Metromix Pty Ltd
ABN: 39 002 886 839

Teralba Quarry Extensions

Groundwater Assessment

Prepared by

RCA Australia

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Metromix Pty Ltd
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Groundwater Assessment

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EXECUTIVE SUMMARY

Teralba Quarry is located on the western side of Lake Macquarie, 160 km north of Sydney. For the purposes of the application by Metromix, the area covered by the application is referred to as the "Project Site".

Extensions to the quarry to the south and north are proposed. As is currently the case, the extraction method will result in the conglomerate resource being extracted down to near the top of the underlying coal seam, the Great Northern Coal Seam (GNCS) which has been extensively mined. This method is expected to result in the induced collapse of overlying conglomerate into the mined voids.

The Project Site is underlain by the Newcastle Coal Measures. The nearest aquifer beneath the extraction area is the mined GNCS which lies below the existing floor of the quarry (approximately at 20m AHD) and occurs at a similar level in the area of the proposed quarry extension. The GNCS dips at approximately 2˚ to 4˚ to the south-southeast.

The primary aquifer in the region is contained within the strata and voids of the GNCS. Aquifers are present at greater depths and include the underlying Fassifern Coal Seam (FCS) (also extensively mined beneath the Project Site). Groundwater flows down dip and flows beneath the site from northern to south-south-eastern corner. Groundwater in the GNCS is partially intercepted within a mine adit located in the south-east of the Project Site. Here it is collected in a dam (the Mine Adit Dam) before discharging into an open channel and eventually to Lake Macquarie via a concrete channel through the suburb of Teralba.

Significant "man-induced" recharge to this aquifer has occurred in the past at the adjacent Rhondda Colliery, located to the west of the Project Site. Large quantities of water from Cockle Creek, waste water treatment works and Teralba Quarry process water were pumped into the aquifer to quench an underground coal seam fire. This operation has been successful and this artificial recharge has now ceased.

Operations at Teralba Quarry require water for conglomerate processing and this water is sourced from the Mine Adit Dam. Previously, used process water was recharged back into the aquifer via a subsidence void located on the quarry floor. This discharge point was up-gradient of the Mine Adit Dam and therefore the quarry is effectively recirculated groundwater from the aquifer. This practice is about to cease with the introduction of silt cells to contain the silts produced in the processing plant. In future, approximately an average of 394ML/yr would be pumped annually from this dam during this process. This water would otherwise discharge to the surface water system.

The impact of the existing operations (to May 2011, based on available data) on groundwater quality was assessed by reviewing monthly monitoring records from discharge monitoring at the Mine Adit Dam which commenced in 1989. It was determined that the existing quarrying operations have not had an observable impact on groundwater quality since the commencement of monitoring.

The proposed quarry extensions are not expected to significantly impact on groundwater quality through general operations. Detailed contingency plans should be developed in the case of a pollution event (preliminary contingencies have been outlined herein).

Monitoring (as outlined in Section 11) should be conducted to allow potential impacts to be identified and assessed and if necessary, contingency plans to be implemented.

Localised groundwater flow regime effects may occur as aquifer transmissivities are reduced as mine voids, underlying the quarried areas, are filled with collapsed conglomerate rubble and fines. However, it is noted that the GNCS aquifer extends considerably further than the area beneath Teralba Quarry and it is likely that groundwater would continue to flow unimpeded through other voids in the former mine towards the Mine Adit Dam. This is not expected to significantly affect the overall flow regime.

1. INTRODUCTION

This groundwater assessment has been prepared for RW Corkery & Co. Pty Limited, on behalf of Metromix Pty Ltd (Metromix) who is proposing to extend the existing extraction areas within Teralba Quarry (see **Figure 1** for the location of Teralba Quarry). The following scope of work has been undertaken for this assessment.

- Review of available groundwater information at the site.
- Review of the regional and local geological information for the site.
- Assessment of the extent of surface water/groundwater interactions.
- Assessment of current impact of the quarry on groundwater quality and predicted future impacts of the proposed extension including groundwater dependent ecosystems.

Each of these matters reflect the requirements set out in the brief for the proposed assessment together with those included in the Director-General's Requirements (DGRs) for the Project.

2. PROJECT OVERVIEW

2.1 PROJECT LOCALITY

The Project Site is located to the west of the Newcastle suburb of Teralba, approximately 7 km north of Toronto and 6 km south of Edgeworth in the Parish of Teralba, in the County of Northumberland. The locality of the Project Site is illustrated in **Figure 1**.

The Project Site encompasses the freehold land incorporating the full area of the existing Teralba Quarry extraction and processing operations, the proposed Southern and Northern extensions and a section of Rhondda Road. The Project Site covers an area of approximately 130 ha and is located entirely within an area of freehold land Metromix leases from the landowner, Mr A C Fowkes.

2.2 PROJECT DESCRIPTION

The Project Site incorporates four extraction areas (see **Figure 2**). The first area, referred to as the "existing Southern Extraction Area," encompasses all approved extraction and processing operations south of Rhondda Road. The second area is referred to as the "existing Mid Pit Extraction Area" which is located north of Rhondda Road. The two areas not yet approved and the subject of the project application are referred to as the "proposed Southern Extension" and the proposed Northern Extension".

2.2.1 Existing Southern Extraction Area

This area encompasses the current active extraction area and all stockpiling and processing facilities, site offices, crib rooms, workshop and weighbridge associated with the existing quarry. **Figure 2** presents the locations of each of these project areas together with the private coal haul road leased to Oceanic Coal and the various transmission lines that traverse the Project Site. The southern boundary of the existing Southern Extraction Area coincides with the boundary nominated in Development Consent DA 130/42.

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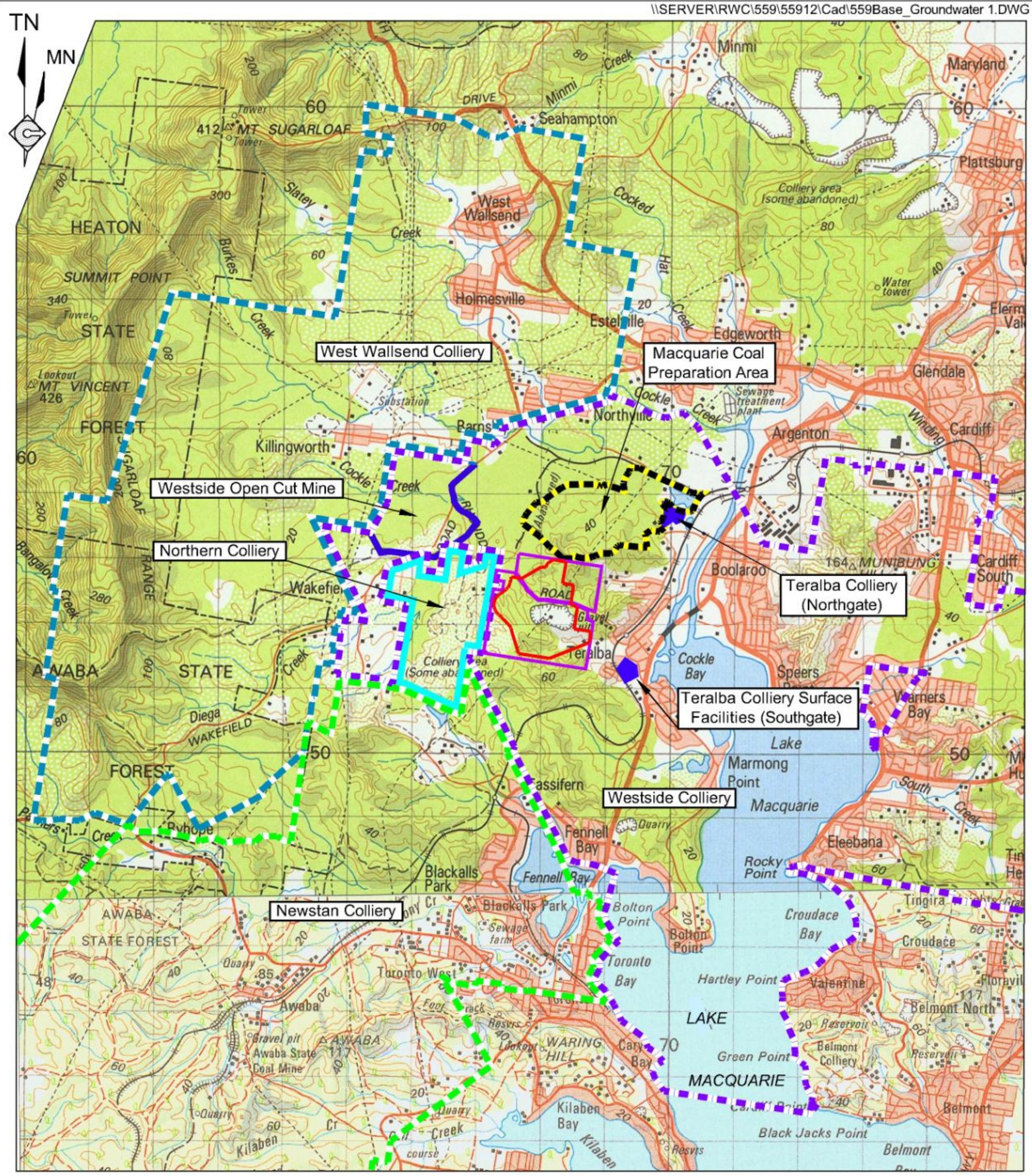


REFERENCE

- Property Boundary
- Project Site Boundary
- Westside Colliery Holding (incorporating Teralba and Northern Extended Collieries)
- Westside Open Cut Mine
- Teralba Colliery Surface Facilities
- Macquarie Coal Preparation Plant
- Northern Colliery Holding (formerly Rhondda Colliery)
- Newstan Colliery Holding
- West Wallsend Colliery Holding

Note: Boundaries between Collieries are drawn from data supplied by the Division of Resources and Energy. Some minor variation may occur on some boundaries due to the presence of sub-leases.

SCALE 1:100 000

1 0 1 2 3 4 5 km

Base Map Source: Newcastle (1983) and Lake Macquarie (1977) 1:100 000 Topographic Maps

Figure 1
LOCALITY PLAN

The existing Southern Extraction Area will be fully extracted by 2012. The area remaining for extraction lies within the floor of the extraction area where the remaining 10m to 12m of conglomerate above the underlying coal seam remains to be extracted. The total area of the existing Southern Extraction Area is approximately 40 ha.

It is noted that in addition to Metromix's quarry operations conducted on the southern side of Rhondda Road, there are currently two other operations undertaken by other companies within the existing Southern Extraction Area (see Section 2.2.5).

The existing Southern Extraction Area also encompasses infrastructure related to the existing quarry operations. This infrastructure includes an access road from the quarry operations to Railway Street, Teralba. This sealed road is used by laden heavy vehicles to exit the Project Site to the east and avoid descending the steep downhill section of Rhondda Road. This road is leased from the owner, Teralba Engineering. Metromix is responsible for maintenance of this road, although it is also used by laden heavy vehicles transporting products for Downer EDI and Civilake.

2.2.2 Existing Mid Pit Extraction Area

The existing Mid Pit Extraction Area covers approximately 7.5 ha. Extraction commenced in this area during September 2010 to supplement the resources extracted from the existing Southern Extraction Area over the next two to three years.

2.2.3 Proposed Southern Extension

The proposed Southern Extension covers approximately 16.5 ha and is located entirely within Lot 2 DP 224037. This Lot is traversed by a number of transmission line easements and a small area is leased to Oceanic Coal for the purposes of a private coal haul road between various coal mines to the north and the Eraring Power Station to the south.

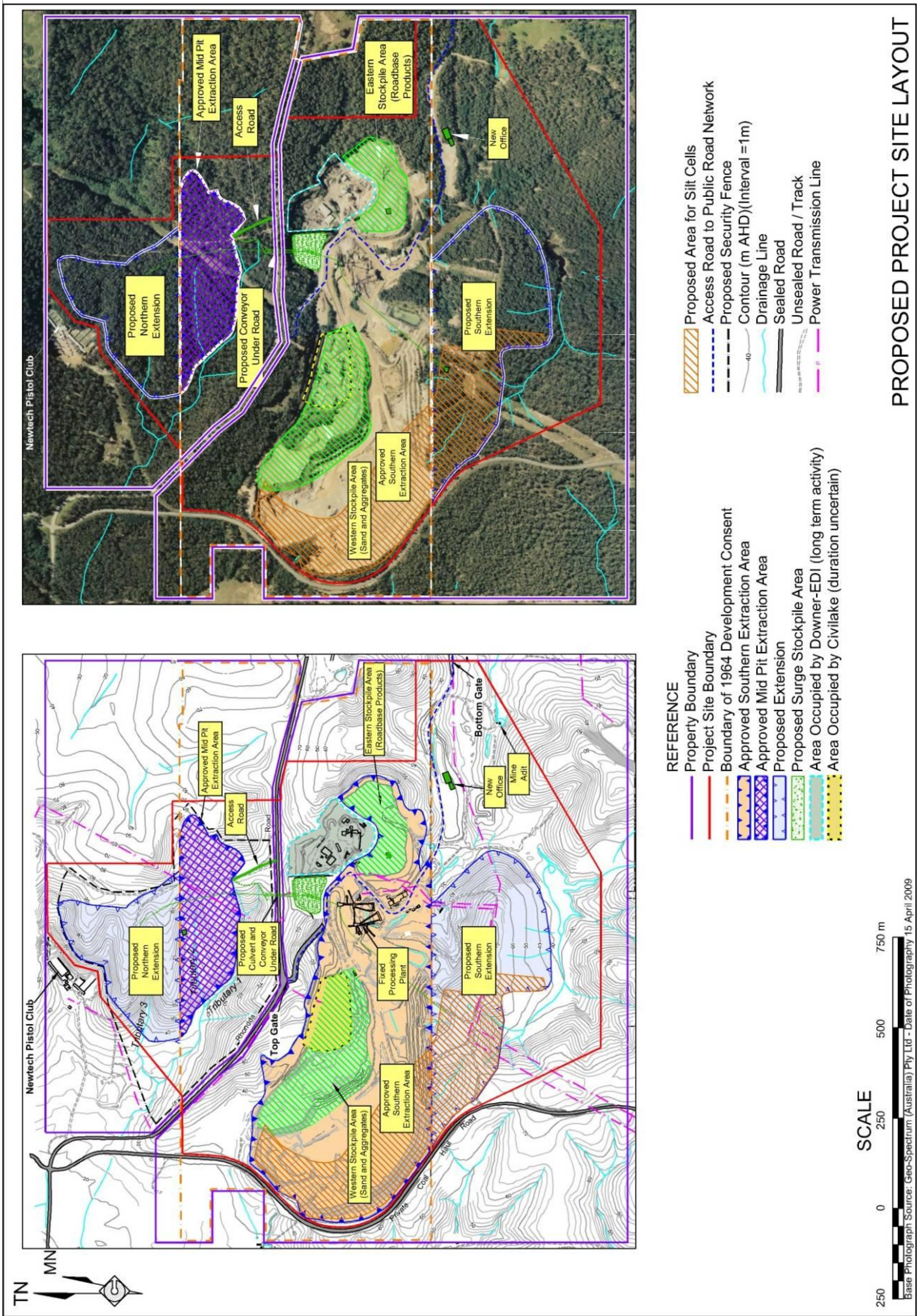
2.2.4 Proposed Northern Extension

The proposed Northern Extension is located entirely within Lot 1 DP 224037, on the northern side of Rhondda Road and comprises an area covering approximately 9.3 ha. The Newtech Pistol Club is located beyond the northwestern boundary of the proposed Northern Extension within the land leased by Metromix.

2.2.5 Non-Project related Commercial Operations

Two non-Project-related commercial operations are located in areas within the Project Site that, for the purposes of this document, are not included as components of the Project. These two commercial operations are undertaken by companies independent of Metromix, who hold agreements with Metromix for their tenure on site. **Figure 2** displays the locations of the Downer EDI asphalt plant and Civilake pugmill.

- Downer EDI – The asphalt plant occupies a 3 ha area within the existing quarry. The plant typically produces approximately 70 000 tonnes of bitumen products annually. The aggregate raw materials for the asphalt plant are all supplied by external sources and are stockpiled immediately north of the Metromix stockpile area. A number of the laden product trucks from this plant also use the road leased through Teralba Engineering to allow trucks to exit via Railway Street and avoid laden trucks travelling down Rhondda Road towards Teralba.


PROPOSED PROJECT SITE LAYOUT
REFERENCE
Property Boundary
Project Site Boundary
Boundary of 1964 Development Consent
Approved Southern Extraction Area
Approved Mid Pit Extraction Area
Proposed Extension
Proposed Surge Stockpile Area
Area Occupied by Downer-EDI (long term activity)
Area Occupied by Civilake (duration uncertain)
Proposed Area for Silt Cells
Access Road to Public Road Network
Proposed Security Fence
Contour (m AHD)(Interval =1m)
Drainage Line
Sealed Road
Unsealed Road / Track
Power Transmission Line
Newtech Pistol Club
Proposed Northern Extension
Approved Mid Pit Extraction Area
Access Road
Proposed Conveyor Under Road
Proposed Culvert and Conveyor Under Road
Eastern Stockpile Area (Roadbase Products)
New Office
Mine Adit
Bottom Gate
Top Gate
Fixed Processing Plant
Proposed Southern Extension
Approved Southern Extraction Area
Western Stockpile Area (Sand and Aggregates)
Tributary 1
Tributary 3
SCALE
250
0
250
500
750 m
Base Photograph Source: Geo-Spectrum (Australia) Pty Ltd - Date of Photography 15 April 2009
TN
MN

- Civilake Pugmill – Civil Lake, as part of Lake Macquarie City Council, operates a road base pugmill within a 2.1 ha area within the existing quarry area. Products from Teralba Quarry and various recycled materials are mixed with a cementitious binder in the pugmill for use in construction products throughout the local government area. The pugmill is also used with the reclamation of asphalt. The pugmill operates under a separate development consent issued by LMCC and the plant is operated in accordance with Environment Protection Licence 13015 for Recovery of General Waste and Waste Storage. The pugmill typically produces up to 100 000tpa of products. Civilake recycles concrete and asphalt through the pugmill, bringing in specialised crushing plant for this purpose, when required. This is a wet process that will not impact upon the impact assessment.

These two operations operate completely independently to the Metromix Quarry. The operation of these plants and their environmental impact and any impact mitigation employed at these plants is not addressed in this document, except in the assessment of cumulative impacts for the entire Project Site.

3. PROPOSED DEVELOPMENT

3.1 QUARRY DEVELOPMENT

Those areas comprising the Project Site are contained within Lot 1 DP 224037 (Vol. 13128 Fol. 19) and Lot 2 DP 224037 (Vol. 13128, Folio 20), Parish of Teralba, County of Northumberland.

The extended Teralba Quarry will comprise the following four areas of development:

The first two areas, described below, are already approved and are currently in operation. However, the current application will seek to bring the four areas under one project approval.

The existing Southern Extraction Area covers approximately 40ha and is located on the southern side of Rhondda Road, Teralba (**Figure 2**). This area encompasses the current Metromix operation, including what remains to be extracted under the current lease and processing plant and administration infrastructure. Extraction from the existing Southern Extraction Area is anticipated to be completed by 2012, including the lower level extraction which will remove the conglomerate resource down to near its base, near the top of the underlying Great Northern Coal Seam (GNCS).

The existing Mid Pit Extraction Area, covers approximately 7.5 ha and is located immediately north of Rhondda Road. Extraction commenced in preliminary clearing and infrastructure construction commenced in September 2010. Estimated completion for the Mid Pit Extraction Area is three to four years.

The following two proposed quarry extension areas are the subject of this approvals process.

1. The proposed Southern Extension, covering approximately 16.5ha, and is located immediately to the south of the existing Southern Extraction Area. This area contains power transmission line easements and an area on the western side of the property which Oceanic Coal leases as a private coal haul road (between coal mines to the north of Rhondda Road and Eraring Power Station).
2. The proposed Northern Extension, covering approximately 9.3 ha on the northern side of Rhondda Road (north of and surrounding the existing Mid Pit Extraction Area) bordering the Newtech pistol club. The western boundary of this area coincides with the approximate edge of the outcrop of the Teralba Conglomerate.

Resource extraction from the existing quarry and proposed extensions will generally proceed according to the following conceptual schedule.

- Extraction from the current (southern) area and from the existing Mid Pit Extraction Area will be undertaken concurrently.
- Extraction would be from both the upper level (i.e., leaving an approximately 12m safe working floor between the top of the GNCS and conglomerate) and the lower level, where the base of the conglomerate would be collapsed into the mined-out workings of the underlying GNCS and excess conglomerate removed.
- Extraction would generally proceed (once the current area is completed) from the Mid Pit Extraction Area, through the Northern Extraction and then into the southern extension area over an estimated term of 30 years.
- The extraction of material from the Mid Pit Extraction Area would reach a hiatus at approximately 40m AHD and then proceed into the balance of the northern area before extraction down to the planned base (approximately 24 m AHD).

3.2 PROCESS WATER SUPPLY

The quarry has a requirement for water during the wet production process (washing/screening raw feed) which, on average, constitutes approximately 65% of the quarry throughput. On this basis, the projected maximum water requirement for processing is approximately 1170ML/annum (based on the production of 900 000 tonnes of products per annum) - a use of approximately 2 000 L/tonne.

Small amounts of water are also required for dust suppression and wheel washing purposes. In total, the combined non-potable water use has been calculated to be 1 219ML (WBM BMT, 2011). It is noted that approximately 821ML or 67% of the water used is recycled.

Water for the quarry operations is currently pumped to Dam G from the Mine Adit Dam, a dam that predominantly collects water flowing from the GNCS and Fassifern Coal Seam in the south-eastern corner of the Project Site.

Water is pumped to the plant from Dam G where it is used in the washing/screening process, as required. Water not lost to quarry product or as evaporation drain is currently collected and stored in a holding tank in the plant area. For many years, this stored water, containing approximately 9% silt, has been directed into the GNCS via a collapsed zone within the floor of the Southern Extraction Area or more recently re-injected into the GNCS workings, through a purpose-built well on the extraction floor.

Based on the design data for the pumps used in the processing plant, Metromix, calculated approximately 80% of process water is currently re-circulated via re-injection into the GNCS workings (with small quantities flowing via overland return flow and seepage to the Mine Adit Dam). This will reduce to approximately 70% in the near future when Metromix ceases its re-injection practice and commences to use above ground silt cells.

Metromix estimates an average make-up water requirement of approximately 394ML/annum (including the 30% water loss, plus losses to dust suppression and wheel washing) for a the average annual production rate of 900 000tpa assuming 65% of products are washed and screened.

