25	11-Aug-2016 16:20
Compound	CAS Number	LOR	Unit		EW1603036-016	EW1603036-017	EW1603036-018	EW1603036-019	EW1603036-020
					Result	Result	Result	Result	Result
EA005FD: Field pH									
pH	----	0.1	pH Unit		7.3	7.6	7.2	----	7.4
EA010FD: Field Conductivity									
Electrical Conductivity (Non Compensated)	----	1	µS/cm		5040	2880	833	----	1610
EA020FD: Field Salinity									
Salinity	----	0.2	g/L		3.3	1.9	0.5	----	1.0
EA116: Temperature									
Temperature	----	0.1	°C		16.9	14.1	14.0	----	17.9
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	----	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	----	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		148	136	116	----	482
Total Alkalinity as CaCO ₃	----	1	mg/L		148	136	116	----	482
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		204	122	36	----	<1
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		1430	728	163	----	202
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		----	----	----	----	116
Magnesium	7439-95-4	1	mg/L		----	----	----	----	23
Sodium	7440-23-5	1	mg/L		----	----	----	----	110
Potassium	7440-09-7	1	mg/L		----	----	----	----	14
ED093T: Total Major Cations									
Calcium	7440-70-2	1	mg/L		66	48	30	----	----
Magnesium	7439-95-4	1	mg/L		112	57	19	----	----
Sodium	7440-23-5	1	mg/L		884	455	101	----	----
Potassium	7440-09-7	1	mg/L		34	19	6	----	----
EG020F: Dissolved Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		----	----	----	<0.001	0.192
Iron	7439-89-6	0.05	mg/L		----	----	----	<0.05	0.09
EG020T: Total Metals by ICP-MS									
Manganese	7439-96-5	0.001	mg/L		0.064	0.052	0.059	----	----
Iron	7439-89-6	0.05	mg/L		1.14	1.28	1.33	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Rocklow Down	Rocklow Middle	Rocklow Up	Blank	MD1A
Client sampling date / time					11-Aug-2016 12:15	11-Aug-2016 13:15	11-Aug-2016 12:30	11-Aug-2016 13:25	11-Aug-2016 16:20
Compound	CAS Number	LOR	Unit		EW1603036-016	EW1603036-017	EW1603036-018	EW1603036-019	EW1603036-020
					Result	Result	Result	Result	Result
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		0.3	0.2	<0.1	----	0.8
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.23	0.17	0.06	----	43.4
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	----	----	----	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	----	----	----	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	----	----	----	<0.01
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	----	----	----	15.3
Total Cations	----	0.01	meq/L		----	----	----	----	12.8
Ionic Balance	----	0.01	%		----	----	----	----	8.89
EN67 PK: Field Tests									
Field Observations	----	0.01	--		----	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		9	9	8	<1	51
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		10	10	9	----	118
EP025FD: Field Dissolved Oxygen									
Dissolved Oxygen	----	0.01	mg/L		8.63	8.21	8.49	----	0.26
Dissolved Oxygen - % Saturation	----	0.1	% saturation		89.0	80.1	83.2	----	2.8
EP035G: Total Phenol by Discrete Analyser									
Phenols (Total)	----	0.05	mg/L		<0.05	<0.05	<0.05	----	0.13
FWI-EN/001: Groundwater Sampling - Depth									
Depth	----	0.01	m		----	----	----	----	1.35

Appendix B



SECTION B - B1

LEGEND

- INFERRED EXTENT OF LEACHATE PLUME
- INFERRED LEACHATE MOVEMENT
- INFERRED GROUNDWATER LEVEL
- INFERRED LOCAL REGIONAL GROUNDWATER FLOW
- EXTENT OF HIGH TIDE LEVEL (& SALINE LEVEL)
- MONITORING WELL
- WELL SCREEN INTERVAL

