
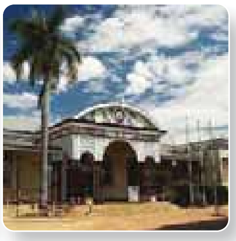
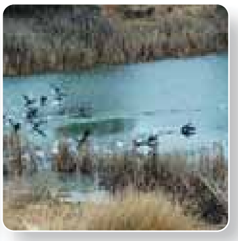

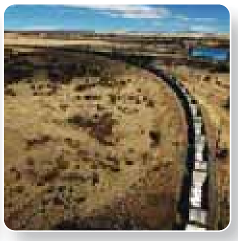

INTEGRA UNDERGROUND MINE LONGWALL EXTENSION MODIFICATION

SURFACE WATER IMPACT ASSESSMENT

for

HV Coking Coal Pty Ltd

November 2017

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

INTEGRA UNDERGROUND MINE
LONGWALL EXTENSION MODIFICATION

SURFACE WATER IMPACT ASSESSMENT

Prepared by:

HANSEN BAILEY
6/127-129 John Street
SINGLETON NSW 2330

20 November 2017

For:

HV COKING COAL PTY LTD
PO Box 320
SINGLETON NSW 2330

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1 INTRODUCTION

Hansen Bailey was commissioned by HV Coking Coal Pty Ltd (HVCC) to complete a Surface Water Impact Assessment which forms part of the Environmental Assessment (EA) being prepared for the Integra Underground Mine (Integra Underground). The EA is being prepared to support an application to modify the Integra Underground's Project Approval (PA 08_0101). The proposed modification will also be the subject of a referral under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.1 DESCRIPTION OF THE MODIFICATION

HV Coking Coal Pty Limited (HVCC) operates the Integra Underground Mine (Integra Underground) in the Upper Hunter Valley of New South Wales (NSW). HVCC is a wholly owned subsidiary of Glencore Coal Pty Limited (Glencore).

Hansen Bailey is currently preparing an application on behalf of HVCC to modify Integra's Project Approval (PA 08_0101). This modification application will be made under Section 75W of the Environmental Planning and Assessment Act 1979 (EP&A Act). HVCC is seeking approval to continue longwall mining of the Middle Liddell Seam further to the north of the currently approved longwall panels (the Modification). The Modification also involves the construction and operation of ancillary surface infrastructure.

The Modification includes the following components:

- Adjustments to the approved mine plan for the Middle Liddell Seam including:
  - Realignment and extension of the main headings further to the north-west;
  - Increases to the lengths and widths of the approved LWs 15-17; and
  - Mining of additional longwall panels (LWs 18-19 or LWs 18-20).
- Construction and use of additional surface infrastructure including:
  - Proposed Goaf Dewatering Site consisting of additional dewatering boreholes and associated infrastructure;
  - Surface auxiliary fans in the maingate of each longwall panel to assist in the efficient ventilation of the longwall mining area;
  - Additional electricity transmission lines and distribution lines;
  - Additional gas drainage boreholes to ensure the safety of underground operations;

- Increased usage of the currently approved gas flares; and
- Relocation of the existing store facility and the construction and use of an additional access road off Middle Falbrook Road.

- Use of the C4 Dam to store raw water from Glennies Creek.

The proposed mining activities and ancillary surface infrastructure associated with the Modification are conceptually illustrated in **Figure 1**.

Integra Underground is located adjacent to the Mount Owen Complex (MOC) which is also owned and operated by Glencore. The Modification does not involve any alterations to the Development Consent for the MOC; however, the proposed mining activities and infrastructure development will be undertaken within the approved boundary of MOC.

1.2 REPORT SCOPE AND STRUCTURE

This report describes the management of surface water and mine-affected water for the Modification. This report is structured as follows:

- **Section 2** provides a description of the surface water setting including the regional catchment setting and local drainage system based upon a desktop study of local surface water drainage features;
- **Section 3** provides a description of the existing Integra Underground water management system, including water supplies and demands and key water storages;
- **Section 4** provides an overview of the proposed water management strategies for the Modification which includes a conceptual plan for site drainage;
- **Section 5** provides an assessment of the proposed water management system based upon water balance modelling for the proposed mining operations;
- **Section 6** provides an assessment of the surface water impacts of the Modification; and
- **Section 7** provides an overview of relevant management plans for the Modification.

Appendix A presents the results of water quality monitoring relevant to the Modification.

This assessment also draws on specialist studies undertaken for this EA, including the *Integra Underground Mine: Subsidence Assessment for Modification to PA 08_0101* and the *Integra Underground Groundwater Impact Assessment*.

2 SURFACE WATER SETTING

2.1 CATCHMENT SETTING

The Modification lies within the broader Bowmans Creek and Glennies Creek catchments, which are both sub-catchments of the Hunter River catchment (**Figure 2**). These catchments cover an area of approximately 200 km^2 and 500 km^2, respectively. The dominant land uses within these catchments include coal mining, agriculture and forestry. Glennies Creek Dam is located in the Glennies Creek catchment and is part of a major regulated water supply scheme.

The Hunter River is a regionally significant watercourse located approximately 5 km south-west of the Modification (**Figure 2**). The Hunter River is characterised by perennial flows, while its tributaries typically exhibit highly ephemeral, short duration, surface water flows that are typically restricted to the wet season (i.e. November to April). Surface water flows are typically non-saline to moderately saline and exhibit naturally elevated suspended sediment loads.

The local topography in the vicinity of the Modification is characterised by several narrow valleys that slope steeply from elevated terrain in the north-east to the low-lying Hunter River floodplain in the south-west (**Figure 2**). These valleys are separated by hills, subtle ridgelines and mining operations that form the local catchment boundaries of Glennies Creek and its tributary Main Creek, Bettys Creek (a tributary of Bowmans Creek) and the approved MOC water management system catchment (**Figure 2**).

The Modification and the approved mining areas at Integra are located within these local catchments (**Figure 2**).

The Modification Underground Extraction Area is located almost entirely within the catchment of the approved MOC water management system (**Figure 2**). The MOC catchment covers an area of approximately 23 km^2 and comprises open cut pits, overburden emplacement areas, mine infrastructure and rehabilitated surfaces associated with the approved mining activities at the MOC. The MOC catchment is an internally draining catchment. Runoff from this catchment is contained and managed in accordance with the approved MOC water management system which is part of the Greater Ravensworth Area Water Sharing Scheme (GRAWSS). The MOC water management system and the GRAWSS are discussed in **Section 3**.

A small proportion of the Modification Underground Extraction Area lies within the Bettys Creek catchment. The Bettys Creek catchment has been extensively modified by the existing mining activities and will be further disturbed by the approved mining activities within this catchment. As a result, the catchment is highly degraded.

2.2 BETTYS CREEK

Bettys Creek has historically been diverted around the MOC in three locations (**Figure 3**).

The Upper Bettys Creek Diversion is located upstream of the MOC and has diverted the upper catchment of Bettys Creek into Main Creek.

A second diversion known as the Middle Bettys Creek Diversion has been constructed downstream of the Mount Owen Mine. This diversion originates immediately upstream of the Modification Underground Extraction Area within the MOC water management system catchment. The Middle Bettys Creek Diversion traverses the Modification Underground Extraction Area for approximately 600 m from north to south. The Middle Bettys Creek Diversion has a low sinuosity and is gently sloping as it traverses the Modification Underground Extraction Area. This reach of the diversion is managed as part of the approved MOC operations, and will be modified as part of the approved operations at the MOC and subsequent MOC final landform and mine closure arrangements.

Downstream of the Modification Underground Extraction Area, the Middle Bettys Creek Diversion traverses above the approved LWs 13 and 14 for approximately 1.5 km and converges with the natural creek channel.

Downstream of this confluence, Bettys Creek continues to traverse the area overlying the approved Integra longwall mining area and flows around the MOC open cut mining areas. A third diversion has been constructed on the lower reach of Bettys Creek (i.e. the Lower Bettys Creek Diversion) to divert flows around the MOC.

Bettys Creek converges with Swamp Creek and drains into Bowmans Creek approximately 5 km downstream of the Modification Underground Extraction Area. Bowmans Creek drains into the Hunter River approximately 12 km downstream of the Modification Underground Extraction Area.

2.3 GLENNIES CREEK AND TRIBUTARIES

Glennies Creek and its tributaries (including Main Creek and an unnamed tributary) are located to the south-east of the Modification Underground Extraction Area.

The existing approved Integra surface facilities are located upstream of a minor unnamed tributary of Glennies Creek (**Figure 3**). The unnamed Glennies Creek tributary drains to the south-west and converges with Glennies Creek approximately 3 km downstream of the approved Integra surface facilities. Glennies Creek drains into the Hunter River approximately 15 km downstream of the approved Integra surface facilities and approximately 4 km downstream of Bowmans Creek.

2.4 SURFACE WATER QUALITY

HVCC undertakes regular surface water monitoring of key watercourses that traverse the Integra Underground. The surface water monitoring program at Integra Underground comprises a total of 7 monitoring sites shown on **Figure 3**, including:

- 3 sites on Glennies Creek (GC1 to GC3) upstream, within and downstream of the Integra Underground. Surface water quality monitoring on at these sites includes monthly measurement of pH and electrical conductivity (EC). Total suspended solids and total dissolved solids are measured monthly at GC3 and quarterly at GC1 and GC2. Major ions and metals are also measured at six monthly intervals at GC1.
- 3 sites on Bettys Creek (BC1 to BC3) as it traverses the Integra Underground downstream of the Middle Bettys Creek Diversion. Surface water quality monitoring on at these sites includes quarterly measurement of pH, electrical conductivity (EC), total suspended solids and total dissolved solids.
- 1 site on Main Creek (MC3) at the downstream extent of the Integra Underground. Surface water quality monitoring on at this site includes quarterly measurement of pH, electrical conductivity (EC), total suspended solids and total dissolved solids.