4. DIRECTOR-GENERAL'S REQUIREMENTS

Table 1 paraphrases the requirements of the Director-General of the Department of Planning and other government agencies relating to the assessment of impacts to groundwater for the proposed Teralba Quarry Extensions.

Table 1 also presents where each requirement is addressed in this document.

Table 1
Director-General's Requirements for the Groundwater Assessment for Teralba Quarry Extensions

Page 1 of 3

GROUNDWATER		
Government Agency	**Paraphrased Requirement**	**Relevant Section(s)**
Department of Planning	The Environmental Assessment of the project must include: • detailed modelling and assessment of potential impacts on:	
	– the quality and quantity of existing surface water and groundwater resources;	Section 9
	– affected licensed water users and basic landholder rights;	Section 9
	– the riparian, ecological, geomorphological hydrological values of watercourses; and	Section 9
	– impacts to agricultural lands;	Section 9
	• A detailed description of measures to mitigate surface water and groundwater impacts.	Section 11
NSW Office of Water	• The Environmental Assessment is required to demonstrate the following.	
	– Adequate and secure water supply is available for the life of the project. Confirmation that water supplies for the ongoing operation of the quarry are sourced from an appropriately authorized and reliable supply.	Section 8
	– Identification of site water supply demands in terms of both volume and timing (including water sources – groundwater and surface water) for the extension and ongoing operations.	Section 8
	– Existing and proposed water licensing requirements are in accordance with the Water Act 1912, Water Management Act 2000 and Water Sharing Plan for the Hunter Unregulated and Alluvial Water Source.	Section 5
	– An assessment of the impact of quarry operations on adjacent licensed water users, basic landholder rights, and groundwater-dependent ecosystems. This is to meet the requirements of the NSW State Groundwater Policy Framework Document (1997) in addition to the Water Act 1912 and Water Management Act 2000.	Section 9
	– An assessment of watercourses that may be impacted and selection of appropriate techniques and mitigation measures to minimise impact. Design and construction of works within 40m of water courses are to be in accordance with NOW Guidelines for Controlled Activities (August 2010)	Section 9
	– Adequate mitigating and monitoring requirements to address any predicted potential surface and groundwater impacts.	Sections 9 and 10

Table 1 (Cont'd)
Director-General's Requirements for the Groundwater Assessment for Teralba Quarry Extensions

Page 2 of 3

GROUNDWATER		
Government Agency	**Paraphrased Requirement**	**Relevant Section(s)**
NSW Office of Water	• The assessment is required to take into account the requirements of the following legislation (administered by NOW), as applicable: • Water Act 1912	Section 5
	• Water Management Act 2000 (WMA)	Section 5
	• If the proposal is within a gazetted WSP area the assessment is required to demonstrate consistency with the rules of the WSP.	Section 5
	• The assessment is required to take into account the following NSW Government policies, as applicable: • NSW Groundwater Policy Framework Document (1997)	Section 5
	• NSW Groundwater Quantity Management Policy (1998)	Section 5
	• NSW Groundwater Quality Protection Policy (1998)	Section 5
	• NSW State Groundwater Dependent Ecosystem Policy (2002)	Section 5
	• NSW Wetlands Management Policy (2010)	Section 5
	• Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)	Section 5
	• Australian and New Zealand Guidelines for Water Quality Monitoring and Reporting (2000)	Section 5
	• Guidelines for the Assessment and Management of Groundwater Contamination (2007)	Section 5
	• Guidelines for Groundwater Protection in Australia	Section 5
	• The NSW Groundwater Dependant Ecosystem Policy provides guidance on the protection and management of GDE and sets out objectives and principles.	Section 9
	• Identification of potential GDEs within the Study Area	Section 9
	• Current GDE condition, water quantity and quality required by the ecosystems (minimum two year baseline data)	Section 9
	• Determine critical thresholds for negligible impacts	Section 9
	• Manage groundwater extraction within defined limits thereby providing flow sufficient to sustain ecological processes and maintain biodiversity	Section 9
	• Ensure sufficient groundwater of suitable quality is available to ecosystems when needed	Section 9
	• Ensure the precautionary principle is applied to protect GDE, particularly the dynamics of flow and availability and the species reliant on these attributes	Section 9
	• The assessment is required to identify groundwater issues and potential degradation to the groundwater source and provide the following: • Details of the predicted highest groundwater table at the development site	Sections 7 and 9
	• Details of any works likely to intercept, connect with or infiltrate the groundwater sources	Sections 8 and 9

Table 1 (Cont'd)
Director-General's Requirements for the Groundwater Assessment for Teralba Quarry Extensions

Page 3 of 3

GROUNDWATER		
Government Agency	**Paraphrased Requirement**	**Relevant Section(s)**
NSW Office of Water	• Details of any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes	Sections 8 and 9
	• Details of the existent groundwater users within the area (including the environment) and include details of the potential impacts on these users	Section 7
	• Details of how the proposed development will not potentially diminish the current quality of groundwater both in the short and long term	Section 9
	• Details on preventing groundwater pollution so that remediation is not required	Section 9
	• Details on protective measures to minimise any impacts on groundwater dependent ecosystems (GDEs)	Section 9
	• Assessment of the need for an acid sulphate management plan prepared in accordance with ASSMAC guidelines.	Section 9
	• Assessment of the potential for saline water intrusion of the groundwater and measures to prevent such intrusion into the groundwater aquifer	Section 9
	• Describe the flow directions and rates and the physical and chemical characteristics of the groundwater source	Section 7
	• Details of the predicted impacts of any final landform on the groundwater regime	Section 9
	• Details of the results of any models or predictive tools used to predict groundwater drawdown, inflows to the site and impacts on affected water sources	Section 9

5. LEGISLATIVE FRAMEWORK

The assessment is required to take into account the requirements of the following legislation, administered by the New South Wales Office of Water (NOW), as applicable:

- Water Act 1912; and
- Water Management Act 2000 (WMA).

Table 2 provides a list of the most applicable sections of legislation relevant to groundwater at the Teralba Quarry.

It is noteworthy that the Water Sharing Plan for the Hunter Unregulated and Alluvial source does not apply to the Great Northern Coal Seam which in turn means the *Water Act 1912* applies to the groundwater within the seam.

Table 2
Groundwater Legislation Relevant to the Proposed Teralba Quarry Project

Page 1 of 2

Water Act 1912	Water Management Act 2000	Water Management (General) Regulation 2004	Water Sharing Plan (WSP) for the Hunter Unregulated and Alluvial Water Source
Section 112 of this Act is applicable since the Water Sharing Plan covering Teralba Quarry does not apply to the Great Northern Coal Seam.	Part 2 *Access licences* Division 1 *Preliminary* Sections 51A – 60 Division 2 *Granting of access licences* Section 61 *Applications for granting of access licences* 61 (1) (a) (b) (c) Applications for granting of access licences 63 (1) and (2) Determination of applications 65 (1) and (2) Controlled allocation of access licences Part 3 *Approvals* Division 1 *Preliminary* Division 2 *Applications for approvals* *Dictionary*	Part 1, Clause 5 *Pre-1999 existing works* Part 3, Division 1 *General*, Clause 8 (1) and (2) *Categories of access licence* Part 3 Division 2 *Exemptions* Clause 18, *Exemption from requirement for access licence* Clause 19 *Applications for specific purpose access licences* Clause 20 *Granting of access licences* Part 4 *Approvals* Division 1 *General*, Division 2 *Exemptions*, Division 3 *Approvals for formerly unlicensed water bores in the Great Artesian Basin.*	Part 1, Clause 4 *Water sources to which this plan applies.* Note: Teralba Quarry falls within Clause 4 (1) (gg) North Lake Macquarie Water Source although the Great Northern Coal Seam is not covered by the plan. Part 7 *Requirements for water under access licences* Clause 32 *Share component of aquifer access licences*. Note: Clause 32 (gg) applies to Teralba Quarry and states: 0 unit shares in the North Lake Macquarie Water Source. Part 8 *Rules for granting access licences* Clause 34 *Rules for granting access licences* Part 9, Division 2 *Water supply works used to take water from the alluvial sediments in these water sources.* Clause 38*Rules for granting or amending approvals for water supply works used to take water from the alluvial sediments in these water sources* Clause 39 *Rules for granting water supply works approvals.* Part 10, Division 2, Clause 48 *Available water determinations* Clause 54*Available water determination for aquifer access licences* Part 11, Division 1 *General* Clause 55 *Rules for managing access licences* Part 11 Division 2 *Water allocation account management* Clause 56 (1) (2) (3) (4) (8) and (13) *Individual access licence account management rules* Part 11 Division 3 Clause 58 *Sharing surface water flows on a daily basis* Clause 59 (1) (3) (4) and (5) *Establishment and assignment of total daily extraction limits*

Table 2 (cont'd)
Groundwater Legislation Relevant to the Proposed Teralba Quarry Project

Page 2 of 2

Water Act 1912	Water Management Act 2000	Water Management (General) Regulation 2004	Water Sharing Plan (WSP) for the Hunter Unregulated and Alluvial Water Source
			Part 11 Division 4 *Management of surface and groundwater connectivity* Clause 68 (1) (3) and (5) *Access licences which nominate a water supply work which may be used to take water from the alluvial sediments in these water sources* Part 12 *Access licence dealing rules* Part 13 *Mandatory conditions* Division 1 *Mandatory conditions on access licences* Clause 75*Mandatory conditions on all access licences* Clause 76*Mandatory conditions relating to the taking of water* Clause 79*Mandatory conditions on aquifer access licences*

- The Teralba Quarry is within the North Lake Macquarie Water Source, which is covered by the *Water Sharing Plan (WSP) for the Hunter Unregulated and Alluvial Water Source.*
- It is understood that the Teralba Quarry does not hold any water licences under the *Water Act 1912;* therefore the *Water Management Act 2000* and the *WSP for the Hunter Unregulated and Alluvial Water Source* provide the applicable water legislative framework for the operations of the Teralba Quarry.
- It is unlikely that Teralba Quarry is defined as a pre-1999 existing work under *Part 1, Clause 5* of the *Water Management (General) Regulation 2004* (refer to **Table 2**) or is exempt from certain legislative requirements as per *Part 3, Division 2* of the *Water Management (General) Regulation 2004* (refer to **Table 2**). Therefore, the standard licencing and approval requirements and procedures apply to the Teralba Quarry as outlined below.
- An aquifer (general security) access licence is required where water from an aquifer is used or proposed to be used. This is the category of access licence that is most likely to be applicable to the Teralba Quarry operations. Rules apply here under the *WSP for the Hunter Unregulated and Alluvial Water Source, or under the Water Act (1912).*
- Instead of the above-mentioned access licence, specific purpose access licence/s may be applicable to Teralba Quarry operations i.e. *an aquifer access licence (subcategory "town water supply"), for the purpose of supply to communities for domestic consumption and commercial activities [Part 3, Div. 2, Clause 19(e)Water Management (General) Regulation 2004].*

- A water supply works approval is required for a work that is constructed or used for the purpose of taking water from a water source e.g., water pump, water bore, tank, dam, water pipe, irrigation channel, bank levee, weir and reticulated system. Rules apply here under the *WSP for the Hunter Unregulated and Alluvial Water Source*.
- An aquifer interference approval is required where any penetration, interference, obstruction, taking of water or disposal of water taken from an aquifer occurs. Rules apply here under the *WSP for the Hunter Unregulated and Alluvial Water Source*.

Other relevant legislation includes:

- *Guidelines for Fresh and Marine Water Quality* (ANZECC 2000). These guidelines were adopted for the evaluation of potential impacts on groundwater quality. The guidelines are endorsed by the NSW Office of Environment and Heritage – (OEH, formerly the Department of Environment, Climate Change and Water (DECCW).

6. GEOLOGICAL SETTING

Teralba Quarry is underlain by strata belonging to the Moon Island Beach Subgroup of the Newcastle Coal Measures (NCM). The Newcastle Coal Measures are of Late Permian age and comprise dominantly coarse clastic and volcanogenic sediments with intervening coal seams. The Moon Island Beach Subgroup is stratigraphically the highest in the NCM and consists of:

- Munmorah Conglomerate;
- Wallarah Coal Seam;
- Teralba Conglomerate;
- Great Northern Coal Seam (GNCS);
- Eleebana Formation; and
- Fassifern Coal Seam (FCS).

Teralba Quarry is located to the north-east of the Macquarie Syncline, a broad flat fold structure which generally has all strata dipping to the south and southeast at approximately 2° to 4°, with groundwater flowing down dip toward the south and southeast. The subsurface catchment is of unknown size, with groundwater coming to the surface to the south of the quarry at the Mine Adit, as discussed below.

Metromix is currently extracting conglomerate of the Teralba Conglomerate, which lies directly above the GNCS. In this area, the GNCS is approximately 6m thick, with the underlying Eleebana Formation ranging from 10m to 20m thick.

The Fassifern Coal Seam (FCS), which is 95% flooded, is approximately 5m thick. Both the GNCS and the FCS have been mined extensively in the vicinity of the Teralba Quarry since the 1800s. Several mining operations have extracted coal from beneath the quarry over the years, with extensive subsidence occurring, including potholing and goafing in the Stage 1 quarry floor.

The nearby Rhondda Colliery (now closed), located to the northwest of Teralba Quarry, mined the GNCS within 5m of the natural surface, ranging to a maximum depth of 20m. However, the Rhondda Colliery operation did not extend under the quarry. It is highly likely however, that the workings beneath the quarry and those of Rhondda Colliery are joined for the passage of water, forming a continuous aquifer.

The Rhondda Colliery closed in 1971 as the result of an underground fire which ignited the GNCS. Action taken to extinguish the fire has consisted of pumping water into the seam over a period of approximately 25 years. Water for this purpose was sourced from the Cockle Creek and Edgeworth Sewage Treatment Works and pumped into the underground workings. This response proved ineffective as the water flowed along the base of the seam whilst the fire continued toward the top of the seam. In more recent years, a new method of extinguishing the fire was used. This consisted of the mixing of flyash, bottom-ash and fine sediment with water (sourced from Cockle Creek from 2001, and from the holding tank on the Rhondda Colliery property into which Metromix pumped the fines from the its processing plant) to create a slurry which was pumped into the seam. The fines infilled voids in the coal seam which prevented rapid egress of water as well as restricting air space, thus making the coal less combustible. The fire was finally extinguished and pumping to the seam at the Rhondda Colliery site ceased in 2006.

Waste or slurry water from the processing operations at Teralba Quarry was pumped ("recirculated") to the GNCS through a dedicated well in the quarry floor. Pumping rates were between three and four ML/day (Ref [4]). Previously, the waste water or slurry was re-injected into the underlying GNCS via a 300mm well located on the quarry floor.

This practice has now ceased and will not form a part of continued operations for the proposed quarry extensions.

Figure 3 presents the geological setting of the Project Site.

7. HYDROGEOLOGY

7.1 GROUNDWATER OCCURRENCE

In the Newcastle Coal Measures, the majority of the aquifers comprise the coal seams with permeability values generally one to two orders of magnitude higher than the interburden strata (Ref [1]). The coal seam aquifers are of secondary porosity with flow along zones of open fractures, joints and cleats. The interburden strata are generally too high in fines content to have interconnected pores and are therefore also of secondary porosity. The interburden strata are generally regarded as aquitards (layers of low permeability that can store groundwater but can only transmit at a slow rate).

In addition to their higher permeability, many of the coal seams have been mined and contain a void, which greatly increases the permeability and storage capacity. Flow in these aquifers is governed by the dip of the strata with recharge at the sub-crop areas and flow occurring down-dip (at 2˚ to 4˚ to the south and south-east).

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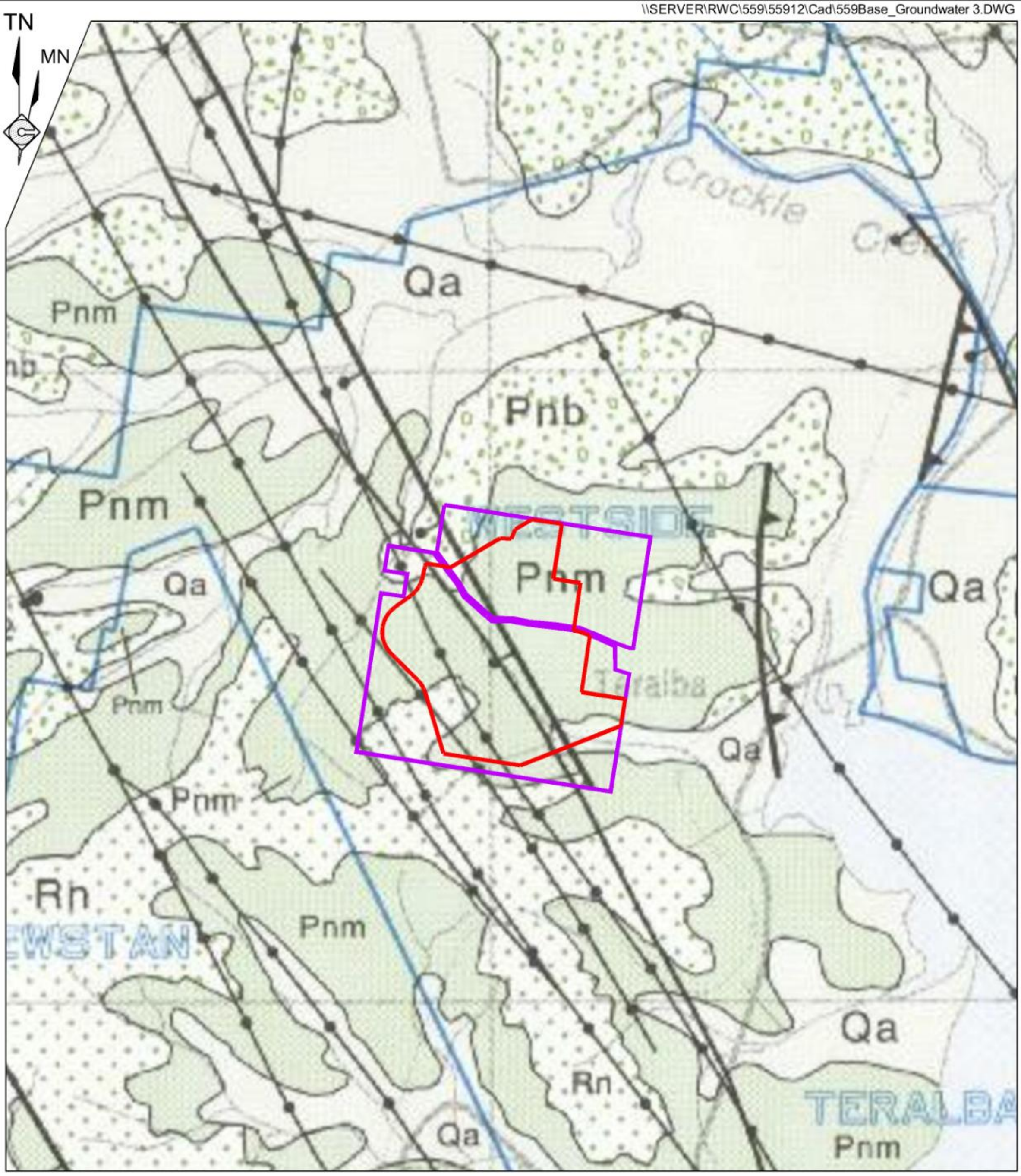

REFERENCE

Property Boundary

Project Site Boundary

Geology

Qa	Gravel, sand, silt, clay
Rn	Conglomerate, sandstone, siltstone, claystone
Pnm	Conglomerate, sandstone, siltstone, tuff, coal
Pnb	Sandstone, conglomerate, siltstone, coal, tuff

SCALE 1:40 000

0.5 0 0.5 1.0 1.5 2.0 km

Source: Newcastle Coalfields Regional Geology (1995)

Figure 3
GEOLOGICAL SETTING

Based on the above geological model and site observations, the primary aquifer beneath the Teralba Quarry and its proposed extensions is the Great Northern Coal Seam (GNCS) which has been extensively mined beneath the site leaving a remnant “room and pillar” void structure. The top of the GNCS occurs at about a level of 19m AHD, below the base of the existing quarry workings.

This seam is a significant aquifer having a large catchment and a large recharge source from the up-gradient Rhondda Colliery adjacent to the north-western boundary of the Teralba Quarry.

Groundwater flow is governed by the dip of the coal seam which is to the south and southeast beneath Teralba Quarry. Groundwater flows from the Rhondda Colliery and then underneath the Teralba Quarry and proposed extension areas. At the southern end of Teralba Quarry (see **Figure 2**) there is a disused mine adit. This was an entry point into the GNCS mine workings when the mine was operational. This mine adit partially intercepts groundwater in the GNCS, at the surface where it flows to a holding dam, the “Mine Adit Dam”. The dam also periodically receives surface water runoff intercepted across the current operational site via a series of sediment dams.

It is understood that flow from the final sediment dam on the eastern side of the quarry site (Dam B) will now be directed to the watercourse downslope of the Mine Adit Dam. In the future, flow into the dam will only comprise groundwater inflow from the adit and the immediate catchment around the dam.

Water flows from the Mine Adit Dam over a weir (formerly a “v-notch weir”, now a triple pipe discharge, with permanent data logger monitoring),before leaving the Project Site along a concrete channel which flows through Teralba (“Murph’s Drain”) eventually discharging to Lake Macquarie near the entry at Cockle Creek. This creek and drain would have been ephemeral prior to coal mining activities, however, since the cessation of coal mining, the flow in this creek and drain has almost been permanent.

As part of the 2007 Site Water Management Plan for Teralba Quarry prepared by GHD (GHD, 2007), it was estimated that groundwater storage in the mined voids comprised 750,000 ML in the GNCS (based on 50% flooded saturation), and 456,000 ML in the FCS (based on 95% saturation). Using assumed average water usage rates (based on existing usage), it was estimated that by the end of the quarry life, nominally to 2042, change in mined coal seam storage would be decreases of 0.74% and 4.9% for the GNCS and FCS, respectively.

These estimates assume recharge from the Oceanic Collieries to the Fassifern Seam at 2.65 ML/day, and does not include any natural recharge (rainfall/infiltration).

Hydrogeology is conceptually represented in **Figure 4**.

Flow leaving Mine Adit Dam and the volume of operation water is recorded and available data for 2003 and 2008 was evaluated.

Table 3 presents the monthly usage and discharge volumes from the dam. The total of these values represents the total flow to the mine adit.

The data indicates that flows to the Mine Adit Dam were 70% higher in 2008 than in 2003. Quarry use remained consistent and excess water is reflected in the increased volume discharged from the weir in 2008. The increased discharge rates could be attributed to the change in discharge locations for process water and/or increased recharge to the groundwater aquifer from rainfall.