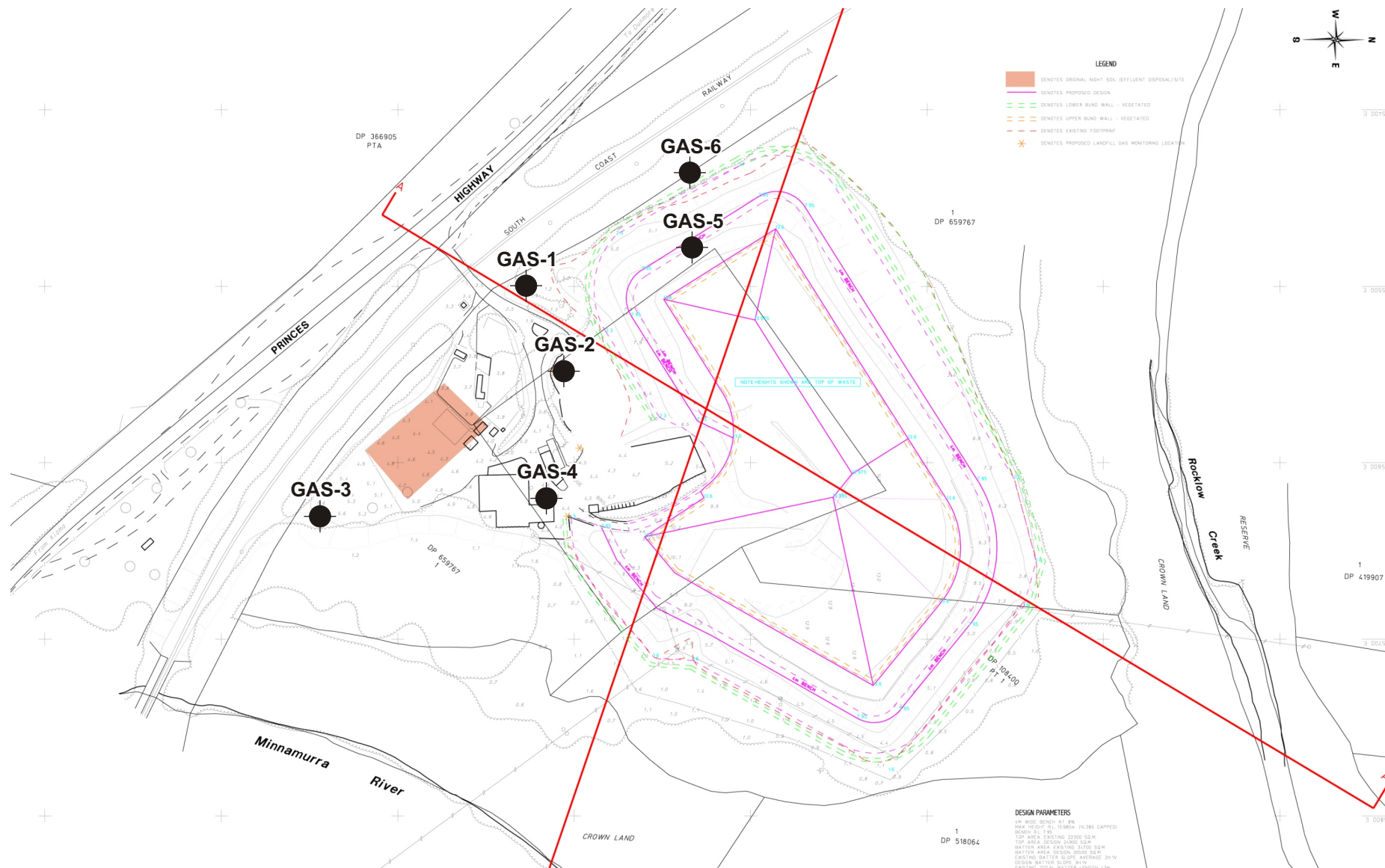
Appendix C

LANDFILL GAS MONITORING (2016)

GAS 1	Site Entrance
GAS 2	40m South of Landfill (Removed)
GAS 3	Carpark South of Landfill
GAS 4	Next to Secondhand Shop
GAS 5	Landfill West Bank, Bench
GAS 6	Landfill West Bank, Bund Wall
TRENCH 1	West Bank
TRENCH 2	North Bank West Side
TRENCH 3	North Bank Middle
TRENCH 4	South Bank Side
TRENCH 5	East Bank Side
TRENCH 6	North Bank East Side
TRENCH 7	Lower Level South Side

LEL % from inside trench pipe cap. This is normally not needed, but wanted to keep a record.