HVCC and the proponents of other Glencore owned mines have established an integrated surface water and mine-affected water management system monitoring program for the Integra Underground, MOC and Greater Ravensworth Area mining operations, and the surrounding surface water drainage network. The integrated monitoring program comprises a total of 45 surface water monitoring sites. The following surface water monitoring sites (shown on **Figure 2** and **Figure 3**) are potentially relevant to the Integra Underground:

- MOC site BC1 located on Bettys Creek and MC1 and MC2 located on Main Creek. These sites are located upstream, or at the upstream extent, of the Integra Underground. Data collected from these sites therefore is unaffected by Integra Underground activities and provides background data for the Modification.
- MOC site BC4 located on Bettys Creek. This site is located downstream of the Integra Underground and the Lower Bettys Creek Diversion.
- MOC site SC4 located on Swamp Creek immediately upstream of the confluence with Bettys Creek. Data collected from this site is unaffected by Integra Underground and therefore is background data for the Modification.
- MOC sites BMC1 to BMC5 located on Bowmans Creek upstream of the confluence with Swamp Creek (and inflows from Bettys Creek). Data collected from these sites is unaffected by Integra Underground and therefore is background data for the Modification.

The existing surface water monitoring programs therefore provide extensive coverage of the local and regional drainage networks relevant to the Modification.

The surface water quality data for the period 2009 to 2017 is summarised in **Appendix A.** Key pH and electrical conductivity data are shown on **Graphs 1 and 2**. Collectively, data shows that:

- Bettys Creek is characterised by neutral to slightly alkaline, low to moderate salinity flows. Elevated levels of suspended sediment were recorded at all monitoring locations. Water quality is variable due to the ephemeral nature of surface water flows in this creek.
- Glennies Creek is characterised by slightly alkaline, fresh water (i.e. low salinity), flows. Water quality is consistent due to the regulated, perennial flows in this creek.
- Main Creek is characterised by neutral to slightly alkaline, fresh to saline flows. Similar to Bettys Creek, water quality is variable due to the ephemeral nature of surface water flows in this creek.
- Bowmans Creek is characterised by slightly alkaline, fresh to brackish flows.
- Swamp Creek is characterised by slightly to moderately alkaline, moderately to highly saline flows. Levels of suspended sediment are typically elevated. These parameters are typically more elevated in the upstream monitoring sites, with the downstream monitoring site (SC4) exhibiting lower concentrations. Similar to Bettys Creek, water quality is variable due to the ephemeral nature of surface water flows in this creek.

3 INTEGRA UNDERGROUND WATER MANAGEMENT SYSTEM

Integra Underground operates an established water management system that manages all water supplies and demands associated with the underground mining operations. **Figure 4** provides a schematic illustration of the water management system, including the relationship between water supplies, key water storages and water demands.

The water management system involves:

- The containment and reuse of:
  - Underground mine water (i.e. water from the underground workings);
  - Rainfall runoff from areas disturbed by open cut mining, including parts of the adjacent Rix’s Creek North Mine (mining and overburden emplacement areas);
  - Seepage from the former Rix’s Creek North Mine and surrounding catchment; and
  - Rainfall runoff from areas disturbed by ancillary mining activities.
- The use of an external raw water supply to meet operational water demands.

Underground mine water is removed from active underground mine workings to facilitate mining operations. Underground mine water is transferred to the Portal Sump (**Figure 5**) via a pipeline along the main drift or dewatering bores. The Portal Sump is a dedicated mine water storage with a storage capacity of approximately 160 Megalitres (ML). Mine water is transferred from the Portal Sump to water storages within the Greater Ravensworth Area Water Sharing Scheme (GRAWSS) or Rix’s Creek North Mine water management system for storage and reuse.

Runoff from parts of the Rix’s Creek North Mine is collected in the Portal Sump and transferred to the GRAWSS or Rix’s Creek North Mine water management system for storage and reuse.

Seepage of rainfall, surface water and groundwater infiltration from the Rix’s Creek North Mine and surrounding catchment is also collected in the Portal Sump and transferred to the GRAWSS or Rix’s Creek North Mine water management system for storage and reuse.

Runoff from the areas disturbed by ancillary mining activities including the workshop, hardstand, administration area and storage areas is collected and stored in the Process Water Dam (**Figure 5**). The Process Water Dam is a catch dam with a storage capacity of approximately 30 ML and an external catchment area of less than 1 ha. Runoff captured from these areas is used for dust suppression, cooling and washdown in the underground operations.

Raw water is supplied via a pumped abstraction from Glennies Creek in accordance with a Water Access Licence (WAL). Integra Underground typically uses up to 300 Megalitres per annum (MLpa) from Glennies Creek under the terms of the WAL. Raw water is used to maintain a buffer supply in the Process Water Dam (**Figure 5**).

The existing approvals for Integra Underground do not allow for controlled discharges from the Integra Underground water management system (**Figure 5**). Any excess water within the Integra Underground water management system is transferred to the GRAWSS or Rix's Creek North Mine under existing approval conditions.

The Integra Underground water management system is operated in accordance with the Integra Underground Water Management Plan (HVCC, 2017), prepared as a requirement of PA 08_0101 (as modified). The Integra Underground Water Management Plan is discussed in **Section 7.1**.

Runoff from disturbed areas that could generate suspended sediment is managed in accordance with the Integra Underground Erosion and Sediment Control Plan. The Erosion and Sediment Control Plan has been prepared in accordance with PA 08_0101 (as modified) and is designed to control suspended sediment in site runoff prior to passive discharge from site. The Erosion and Sediment Control Plan is a component of the Integra Underground Water Management Plan.

3.1.1 Greater Ravensworth Area Water Sharing Scheme

The GRAWSS is an integrated mine water management and sharing system that comprises the Ravensworth Complex, Liddell Mine, MOC and Integra Underground water management systems. Glencore established the GRAWSS to enable mine water to be readily transferred between these mines. The GRAWSS therefore allows the water demands of any of these mines to be satisfied by surplus water from the other mines. The key benefits of this system are that it reduces both the external raw water demands from, and the need for controlled discharge of mine-affected water to, the Hunter River and its tributaries.

Any excess water in the Integra Underground water management system is transferred to the MOC water management system component of the GRAWSS. Mine-affected water is transferred via an approved pipeline from the Integra Underground to the mine water management system at MOC. The approved pipeline has sufficient capacity to allow the transfer of all water from the Portal Sump to the GRAWSS. Water transferred to the MOC is preferentially used across the GRAWSS for coal washing and dust suppression at the MOC, Liddell Mine and Ravensworth operations to reduce the volume of raw water extracted from Glennies Creek and the Hunter River.

Excess water within the MOC water management system (and the wider GRAWSS) is discharged to the Hunter River from licenced discharge points at Liddell Mine and Ravensworth Complex. All controlled discharges are undertaken in accordance with the

Hunter River Salinity Trading Scheme and relevant Environmental Protection Licence (EPL) requirements.

3.1.2 Rix's Creek North Mine Water Management System

Rix's Creek North Mine has an established water management system with a significant available dam and in-pit storage capacity of approximately 4.5 Gigalitres (GL). Any surplus mine water is contained within the in-pit storages.

Water transfers to and from the Integra Underground to Rix's Creek North Mine are undertaken in accordance with a commercial agreement between HVCC and Bloomfield Collieries Pty Limited (operators of Rix's Creek North Mine). This agreement requires Rix's Creek North Mine to accept run-off and seepage from the open cut pit that enters the portal sump and to allow emergency transfers resulting from rainfall and flood events. At other times, water can also be transferred to Rix's Creek North Mine in order to supply open cut mining and coal handling and preparation plan (CHPP) demands.

4 MODIFICATION WATER MANAGEMENT STRATEGIES

The Modification involves undertaking longwall mining within the Modification Underground Extraction Area as shown on **Figure 1**. The Modification also involves the construction of limited surface infrastructure to support the mining activities, including surface auxiliary fans, electricity infrastructure, dewatering infrastructure, and a materials storage facility and access road. The Modification also involves the use of Rix's Creek North Mine's C4 Dam as a raw water storage.

The Modification will therefore require the management of the following waters:

- Site drainage including:
  - Interactions with Bettys Creek;
  - Runoff from areas disturbed by the construction of surface infrastructure; and
  - Runoff from areas undisturbed by the Modification.
- Underground mine water.

The proposed management strategy for each type of water generated by the Modification is based on the quality of the water and is designed to prevent any adverse impacts on downstream surface water values. The requirements to maximise the reuse of captured water for operational activities, minimise the demand for external water supply and minimise the risk of uncontrolled discharge of poor quality water, were key considerations in the development of appropriate water management strategies.

The proposed water management strategies for the Modification are discussed in the following sections.

4.1 SITE DRAINAGE

4.1.1 Interactions with Creeks

Middle Bettys Creek Diversion traverses the Modification Underground Extraction Area (**Figure 3**). Glennies Creek and its tributaries are located east of the Modification Underground Extraction Area. Bowmans Creek and its tributary Swamp Creek are located west of the Modification Underground Extraction Area.

The ancillary surface infrastructure for this Modification will be sited to avoid interactions with these watercourses. A watercourse diversion is therefore not required for the Modification.

The ancillary surface infrastructure will also avoid encroachment on the 1 in 100 year flood extents associated with these watercourses. The *Surface Water Assessment Report for the Integra to Mount Owen Complex Water Pipeline Modification EA* (WRM, 2017) and the

Surface Water Assessment for the Integra Coal Mine Barrett/Hebden Underground Mine Extension Project (WRM, 2009) provides a detailed description of the modelling undertaken to delineate the flood extents.