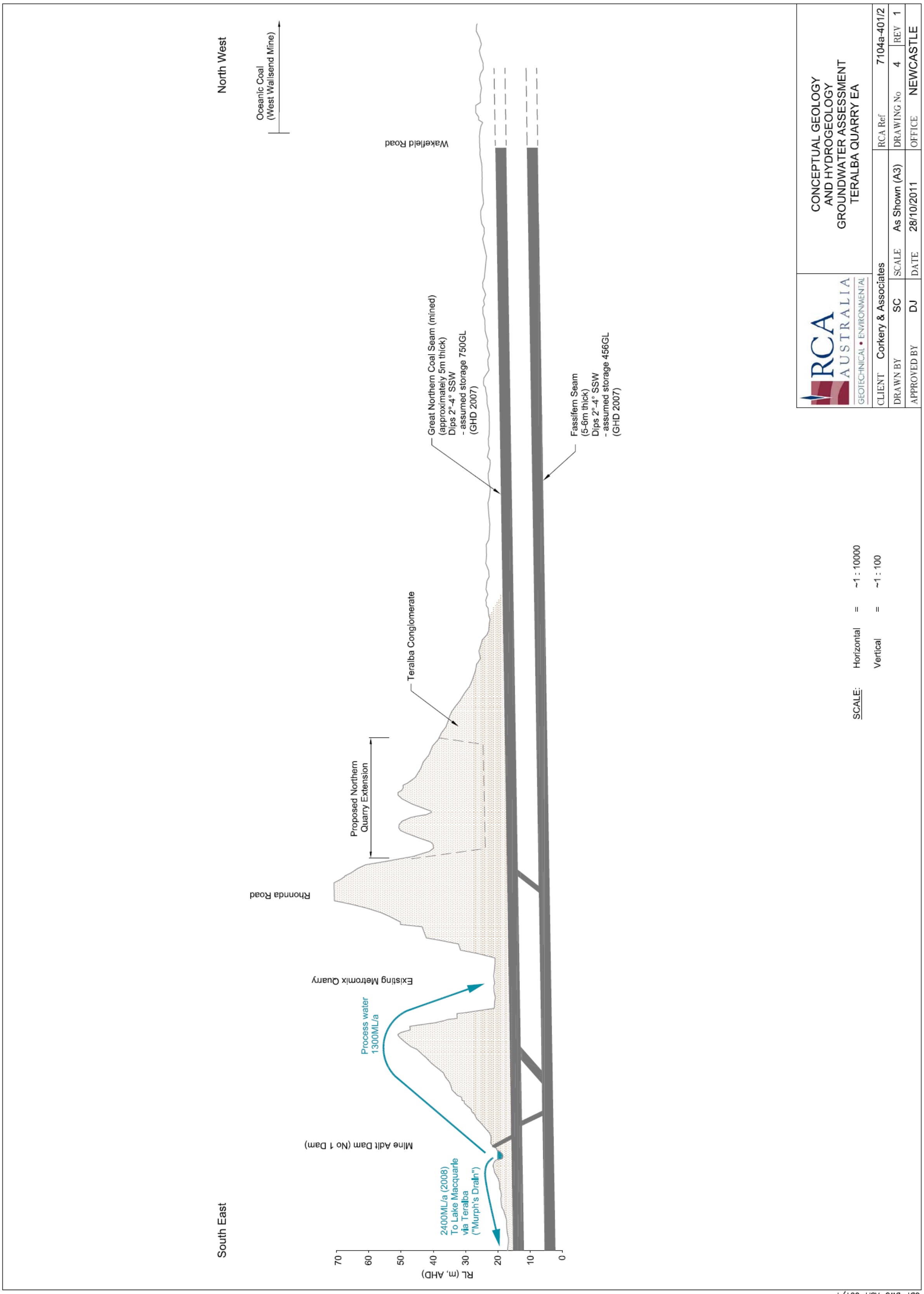

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Figure 4 Conceptual Hydrogeology

Table 3
Flows in the Mine Adit Dam and % Usage by the Quarry

	Mine Adit Dam Flow (ML)		Quarry Use (ML)		Total Flow (ML)		% Use of Dam Water By Quarry	
Month	2003	2008	2003	2008	2003	2008	2003	2008
January	52.2	144.9	83.8	79.6	136.0	224.4	62%	35%
February	46.0	298.8	104.6	89.9	150.6	388.6	69%	23%
March	91.1	409.7	116.0	95.7	207.1	505.4	56%	19%
April	101.0	224.5	108.4	96.2	209.5	320.7	52%	30%
May	162.9	287.0	93.9	101.8	256.8	388.8	37%	26%
June	154.3	252.9	95.6	107.5	249.8	360.3	38%	30%
July	120.4	144.9	113.0	103.2	233.4	248.1	48%	42%
August	79.2	115.3	131.4	115.1	210.6	230.4	62%	50%
September	80.1	252.8	115.9	122.7	196.0	375.4	59%	33%
October	58.6	118.6	102.1	109.4	160.7	228.0	64%	48%
November	67.2	65.4	115.9	93.9	183.1	159.3	63%	59%
December [1]	131.3	98.2	87.5	120.5	218.8	218.8	40%	55%
Total	1144.3	2412.9	1267.9	1235.4	2412.2	3648.3	53%	34%

[1] Data for December 2007 used in the 2008 data set.

In 2006, the discharge location for process water was moved from the Rhondda Colliery to the Teralba Quarry site. The new discharge location had a shorter flow path and may reflect the increased water flow to the Mine Adit Dam.

A review of rainfall recorded at the Toronto Wastewater Treatment Plant (Bureau of Meteorology) found the annual 2003 rainfall to be 862mm compared to an annual 2008 rainfall of 1498mm. Historical data for this monitoring station records an annual mean rainfall of just under 1200mm. The data shows that rainfall in 2003 was representative of the 10^{th} percentile annual rainfall for the area and is an unusually low rainfall rate. Annual rainfall data for 2000 and 2001 is also below average (data for 2002 was not complete but also expected to be low based on regional climatic conditions). Annual rainfall steadily increased from 2003 and was above average in 2007 and 2008.

The increase in flow rates to the Mine Adit Dam is reflective of increased rainfall rates.

The contribution from rainfall is likely to be higher than the observed increase in the flow rates, as 2003 is representative of flow to the Mine Adit Dam during aquifer recharge at Rhondda Colliery. Recharge at Rhondda Colliery during that period was in the order of 4 415ML/year (based on 140L/s). As previously noted, this recharge no longer occurs.

The contribution from Rhondda Colliery recharge is approximately 20% of the total volume of water within the GNCS voids (750 000ML), based on 35 years of recharge. The remaining groundwater recharge is from rainfall and the response to rainfall observed at the Mine Adit Dam indicates the importance of rainfall recharge to the aquifer.

Figure 5 presents average daily water flows at the Mine Adit Dam plotted against residual rainfall mass (a cumulative plot of above or below average rainfall for each month, allowing comparison of rainfall with adit flows). It is considered that the dam flows reflect natural variations (i.e., rainfall).

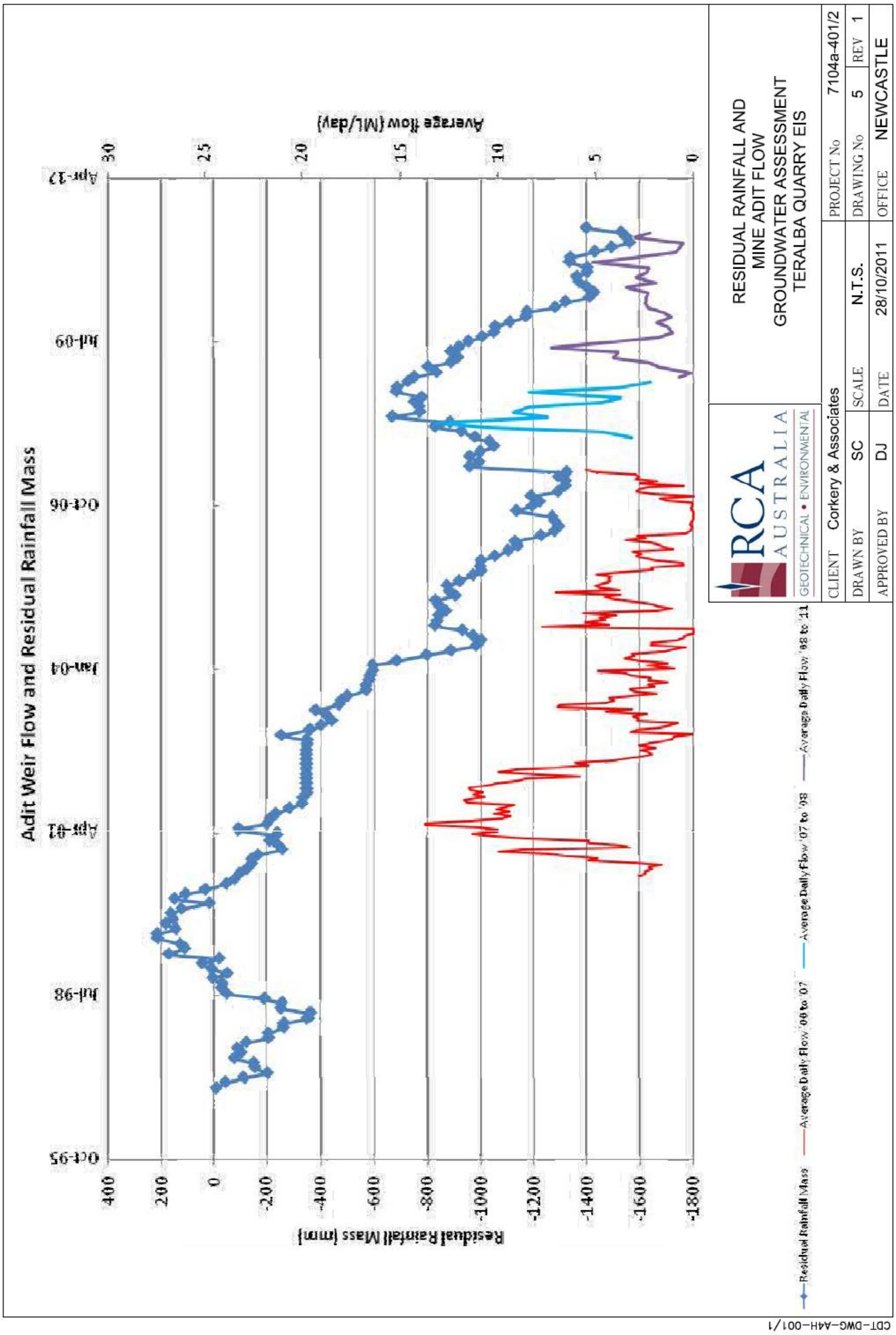

Figure 5 Residual Rainfall and Mine Adit Flow

Mr Bill Sanderson (Metromix) has advised RCA that rainfall within the Teralba Quarry rapidly infiltrates or flows overland to one of a number of sediment dams and infiltrates at those locations with little observed residence time within the conglomerate. The strata overlying the GNCS at the Teralba Quarry (i.e., the conglomerate resource) have high infiltration rates and this is consistent with the observed groundwater response to rainfall.

As part of this assessment, unsaturated infiltration rates in the top (near-surface) of the conglomerate profile (weathered zone) were investigated. An average, unsaturated permeability of 7×10^{-7} m/s was calculated. It is considered likely however, that at depth, permeability would be controlled by secondary porosity in the form of rock defects/fractures and the permeability would be higher.

A drilling exploration program was undertaken in 2004 managed by Rangott Mineral Exploration which comprised six percussion holes across the proposed Southern Extension, through the conglomerate profile and in some cases, intersecting the top of the GNCS or mined voids. No groundwater was recorded within the conglomerate.

Recharge from the Teralba Quarry operations process water continues and represents 1029.6ML annually, a net annual loss (difference between discharge and recharge) from the aquifer of approximately 205ML (projected to rise to a maximum of approximately 1250ML/annum, based on 1 million tonnes production per annum, with a net annual loss of approximately 370ML).

The annual groundwater discharge from the Mine Adit represents 0.5% of the water within the GNCS. As the Rhondda Colliery recharge contribution represented only 20% of the estimated groundwater within the GNCS it is unlikely that the loss of this recharge source will be observed in the Mine Adit discharge.

Groundwater also occurs in the underlying Fassifern Coal Seam (FCS) which has also been mined beneath the Teralba Quarry. This is separated from the GNCS by the Eleebana Formation, comprising predominantly tuff, which are generally of low permeability and would typically act as an aquitard (very low permeability unit).

Based on this, and the distance between the two aquifers, (approximately 6m to 10m), no significant interaction between the aquifers would be expected, however adits (shafts connecting the different levels) have been identified on old plans of the mined seams which indicates some inter-relation exists between the GNCS and FCS. It is likely that a proportion of the groundwater that supplies the Mine Adit Dam comprises water from the FCS.

7.2 NEIGHBOURING GROUNDWATER USERS

A groundwater database search was conducted and the nearest well down-gradient is stock/domestic well GW080494 in Fassifern Road, Fassifern, approximately 2.6km to the south (no well details were available). It is considered unlikely that quarry activities would impact on this well.

Other neighbouring potential groundwater users include the surrounding coal mines.

- The now-closed Rhondda Colliery (owned by Coal & Allied Industries Limited), immediately to the west of Teralba Quarry. From approximately 1994 until 2008, fines-containing water (post process waste water from the processing plant) was pumped from Teralba Quarry (among other sources) to assist in extinguishing an underground coal seam fire, and in later years used to fill land on the Rhondda site (GHD 2007). The water pumped into the mine was effectively recycled by down-gradient flow through the coal seam. Rhondda Colliery has a licensed discharge point on the south-east corner of the Metromix site (Mine Adit Dam, EPL 3139).

- Oceanic Coal Mines (owned by Xstrata) - underground West Wallsend Mine and open cut Westside mine. Located approximately 3km to the north-west both currently dewatering mine workings at approximately 2.6 ML/day. This water is currently discharged into Cockle Creek via a licensed discharge point (EPL1360).
- Centennial Coal Newstan mine - 2.5km to the southwest. Newstan dewaters approximately 6 to 7 ML/day from the GNCS and Fassifern from workings. Water is discharged to LT Creek at Fassifern (with some water use in mine).

The neighbouring coal mining operations are not directly down-hydraulic gradient of the quarry and they are net groundwater producers rather than groundwater users (i.e., the mines remove water from the coal seam aquifers to allow mining).

7.3 GROUNDWATER QUALITY

The Mine Adit Dam on the eastern side of Teralba Quarry is the licensed discharge point (EPL3139) for Rhondda Colliery and groundwater quality has been measured (by Coal & Allied Industries Limited) at regular intervals (generally monthly), since January 1989. Samples have been taken from the weir on the eastern side of Mine Adit Dam, see **Figure 2**.

The available data including parameters measured and the period and frequency of monitoring are listed in **Table 4** below.

Results are compared to the licence requirements of EPL3139 (Discharge Licence for Rhondda Colliery) and/or the ANZECC 2000 Guidelines for Fresh and Marine Water Quality for comparison.

Table 4
Summary of Available Groundwater Chemistry

Analyte	No of samples	Guidelines [a]	Concentrations		
			Mean	Min	Max
pH [b]	274[1]	6.5 to 8.5	7.1	6.2	8.6
Conductivity (µS/cm)	152[2]	N/A	6 541	471	13 600
Dissolved Organic Carbon (mg/L as C)	122[3]	N/A	3.7	0.5	32
Ammonia (mg/L as N)	260[1]	1.43	0.23	0.0025	4.02
TKN Filtered (mg/L as N)[c]	149[2]	N/A	0.85	0.02	3.4
Nitrates (mg/L as N)	275[1]	3.4	0.25	0.0025	10.9
Suspended Solids (mg/L) [b]	271[1]	50 [b]	21.4	0.5	248
Chloride (mg/L)	244[1]	No GL	1 800	86	5 200
Sulfate (mg/L)	123[3]	No GL	509	48	1 200
Total Phosphorus (mg/L as P)	272[1]	0.01	0.078	0.003	0.71
Zinc (mg/L)	123[3]	0.015	0.023	0.01	1.0
Selenium (µg/L)	123[3]	0.011	0.51	0.25	7
Arsenic (µg/L)	123[3]	0.094	1.31	0.05	8.6
Boron (mg/L)	123[3]	0.68	0.45	0.07	1
Bromide (mg/L)	123[3]	No GL	6.59	0.1	50
Fluoride (mg/L)	120[2]	No GL	0.4	0.2	1.2

Source: Rhondda Colliery Monitoring Records. a ANZECC 2000 Freshwater Guideline for 90% protection.
b EPL3139. c Total Kjeldahl Nitrogen. N/A = Not Applicable.
Sampling Duration: 1 ~ Approximately 20 years. 2 ~ Approximately 10 years. 3 ~ Approximately 7 years.

The monitoring data is presented in **Appendix 1** along with a statistical interpretation of the results which are discussed in the following section. In general, the results indicate the following:

- pH is found to be neutral on average with variation to alkaline and slightly acidic values.
- The average ammonia concentration was found to be low and below the guideline. Three samples (of 260 samples) were found to be above the guideline.
- The average nitrate concentration was found to be low and below the guideline. Two samples (of 275 samples) were found to be above the guideline.
- The average suspended solids concentration was found to be low and below the guideline. Twenty three samples (of 271 samples) were found to be above the guideline.
- The average total phosphorus concentration was found to be above the guideline.
- The average concentrations for zinc, selenium and arsenic were found to be above the guideline.
- The average boron concentration was found to be low and below the guideline. Sixteen samples were found to be above the guideline.

Figure 6 presents a summary of available salinity data comparing conductivity measurements made in the Mine Adit Dam, Lower Cockle Creek (down-stream from the weir) and the waterway adjacent to Teralba Caravan Park (down-stream from the Mine Adit Dam (i.e. Murph's Drain), immediately before discharge to Lake Macquarie) - monitoring undertaken by Rhondda Colliery.

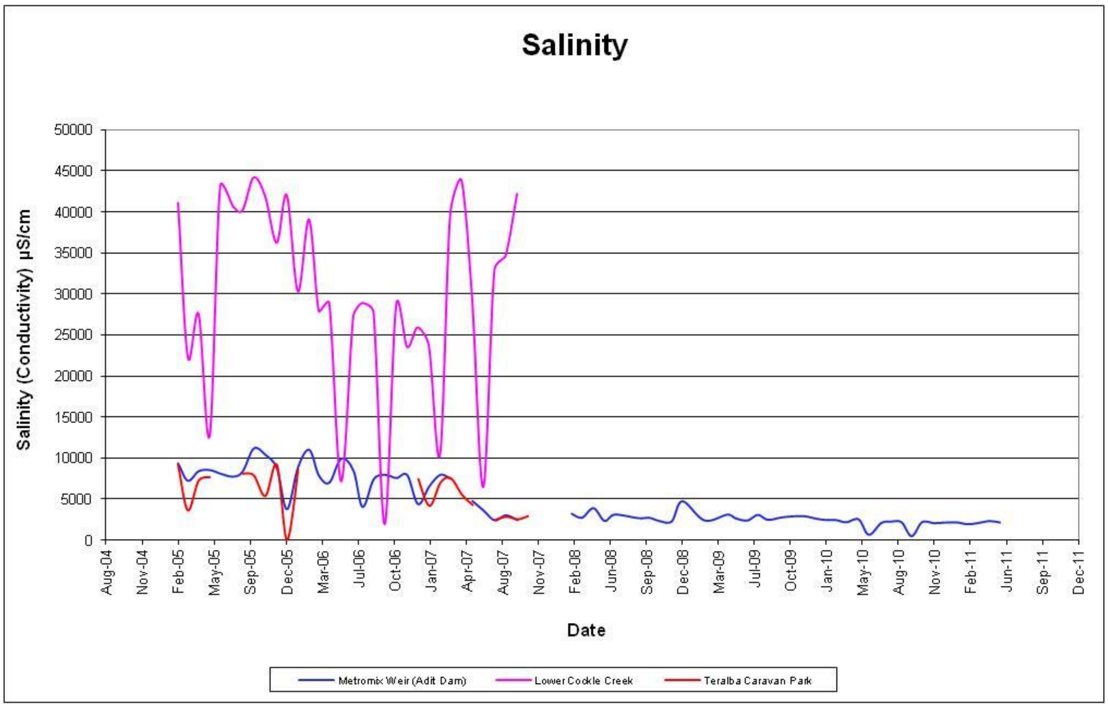

Figure 6
Monitored Salinity – Mine Adit Dam

Salinity is very similar for both the Mine Adit Dam and downstream, in the caravan park samples with average electrical conductivity values of 6 000 to 7 000µS/cm and maximum values of 9 000 to 11 000µS/cm. This is contrasted with lower Cockle Creek (tidal, reflecting Lake Macquarie values) with an average salinity of approximately 29 000µS/cm and a maximum value of approximately 44 000µS/cm. There appears to be no evidence of a significant downstream effect from the quarry with respect to salinity. Monitoring undertaken subsequently (to May 2011) indicates a continuing downward trend in salinity for water from the Mine Adit Dam.

7.4 GROUNDWATER BENEFICIAL USE

Beneficial use classes have been assessed for the groundwater underlying the Project Site, based on the available groundwater quality monitoring data (from monitoring at the Mine Adit Dam undertaken by Coal and Allied Industries Limited as part of their environment protection licence EPL3139

The Mine Adit Dam receives groundwater via an adit from old workings in the Great Northern Coal Seam and Fassifern Seams which are present beneath the existing and proposed extensions to the Teralba Quarry.

Beneficial use (environmental values) of the groundwater has been assessed using limiting criteria or water quality targets (where information is available) defined for south-east (NSW) lowland rivers ecosystems, as presented in the Department of Sustainability, Environment, Water Population and Communities website.

- http://www.environment.gov.au/water/publications/quality/targets-online/

Beneficial uses (environmental values) fall into the following general categories:

- Aquatic Ecosystem Protection
- Recreation
- Irrigation
- Livestock Drinking Water
- Drinking Water
- Aquaculture/Human consumption aquatic food ; and
- Industrial Water (not specifically defined but generally falls into this category where parameter concentrations exceed the limiting criteria used to define the other uses – although individual industries may have specific limiting parameter concentrations, e.g. salinity).

The limiting criteria concentrations have been sourced from the ANZECC guidelines and the NHMRC/ARMCANZ drinking water guidelines, among others.

Table 5, presents the results of the beneficial use assessment based upon the ANZECC guidelines. In summary the beneficial use of the groundwater is limited to stock watering (for tolerant species, e.g. sheep) and industrial water, based mainly on salinity.