WELL ID	DATE	TIME	LEL PPM				COMMENTS
			MAX		STABLE		
			LEL%	PPM	LEL%	PPM	
Trench 4	8-Feb-16	1020		1,000		490	Good Readings
Trench 1	8-Feb-16	1025	100	600		230	*****
Trench 2	8-Feb-16	1030		450		100	*****
Trench 3	8-Feb-16	1035	100	1,100		160	*****
Trench 6	8-Feb-16	1040		690		100	*****
Trench 5	8-Feb-16	1045	100	700		140	*****
Trench 7	8-Feb-16	1050	80	1,000		180	*****
Gas 1	8-Feb-16	1055		160		100	*****
Gas 2	8-Feb-16						Removed due to new CRC site
Gas 3	8-Feb-16	1100		360		110	*****
Gas 4	8-Feb-16	1110		350		120	*****
Weighbridge	8-Feb-16	1120		0		0	All Building with clear readings
Cleaning She	8-Feb-16	1125		0		0	*****
MRF	8-Feb-16	1130		0		0	*****
Lunchroom	8-Feb-16	1135		0		0	*****
Ute Shed	8-Feb-16	1140		0		0	*****
Trench 4	23-May-16	845		1,000		510	Good Readings
Trench 1	23-May-16	850	100	900		200	*****
Trench 2	23-May-16	855		460		120	*****
Trench 3	23-May-16	900	100	1,210		210	*****
Trench 6	23-May-16	905		720		180	*****
Trench 5	23-May-16	910	100	700		120	*****
Trench 7	23-May-16	915	90	1,100		180	*****
Gas 1	23-May-16	925		300		120	*****
Gas 2	23-May-16						Removed due to new CRC site
Gas 3	23-May-16	935		360		120	*****
Gas 4	23-May-16	940		340		110	*****
Weighbridge	23-May-16	745		0		0	All Building with clear readings
Cleaning She	23-May-16	750		0		0	*****
MRF	23-May-16	755		0		0	*****
Lunchroom	23-May-16	800		0		0	*****
Ute Shed	23-May-16	805		0		0	*****
Trench 4	7-Sep-16	1000		1,100		400	Slightly windy at time of sample
Trench 1	7-Sep-16	1005	90	700		170	*****
Trench 2	7-Sep-16	1010		420		170	*****
Trench 3	7-Sep-16	1020	90	970		200	*****
Trench 6	7-Sep-16	1025		520		230	*****
Trench 5	7-Sep-16	1030		720		420	*****
Trench 7	7-Sep-16	1035	85	800		200	*****
Gas 1	7-Sep-16	1045		290		220	*****
Gas 2	7-Sep-16	1050					Removed due to new CRC site
Gas 3	7-Sep-16	1055		280		100	Slightly windy at time of sample
Gas 4	7-Sep-16	1100		180		100	*****
Weighbridge	7-Sep-16	1110		0		0	All Building with clear readings
Cleaning She	7-Sep-16	1115		0		0	*****
MRF	7-Sep-16	1120		0		0	*****
Lunchroom	7-Sep-16	1125		0		0	*****
Ute Shed	7-Sep-16	1130		0		0	*****



Source: Neil Charters Pty Ltd

GAS WELL MONITORING LOCATIONS

KIAMA MUNICIPAL COUNCIL - MINNAMURRA LANDFILL

Date: 7 August 2006

Reference: E2W_047_10.cdr

Figure 1

LAST PAGE OF REPORT



*Thank you for the opportunity to work with
Council.*

Feedback is welcomed at Earth2Water
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Pty Ltd
Environmental & Groundwater Consulting