The proposed dewatering site will be located adjacent to the Middle Bettys Creek Diversion (**Figure 1**). The conceptual footprint of the proposed dewatering site will be refined as necessary during detailed design to avoid encroachment on the creek or its 1 in 100 year flood extents.

The conceptual sites for the surface auxiliary fans, mine access road and storage facility are not located in proximity to any drainage features.

The 1 in 100 year flood is an extreme flood event that has an average exceedance probability (AEP) of 1%. There is an extremely low probability (less than 1% in any year) that a larger flood resulting in floodwater encroachment on the proposed surface infrastructure areas will occur during the operating life of the mine. The potential risks of flooding to people and the environment are therefore extremely low. No flood protection levees are therefore required to manage flood water or associated risks.

The interaction with creeks traversing the Modification is therefore limited to:

- The surface above LW15 which is traversed by part of the Middle Bettys Creek Diversion (**Figure 1**); and
- A single location within the Assessment Boundary where the proposed 66kV electricity transmission line crosses Bettys Creek (**Figure 1**).

The potential impacts of the proposed underground mining and 66 kV electricity transmission line crossing on the Middle Bettys Creek Diversion are discussed in **Section 6.5** and **Section 6.2**, respectively.

4.1.2 Runoff from the Dewatering Site

The Dewatering Site will be located above longwall panels LW14 and LW15 in the north-eastern extent of the Modification Underground Extraction Area (**Figure 1**). The Dewatering Site will comprise a small hardstand area.

Runoff from the Dewatering Site may contain elevated levels of suspended sediment. The Dewatering Site will be isolated with diversion drains and/or bunding, where necessary. Runoff from these areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment. Sediment dams will passively discharge from site if water quality meets water quality objectives, or will be pumped to the underground workings for storage and reuse.

Collection drains will be designed with sufficient capacity to convey runoff from the 10% Annual Exceedance Probability (AEP) (1 in 10 year) storm event. The collection drains will typically be contour drains. Longitudinal grades will be typically 1% and cross section batters will be constructed to stable slopes and revegetated to minimise erosion. Any steeper sections will be constructed with velocity control structures or scour protection. Discharge points to natural drainage lines will be designed with energy dissipation measures, where necessary, to prevent any scouring and ensure stability.

Collected runoff will generally be directed to one or more sediment dams prior to draining from the site. In addition to sediment dams, a network of smaller sediment traps will also be installed close to any significant sources of sediment. This will effectively achieve a staged approach to removal of suspended sediment from site drainage water with coarse sediments being trapped close to the source and fine sediments trapped in the larger sediment dams. Sediment traps will generally be constructed as excavated pits at a size readily desilted by an excavator. The precise number and location of sediment traps will be determined during the update of the Integra Underground Water Management Plan. The Integra Underground Water Management Plan is discussed in more detail in **Section 7.1**.

Sediment dams will be designed and constructed generally in accordance with relevant engineering guidelines including *Managing Urban Stormwater: Soils and Construction* (the Blue Book) (Landcom, 2004). The detailed design of each dam will be dependent on specific site conditions and the design life of the dam, but will typically be designed to manage inputs from the 95th percentile, 5-day storm event. All sediment traps and sediment dams will be regularly desilted to ensure their continued effective operation.

Rehabilitation of the Underground Services Infrastructure Area will be undertaken as part of the mine closure process. Rehabilitation will involve establishment of a stable final landform that will promote surface runoff. Contour drains will be constructed on the rehabilitated final surface, where necessary, to prevent erosion of the final landform. Rehabilitated areas will generate clean runoff that will be allowed to drain passively to downstream overland flowpaths.

4.1.3 Runoff from Surface Auxiliary Fan Sites

A series of surface auxiliary fans will be located above the Modification Underground Extraction Area (**Figure 1**), within a rehabilitated overburden emplacement area at MOC. Each surface auxiliary fan site will comprise a small hardstand area.

Runoff from the surface auxiliary fan sites may contain elevated levels of suspended sediment. The surface auxiliary fan sites will be isolated with diversion drains and/or bunding, where necessary. Runoff from these areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment until ground cover is established. Sediment traps and ponds will passively discharge to the MOC overburden emplacement area catchment.

4.1.4 Runoff from the Relocated Store and Access Road

The relocated store and new access road will be located southwest of the existing approved surface facilities (**Figure 1**). The store will comprise a small hardstand area of approximately 0.1 ha. A small light vehicle washdown bay will be located at the store. The access road will be surfaced with gravel.

Runoff from the store and access road may contain elevated levels of suspended sediment. The store will be isolated with diversion drains and/or bunding, where necessary. Runoff from this area will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment. Sediment dams will passively discharge from site if water quality meets water quality objectives, or will be directed to the Integra Underground water management system, via pit ramps or highwall drains.

Runoff from the access road will be captured in road drains and directed through grassed sediment traps and grassed swales for control of suspended sediment prior to passive discharge from site.

Drainage and sediment control measures will be designed and constructed generally in accordance with relevant engineering guidelines including the Blue Book, as required.

4.1.5 Runoff from Areas Undisturbed by Mining Activities

Wherever possible, runoff from undisturbed areas will be diverted around (and away from) areas disturbed by mining activities and allowed to drain from site.

4.2 UNDERGROUND MINE WATER

Underground mine water comprises groundwater inflow to the active underground mine workings and recycled underground water supply.

Groundwater inflow to the underground workings is discussed in detail in the *Groundwater Impact Assessment*. Groundwater inflows to the underground workings will predominantly occur from the target coal seam. Groundwater will flow into the underground workings over the life of the mine as water pressure in the surrounding geology decreases. The *Groundwater Impact Assessment* states that modelled groundwater inflows to the underground workings will range from 487 MLpa at commencement of the Modification and peak at 836 MLpa. It is proposed that groundwater drainage activities that may be undertaken in advance of longwall mining. Groundwater drainage will reduce the rate of groundwater inflow to the underground workings. The predicted inflow rates to the underground workings are therefore a conservatively high estimate of groundwater inflow rates. In addition, a significant proportion of groundwater inflow will be lost to surface wetting, evaporation and infiltration to the walls and floors of the mine workings. Monitoring data collected from the Portal Sump during periods when the longwall is not in operation (i.e. there is no pumped water supply to the underground workings) shows that approximately 60% of groundwater inflows are available for dewatering from the underground mine.

The residual groundwater inflow will drain to underground sumps with the water recycled from the operating longwall, and the resulting underground mine water will be dewatered from the underground workings to the Portal Sump.

Underground mine water quality will vary depending on the relative contributions from recycled raw water and groundwater inflow. The *Groundwater Impact Assessment* indicates that groundwater is typically slightly alkaline and moderately to highly saline. Water quality data for the Process Water Dam indicates that underground water supply is likely to be pH neutral and non-saline. On balance, based upon these contributions, underground mine water generated by the Modification is likely to be slightly alkaline and moderately to highly saline.

The Portal Sump catchment is a contained disturbed catchment that includes the Rix's Creek North open cut mining area, as well as in-pit overburden emplacement areas and areas above the highwall that cannot be drained around or away from the open cut mining area. The Portal Sump catchment will remain relatively consistent over the life of the mine.

Portal Sump water quality will vary depending on the relative contributions from underground mine water and open cut mine water (comprising overburden emplacement seepage from Rix's Creek North Mine and Portal Sump catchment runoff). Overburden emplacement seepage and runoff is likely to be slightly alkaline and variably saline throughout the year. Runoff from undisturbed catchment areas is likely to be pH neutral and non-saline. On balance, based upon these contributions, water collected in the Portal Sump is likely to be neutral to slightly alkaline and moderately to highly saline. This is consistent with existing mine water monitoring data collected from the Portal Sump (**Appendix A**) which confirms that water in the Portal Sump is neutral to slightly alkaline, and moderately to highly saline with levels of sulphate that are typically elevated. While pH is typically less alkaline than the downstream surface waters, salinity is typically elevated. The elevated salinity is due to the influence of groundwater inflows on underground mine water and periodically saline overburden emplacement seepage. The Modification therefore is not predicted to result in any significant change in the water quality within the Integra Underground water management system.

Water in the Portal Sump will continue to be pumped to the GRAWSS or Rix's Creek North Mine in accordance with the current approved Water Management Plan and existing commercial agreements.

5 MODIFICATION WATER MANAGEMENT SYSTEM

The proposed water management system for the Modification is limited to the containment and reuse of any additional underground mine water generated by the Modification. Underground mine water is described in **Section 4.2**. The proposed water management system for the Modification is therefore consistent with the existing Integra water management system schematic presented in **Figure 4**. The Modification does not involve any changes to the approved Integra Underground water management system or infrastructure.

5.1 MODIFICATION WATER SUPPLIES AND DEMANDS

An underground water supply requirement of up to approximately 208 MLpa is forecast for the Modification. The Modification will therefore not result in any increase in underground water supply requirement. The existing external raw water supply from Glennies Creek is sufficient to meet the water requirements of the Modification, and therefore no additional external water supply is required.

The external water supply required for the Modification will be continue to be supplied from the Process Water Dam in accordance with the current approved operations. The Modification may also involve the use of Rix's Creek North C4 Dam (**Figure 5**) for the storage of raw water abstracted from Glennies Creek. This arrangement is subject to HVCC entering a legal agreement with Bloomfield Collieries Pty Limited (operators of Rix's Creek North Mine).