Table 5
Summary of Beneficial Use Assessment

Beneficial Uses	Use Pass/Fail	Water Quality Target Parameter	Water Quality Target Conc.	Comment	Metromix Weir (mean conc.)	
Aquatic Ecosystem Protection	χ	Total N (µg/L)	350		1328	χ
		Nitrate (µg/L)	10		248	χ
		Total P (µg/L)	10		78	χ
		Turbidity. (NTU)	1 - 20		-	-
		Salinity (µS/cm)	20-30		6541	χ
Recreation (primary &Secondary)	χ	Ammonia N (µg/L)	10		230	χ
		Nitrate (µg/L)	44300		248	✓
		Total P (µg/L)	NA		-	-
		Turbidity. (NTU)	NA		-	-
		Salinity (µg/l)	300000 (Na)		1800000 (assumed)	χ
			400000 (Cl)		1800000	χ
Irrigation	χ	Total N (µg/L)	25000 to 125000		1328	✓
		Total P (µg/L)	800-12000		78	✓
		Turbidity. (NTU)	NA		-	
		Salinity (most tolerant)	< 460mg/l (Na)		1800	χ
			<700 mg/l (Cl)		1800	χ
Livestock Drinking	✓	Nitrate (µg/L)	<400,000		248	✓
		Total P (µg/L)	NA		-	
		Turbidity. (NTU)	NA		-	
		Salinity (µS/cm) (most tolerant - sheep - moderate effect)	15000		6541	✓
Drinking Water	χ	Nitrate (µg/L)	50000		248	✓
		Ammonia N (µg/L)	500	taste/odour	230	✓
		Total P (µg/L)	NA		-	
		Turbidity. (NTU)	NA		-	
		Salinity (µg/l)	180000 (Na)	aesthetic	1800000	χ
			250000 (Cl)	aesthetic	1800000	χ
Aquaculture/Human consumption aquatic food	χ	Nitrate (µg/L)	<50000	(fresh)	248	✓
		Ammonia N (µg/L)	<20	cold water	230	χ
		Total P (µg/L)	<100		78	✓
		Turbidity (µg/l)	<10000	Susp. solids	21400	χ
		Salinity (µS/cm)	49000 to 55000		6541	✓

Notes: P is phosphorous N is nitrogen
Metromix mean concentrations are based on Table 4

8. WATER SUPPLY FOR PROPOSED QUARRY EXTENSIONS

Metromix has indicated the 1Mtpa production rate to be a maximum production throughout the life of the quarry (including the proposed extensions). For planning purposes, Metromix is proposing an average production rate throughout the remaining quarry life of 900 000tpa.

In 2007, GHD prepared a Site Water Management Plan (GHD, 2007), including a review of potential water supply options. These included:

- current arrangement using water from GNCS (as pumped from Mine Adit Dam). Water re-circulated;
- bore and pump from Fassifern seam with upgradient recharge directly into seam by Oceanic Coal (West Wallsend Coal mine) which is currently discharging excess dewatering water into Cockle Creek;
- direct supply of water from West Wallsend/Westside (Oceanic) mines (i.e., construction and use of a pipeline);
- supply direct from Cockle Creek (via neighbouring Rhondda Coal mine);
- wastewater from Teralba Wastewater Treatment Plant; and
- harvesting of surface water from within Metromix catchment.

The 2007 report recommended either:

i) continuing the existing arrangement (pumping of water from the Mine Adit Dam and "re-circulation" of process water via recharge to up-gradient quarry floor voids or a purpose-built recharge well to the underlying GNCS aquifer. This option may require a contingency where water from the dam is not able to meet demand (typically during excessively dry periods). This was proposed as development of infrastructure (e.g. cyclone separators) to reuse process water (rapidly remove fines); or

ii) installation of a bore/pump system to extract water from the Fassifern seam (in conjunction with recharge from the Oceanic Coal works).

Negotiations are currently underway concerning the ongoing supply of water from Oceanic Coal either by direct recharge of the Fassifern Seam or via overland pipeline. The construction of an overland pipeline has been given tentative approval by Lake Macquarie City Council.

- Negotiation with Oceanic Coal (Xstrata), for supply of additional water must necessarily also include agreement with the former Rhondda Colliery (owned by Coal and Allied/Rio Tinto), across whose lease the groundwater will flow (in the direct up-gradient recharge to the Fassifern Seam model). Even if the water was to be piped directly to Metromix via surface pipeline, the on-flow would exit the site via the Mine Adit Dam (at Rhondda's licensed discharge point); and
- as mentioned above, the discharge point is currently licensed to Rhondda Colliery (Rio Tinto) and this may have to be assumed by Metromix after consultation with OEH (formerly DECCW), and agreement with Rhondda.

9. RECOMMENDED DESIGN AND OPERATIONAL SAFEGUARDS

9.1 GROUNDWATER QUALITY

Mitigation measures relevant to the Project relate to measures to be undertaken if degraded water quality was identified as a result of groundwater contamination caused by the quarry extensions or any other activity undertaken by Metromix.

A Groundwater Contingency Plan should be prepared for the site identifying the trigger levels to be determined (potentially in consultation with OEH/NOW). It is considered that the plan should include the following components.

- Monitoring quality parameters may include those parameters detailed in the previous section, historically monitored at the adit dam discharge point (by Rhondda Colliery).
- In the event that routine monitoring indicates that water quality parameter/show an increasing trend, an increase in the analytes monitored and/or frequency of sampling to confirm the magnitude and extent of the change in water chemistry and verify the change is a consequence of quarry activities would result. Should the change be a result of quarry activities, the Groundwater Contingency Plan would require that an appropriate solution would be sought in consultation with NOW.
- Some fuels and lubricants are stored on site by Metromix including:
  - one 15 800L and one 27 400L diesel fuel tanks (fully bunded); and
  - up to approximately 4 500L of fuels and lubricants in 20L and 205L drums in a bunded shed.

A spill management plan should be developed and implemented at the site. In the event of a significant spill (eg, diesel leak outside bunded area possibly during storage refuelling activity), the following steps would be taken:

i) recovery as much of the source as possible using plant and placement on impermeable surface for later treatment/disposal; and

ii) possible excavation near the centre of the spill area and pumping to achieve a hydraulic gradient towards recovery area.

All placed material (backfill/VENM/ENM) should undergo scrutiny prior to placement to refuse any materials that may have the potential for long term leaching of contaminants to groundwater (e.g. acid sulfate soils).

9.2 GROUNDWATER QUANTITY

This assessment has determined that:

- there are no significant downstream groundwater users; and
- the water supply required for the quarry will have a minimal impact on groundwater quantities.

Nevertheless, should a reduction in groundwater quantities be identified by monitoring, and that is identified to be an issue of concern, potential mitigation measures may include the commissioning of a study to assess if the cause of the identified reduction is a result of quarrying operations and, if so, development of alternative water supply options in consultation with NOW.

10. IMPACT OF EXTRACTION ON GROUNDWATER

10.1 EXISTING QUARRY OPERATIONS

Water used in the processing plant has been, to date, sourced from the Mine Adit Dam. As noted above, this water originates from the GNCS aquifer and is pumped from the Mine Adit Dam to storage Dam G, adjacent to the processing plant, where it is used as needed within the processing plant. The average use of water in the processing plant is in the order of 90L/s for a 10 hour period which equates to a daily usage of 35L/s/day (24 hours) or approximately 3 ML per day (pers. comm. Bill Sanderson). In dry periods, this amount of water can impact on the levels in the Mine Adit Dam with the dam recovering over night before flowing over the weir and leaving the Teralba Quarry site.

It is noted that in 2001, part of the floor of the existing quarry subsided providing a direct conduit from the floor of the existing Southern Extraction Area to the underlying GNCS aquifer. Fines from the processing plant have been allowed to discharge into the void regularly since 2006 thus recharging the GNCS aquifer at this point and recirculating the process water through the aquifer.

The addition of dissolved contaminants to the process water is not expected to occur during the processing operations[1]. Process water is used to remove fines from the raw feed during processing (which is known to be free of significant contaminant concentrations) and no chemicals are added. The process creates a slurry of fines which travels via an open channel before discharging to the void. The majority of solids settle out along the flow path resulting in only water entering the void. Previously this slurry was pumped to Rhondda Colliery to assist in extinguishing the workings fire.

10.2 STATISTICAL ASSESSMENT OF CURRENT IMPACT

The water quality data collected at the Mine Adit Dam has been statistically assessed to establish whether the collapse of conglomerate[2] and subsequent recirculation of the water to the aquifer has had an identifiable impact on groundwater quality.

A simple statistical check for changes in water quality is the cumulative sum chart or “cusum” chart (ANZECC 2000). This type of chart is useful when the expected disturbance to a process is subject to a step change (as could occur in the case the subsidence in the quarry floor in 1995). The chart can be used to separate natural variations in data from significant changes. The cusum is calculated as follows:

[1]Given continued restriction on potentially contaminating activities within the catchment area and/or implementation of contamination mitigation measures (e.g. appropriate storage and use of fuels/lubricants/chemicals)
[2] Collapse of conglomerate into the GNCS working has occurred periodically for many years and occurred, in a planned manner, since 2007.

At time t, the calculated point is $\sum_{i=1}^{t}(X_i$ - T), where T is a target or historical level (typically the mean). This simply means that each raw data point is subtracted from the mean of the data for a particular analyte and summed over time. When consistent changes occur either side of the mean, the cusum value increases or decreases rapidly, indicating that an impact is occurring.

As we are only interested in when the data increases, then a modified one-sided cusum chart gives an even clearer picture of when action is required. This chart is constructed by adjusting the target value to reflect only upward accumulation. For a one-sided cusum chart, a cusum limit value can be used to indicate when the impact is occurring, i.e., if the cusum value exceeds the limit value then an impact may be occurring and further investigation may be warranted.

A typical limit value (assuming that one standard deviation is chosen as the target and that there is only a 1% chance of returning a false positive result) is given by the product of 4.6 times the standard deviation.

Cusum charts have been prepared for the parameters measured at the weir and are given in **Appendix 1**. The charts show that, in general, no significant changes in water quality have occurred with the only times when possible changes have occurred are as follows.

- pH –values increasing above the action limit are observed in 1994 and 1995. Other pH values above the average are observed but a continued increasing trend is not evident.
- Ammonia – concentrations increasing above the action limit are observed in 1989, 1990 and 1999. In all cases the increasing trends are not sustained and ammonia concentrations appear stable for the remainder of the monitoring period.
- Suspended Solids – concentrations increasing above the action limit are observed in 1989, 2007 and 2011. In all cases the increasing trends are not sustained and suspended solids concentrations appear return to a stable situation.
- Nitrate – concentrations increasing above the action limit are observed in 1989 and 1991. In all cases the increasing trends are not sustained and nitrate concentrations appear stable for the remainder of the monitoring period.
- Chloride – shows periodically increasing concentrations since 1995. Concentrations increasing above the action limit are observed in 1996, 1998, 2002 and 2006.
- Fluoride – concentrations increasing above the action limit are observed in 1999. In all cases the increasing trends are not sustained and fluoride concentrations appear stable for the remainder of the monitoring period.
- Total Phosphorus - concentrations increasing above the action limit are observed twice in 1989. In both cases the increasing trends are not sustained and concentrations appear stable for the remainder of the monitoring period.
- Zinc – concentrations were observed once above the action limit in 2011. No sustained increasing trends were observed over the monitoring period.

- Selenium - concentrations increasing above the action limit are observed in 2004. The increasing trend is not sustained and selenium concentrations appear stable for the remainder of the monitoring period.
- Arsenic - concentrations increasing above the action limit are observed in 2011. However the increasing trend is not sustained.
- Boron - concentrations increasing above the action limit are observed in 2002. The increasing trend is not sustained and boron concentrations appear stable for the remainder of the monitoring period.
- Bromide - concentrations increasing above the action limit are observed in 2001. The increasing trend is not sustained and bromide concentrations appear relatively stable for the remainder of the monitoring period.

With the exception of chloride, the increasing trends appear independent of each other and are most likely independent of any specific site activities. Chloride shows continued increasing trends beginning in January 1995. A review of the raw data shows that the chloride concentrations began to increase in August 1992. This increase occurs prior to direct pumping of process water to the workings at Teralba Quarry. The increase may reflect the movement of water from the Rhondda Colliery recharge point, where water from the Sewage Treatment Works and Cockle Creek was discharged, both water sources are likely to have elevated chloride concentrations.

The cusum analysis indicated that there has been no significant impact on groundwater quality as a result of existing quarry operations since the subsidence in the quarry floor which occurred in 1995.

In light of this statistical assessment, it is considered that Metromix's proposed monitoring need not analyse for the extended suite of parameters (including metals, arsenic, ammonia, bromide, boron, phosphorous, nitrate and fluoride), currently monitored at the Mine Adit Dam discharge by Coal and Allied Industries as part of EPL 3139.

10.3 PREDICTED QUARRY EXTENSION IMPACTS

10.3.1 Water Quality

The proposed quarry extensions would occur in a southerly direction (the "Southern Extension") and northerly direction (the "Northern Extension") (across Rhondda Road). Ultimately extraction would result in removal of the conglomerate resource to within approximately 1m of the underlying GNCS, and including the planned, induced collapse of conglomerate into mined voids (in the GNCS).

This would potentially provide further interaction between surface water and groundwater. The floor surface of the extraction area where the collapse of conglomerate had occurred would potentially have a higher permeability, allowing a higher infiltration of surface water into the underlying coal seam aquifer.

However, given that surface water inflow is already occurring in the existing extraction areas and, based on a statistical review of the water quality data, no significant changes in water quality have been detected, the proposed quarry extensions are not expected to have a detrimental effect on the groundwater quality, conditional on the exclusion of uncontrolled contaminating activities from the quarry surface catchment area.

10.3.2 Groundwater Quantities/Flow

The ongoing collapse of conglomerate in the floor of the existing extraction area may result in an increase in recharge to the aquifer through rainfall. However, given the large aquifer catchment size, this would be not have a significant effect.

For example, if the amount of infiltration over the extended extraction floor increased to 50% of rainfall, then a conservative estimate of the amount of water recharging would be in the order of 36ML/yr. The impacts from variable rainfall at the Mine Adit Dam appear to be upwards of 1000ML/yr based on a comparison of mine adit flow between Years 2003 and 2008. The change from variable recharge in the quarry floor would thus represent less than 5% of the variation.

The proposed quarry extensions, and the existing quarry operations maintain a direct pathway with the shallow GNCS aquifer and this increases the potential for contamination of the aquifer and surface water from point source pollution events.

It is additionally recommended that oil and grease be included in the monitoring suite to reflect the potential for pollution from on-site fuel usage.

As the mined voids within the GNCS are progressively filled by induced collapse of the overlying conglomerate (in order to maximise recovery of the conglomerate and provide quarry floor stability), it is envisaged that the overall transmissivity of the GNCS aquifer will be locally reduced as open voids are replaced by broken rock and fines materials. However, it is envisaged that, given the large area of mining that has occurred within both the GNCS and FCS that the overall flow regime will remain.

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10.3.3 Groundwater Dependent Ecosystems

It is considered that there will be no impacts on groundwater dependent ecosystems (GDEs) given that no groundwater is present within the proposed quarry workings and no significant GDEs have been identified.

10.3.4 Proposed Final Landforms

Figures 7 and **8** present the conceptual final landforms for the areas to the south and north of Rhondda Road following the cessation of quarrying and rehabilitation works.

The final landform on the southern side will comprise a maximum depth of excavation to approximately 20m AHD with formed slopes using backfill and VENM/ENM. The northern side will be excavated to a maximum depth of approximately 25m AHD with stabilised slopes.

All finished levels will be above the groundwater and, as such, the final landform is not expected to impact on groundwater.

10.3.5 Acid Sulfate Potential

Review of the 1:25,000 Acid Sulfate Risk Map of the area (Department of Land and Water Conservation, *Acid Sulfate Soils Risk Map, Wallsend, 1:25,000,* Edition 2, December 1997) indicated that the site is in an area where acid sulfate soils are not known nor expected to occur.

Furthermore, all quarry operations/activities will be undertaken above the water table.

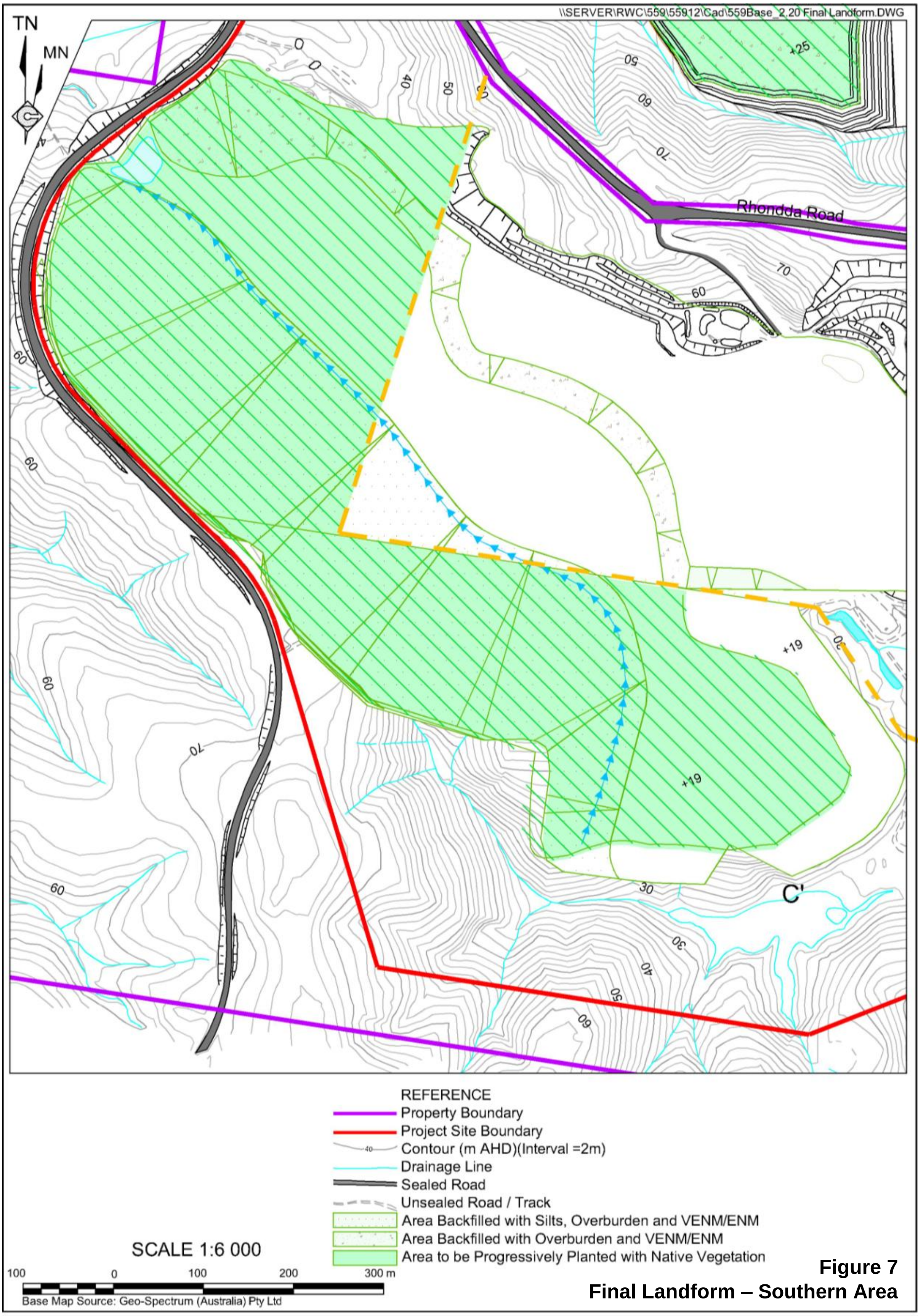

Figure 7
Final Landform – Southern Area

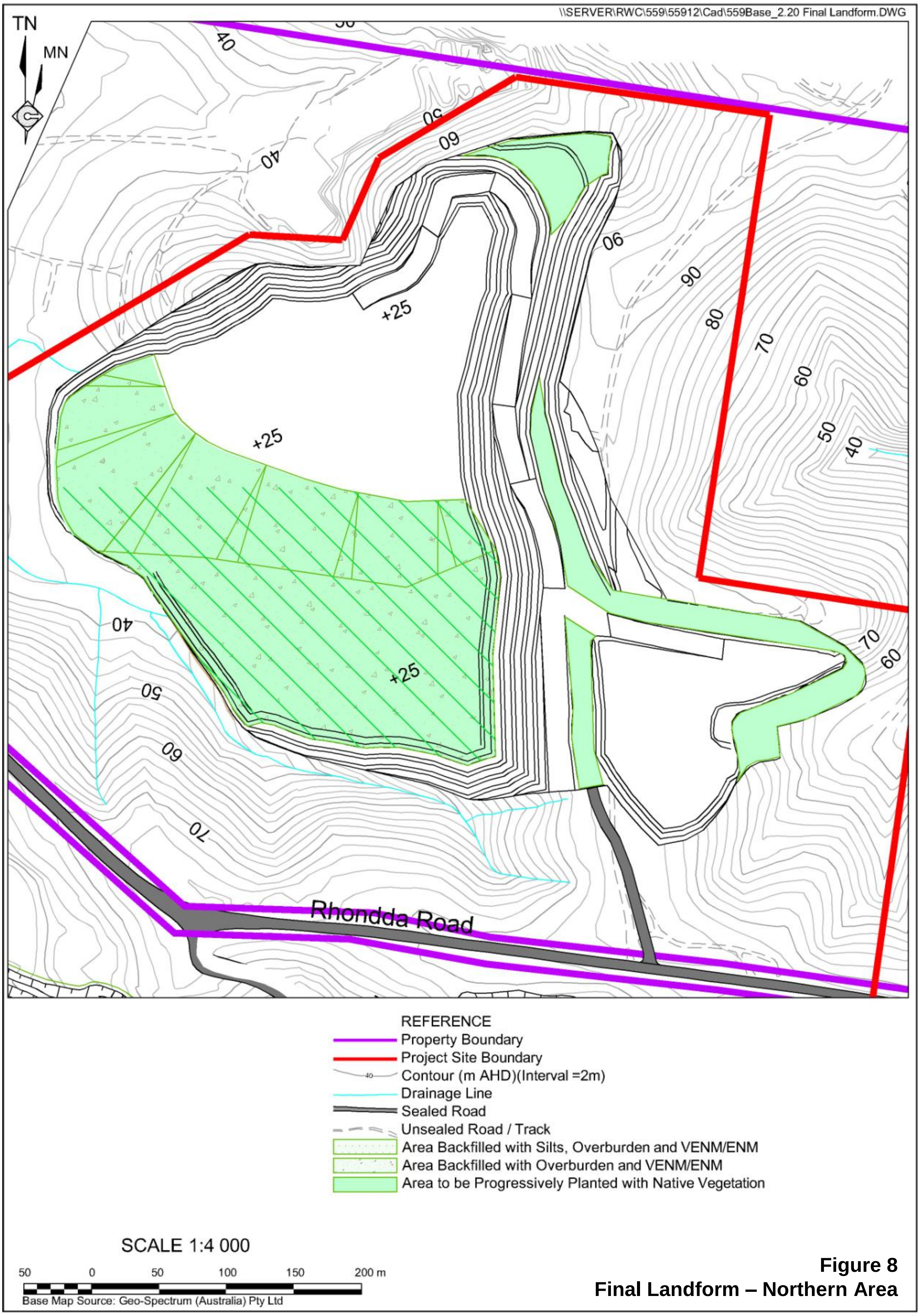

Figure 8
Final Landform – Northern Area

11. MONITORING

A comprehensive groundwater monitoring program would be implemented at the site for water reporting to and/or discharging from the Mine Adit Dam. This program would form part of the Soil and Water Management Plan for the quarry with all monitoring undertaken in conjunction with that proposed for surface water.

Monitoring of water quality at the Mine Adit Dam should continue to be undertaken by Coal and Allied Industries at monthly intervals for the following analytes currently being monitored.

- pH;
- Electrical conductivity;
- Total suspended solids; and
- Oil and grease.

If oil and grease is detected above the detected limit on two successive monthly sampling events, a full hydrocarbon sampling suite would be conducted on the samples collected during the following monthly period.

In the event EPL 3193 is modified or cancelled during the life of the Teralba Quarry Extensions, Metromix should take over the monitoring of these four analytes. The frequency of monitoring may be approximately reviewed at that time.

Flows/discharges would also be recorded from the dam and records also kept of quarry water usage.

The monitoring results would be reviewed following each monitoring round to identify trends which may indicate impacts and require adoption of additional mitigation measures.

All monitoring data would be incorporated into each Annual Environment Management Report for the Teralba Quarry. Each annual review would also include a review of the value of the data being collected and whether it is meaningful.

12. SUMMARY AND CONCLUSIONS

Teralba Quarry is underlain by the Newcastle Coal Measures with the nearest aquifer beneath the extraction area being the mined Great Northern Coal Seam (GNCS) which exists below the existing floor of the quarry and occurs at a similar level in the area of the proposed quarry extension.

The primary aquifer in the region is contained within the strata and voids of the GNCS. Aquifers are present at greater depths and include the Fassifern Coal Seam. Groundwater flows down dip and is directed beneath the site flowing from north to south/ south-east. Groundwater in the GNCS is partially intercepted within a mine adit located in the southeast of the Project Site where it is collected in a dam before discharging over a weir into an open channel and eventually to Lake Macquarie.

Significant recharge to this aquifer was undertaken previously at the adjacent Rhondda Colliery located to the north of the site. Large quantities of water from Cockle Creek, Sewage Treatment Works and Teralba Quarry process water were pumped into the aquifer to quench an underground fire. This operation has been successful and this recharge has now ceased.

Operations at Teralba Quarry require water for processing the raw feed recovered from the extraction areas. This water is sourced from the Mine Adit Dam.

The impact of the existing operations (to 2008, based on available data) on groundwater quality was assessed by reviewing monthly monitoring records from discharge monitoring at the Mine Adit Dam which commenced in 1989. It was determined that the existing quarrying operations have not had an observable impact on groundwater quality since the commencement of monitoring.

The proposed quarry extensions are also not expected to significantly impact on groundwater quality through general operations. Contingency plans in the form of spill response or emergency response plans should be developed in the case of a pollution event.

Monitoring (as outlined in Section 11) should be conducted to allow potential impacts to be identified and assessed and if necessary, contingency plans to be implemented.

The aquifer flow regime may be locally affected as the aquifer transmissivities are locally reduced as the mine voids underlying the quarried areas are incrementally filled with collapsed conglomerate. Monitoring of the groundwater flows and quality will also assist in determining impacts as the quarry extensions further develop.

13. REFERENCES

1. **ANZECC (2000)** *Australian and New Zealand Guideline for Fresh and Marine Water Quality 2000* Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

2. **Bureau of Meteorology,** *www.bom.gov.au*

3. **Department of Land and Water Conservation (1997)**, *Acid Sulfate Soils Risk Map, Wallsend, 1:25,000,* Edition 2, December 1997.

4. **GHD Pty Ltd (2007)** *Teralba Quarry Water Management Plan*, August 2007.

5. **Hitchcock P (1995)**. *The Hydrogeology of the Newcastle-Gosford Region. Engineering Geology Conference of the Newcastle-Gosford Region, pp147-168,* Australian Geomechanics Society, February 1995.

6. **Rangott Mineral Exploration (2004)**, *Records of Drilling at Teralba Quarry Extension, 6 to 8 January 2004, Geological Description.* February 2004.

Appendices

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Appendix 1

Graphed CuSum Data

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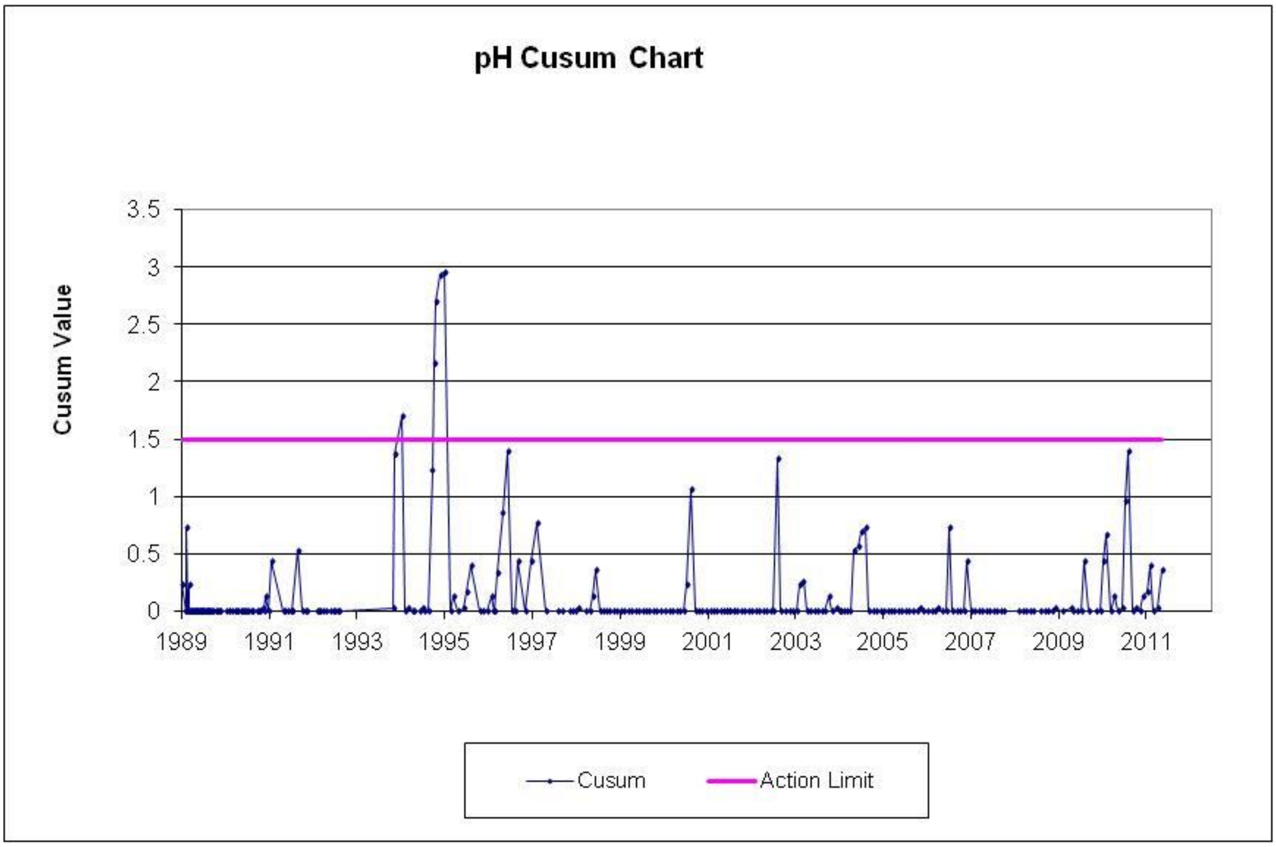
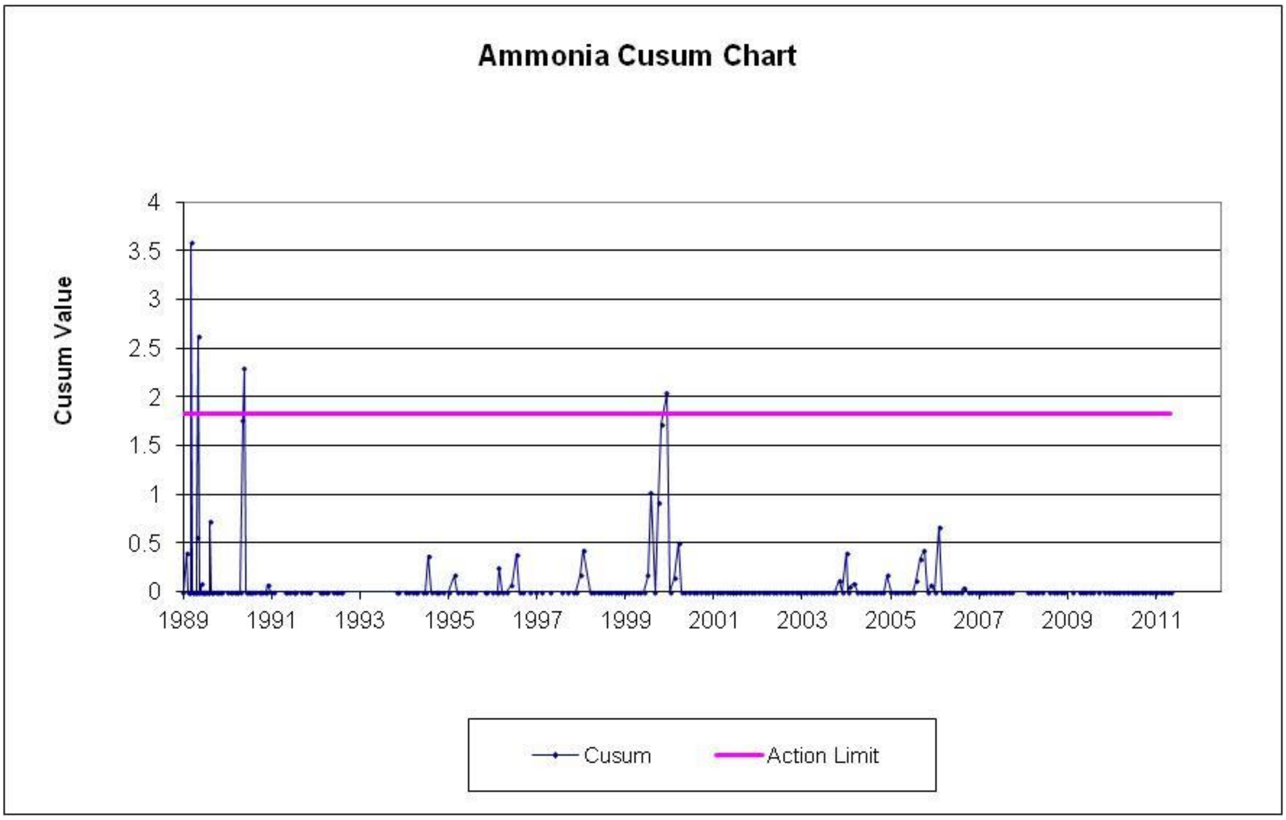
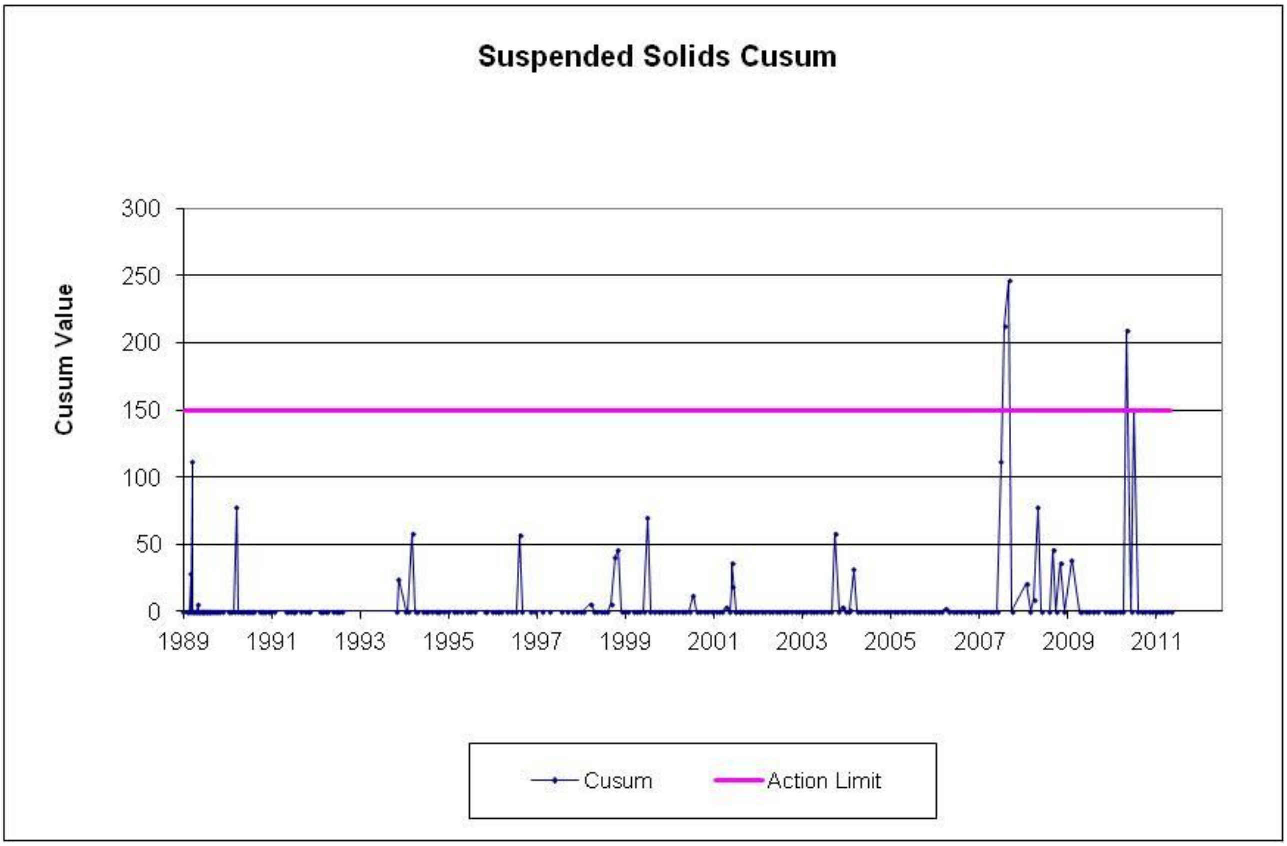
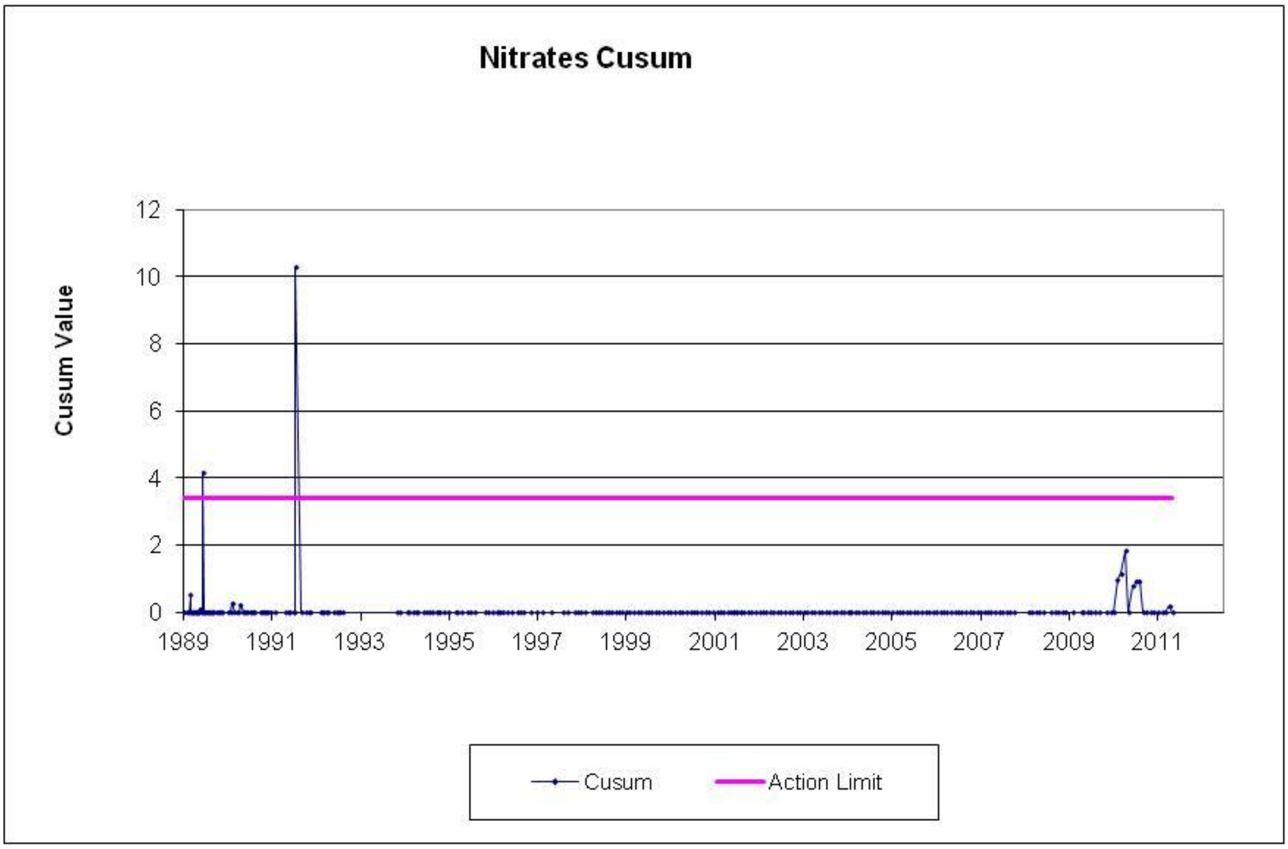
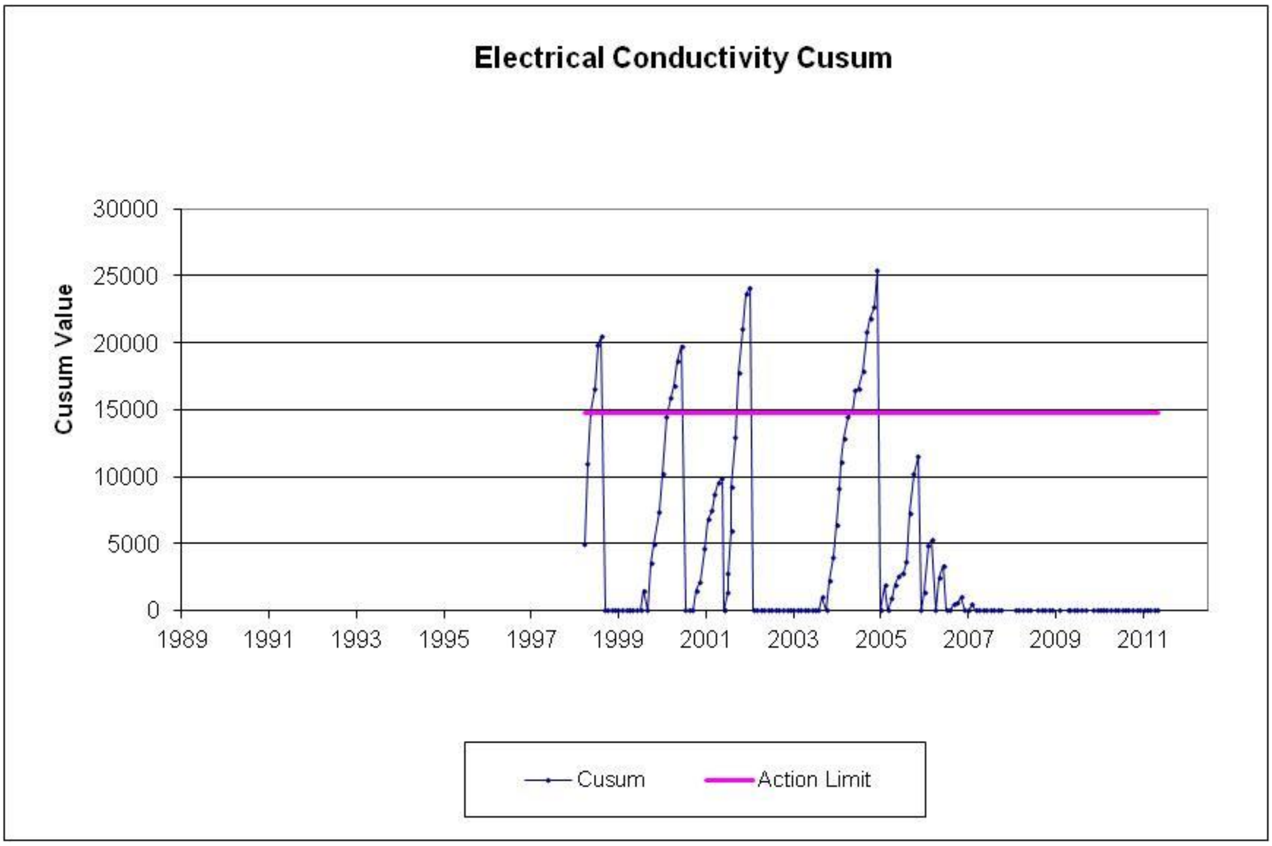
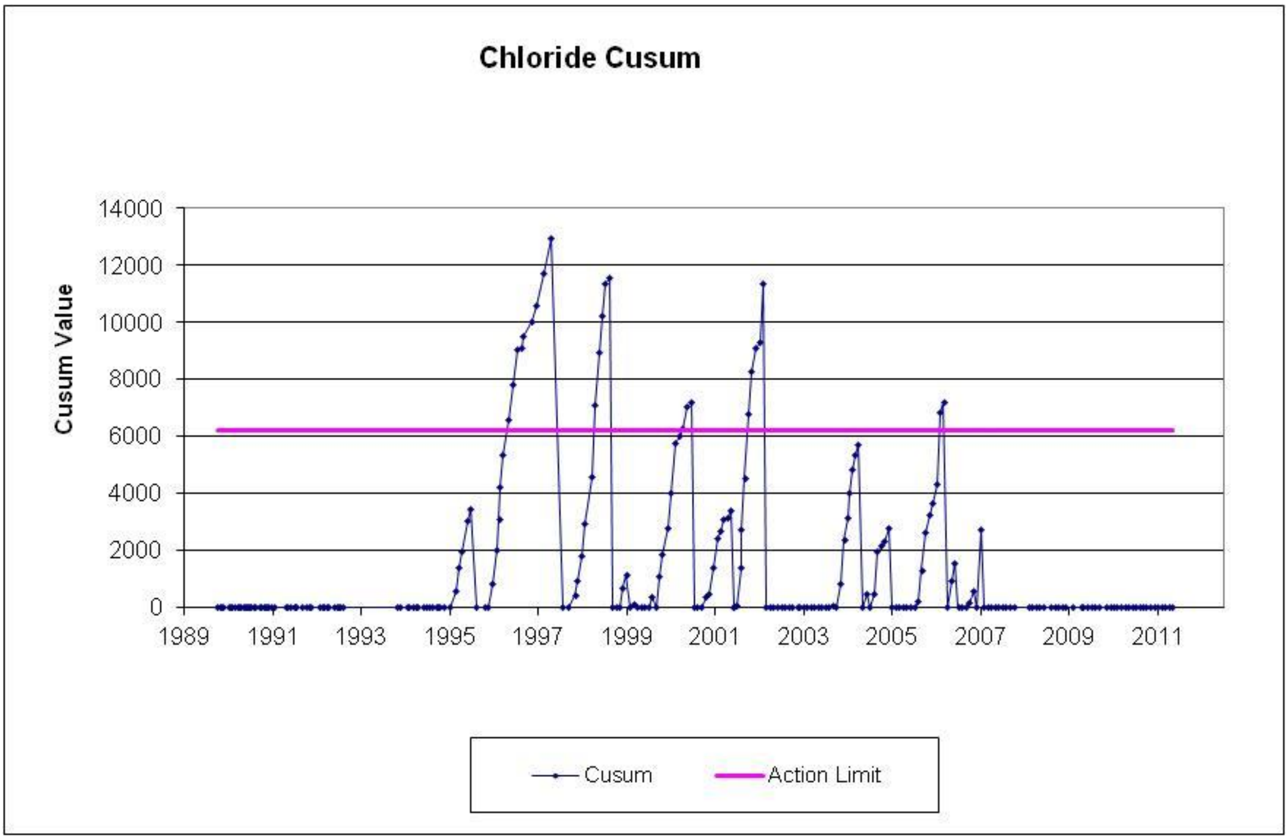

pH Cusum Chart
Cusum Value
3.5
3
2.5
2
1.5
1
0.5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