C4 Dam is a catch dam with a contributing catchment area of approximately 25 ha and a storage capacity of 90 ML. Rainfall runoff will collect in C4 Dam following storm events. Runoff collected in C4 Dam will be used as the priority raw water supply for the Modification in order to reinstate runoff containment capacity in the dam. HVCC may also use any excess storage capacity in C4 Dam as a buffer storage for raw water from Glennies Creek. HVCC will ensure that any buffer supply maintained in C4 Dam is managed in order to ensure that there is no change in the performance of the dam during storm events or the potential for discharge.

5.2 MODIFICATION WATER MANAGEMENT SYSTEM MODELLING

A water balance model has been developed to confirm the water management system inventory and storage requirements over the remainder of the Project duration (i.e. until the end of 2035). The model provides a dynamic simulation of the water management system based upon detailed progression of longwall mine development, groundwater inflows and catchment areas over the remainder of the Project duration, and has been assessed using a series of historical climate sequences. The performance of the water management system was simulated using 108 consecutive 18-year climate sequences taken from the 126 years of historical climate records available for the site. The performance of the water management system has therefore been evaluated for all possible combinations of mine development timing and climate sequences on record. This includes the worst case combinations of mine development timing and high and low rainfall sequences.

The key modelling assumptions are as follows:

- A loss factor of 0.6 has been applied to the modelled groundwater inflow rates of up to 836 MLpa to convert them to underground dewatering rates, taking into account losses due to surface wetting, evaporation and infiltration to the walls and floor of the pits as described in **Section 4.2**. The calculated groundwater component of the underground pit water is therefore up to 501 MLpa. In addition, it has been conservatively assumed that 100% of the 208 MLpa underground water supply is recycled and dewatered from the underground mine workings. The modelled underground pit dewatering rate is therefore up to 709 MLpa.
- The rate of runoff from contained catchments will be dependent on rainfall rates, the contributing catchment areas and the storage and runoff characteristics of the catchment surfaces. For the purpose of the water management system model, a long-term climate dataset was acquired from the Bureau of Meteorology. The dataset comprised 126 complete years (1889 to 2016 inclusive) of rainfall and evaporation data interpolated from recorded meteorology data.
- The proposed catchment areas are consistent with the Integra Underground Water Management Plan (HVCC, 2017) and comprise a Portal Sump catchment area of 75 ha, a Process Water Dam catchment area of 1.6 ha and approximately 465 ha of Rix's Creek North Mine.
- Runoff from each catchment has been modelled using runoff rates derived from the Australian Water Balance Model (AWBM). The AWBM is a catchment-scale runoff model that is widely used to calculate runoff on mine sites in Australia. The AWBM model parameters are consistent with the Integra Underground Water Management Plan (HVCC, 2017).
- Pumping rates and water storage geometry are consistent with the approved Integra Underground Water Management Plan (HVCC, 2017).

The water balance results for the Integra Underground water management system are presented in **Table 1**.

Table 1

Predicted Water Balance

Source	**Annual Water Balance (MLpa)**	
	Existing Operations	**Modification**
Water Supplies (Inputs)		
Underground Mine Dewatering: - Dewatered Groundwater Inflows (Peak) - Recycled Raw Water Supply	 292 208	 501 208
Runoff from Portal Sump Catchment	96	96
Seepage from: - In-Pit Overburden Emplacement Area - Pit Catchment	 1,095 123	 1,095 123
Total Supplies	**1,814**	**2,023**
Water Demands (Outputs)		
Transfer to MOC*	1,798	2,004
Net Evaporation	16	19
Total Demands	**1,814**	**2,023**
Stored Water Volume Change	**0**	**0**

** A portion of this quantity may be transferred to Rix's Creek North Mine*

These modelling results show that:

- The Modification will generate an annual surplus of mine-affected water of up to 2,004 ML. The majority of the predicted surplus (1,218 ML) is estimated seepage from the Rix's Creek North open cut mining area. The seepage rates are consistent with the existing mine approvals;
- The predicted surplus is an increase of up to 206 ML above the approved 1,798 ML surplus reported in the existing mine approvals. This increase is due to predicted increases in underground mine dewatering rates as a result of the Modification;
- The Modification has limited contained catchments and consequently does not generate significant volumes of mine-affected water during high rainfall conditions; and
- This surplus can be adequately contained within the Portal Sump prior to transfer of stored mine-affected water to either MOC (as part of the GRAWSS) or the Rix's Creek North Mine (under the existing commercial agreement) for in-pit storage.

As discussed in **Section 3**, Glencore has established the GRAWSS, which enables mine-affected water to be readily transferred between Integra Underground and other Glencore mines so that the water demands of a particular mine can be satisfied using surplus water from the other mines. This reduces the quantity of water that needs to be taken from the

Hunter River or its tributaries (in accordance with Water Access Licences) as well the need to discharge water to the Hunter River or its tributaries (in accordance with the Hunter River Salinity Trading Scheme) and EPL.

5.3 CUMULATIVE WATER MANAGEMENT SYSTEM MODELLING

Glencore maintains a water balance model for the GRAWSS. This water balance model was used to determine the effects of the additional water transfers from the Integra Underground water management system on the GRAWSS. The results of the GRAWSS modelling show that:

- The coal processing water demand will generally consume the additional mine-affected water (up to 206 ML) transferred from Integra Underground to MOC in any operating year without the need for additional transfers to the wider GRAWSS or additional discharges from the licensed discharge points;
- Following completion of the approved mining activities at MOC, on average, there will be a net decrease in water demands at MOC. Any surplus water transferred from Integra Underground to MOC (including any additional transfers due to the Modification) may be stored in the mining voids at MOC or within the wider GRAWSS. The Modification is therefore likely to increase the water inventory at MOC or within the wider GRAWSS by up to 206 ML under average conditions. However, this would increase the rate of evaporation from the in-pit storages and largely offset the additional transfer from Integra Underground;
- The Modification will therefore have negligible effect on the inventory of the wider GRAWSS over the remainder of the Project duration. The Modification is predicted to result in less than 2% change in the total volume of water discharged from the approved GRAWSS. This corresponds to an average of change of less than 20 MLpa; and
- In the unlikely event that discharge of excess water is required as a result of the Modification, this would be conducted in accordance with the established GRAWSS controlled release system and the Hunter River Salinity Trading Scheme (HRSTS) credits. Glencore holds sufficient HRSTS credits to accommodate the minor predicted changes in discharges from the GRAWSS. As discussed in **Section 4.2**, the Modification is not expected to result in any significant change in water quality within the Integra Underground water management system. The Integra Underground water management system will therefore continue to generate moderately to highly saline water that is consistent with monitoring data and within the predicted range for the GRAWSS (GHD, 2017). On this basis, the potential for a marginal increase in discharges from the GRAWSS can be accommodated within the available GRAWSS Hunter River Salinity Trading Scheme credits.

6 IMPACT ASSESSMENT

Surface infrastructure construction and longwall mining operations at Integra Underground have the potential to result in the following impacts on surface water:

- Reduced catchment yields and downstream flows resulting from the creation of contained catchments;
- Drainage impacts associated with electricity transmission line crossings;
- Sedimentation of downstream watercourses during construction and operations due to erosion from disturbed areas associated with the Modification;
- Water quality impacts on downstream environmental values and water users due to the controlled discharge of mine-affected water; and
- Impacts of the final landform on surface water drainage and quality.

The following sections provide a summary of the potential surface water impacts of the Modification and the management measures proposed.

6.1 CATCHMENT YIELD IMPACTS

The operations and post mining drainage arrangement will result in containment of up to approximately 3 ha of the Bettys Creek catchment and 0.1 ha of the Glennies Creek catchment.

The contained portion of the Bettys Creek catchment is located within the contained catchment of the MOC mine water management system. The Modification will therefore not result in any further decrease in the Bettys Creek catchment.

There will be a minor decrease (<0.001%) in the Glennies Creek catchment area and a corresponding proportional decrease in catchment yields. There are no surface water users on Glennies Creek downstream of Integra Underground and therefore this minor decrease in catchment yield will not impact downstream surface water users or impact on stream flows.

6.2 DRAINAGE IMPACTS

As discussed in **Section 4.1.1**, the additional surface infrastructure will be designed to avoid encroachment on Glennies Creek and its tributaries. Potential drainage impacts are therefore limited to the proposed electricity transmission line crossing of Bettys Creek shown on **Figure 1**.

The crossing will comprise an electricity transmission line installed above ground within a single span over the creek bed and banks.

The crossing will not result in any change to the shape or cross-section of the creek channel that could obstruct or constrain flows. The crossing is therefore not predicted to result in any change to the drainage or flood characteristics of the creek.

Any works within the creek or its surrounds will be undertaken generally in accordance with the DPI-Water *Guidelines for Controlled Activities* (2012). Any works undertaken within 40 m of the creek will be designed, constructed and maintained generally in accordance with the latest versions of the *Guidelines for Controlled Activities on Waterfront Land, Policy and Guidelines for Fish Friendly Waterway Crossings* and *Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings* as listed in Schedule3, Condition 3 of PA 08_0101 (as modified) and the existing approved Integra Underground Water Management Plan.

6.3 EROSION AND SEDIMENT IMPACTS

Runoff from areas disturbed by construction and mining activities may contain elevated levels of suspended sediment.

The existing Integra Underground Water Management Plan will be updated prior to commencement of construction to address erosion and the control of suspended sediment in drainage from the site. The Exploration Activities and Minor Surface Infrastructure Management Plan will be similarly updated, as necessary, to ensure consistency with the updated Water Management Plan.

Runoff from disturbed areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment. Sediment dams will passively discharge from site if water quality meets water quality objectives, or will be pumped to the mine-affected water management system for storage and reuse. Sediment collected in sediment dams will be excavated at regular intervals. Diversion drains will be installed to divert overland flow from upstream areas around disturbed areas.