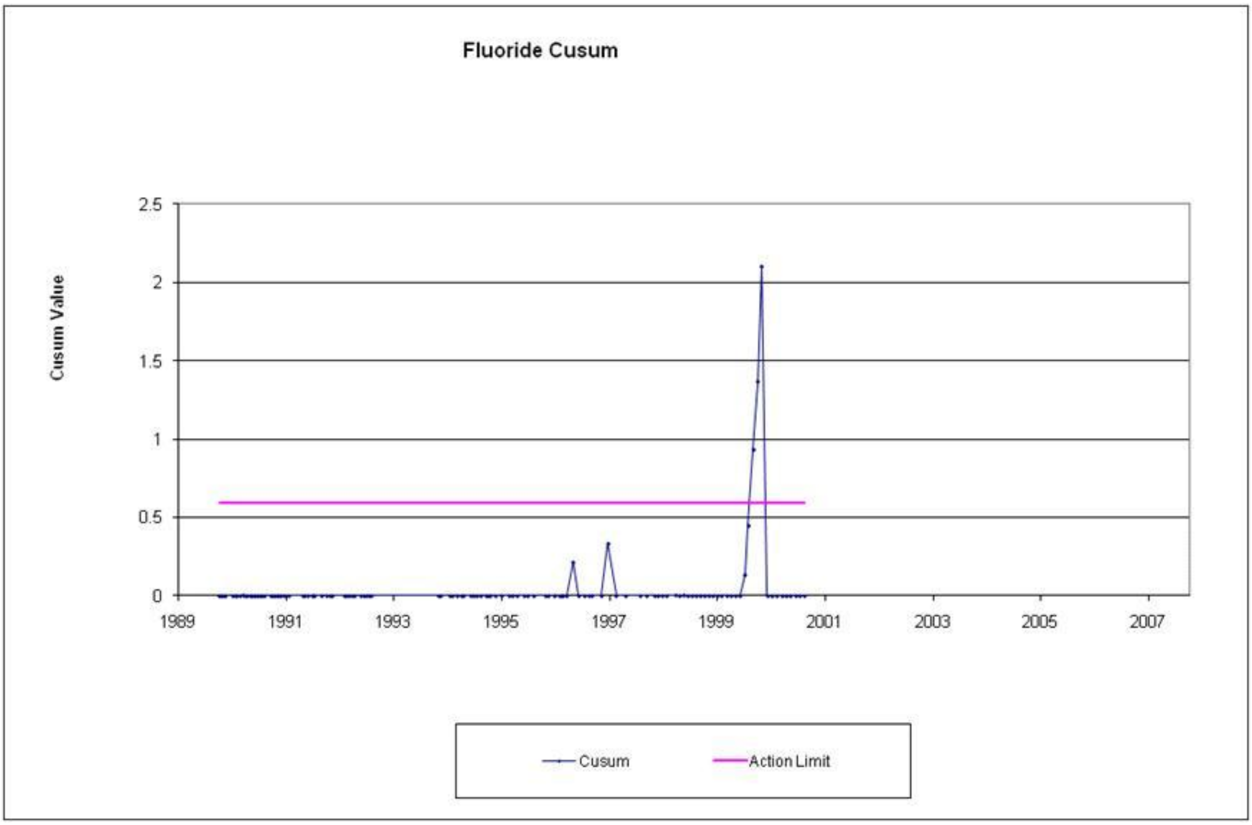

Ammonia Cusum Chart
Cusum Value
4
3.5
3
2.5
2
1.5
1
0.5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

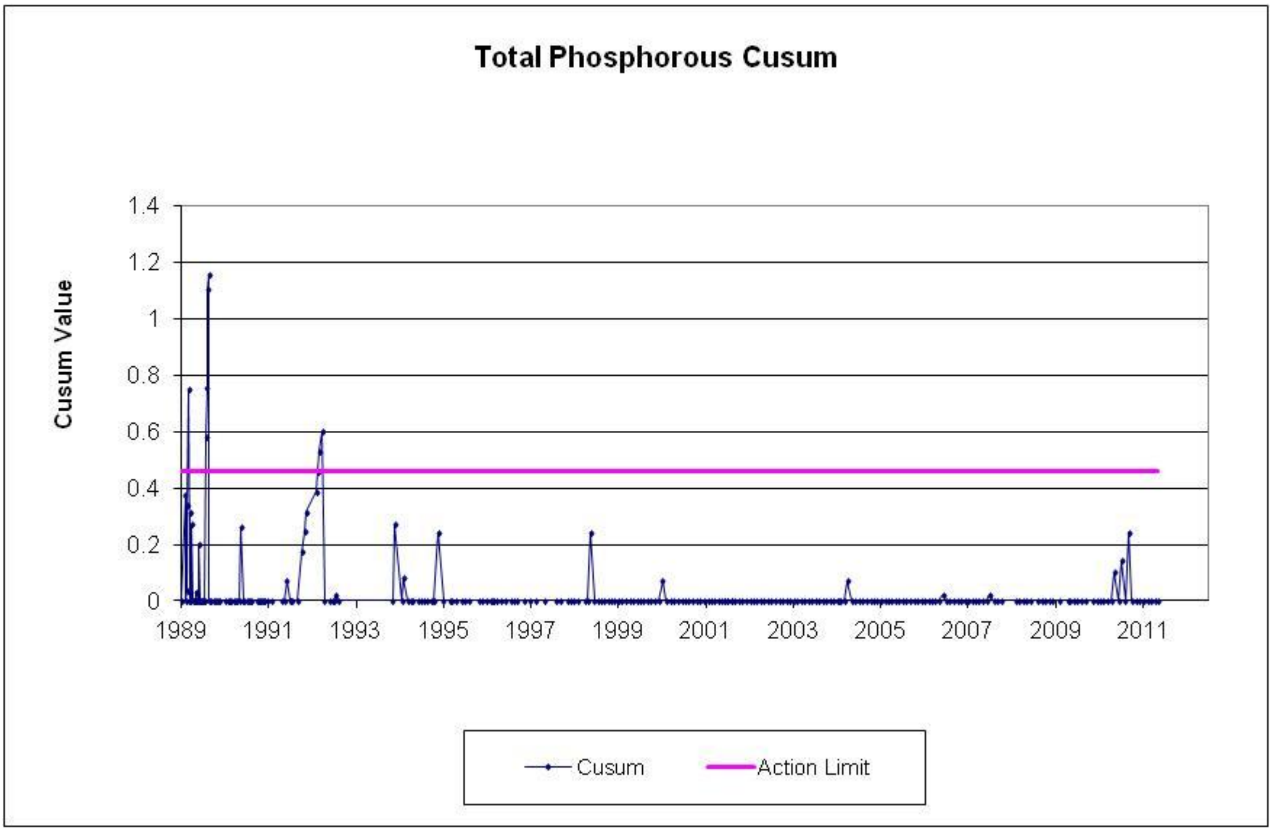

Suspended Solids Cusum
Cusum Value
300
250
200
150
100
50
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

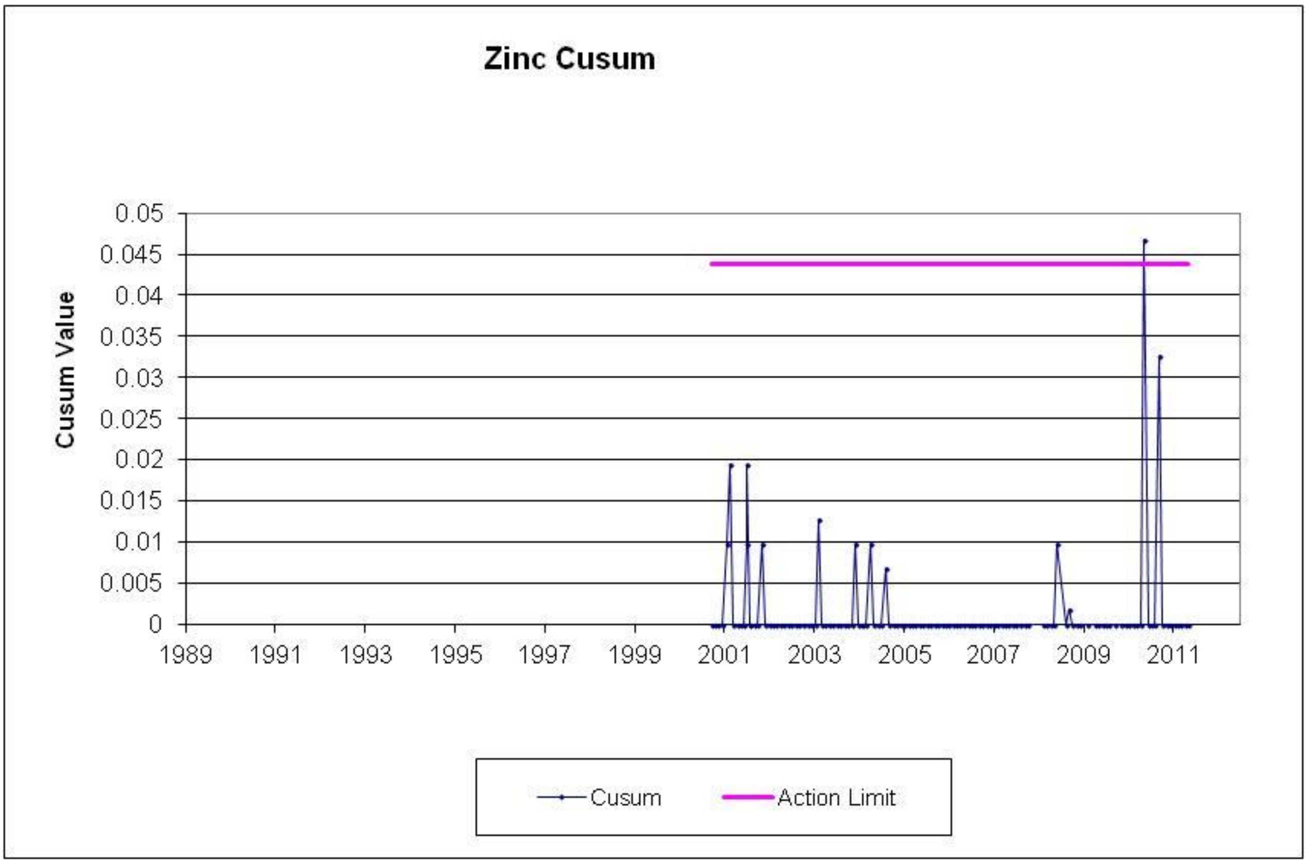

Nitrates Cusum
Cusum Value
12
10
8
6
4
2
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

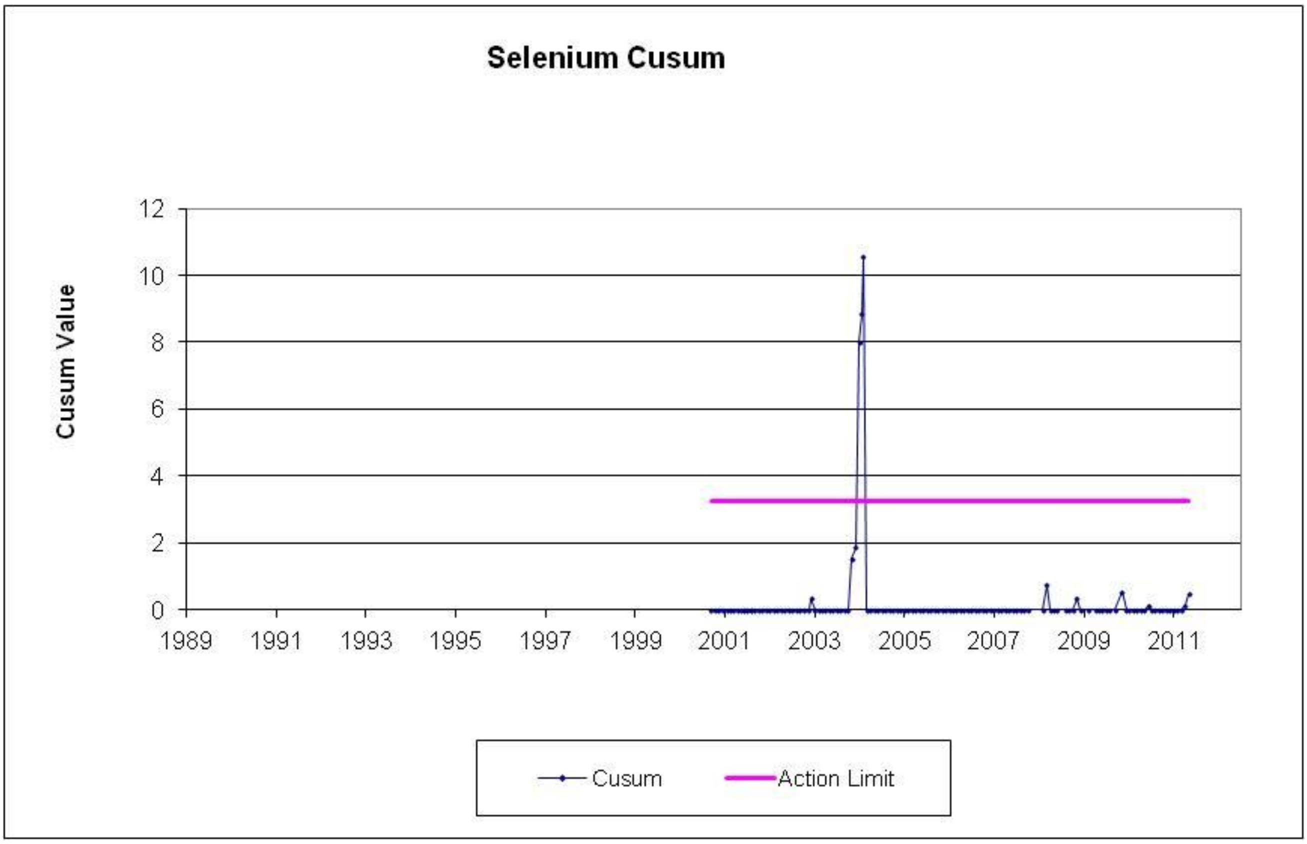

Electrical Conductivity Cusum
Cusum Value
30000
25000
20000
15000
10000
5000
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

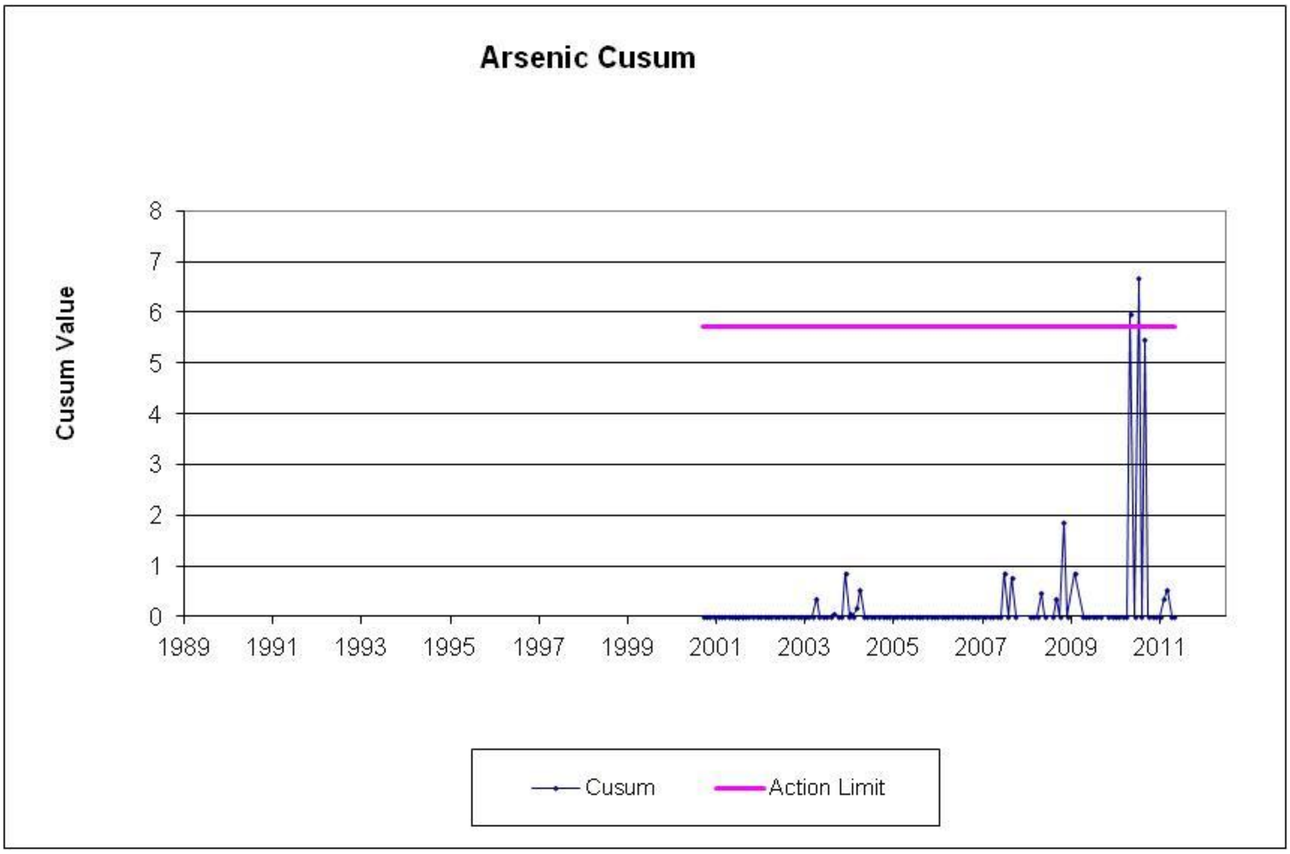

Chloride Cusum
Cusum Value
14000
12000
10000
8000
6000
4000
2000
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

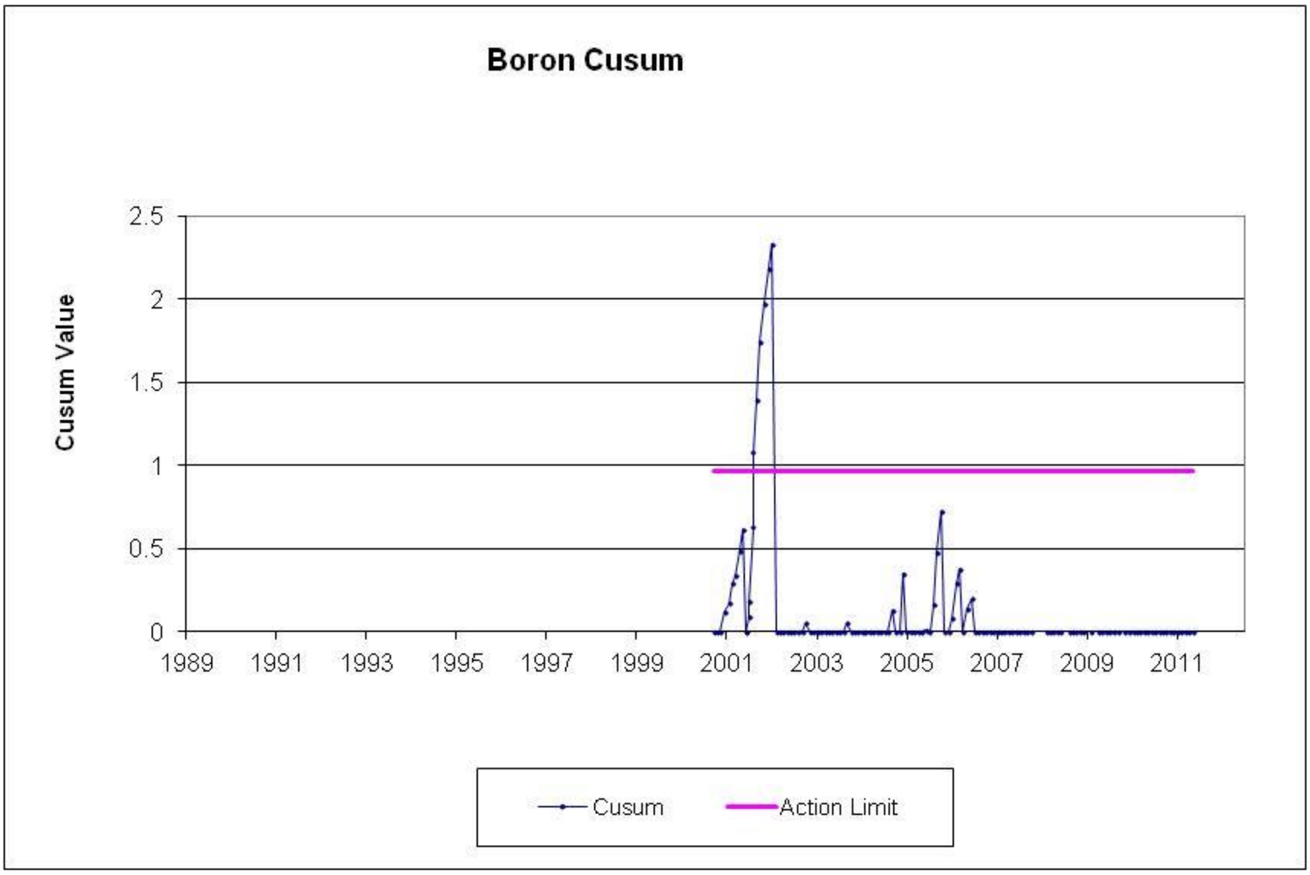

Fluoride Cusum
Cusum Value
2.5
2
1.5
1
0.5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Cusum
Action Limit