All works will be designed and constructed generally in accordance with relevant engineering guidelines including the Blue Book and the Integra Underground Water Management Plan.

6.4 WATER QUALITY IMPACTS

As discussed in **Section 5**, any controlled release of excess mine-affected water from the GRAWSS will be conducted in accordance with the existing approved GRAWSS controlled release system and the discharge conditions under the HRSTS and EPL.

The EPL conditions include limits on discharge water volume and quality that are specifically designed to protect downstream water quality and environmental values.

6.5 SUBSIDENCE IMPACTS

The Integra Underground has extracted 12 longwall panels from the Middle Liddell Seam as part of the approved Integra Underground activities. As discussed in the approved Water Management Plan, subsidence monitoring has confirmed that the extent and magnitude of subsidence associated with these panels is consistent with modelling predictions. No significant surface water impacts have been identified as a result of the extraction of these longwall panels.

The Integra Underground has approval to extract a further five panels (LWs 13-17) from the Middle Liddell Seam, lowering the overlying ground surface by up to 1.9 m. LWs 13 and 14 are traversed by the Middle Bettys Creek Diversion and will subside the diversion channel.

The Integra Underground also has approval for longwall mining in the deeper Hebden Seam below the approved Middle Liddell Seam mining area, resulting in up to 3.4 m of vertical subsidence.

As discussed in **Section 1**, the Modification involves increases to the lengths and widths of the approved LWs 15-17 and mining of additional longwall panels (LWs 18-19 or LWs 18-20) in the Middle Liddell Seam. (**Figure 1**). The Modification's longwall mining activities are likely to result in subsidence and lead to the progressive development of shallow, trough-like depressions in the Middle Bettys Creek Diversion and the surrounding landscape.

Subsidence associated with the Modification therefore has the potential to result in direct and indirect impacts on surface water drainage. These include:

- The direct impact of subsidence creating depressions within the Bettys Creek channel and on the floodplain.
- Indirect impacts on the Bettys Creek channel such as:
  - Pooling of water in subsidence depressions leading to a reduction in downstream flows and associated flood extents and depths during flow events;
  - Lowering of the river bed upstream and downstream of the subsidence area due to the capture of sediment in subsidence depressions, reducing sediment deposition immediately adjacent to the depressions and potentially resulting in erosion and instability; and
  - Bank scour and instability due to increases in flow velocities and stream energy above the proposed chain pillars as flows enter the subsidence depressions.
- Indirect impacts on the Bettys Creek floodplain such as:
  - Ponding of water in localised shallow subsidence depressions resulting in:
    - Reduced catchment yield and downstream watercourse flows;
    - Evapo concentration of ponded water and the accumulation of poor quality water on the floodplain; and

  - Erosion and incision of the floodplain above the proposed chair pillars where ponded water overtops subsidence depressions during flood events.
- Creation of avulsion pathways (i.e. preferential flowpaths for Bettys Creek) on the floodplain.

Sections 6.5.1 and 6.5.2 describe the processes by which these impacts may occur on the Bettys Creek channel and floodplain, respectively, and assess the potential for such impacts as a result of the Modification.

6.5.1 Bettys Creek Channel

Direct Impacts

LW15 is located beneath the Middle Bettys Creek Diversion (**Figure 1**) and subsidence from longwall mining is predicted to lower the bed of Bettys Creek by up to 1.4 m above this panel. This will create a shallow depression in the bed of Bettys Creek up to approximately 1 m deep and 400 m long. The total volume of the depression created by mining LW15 will be approximately 400 m^3. The depression will be constrained by more elevated sections of the creek bed located above the chain pillars.

The subsided section of the Middle Bettys Creek Diversion is located within the MOC final landform and is likely to be removed and/or substantially modified as part of the approved operations at MOC and subsequent MOC mine closure arrangements.

Any potential for indirect subsidence impacts on the Middle Bettys Creek Diversion above LW15 due to the Modification is therefore expected to be highly localised and limited to the short term period prior to the removal or modification of the Middle Bettys Creek Diversion. These short term, indirect impacts are discussed below.

Mining LW15 is also predicted to result in additional subsidence above the adjacent LW14. The approved extraction of LW13 and LW14 is predicted to lower the bed of the Middle Bettys Creek Diversion by up to 1.4 m above LW14. LW15 is predicted to lower the bed of Middle Bettys Creek Diversion above LW14 by up to 0.5 m above LW14. The total predicted subsidence above LW 14 is 1.9 m.

Previous studies (WRM, 2009) have confirmed that the sediment transport regime within Bettys Creek deposited 0.2 m of sediment within the bed of the Middle Bettys Creek Diversion over a period of approximately 2 years. This indicates that mobile bed sediments are present within this reach of Bettys Creek and that depositional conditions are present within the Middle Bettys Creek Diversion.

Previous modelling predictions indicate that flow velocity, shear stress and stream power are likely to decrease within subsidence depressions. This will create conditions favourable to the deposition of sediment within the subsidence depressions and supports the conclusion that infilling will occur during flow events. It can therefore be expected that ongoing sediment transport and infilling will occur in the creek above LW14, and therefore subsidence would be expected to have limited or no regional impact on geomorphic processes in the creek. Impacts would be short term and limited to a local scale. These short term, indirect impacts are discussed below.

Indirect Pooling Impacts

Surface water is likely to collect in the subsidence depression during and immediately following flow events in Bettys Creek. The presence of pools was a feature of the natural creek channel and an integral part of the approved Middle Bettys Creek Diversion design. In addition, modelling results indicate that pooling of water in these depressions is unlikely to result in any significant change in downstream flows or associated flood depths or extents. No management measures are proposed.

Indirect Bed Lowering Impacts

The capture of sediment in the subsidence depression during smaller flow events (< 10 year ARI flood events) is likely to reduce sediment deposition immediately downstream of the depressions. As a result, some surface water flow events could potentially mobilise bed sediments more quickly than they are deposited in the river bed downstream of the depressions. The downstream river bed could potentially be lowered as a result, exposing the river banks to erosion and instability.

Minor lowering of the Middle Bettys Creek Diversion bed could potentially occur immediately downstream of LW14 and LW15 during smaller flood events. However, based upon the limited scale, extent and duration of bed lowering in this area, this is not predicted to result in any adverse impacts on the Middle Bettys Creek Diversion (e.g. bank erosion or instability).

Monitoring will be conducted to identify any bed lowering that may occur downstream of LW14 and LW15 and confirm the extent and effects on the stability of Bettys Creek.

Monitoring of the effects of subsidence on the creek channel will be undertaken in accordance with the Water Management Plan and will specifically include a program of major annual monitoring events and more regular minor monitoring events in order to characterise the condition of each reach and identify any bed lowering effects due to the Modification. A detailed description of the proposed creek diversion monitoring program is provided in **Section 7.1.1.**

Where necessary, appropriate channel management measures will be implemented in accordance with the Water Management Plan. Channel management measures will be determined.

Indirect Bank Instability Impacts

Modelling predictions indicate that localised increases in flow velocity, shear stress and (to a lesser extent) stream power are likely to occur at the elevated sections of the creek bed between the subsidence depressions above the chain pillars around LW14 and LW15 (**Figure 1**). Flow velocities are predicted to typically increase by less than 0.5 m/s during the modelled flow events, with peak increases of approximately 1 m/s expected above the upstream limit of LW15. Shear stresses are predicted to typically increase by less than 20 Newtons/m^2 while stream power is predicated to typically be unchanged as a result of the Modification.

The predicted increases in flow velocities and shear stresses represent minor increases in the baseline conditions within the Middle Bettys Creek Diversion. However, due to the moderate baseline velocities and locally elevated shear stresses within the Middle Bettys Creek Diversion, these minor increases could potentially exacerbate localised bank instability above the chain pillars.

Monitoring of the effects of subsidence on the Middle Bettys Creek Diversion will be undertaken in accordance with the Water Management Plan described in **Section 7.1**. Where necessary, appropriate channel management measures will be implemented in accordance with the Water Management Plan.

6.5.2 Impacts on the Bettys Creek Floodplain

Indirect Ponding Impacts

Subsidence may lead to the ponding of overland flow in localised shallow surface depressions on the Bettys Creek floodplain and rehabilitated areas of MOC. The ponding of overland flow has the potential to reduce catchment yield and flows in downstream rivers and flowpaths, lead to the accumulation of poor quality water on the floodplain and result in erosion and incision of the floodplain and rehabilitated areas of MOC.

A drainage strategy has been developed to ensure the establishment of a stable, free-draining post mining landform with no residual ponding on the Bettys Creek floodplain and rehabilitated areas of MOC. Ponding of surface water due to subsidence will be remediated by the installation of minor remedial drainage earthworks to re-establish free drainage, where practical. Drainage works will include the construction of excavated trapezoidal drainage channels, designed with sufficient capacity to cater for contributing catchments and with stable batter slopes. These channels would enable free drainage of subsidence depressions. Drainage channels will be located to avoid sensitive features and vegetation communities, as far as practicable.

The detailed design of the minor remedial drainage works will be based on an accurate survey of the actual subsided ground surface. These drainage works will be conducted in accordance with the Water Management Plan.

With the application of the proposed remedial drainage measures, it is unlikely that there will be any residual surface water drainage impacts associated with subsidence of the Bettys Creek floodplain and rehabilitated areas of MOC.

Avulsion Pathways

Avulsion is the process of stream channel formation and abandonment. Avulsion pathways typically occur where shorter, more steeply sloping flowpaths or channels are available to the stream.

Subsidence depressions can potentially cause avulsion where the orientation and depth of the depression creates preferential flowpaths across a floodplain. Over time, flood events in the river channel can engage these flowpaths, resulting in erosion and incision of a new channel and avulsion of the stream.

Modelling results show that the Middle Bettys Creek Diversion has a large bank full capacity under baseline and post-mining conditions and hence, there is an extremely low likelihood of out-of-channel flow events occurring in the vicinity of the Modification Underground Extraction Area. In addition, the proposed longwall panels are orientated cross-stream and the orientation of subsidence depressions will not create shorter, preferential pathways across the floodplain.

It is therefore extremely unlikely that the Modification will result in creek flows traversing the floodplain and incising a new channel. Subsidence associated with the Modification is therefore not expected to increase the potential for avulsion of the Middle Bettys Creek Diversion, even during extreme flood events.

6.5.3 Cumulative Impacts

Existing and approved future mining of Bettys Creek upstream of the Modification Underground Extraction Area includes open cut mining activities at MOC. The existing operations at Integra Underground involve longwall mining under Bettys Creek downstream of the Modification Underground Extraction Area. Bettys Creek has been diverted around the open cut mining operations at Glendell Mine, downstream of the Modification.

As discussed in **Section 6.5.1**, there is potential for the proposed longwall mining to have some indirect impacts by causing changes to the geomorphic processes and condition of the creek. As discussed in **Section 6.5.1**, these impacts are expected to be temporary.

The contribution of the Modification to indirect impacts such as bed lowering and bank instability are expected to be localised within the vicinity of LW14 and LW15. Bed lowering and the potential impacts on bank stability will be monitored in accordance with the monitoring program described in **Section 7.1.1**. Where necessary, appropriate channel management measures will be implemented in accordance with the Water Management Plan.

The Modification is unlikely to generate additional cumulative impacts with the upstream MOC or the Integra Underground due to the minor influence of subsidence from the Modification on surface drainage at a catchment scale.

7 IMPACT MITIGATION AND MANAGEMENT

Potential impacts on surface water at Integra Underground are managed in accordance with the Integra Underground Water Management Plan, Bettys Creek Diversion Asset Management Plan and the Subsidence Monitoring Program. These plans and programs have been prepared in accordance with PA 08_0101 (as modified) and will be updated to address the impacts of the Modification, prior to commencement of activities associated with the Modification. The requirements of these plans and their application to the Modification is discussed in the following sections.

7.1 WATER MANAGEMENT PLAN

The Integra Underground Water Management Plan outlines the management practices and monitoring programs that form part of the Integra Underground water management system and aim to minimise the potential for surface water (and groundwater) impacts. The Water Management Plan comprises the following key surface water management and monitoring plans:

- A creek diversion management plan;
- An erosion and sediment control plan; and
- A surface water management plan.

As discussed in **Section 6**, the existing management and mitigation measures described within the Water Management Plan and implemented at Integra Underground will adequately address any potential impacts associated with the Modification.

The Water Management Plan will be updated to address the potential impacts of the Modification. The plan will also be updated to address water management for all stages of the Modification including construction, operations and closure.

General updates to the Water Management Plan will include:

- A description of the Modification setting including the surface water catchment and drainage setting, hydrogeology, and an overview of the existing surface and groundwater values, users and water quality;
- A description of the regulatory setting of the Modification;
- The water management objectives for the Modification;
- A description of potential Modification impacts on water;

- Control strategies including a description of the surface water drainage arrangements, water management system and water balance for the Modification. This will include a discussion of options and alternatives for meeting the proposed water management objectives;
- A detailed description of the water management and monitoring measures to address each of the Modification impacts and maintain the effective operation of the control strategies; and
- A description of the review process and remedial measures to address any Modification impacts or potential water management issues identified through monitoring.

The component management measures and monitoring programs are discussed in the following sections, along with any updates required as part of the Modification.

7.1.1 Creek Diversion Management and Monitoring

The proponent has established an extensive subsidence monitoring program for the approved underground mining area. The monitoring results have informed the development of Extraction Plans and built upon data collected as part of the previous surface water assessments.

The established subsidence monitoring program involves monitoring changes in geomorphic conditions within the Middle Bettys Creek Diversion and its floodplain in order to identify and manage subsidence impacts on the watercourse. Changes in geomorphic conditions are identified from desktop assessment and field surveys. Field surveys are conducted at a network of monitoring sites in the Middle Bettys Creek Diversion and across the floodplain within the approved Integra mining area, including sites immediately upstream and downstream of LW14 and LW15.

The operations monitoring program involves:

- Reviewing recent aerial photography;
- Reviewing and analysing stream flow gauging data;
- Analysing elevation survey data, including long-sections and cross sections of Bettys Creek;
- Collecting photographs at each monitoring site;
- Assessing the condition and efficacy of existing management measures;
- Calculating an Index of Diversion Condition score for each monitoring site on Bettys Creek and rating the condition of the creek at these locations; and
- Identifying areas of erosion and/or instability and potential additional management measures.

A full and detailed monitoring assessment is undertaken on an annual basis and following the completion of each longwall panel. In addition, interim monitoring assessments are undertaken more frequently following each flow event. The findings are compared to established baseline conditions in order to identify any significant change in conditions. The findings are also used to assess the performance of mitigation measures. The monitoring program is reviewed and updated annually using the findings of the monitoring program.

This operations monitoring program is consistent with relevant guidelines and established monitoring programs that have been successfully implemented at other mines for in excess of 10 years.

Schedule 3, Condition 29 of PA 08_0101 requires the proponent to commission a suitably qualified and independent expert to undertake a detailed survey of the geotechnical, geomorphic and ecological baseline condition of the Middle Bettys Creek Diversion prior to commencement of second workings under the creek diversion. This is applicable and required prior to the commencement of longwall mining associated with the Modification. A subsequent assessment will be undertaken within 6 months of completing longwall mining in these panels. Nominally, this will include existing operations monitoring program sites located immediately upstream and downstream of LW14 and LW15.

In addition, the existing operations monitoring program will be expanded to include the Modification Underground Extraction Area. The proponent will establish additional monitoring sites as necessary to monitor the potential impacts of the Modification (i.e. sites where potential instability has been identified). The monitoring program will continue to be reviewed on an annual basis.

7.1.2 Erosion and Sediment Control Management and Monitoring

The proponent has established erosion and sediment measures for the existing operations. These measures include:

- Minimising the extent of disturbance consistent with operational requirements;
- Establishing and/or maintaining vegetation cover on non-operational undisturbed areas;
- Implementing the Glencore Ground Disturbance Permit process for any ground disturbance proposed;
- Rehabilitating disturbed areas when no longer required for operational purposes;
- Redirecting rainfall runoff from undisturbed catchments;
- Designing drainage to enable the transfer of water at non-erosive velocities;
- Using sediment containment fencing downstream of cleared areas;
- Using containment structures such as sedimentation dams or sumps to allow the settlement of suspended sediment in site drainage; and

- Topsoiling and revegetating constructed drains to stabilise the ground surface.

These controls are implemented on an as-needs basis and are undertaken generally in accordance with the Blue Book and the existing approvals.

The effectiveness of these erosion and sedimentation controls is assessed as part of the erosion and sediment control monitoring program. The erosion and sediment control monitoring program includes:

- Regular inspections of subsided areas, drill pads, gas drainage sites and associated unsealed roads, collection drains and bunding, and monitoring sites located on natural drainage features traversing LW13 and LW14. Inspections are undertaken on a monthly basis, following significant flow events and over the duration of any disturbance activities; and
- Annual monitoring including a detailed review of the regular inspection results, inspection of subsided ground, structures and drainage features, and an inspection of historical subsidence remediation works is undertaken by a suitably qualified and experienced person. An annual photographic record is also compiled during the annual monitoring.

The erosion and sediment control monitoring program is reviewed and updated annually. Erosion and sediment control works are implemented on an as needs basis.

The proposed erosion and sediment controls described in **Section 4** as part of the Modification water management strategies are consistent with these measures and will be implemented in accordance with the Blue Book and relevant guidelines.

The existing monitoring program will be expanded to include the Modification Underground Extraction Area and ancillary infrastructure. The proponent will undertake routine inspections as necessary to monitor the potential impacts of the Modification. Additional annual inspection sites will be established in response to any erosion or sediment control issues identified through the routine monitoring program. The monitoring program will continue to be reviewed on an annual basis.

7.1.3 Surface Water Management and Monitoring

The proponent has an established monitoring program for the Integra Underground water management system. The water management system monitoring program includes:

- Monthly monitoring of water levels in the Process Water Dam and Portal Sump;
- Monthly monitoring of underground mine dewatering rates and water transfers;

- Monthly monitoring of water quality in the Process Water Dam and Portal Sump for pH, electrical conductivity, salinity, major ions and nutrients; and
- Monthly monitoring of water quality in the Portal Sump for petroleum hydrocarbons, bacterial counts and oxygen demand.

Controlled releases from the GRAWSS to receiving waters are currently monitored in accordance with the approvals for the Ravensworth Complex and Liddell Mine. The Integra Underground does not have any licensed discharge points. Nonetheless, surface water monitoring points for receiving waters in the vicinity of Integra Underground are monitored as discussed in **Section 2** and shown on **Figure 3**.

Any controlled releases from the GRAWSS will continue to be monitored in accordance with the existing approvals for the component mines. The effects on receiving waters will continue to be monitored through the existing surface water monitoring points including those specified in the Integra Underground Water Management Plan.