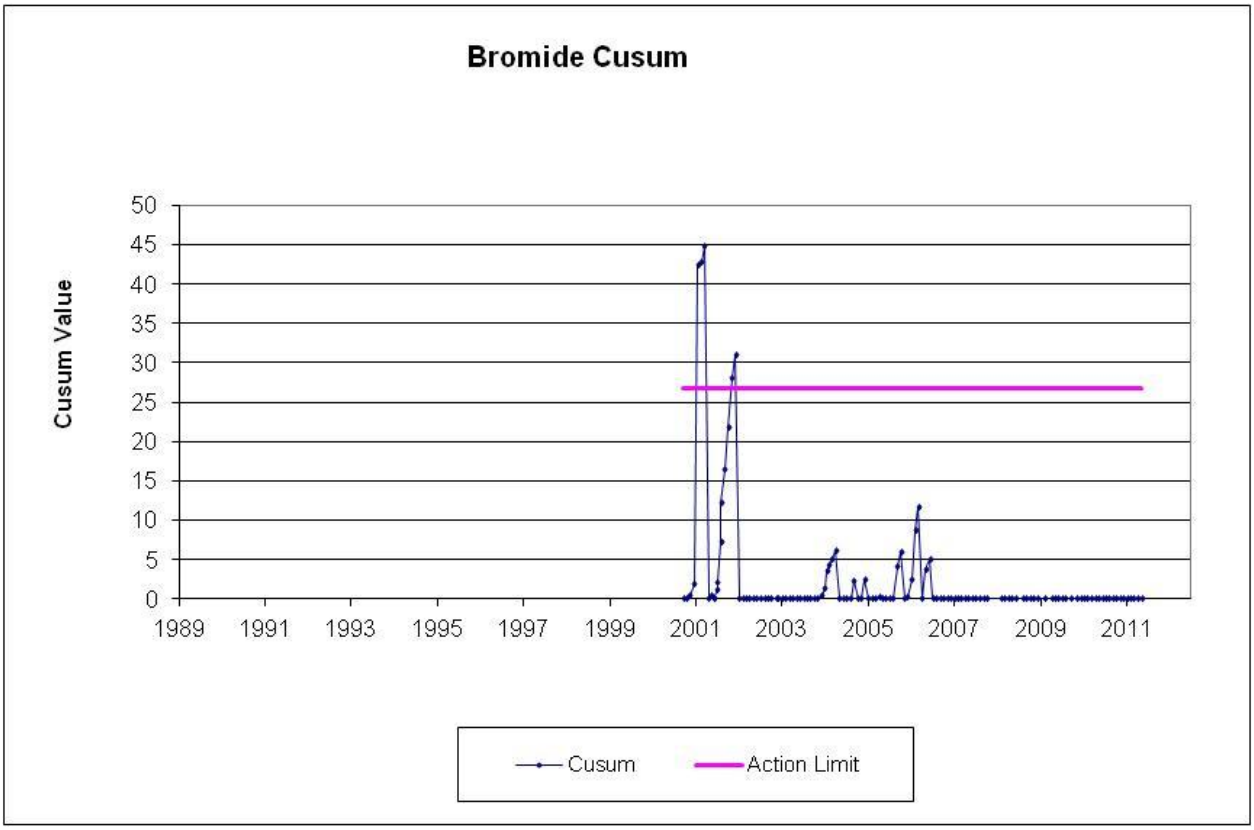

Total Phosphorous Cusum
Cusum Value
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit


Zinc Cusum
Cusum Value
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit


Selenium Cusum
Cusum Value
12
10
8
6
4
2
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit


Arsenic Cusum
Cusum Value
8
7
6
5
4
3
2
1
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit


Boron Cusum
Cusum Value
2.5
2
1.5
1
0.5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit


Bromide Cusum
Cusum Value
50
45
40
35
30
25
20
15
10
5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Cusum
Action Limit

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Appendix 2

Tabulated Water Quality Data (Metromix Weir)

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Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
18-May-11	7.6	2150	2.1	0.06	0.8	0.57	8	420	210	0.021	1	1.2	1.5	0.20	0.9	*	*
20-Apr-11	7.3	2320	3.7	0.01	0.6	0.82	0.5	420	255	0.025	0.01	1	1.4	0.23	0.8	*	*
16-Mar-11	7.2	2060	2.2	0.16	0.6	0.15	2	400	170	0.023	0.005	0.25	2.1	0.22	0.8	*	*
17-Feb-11	7.5	1930	8.5	0.04	1.7	0.14	7	510	180	0.054	0.006	0.6	2.3	0.17	0.8	*	*
19-Jan-11	7.3	2150	2.9	0.16	0.6	0.27	22	450	190	0.12	0.006	0.25	1.3	0.25	0.8	*	*
16-Dec-10	7.4	2130	3	0.03	0.25	0.16	0.5	428	180	0.015	0.006	0.5	1.3	0.20	0.8	*	*
17-Nov-10	7.1	2060	2.6	0.01	0.25	0.34	6	378	171	0.018	0.007	0.5	1.1	0.19	0.8	*	*
14-Oct-10	7.3	2180	2.3	0.03	0.25	0.19	3	460	160	0.012	0.005	0.25	0.7	0.19	1	*	*
15-Sep-10	7.2	471	8	0.09	0.8	0.06	232	120	110	0.37	0.053	0.25	7.4	0.23	0.1	*	*
18-Aug-10	7.7	2170	1.9	0.05	0.6	0.65	0.5	420	170	0.007	0.005	0.25	0.8	0.19	1	*	*
21-Jul-10	8.2	2260	2.3	0.05	0.25	0.76	188	490	246	0.27	0.02	0.25	8.6	0.20	1.2	*	*
23-Jun-10	7.3	2080	2.3	0.14	0.25	1.4	10	480	240	0.037	0.016	1	1.6	0.19	1	*	*
19-May-10	7.1	648	4.2	0.13	0.25	0.08	248	348	48	0.23	0.067	0.25	7.9	0.07	0.2	*	*
21-Apr-10	7.4	2520	2.3	0.06	0.25	1.3	9	570	270	0.017	0.005	0.25	1.3	0.21	1.3	*	*
17-Mar-10	7.2	2170	2.4	0.04	0.25	0.8	1	490	140	0.015	0.006	0.25	1.2	0.19	1.2	*	*
17-Feb-10	7.5	2440	2.6	0.025	0.25	1.6	2	432	200	0.006	0.004	0.25	1	0.20	1.1	*	*
20-Jan-10	7.7	2450	3.9	0.16	0.8	0.09	1	544	230	0.013	0.003	0.6	0.6	0.21	1.2	*	*
23-Dec-09	7.1	2610	2	0.06	0.6	0.55	9	530	180	0.012	0.005	0.25	1.3	0.27	1.3	*	*
18-Nov-09	7.2	2920	2	0.09	0.8	1.3	16	660	320	0.022	0.003	1.4	1.9	0.25	1.5	*	*
23-Sep-09	7.2	2790	2	0.1	1.4	0.025	3	760	280	0.018	0.005	0.8	1.2	0.27	1.6	*	*
12-Aug-09	7.7	2470	2.3	0.025	0.25	0.07	11	572	190	0.018	0.005	0.25	1.3	0.22	1.5	*	*
15-Jul-09	7.2	3070	2.2	0.025	0.25	0.21	10	720	340	0.008	0.004	0.5	1.6	0.28	1.9	*	*
16-Jun-09	7.1	2380	3.5	0.05	1.6	0.09	5	500	170	0.011	0.005	0.5	1.8	0.20	1.4	*	*
14-May-09	7.2	2660	2.3	0.05	0.6	0.11	5	540	230	0.012	0.002	0.25	1.2	0.21	1.7	*	*
22-Apr-09	7.3	3110	3.6	0.01	0.25	0.025	4	790	330	0.009	0.011	0.5	1	0.23	2.2	*	*
17-Feb-09	7.2	2390	3.3	0.32	0.25	0.16	76	550	220	0.094	0.015	0.25	2.8	0.23	1.5	*	*
17-Dec-08	7.3	4740	2.6	0.01	0.25	0.11	3	1760	520	0.012	<0.002	0.25	0.9	0.28	3.7	*	*
18-Nov-08	6.9	2280	2.5	0.13	1.1	0.07	74	548	190	0.052	0.007	1.2	3.8	0.31	0.2	*	*
15-Oct-08	7.1	2320	2.6	0.11	0.6	0.09	17	530	182	0.015	0.006	0.25	1.5	0.21	1.4	*	*
17-Sep-08	7.1	2710	2.8	0.06	0.25	0.14	84	645	251	0.11	0.022	0.25	2.3	0.24	1.6	*	*
18-Aug-08	7.1	2670	2.9	0.21	0.25	0.34	18	620	244	0.016	0.009	0.25	1.9	0.22	1.8	*	*
13-Jun-08	7	3100	3	0.01	0.25	0.19	22	750	320	0.015	0.03	0.25	1.6	0.21	2.1	*	*
15-May-08	6.9	2340	3.5	0.11	0.25	0.15	107	472	197	0.12	0.02	0.25	2.4	0.17	1.3	*	*
15-Apr-08	6.9	3890	3	0.13	0.6	0.23	47	930	347	0.028	0.01	0.25	0.25	0.26	2.8	*	*
14-Mar-08	6.9	2720	2.4	0.01	0.25	0.22	29	560	250	0.037	0.01	1.6	0.25	0.20	1.7	*	*
15-Feb-08	7	3200	2.6	0.01	0.25	0.12	59	600	265	0.069	0.01	0.25	1.5	0.20	2.1	*	*
16-Oct-07															Nil Discharge	*	*
17-Sep-07	6.9	2430	2.7	0.07	0.25	0.11	71	520	240	0.092	0.02	0.25	2.7	0.17	1.1	*	*
15-Aug-07	6.9	3020	2.8	0.19	1.4	0.14	139	670	250	0.012	0.02	0.25	1.7	0.24	1.6	*	*
15-Jul-07	6.8	2410	3.1	0.05	0.8	0.025	150	480	220	0.15	0.02	0.25	2.8	0.18	1.0	*	*
15-Jun-07	7.0	3600	2.5	0.01	0.56	0.19	17	850	340	0.024	0.02	0.5	0.9	0.22	2.5	*	*
15-May-07	6.9	4750	3.5	0.07	0.25	0.09	3	1260	360	0.02	0.01	0.25	1.2	0.27	3.3	*	*
14-Apr-07	*			NIL				drought					Sample	due	to	*	*
15-Mar-07	7.0	7466	2.7	0.15	0.25	0.18	7	2110	500	0.005	0.01	0.25	0.7	0.40	5.0	*	*
15-Feb-07	7.0	7958	2	0.06	0.25	0.2	5	2180	600	0.11	0.01	0.7	1.1	0.41	6.7	*	*

NB Value underlined is half detection limit for statistical use
* = No data available.

Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
15-Jan-07	6.9	6519	2	0.01	0.25	0.24	8	5200	540	0.008	0.01	0.25	1	0.39	6.3	*	*
15-Dec-06	7.7	4383	4.6	0.01	0.25	0.025	8	2400	520	0.013	0.01	0.25	0.6	0.37	6.6	*	*
15-Nov-06	6.9	7918	2.4	0.09	0.25	0.16	7	2900	700	0.008	0.01	0.25	1.1	0.47	9.1	*	*
16-Oct-06	6.9	7559	2.2	0.01	0.25	0.025	16	2600	870	0.021	0.01	0.25	0.25	0.48	8.0	*	*
14-Sep-06	7.0	7950	2.2	0.47	0.87	0.11	6	2420	700	0.038	0.01	0.25	0.25	0.49	8.9	*	*
14-Aug-06	6.9	7400	2.1	0.16	0.25	0.14	3	2220	580	0.005	0.01	0.25	0.8	0.44	7.9	*	*
14-Jul-06	8.0	4040	4.1	0.09	0.25	0.025	6	1930	490	0.003	0.01	0.25	0.25	0.40	7.0	*	*
19-Jun-06	7.1	8422	2.2	0.17	0.1	0.28	11	3100	775	0.15	0.01	0.25	0.25	0.61	10.7	*	*
16-May-06	7.1	9918	2.9	0.08	0.25	0.34	9	3400	850	0.005	0.01	0.25	0.25	0.69	13.3	*	*
13-Apr-06	7.3	7000	3.3	0.13	1.1	0.025	40	2050	650	0.043	0.01	0.25	1.4	0.45	7.8	*	*
15-Mar-06	7.2	7838	2.2	0.38	1.1	0.32	11	2840	800	0.004	0.01	0.25	0.7	0.64	12.5	*	*
16-Feb-06	6.7	10990	2.0	1.1	1.7	0.38	9	5000	1200	0.022	0.01	0.25	0.3	0.76	15.8	*	*
16-Jan-06	7.1	8877	2.1	0.36	0.60	0.025	21	3100	1100	0.023	0.01	0.25	0.5	0.63	11.6	*	*
16-Dec-05	6.8	3752	2.2	0.50	1.1	0.14	10	2880	850	0.022	0.02	0.25	1.2	0.50	9.8	*	*
18-Nov-05	7.3	8779	2.0	0.16	0.25	0.12	12	3100	700	0.006	0.02	0.25	1.2	0.52	9.5	*	*
17-Oct-05	6.8	10400	2.0	0.53	1.1	0.40	15	3800	925	0.093	0.02	0.25	0.5	0.80	11.3	*	*
15-Sep-05	6.9	11140	6.0	0.66	1.32	0.59	18	3600	950	0.013	0.01	0.25	0.6	0.87	13.6	*	*
15-Aug-05	7.1	8320	10.0	0.54	0.25	0.19	1	2640	710	0.011	0.01	0.25	0.8	0.71	8.8	*	*
19-Jul-05		7726	3.6	0.34	0.63	0.12	11	2250	600	0.039	0.02	0.25	1.1	0.50	7.0	*	*
14-Jun-05	6.8	8100	5.0	0.33	0.63	0.13	0.5	2000	650	0.034	0.02	0.25	0.9	0.56	7.9	*	*
16-May-05	6.9	8528	4.9	0.37	0.25	0.12	7	2500	680	0.044	0.02	0.25	1.8	0.50	8.3	*	*
15-Apr-05	6.8	8387	7.0	0.35	0.8	0.12	12	2820	825	0.016	0.01	0.25	1.0	0.52	9.8	*	*
16-Mar-05	7.0	7226	4.4	0.36	0.8	0.089	9	2900	720	0.027	0.01	0.25	0.5	0.53	8.3	*	*
17-Feb-05	6.8	9341	0.5	0.58	1.4	0.13	9	2760	750	0.041	0.01	0.25	0.6	0.58	9.4	*	*
14-Jan-05	*			NIL				Drought					Sample	Due	To	*	*
15-Dec-04	6.8	10210	9	0.60	1.1	0.20	6	2900	625	0.020	0.02	0.25	1.1	0.90	12.0	*	*
17-Nov-04	6.8	8317	4	0.38	2.0	0.080	10	2670	640	0.025	0.02	0.25	0.6	0.52	8.4	*	*
19-Oct-04	6.8	8550	6	0.31	1.1	0.060	13	2640	660	0.076	0.01	0.25	1.0	0.55	8.6	*	*
16-Sep-04	6.7	10440	5	0.36	1.10	0.0025	10	4000	800	0.019	0.01	0.25	0.6	0.68	11.8	*	*
17-Aug-04	7.3	8736	4	0.042	1.4	0.027	9	2900	660	0.027	0.027	0.25	1.1	0.53	9.0	*	*
15-Jul-04	7.4	7621	15	0.075	1.7	0.087	14	1460	580	0.056	0.01	0.25	0.8	0.40	8.5	*	*
16-Jun-04	7.3	9026	2	0.024	1.1	0.28	12	2920	740	0.025	0.02	0.25	1.1	0.50	9.0	*	*
17-May-04	7.8	7931	31	0.044	1.7	0.046	14	2400	580	0.027	0.01	0.25	0.3	0.54	8.22	*	*
14-Apr-04	7.0	9072	32	0.098	2.2	0.33	24	2850	700	0.20	0.03	0.25	2.3	0.69	10.6	*	*
15-Mar-04	7.1	9255	1.8	0.46	3.4	0.27	68	3000	740	0.068	0.02	0.25	2.1	0.58	10.2	*	*
16-Feb-04	6.9	9506	2.1	0.49	1.4	0.61	39	3250	740	0.061	0.01	2.6	0.8	0.65	10.3	*	*
30-Jan-04	7.0	10140	3.9	0.18	1.1	0.038	9	3350	710	0.076	0.01	1.7	2.0	0.65	11.8	*	*
14-Jan-04	6.9	9900	2.6	0.83	2.7	0.15	10	3260	720	0.028	0.01	7.0	0.8	0.78	10.4	*	*
16-Dec-03	7.3	9301	2.9	0.30	2.8	0.33	41	4000	680	0.12	0.03	1.2	2.8	0.57	9.9	*	*
14-Nov-03	7.0	9660	1.9	0.55	2.20	0.18	33	3300	680	0.022	0.01	2.4	1.7	0.58	8.9	*	*
16-Oct-03	7.4	5291	2.0	0.0025	2.0	0.13	96	1480	440	0.022	0.01	0.25	0.7	0.40	3.7	*	*
15-Sep-03	7.0	8482	1.2	0.32	2.24	0.42	34	2520	640	0.069	0.01	0.25	2.0	0.60	7.9	*	*
15-Aug-03	7.1	7451	1.0	0.0025	1.30	0.35	14	2300	520	0.018	0.01	0.25	1.2	0.52	6.8	*	*
16-Jul-03	6.5	5155	1.5	0.041	1.40	0.34	9	1870	450	0.069	0.02	0.25	1.6	0.42	6.0	*	*
16-Jun-03	7.0	5803	1.5	0.056	2.04	0.014	15	1620	400	0.037	0.01	0.25	1.0	0.41	5.6	*	*

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Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
16-May-03	7.1	3264	3.4	0.012	1.40	0.14	5	100	300	0.034	0.01	0.5	1.3	0.25	3.1	*	*
16-Apr-03	7.0	6066	2.5	0.041	1.10	0.21	24	2140	420	0.015	0.01	0.25	2.3	0.48	6.8	*	*
21-Mar-03	7.3	5337	2.4	0.097	1.7	0.087	16	1620	440	0.044	0.01	0.25	1.1	0.39	5.3	*	*
17-Feb-03	7.5	6726	2.4	0.17	1.4	0.037	22	2150	520	0.094	0.033	0.7	1.3	0.40	6.5	*	*
20-Jan-03	7.0	6399	2.6	0.061	0.8	0.080	22	1930	500	0.014	0.01	0.25	1.2	0.48	6.3	*	*
17-Dec-02	6.9	7103	1.3	0.03	0.2	0.23	6	2140	570	0.022	0.02	1.2	1.8	0.50	6.9	*	*
26-Nov-02	7.1	7510	1.6	0.031	1.4	0.005	12	2240	620	0.02	0.02	0.6	0.5	0.53	7.2	*	*
18-Oct-02	7.1	7241	2.6	0.02	0.83	0.04	2	2140	550	0.02	0.02	0.5	0.8	0.60	6.3	*	*
17-Sep-02	7	6020	1.9	0.02	2.2	0.11	11	1740	460	0.02	0.02	0.5	1.1	0.40	5.6	*	*
19-Aug-02	8.6	5108	2.4	0.04	0.6	0.02	17	1560	440	0.02	0.02	0.5	1.4	0.41	4.6	*	*
15-Jul-02	7	5197	4	0.03	0.29	0.1	6	1560	460	0.02	0.02	0.5	1.1	0.34	4.5	*	*
17-Jun-02	7.1	4340	3.3	0.04	0.43	0.07	23	1160	340	0.02	0.02	0.5	1.4	0.43	3.7	*	*
15-May-02	6.9	4560	3.4	0.02	0.54	0.05	14	1400	280	0.01	0.02	0.5	1.1	0.43	4	*	*
16-Apr-02	6.8	3880	1	0.03	0.58	0.09	17	1140	340	0.01	0.02	0.5	0.9	0.35	3.3	*	*
14-Mar-02	7	5130	2	0.05	0.02	0.06	28	1430	82	0.03	0.02	0.5	1.1	0.40	4.9	*	*
18-Feb-02	6.8	5800	21	0.02	0.69	0.1	12	4500	460	0.01	0.02	0.5	1	0.48	7	*	*
17-Jan-02	7.1	7950	3	0.02	0.4	0.18	29	2700	700	0.04	0.02	0.5	1.1	0.70	0.3	*	*
17-Dec-01	6.8	10100	*	0.1	0.5	0.24	21	3280	850	0.02	0.02	0.5	0.8	0.76	12.5	*	*
15-Nov-01	6.9	10800	2.7	0.02	1.4	0.29	27	3980	950	0.08	0.03	0.5	0.5	0.78	15.7	*	*
15-Oct-01	6.9	12300	2.6	0.03	0.54	0.27	37	4700	850	0.04	0.02	0.5	0.5	0.90	15	*	*
17-Sep-01	6.8	11200	7.2	0.06	0.43	0.27	13	4300	875	0.03	0.02	0.5	0.6	0.87	13.7	*	*
15-Aug-01	7	10700	3.1	0.11	0.4	0.52	32	3800	1180	0.06	0.02	0.5	1	1.00	14.5	*	*
15-Aug-01	7	10700	3.1	0.11	0.4	0.52	32	3800	1180	0.06	0.02	0.5	1	1.00	14.5	*	*
17-Jul-01	7.2	8870	2.7	0.03	0.52	0.19	35	2500	720	0.04	0.03	0.5	0.8	0.64	10.6	*	*
17-Jul-01	7.2	8870	2.7	0.03	0.52	0.19	35	2500	720	0.04	0.03	0.5	0.8	0.64	10.6	*	*
15-Jun-01	7.2	7170	3.2	0.08	0.2	0.33	56	2040	610	0.05	0.02	0.5	1.2	0.53	8.3	*	*
15-Jun-01	7.2	7170	3.2	0.08	0.2	0.33	56	2040	610	0.05	0.02	0.5	1.2	0.53	8.3	*	*
29-May-01	6.9	7900	6.4	0.24	0.24	0.23	34	2720	500	0.04	0.02	0.5	0.8	0.68	10	*	*
01-May-01	6.9	8280	2.7	0.09	0.54	0.2	41	2540	530	0.04	0.02	0.5	0.9	0.70	9.5	*	*
29-Mar-01	7	8750	2.4	0.21	0.78	0.3	31	2900	625	0.052	0.02	0.5	1	0.60	11.6	*	*
05-Mar-01	6.9	8140	2.4	0.02	0.56	0.18	19	2700	438	0.026	0.03	0.5	0.5	0.67	9.8	*	*
01-Feb-01	7	9650	2.1	0.03	0.3	0.25	28	3520	700	0.063	0.03	0.5	0.5	0.60	50	*	*
02-Jan-01	6.8	10000	2.3	0.32	0.3	0.19	26	3400	800	0.025	0.02	0.5	0.5	0.67	11	*	*
27-Nov-00	6.9	8140	2	0.12	0.6	0.15	13	2580	520	0.009	0.02	0.5	0.5	0.44	10	*	*
30-Oct-00	6.9	8950	2.2	0.09	0.8	0.16	20	2820	580	0.067	0.02	0.5	0.05	0.50	9	*	*
29-Sep-00	7	4040	1.9	0.05	0.6	0.08	14	1060	280	0.093	0.02	0.6	0.5	0.24	3.3	*	*
25-Aug-00	8.1	5480	*	0.08	0.35	0.01	15	1500	*	0.023	*	*	*	*	*	0.43	*
26-Jul-00	7.5	2300	*	0.05	1.4	0.06	50	664	*	0.055	*	*	*	*	*	0.35	*
29-Jun-00	6.9	8640	*	0.02	0.43	0.28	18	2600	*	0.015	*	*	*	*	*	0.4	*
24-May-00	7	9280	*	0.19	0.8	0.32	34	3270	*	0.036	*	*	*	*	*	0.41	*
26-Apr-00	6.8	8390	*	0.29	0.2	0.3	19	2700	*	0.021	*	*	*	*	*	0.4	*
29-Mar-00	6.8	8890	*	0.8	0.6	0.22	17	2750	*	0.022	*	*	*	*	*	0.39	*
22-Feb-00	6.7	11800	*	0.57	0.65	0.12	20	4200	*	0.012	*	*	*	*	*	0.26	*
20-Jan-00	6.8	10300	*	0.41	0.84	0.19	14	3700	*	0.2	*	*	*	*	*	0.4	*
21-Dec-99	6.9	9930	*	0.75	0.56	0.2	16	3440	*	0.019	0.02	*	*	*	*	0.37	*

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Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
09-Nov-99	6.68	8910	*	1.24	2.1	0.1	8	3219	*	0.1	*	*	*	*	*	1.2	*
14-Oct-99	6.69	11000	*	1.35	*	0.1	23	3545	*	*	*	*	*	*	*	0.9	*
16-Sep-99	6.71	6880	*	0.37	*	0.1	11	2340	*	*	*	*	*	*	*	0.95	*
13-Aug-99	6.6	8950	*	1.29	*	0.1	15	2836	*	*	*	*	*	*	*	0.78	*
19-Jul-99	6.87	5110	*	0.6	*	0.2	108	1574	*	*	*	*	*	*	*	0.6	*
17-Jun-99	7	7520	*	0.38	0.67	0.11	14	2150	*	0.042	*	*	*	*	*	0.34	*
18-May-99	6.8	7280	*	0.2	1.4	0.13	15	2050	*	0.018	*	*	*	*	*	0.34	*
19-Apr-99	6.9	3360	*	0.37	0.74	0.13	14	2060	*	0.018	*	*	*	*	*	0.31	*
22-Mar-99	6.8	6690	*	0.45	0.94	0.23	31	2580	*	0.026	*	*	*	*	*	0.36	*
12-Feb-99	6.7	6700	*	0.5	0.72	0.12	36	2300	*	0.02	*	*	*	*	*	0.38	*
15-Jan-99	6.9	8080	*	0.48	1.03	0.29	26	2900	*	0.1	*	*	*	*	*	0.34	*
16-Dec-98	6.8	9600	*	*	1.7	0.16	31	3150	*	0.1	*	*	*	*	*	0.35	*
19-Nov-98	6.8	*	*	*	1.05	0.22	44	2100	*	0.045	*	*	*	*	*	0.38	*
21-Oct-98	7	7100	*	*	1.57	0.19	73	2000	*	0.1	*	*	*	*	*	0.37	*
23-Sep-98	7	6780	*	*	0.86	0.25	43	2060	*	0.037	*	*	*	*	*	0.39	*
25-Aug-98	6.8	8130	*	*	1.7	0.54	20	2650	*	0.1	*	*	*	*	*	0.35	*
28-Jul-98	6.9	10700	*	*	1.7	0.12	25	3600	*	0.12	*	*	*	*	*	0.33	*
30-Jun-98	7.5	9240	*	*	2.4	0.11	12	3800	*	0.017	*	*	*	*	*	0.37	*
01-Jun-98	7.4	11300	*	*	1.4	0.04	22	4300	*	0.37	*	*	*	*	*	0.47	*
04-May-98	7	13600	*	*	1.31	0.6	18	5000	*	0.007	*	*	*	*	*	0.45	*
08-Apr-98	7.2	12400	*	*	0.2	0.1	43	4100	*	0.028	*	*	*	*	*	0.47	*
06-Feb-98	7.3	*	*	0.69	*	0.22	20	3640	*	0.1	*	*	*	*	*	0.41	*
09-Jan-98	7	*	*	0.6	*	0.1	25	3300	*	0.1	*	*	*	*	*	0.38	*
10-Dec-97	7.1	*	*	0.34	*	0.09	23	3000	*	0.1	*	*	*	*	*	0.4	*
18-Nov-97	6.9	*	*	0.06	*	0.01	8	2880	*	0.1	*	*	*	*	*	0.43	*
24-Sep-97	7.2	*	*	0.02	*	0.1	7	1920	*	0.1	*	*	*	*	*	0.31	*
12-Aug-97	7.1	*	*	0.02	*	0.02	11	2020	*	0.1	*	*	*	*	*	0.42	*
05-May-97	7	*	*	0.02	*	0.08	10	3750	*	0.1	*	*	*	*	*	0.4	*
28-Feb-97	7.6	*	*	0.05	*	0.01	14	3600	*	0.1	*	*	*	*	*	0.44	*
06-Jan-97	7.7	*	*	0.03	*	0.04	14	3000	*	0.1	*	*	*	*	*	0.8	*
22-Nov-96	7.1	*	*	0.03	*	0.06	12	3000	*	0.1	*	*	*	*	*	0.32	*
19-Sep-96	7.7	*	*	0.02	*	0.06	21	2900	*	0.1	*	*	*	*	*	0.34	*
30-Aug-96	6.9	*	*	0.03	*	0.05	95	2500	*	0.1	*	*	*	*	*	0.34	*
31-Jul-96	7	*	*	0.75	*	0.05	30	3750	*	0.1	*	*	*	*	*	0.34	*
21-Jun-96	7.8	*	*	0.5	*	0.06	14	3700	*	0.014	*	*	*	*	*	0.33	*
13-May-96	7.8	*	*	0.04	*	0.14	32	3700	*	0.043	*	*	*	*	*	0.68	*
01-Apr-96	7.6	*	*	0.18	*	0.06	22	3600	*	0.013	*	*	*	*	*	0.38	*
06-Mar-96	7.1	*	*	0.68	*	0.14	3	3580	*	0.013	*	*	*	*	*	0.37	*
29-Feb-96	7.2	*	*	0.12	*	0.22	22	3550	*	0.02	*	*	*	*	*	0.38	*
13-Feb-96	7.4	*	*	0.32	*	0.25	18	3700	*	0.014	*	*	*	*	*	*	*
09-Jan-96	7	*	*	0.37	*	0.03	5	3260	*	0.005	*	*	*	*	*	0.32	*
29-Nov-95	7	*	*	0.18	*	0.08	12	1550	*	0.1	*	*	*	*	*	0.38	*
10-Nov-95	7.2	*	*	0.06	*	0.03	9	1400	*	0.1	*	*	*	*	*	0.39	*
22-Aug-95	7.5	*	*	0.05	*	0.06	19	2450	*	0.1	*	*	*	*	*	0.36	*
13-Jul-95	7.4	*	*	0.15	*	0.1	11	2860	*	0.1	*	*	*	*	*	0.21	*

NB Value underlined is half detection limit for statistical use
* = No data available.

Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
19-Jun-95	7.3	*	*	0.1	*	*	17	3550	*	0.1	*	*	*	*	*	0.33	*
03-May-95	7.2	*	*	0.2	*	0.1	18	3049	*	0.1	*	*	*	*	*	0.35	*
31-Mar-95	7.4	*	*	0.12	*	0.06	6	3319	*	0.1	*	*	*	*	*	0.35	*
10-Mar-95	6.9	*	*	0.6	*	0.03	10	3000	*	0.1	*	*	*	*	*	0.3	*
17-Jan-95	7.3	*	*	0.05	*	0.03	4	1150	*	0.1	*	*	*	*	*	0.34	*
07-Dec-94	7.5	*	*	0.05	*	0.03	6	910	*	0.37	*	*	*	*	*	0.38	*
02-Nov-94	7.8	*	*	0.05	*	0.03	11	650	*	0.1	*	*	*	*	*	0.4	*
19-Oct-94	8.2	*	*	0.05	*	0.03	18	720	*	0.1	*	*	*	*	*	0.2	*
05-Oct-94	8.5	*	*	0.05	*	0.03	10	740	*	0.1	*	*	*	*	*	0.25	*
30-Aug-94	6.9	*	*	0.05	*	0.05	3	770	*	0.1	*	*	*	*	*	0.42	*
02-Aug-94	7.2	*	*	0.8	*	0.03	8	836	*	0.1	*	*	*	*	*	0.42	*
12-Jul-94	7.3	*	*	0.1	*	0.03	1	960	*	0.1	*	*	*	*	*	0.41	*
22-Jun-94	7.2	*	*	0.1	*	0.03	34	1040	*	0.1	*	*	*	*	*	0.36	*
05-May-94	7.1	*	*	0.1	*	0.03	6	2010	*	0.1	*	*	*	*	*	0.38	*
21-Apr-94	7.2	*	*	0.1	*	0.03	22	2300	*	0.1	*	*	*	*	*	0.29	*
23-Mar-94	7.3	*	*	0.1	*	0.03	96	1100	*	0.1	*	*	*	*	*	0.34	*
18-Feb-94	6.9	*	*	0.1	*	0.07	4	1720	*	0.21	*	*	*	*	*	0.31	*
01-Feb-94	7.6	*	*	0.1	*	0.03	8	1060	*	0.1	*	*	*	*	*	0.34	*
02-Dec-93	8.6	*	*	0.2	*	0.03	62	720	*	0.4	*	*	*	*	*	0.37	*
17-Nov-93	7.3	*	*	0.1	*	0.03	1	770	*	0.1	*	*	*	*	*	0.29	*
18-Aug-92	7.1	*	*	0.15	*	0.03	3	165	*	0.1	*	*	*	*	*	0.4	0.01
03-Aug-92	7.1	*	*	0.05	*	0.03	31	174	*	0.15	*	*	*	*	*	0.36	0.01
15-Jul-92	7.1	*	*	0.05	*	0.03	4	166	*	0.1	*	*	*	*	*	0.4	0.02
30-Jun-92	7.1	*	*	0.05	*	0.09	10	178	*	0.1	*	*	*	*	*	0.37	0.01
09-Jun-92	7	*	*	0.05	*	0.4	2	177	*	0.1	*	*	*	*	*	0.32	0.01
27-Apr-92	7.2	*	*	0.1	*	0.25	1	172	*	0.09	*	*	*	*	*	0.35	0.05
10-Apr-92	7.2	*	*	0.1	*	0.15	8	146	*	0.2	*	*	*	*	*	0.42	0.05
20-Mar-92	7.1	*	*	0.1	*	0.05	2	228	*	0.2	*	*	*	*	*	0.36	0.05
03-Mar-92	7.1	*	*	0.1	*	0.05	4	185	*	0.2	*	*	*	*	*	0.46	0.05
18-Feb-92	7.1	*	*	0.3	*	0.05	3	192	*	0.2	*	*	*	*	*	0.43	0.05
28-Nov-91	6.8	*	*	0.1	*	0.05	1	222	*	0.2	*	*	*	*	*	0.35	0.05
14-Nov-91	6.8	*	*	0.1	*	0.05	4	244	*	0.2	*	*	*	*	*	0.36	0.05
22-Oct-91	7	*	*	0.2	*	0.05	6	230	*	0.3	*	*	*	*	*	0.34	0.05
17-Sep-91	7.8	*	*	0.1	*	0.05	2	300	*	0.1	*	*	*	*	*	0.43	0.01
01-Aug-91	7.2	*	*	0.4	*	10.9	1	232	*	0.1	*	*	*	*	*	0.44	0.1
23-Jul-91	7	*	*	0.1	*	0.05	1	280	*	0.1	*	*	*	*	*	0.37	0.01
18-Jul-91	7.1	*	*	0.1	*	0.14	2	190	*	0.01	*	*	*	*	*	0.4	0.14
18-Jun-91	7	*	*	0.2	*	0.13	2	191	*	0.2	*	*	*	*	*	0.43	0.09
28-May-91	7.1	*	*	0.1	*	0.05	2	300	*	0.1	*	*	*	*	*	0.44	0.01
14-May-91	7	*	*	0.01	*	0.05	2	208	*	0.1	*	*	*	*	*	0.35	0.01
08-Feb-91	7.7	*	*	0.1	*	0.05	2	192	*	0.1	*	*	*	*	*	0.38	0.01
08-Jan-91	7.2	*	*	0.1	*	0.2	3	208	*	0.1	*	*	*	*	*	0.39	0.01
18-Dec-90	7.4	*	*	0.5	*	0.05	1	206	*	0.1	*	*	*	*	*	0.41	0.01
04-Dec-90	7	*	*	0.07	*	0.05	4	194	*	0.007	*	*	*	*	*	0.36	0.01
20-Nov-90	7.3	*	*	0.03	*	0.05	4	185	*	0.03	*	*	*	*	*	0.36	0.01

NB Value underlined is half detection limit for statistical use
* = No data available.

Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
06-Nov-90	7.1	*	*	0.11	*	0.05	16	190	*	0.05	*	*	*	*	*	0.44	0.01
23-Oct-90	7	*	*	0.02	*	0.2	14	191	*	0.03	*	*	*	*	*	0.39	0.01
09-Oct-90	6.9	*	*	0.42	*	0.13	4	186	*	0.012	*	*	*	*	*	0.4	0.01
28-Aug-90	7	*	*	0.02	*	0.22	3	172	*	0.02	*	*	*	*	*	0.38	0.01
14-Aug-90	6.9	*	*	0.06	*	0.6	4	156	*	0.02	*	*	*	*	*	0.35	0.01
31-Jul-90	6.9	*	*	0.02	*	0.1	5	168	*	0.07	*	*	*	*	*	0.38	0.01
17-Jul-90	6.9	*	*	0.08	*	0.31	1	160	*	0.04	*	*	*	*	*	0.37	0.01
03-Jul-90	7	*	*	0.08	*	0.54	3	170	*	0.101	*	*	*	*	*	0.36	0.01
19-Jun-90	7	*	*	0.06	*	0.6	1	150	*	0.04	*	*	*	*	*	0.38	0.01
05-Jun-90	7	*	*	0.97	*	0.15	2	147	*	0.39	*	*	*	*	*	0.27	0.01
23-May-90	6.8	*	*	2.2	*	0.22	5	149	*	0.12	*	*	*	*	*	0.41	0.01
01-May-90	6.9	*	*	0.04	*	0.85	1	132	*	0.06	*	*	*	*	*	0.45	0.01
17-Apr-90	6.8	*	*	0.32	*	0.08	15	86	*	0.032	*	*	*	*	*	0.37	0.01
03-Apr-90	7	*	*	0.16	*	0.54	116	142	*	0.003	*	*	*	*	*	0.47	0.02
15-Mar-90	6.9	*	*	0.24	*	0.08	1	146	*	0.003	*	*	*	*	*	0.39	0.02
21-Feb-90	6.9	*	*	0.05	*	0.89	4	125	*	0.013	*	*	*	*	*	0.38	0.01
12-Feb-90	6.9	*	*	0.05	*	0.05	7	118	*	0.08	*	*	*	*	*	0.43	0.01
24-Jan-90	7.2	*	*	0.07	*	0.05	4	191	*	0.006	*	*	*	*	*	0.42	0.01
06-Dec-89	6.8	*	*	0.02	*	0.05	*	190	*	0.025	*	*	*	*	*	0.46	0.01
22-Nov-89	7.1	*	*	0.11	*	0.07	11	179	*	0.02	*	*	*	*	*	0.44	0.01
08-Nov-89	*	*	*	0.18	*	0.05	1	190	*	0.02	*	*	*	*	*	0.39	0.01
25-Oct-89	6.2	*	*	0.15	*	0.06	5	180	*	0.02	*	*	*	*	*	0.38	0.01
11-Oct-89	7	*	*	0.15	*	0.07	8	*	*	0.003	*	*	*	*	*	*	*
27-Sep-89	7	*	*	0.07	*	0.05	2	*	*	0.003	*	*	*	*	*	*	0.01
12-Sep-89	7	*	*	0.02	*	0.12	3	*	*	0.003	*	*	*	*	*	*	0.01
04-Sep-89	6.9	*	*	0.19	*	0.09	2	*	*	0.18	*	*	*	*	*	*	0.01
29-Aug-89	6.9	*	*	1.16	*	0.32	1	*	*	0.48	*	*	*	*	*	*	0.01
21-Aug-89	7.1	*	*	0.09	*	0.15	11	*	*	0.3	*	*	*	*	*	*	0.01
15-Aug-89	7	*	*	0.07	*	0.2	5	*	*	0.71	*	*	*	*	*	*	0.01
31-Jul-89	6.9	*	*	0.74	*	0.29	5	*	*	0.05	*	*	*	*	*	*	0.01
24-Jul-89	7	*	*	*	*	0.4	1	*	*	0.04	*	*	*	*	*	*	0.01
17-Jul-89	6.9	*	*	*	*	0.25	9	*	*	0.11	*	*	*	*	*	*	0.02
11-Jul-89	6.9	*	*	*	*	0.49	3	*	*	0.05	*	*	*	*	*	*	*
03-Jul-89	6.9	*	*	*	*	0.31	11	*	*	0.003	*	*	*	*	*	*	0.01
27-Jun-89	6.9	*	*	*	*	4.79	7	*	*	0.003	*	*	*	*	*	*	*
19-Jun-89	6.9	*	*	0.02	*	0.42	11	*	*	0.33	*	*	*	*	*	*	0.01
14-Jun-89	7.2	*	*	0.51	*	0.11	30	*	*	0.08	*	*	*	*	*	*	0.01
05-Jun-89	6.9	*	*	0.1	*	0.74	5	*	*	0.03	*	*	*	*	*	*	0.01
29-May-89	6.9	*	*	*	*	0.05	12	*	*	0.05	*	*	*	*	*	*	0.01
23-May-89	7.1	*	*	2.51	*	0.25	43	*	*	0.16	*	*	*	*	*	*	0.06
15-May-89	6.9	*	*	0.99	*	0.05	16	*	*	0.04	*	*	*	*	*	*	0.01
08-May-89	6.9	*	*	0.26	*	0.05	19	*	*	0.03	*	*	*	*	*	*	0.01
01-May-89	7	*	*	0.02	*	0.12	25	*	*	0.08	*	*	*	*	*	*	0.01
26-Apr-89	6.9	*	*	0.21	*	0.09	*	*	*	0.02	*	*	*	*	*	*	0.01
17-Apr-89	6.9	*	*	0.02	*	0.15	3	*	*	0.4	*	*	*	*	*	*	0.01

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Date	pH	Conductivity (uS/cm)	Dissolved Organic Carbon (mg/L as C)	Ammonia (mg/L as N)	TKN Filtered (mg/L as N)	Nitrates (mg/L as N	Suspended Solids (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Phosphorus (mg/L as P)	Zinc (mg/L)	Selenium (ug/L)	Arsenic (ug/L)	Boron (mg/L)	Bromide (mg/L)	Fluoride (mg/L)	Nitrites (mg/L)
10-Apr-89	6.9	*	*	0.19	*	0.04	*	*	*	0.003	*	*	*	*	*	*	0.01
03-Apr-89	7	*	*	0.02	*	0.09	150	*	*	0.44	*	*	*	*	*	*	0.01
28-Mar-89	7.2	*	*	4.02	*	0.19	32	*	*	0.1	*	*	*	*	*	*	0.01
20-Mar-89	7.5	*	*	0.05	*	0.09	66	*	*	0.54	*	*	*	*	*	*	0.02
13-Mar-89	6.9	*	*	0.01	*	1.15	4	*	*	0.43	*	*	*	*	*	*	0.01
06-Mar-89	6.9	*	*	0.05	*	0.05	11	*	*	0.165	*	*	*	*	*	*	0.01
27-Feb-89	8	*	*	0.36	*	0.05	*	*	*	0.005	*	*	*	*	*	*	0.01
21-Feb-89	7.2	*	*	0.83	*	0.12	23	*	*	0.5	*	*	*	*	*	*	*
19-Jan-89	7.5	*	*	0.02	*	0.2	*	*	*	0.03	*	*	*	*	*	*	0.01

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* = No data available.

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