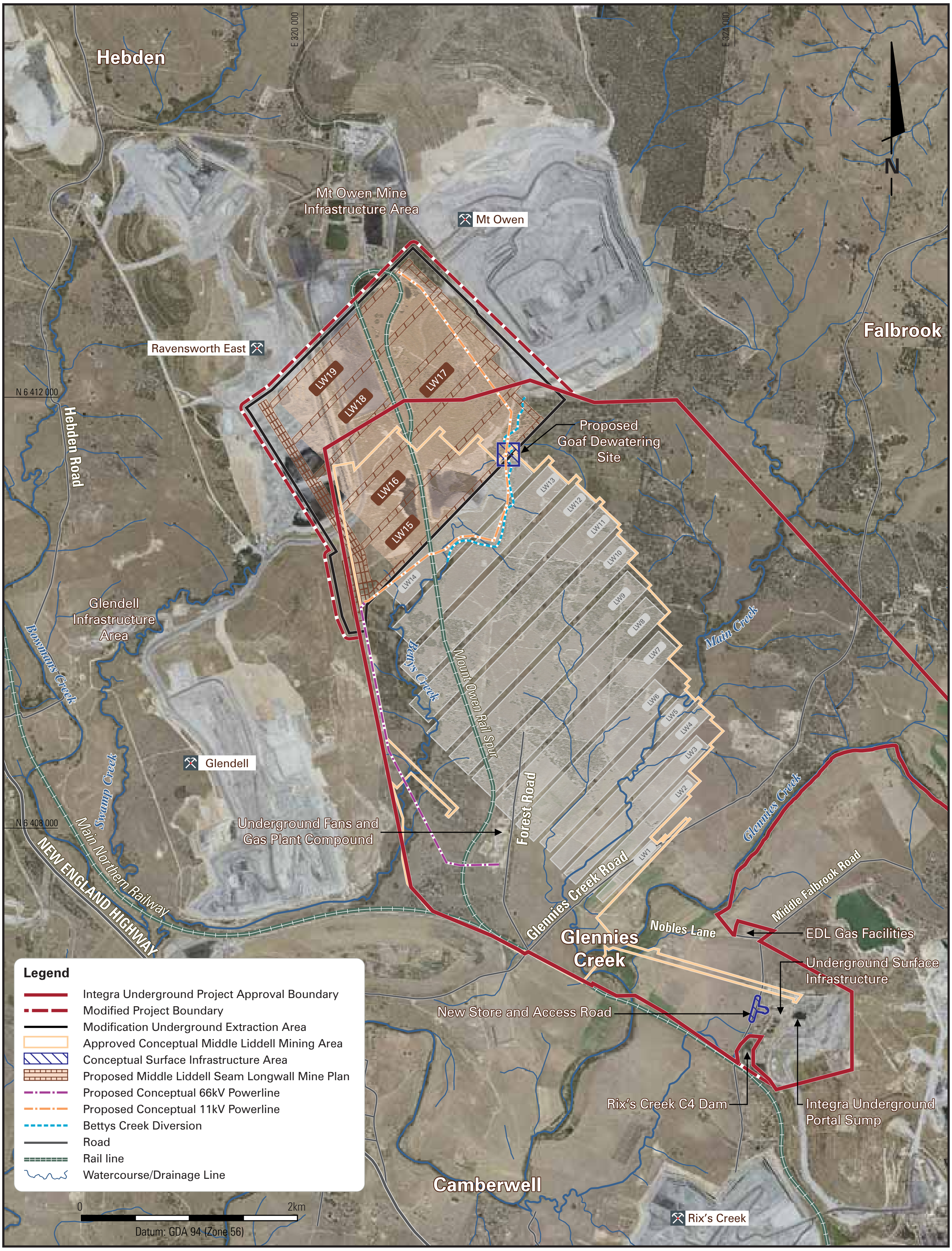
*　　　　　*　　　　　*

for
HANSEN BAILEY

Ross Edwards
Senior Environmental Scientist

James Bailey
Director

FIGURES



INTEGRA UNDERGROUND MINE

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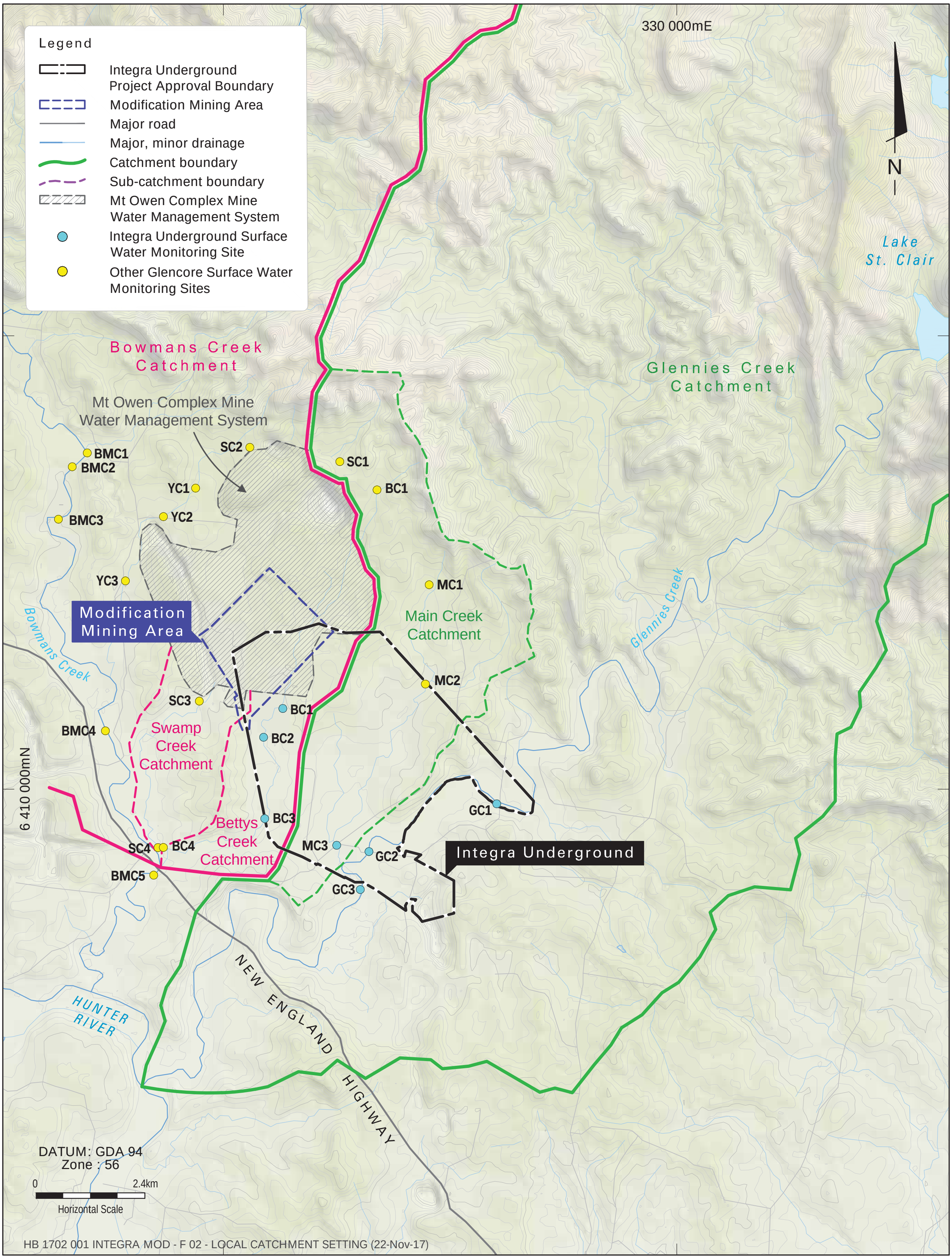
Conceptual Modification Overview

FIGURE 1



INTEGRA UNDERGROUND MINE

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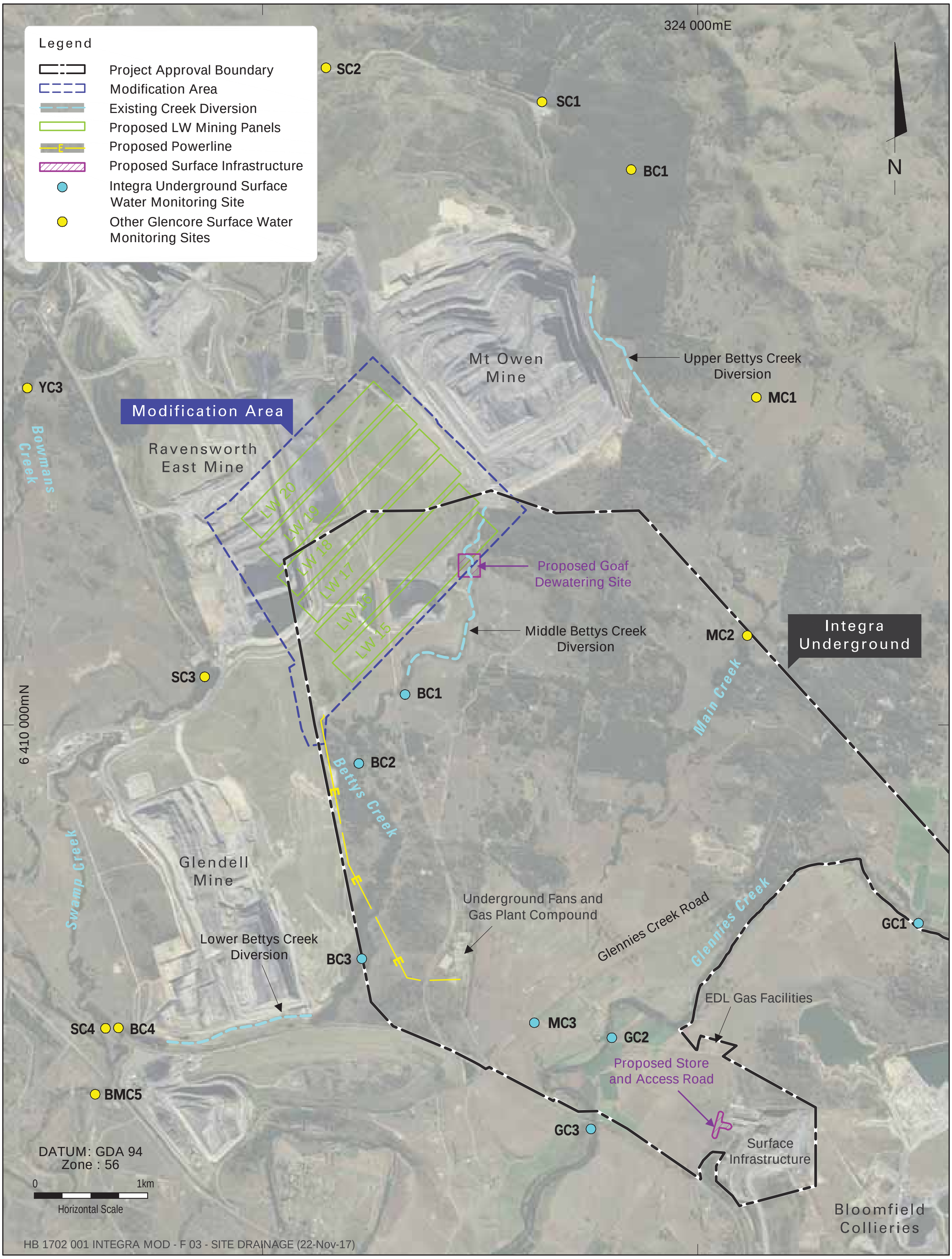
Local Catchment Setting

FIGURE 2



INTEGRA UNDERGROUND MINE

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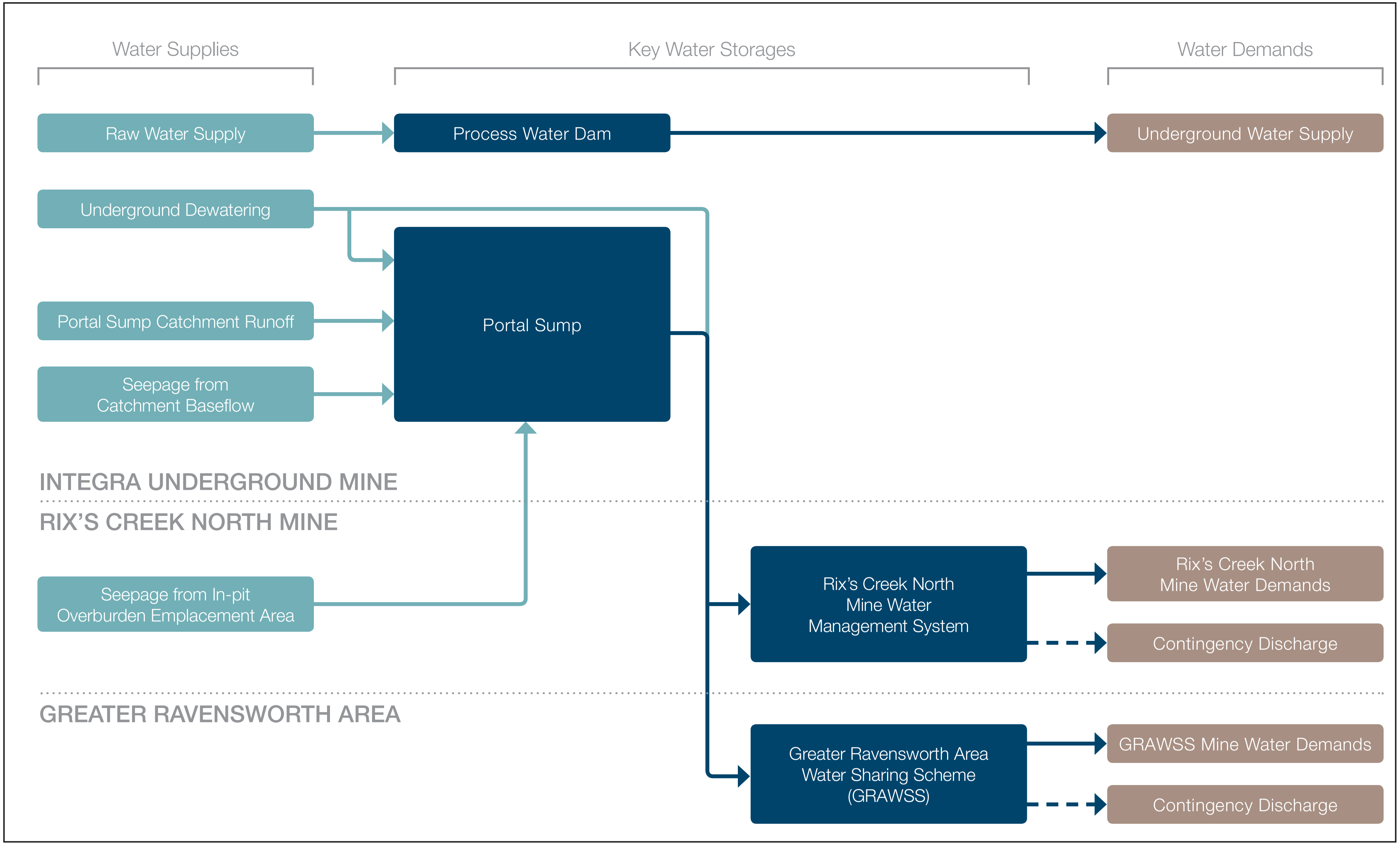
Site Drainage

FIGURE 3



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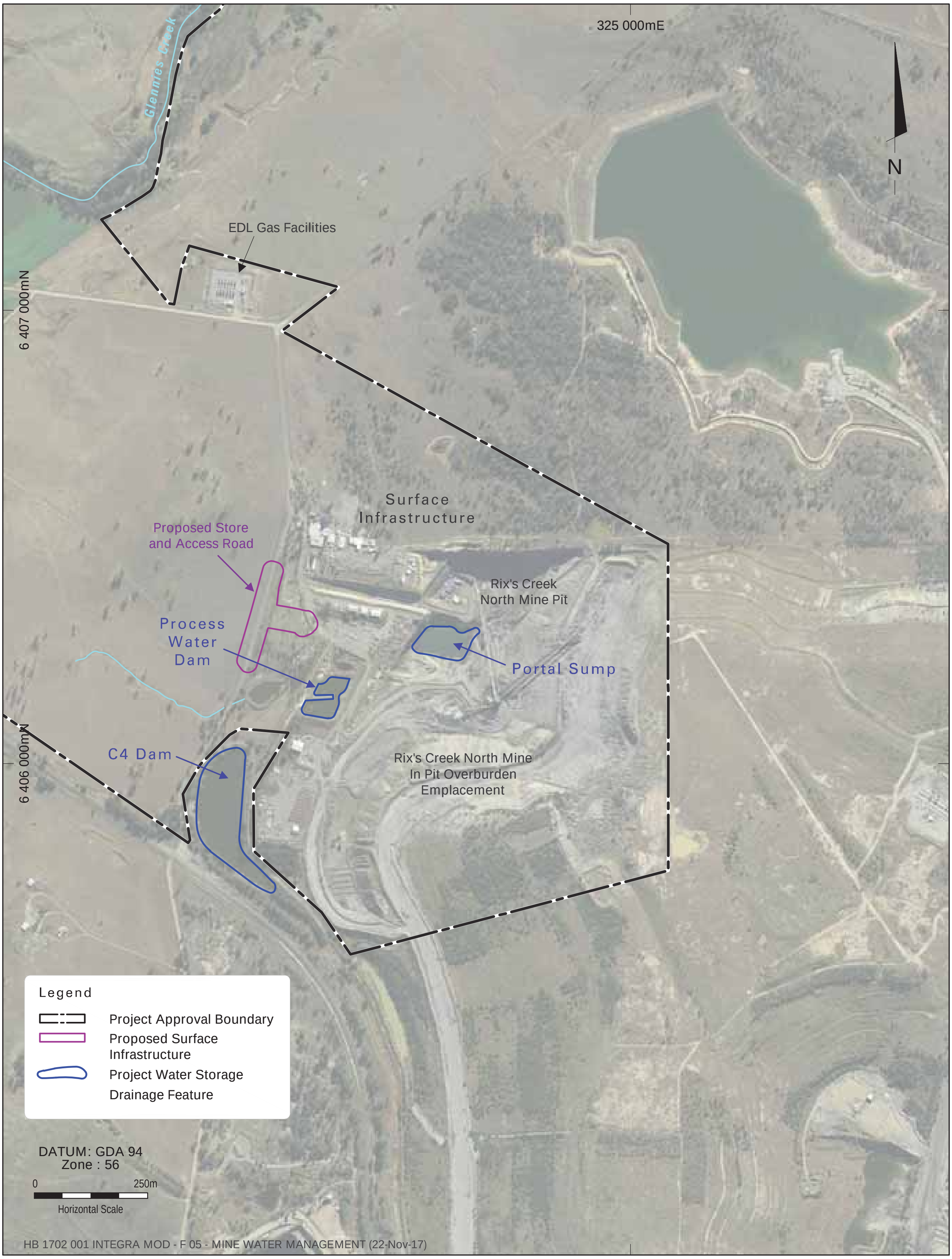
INTEGRA UNDERGROUND MINE

Water Management System Logic

FIGURE 4



INTEGRA UNDERGROUND MINE

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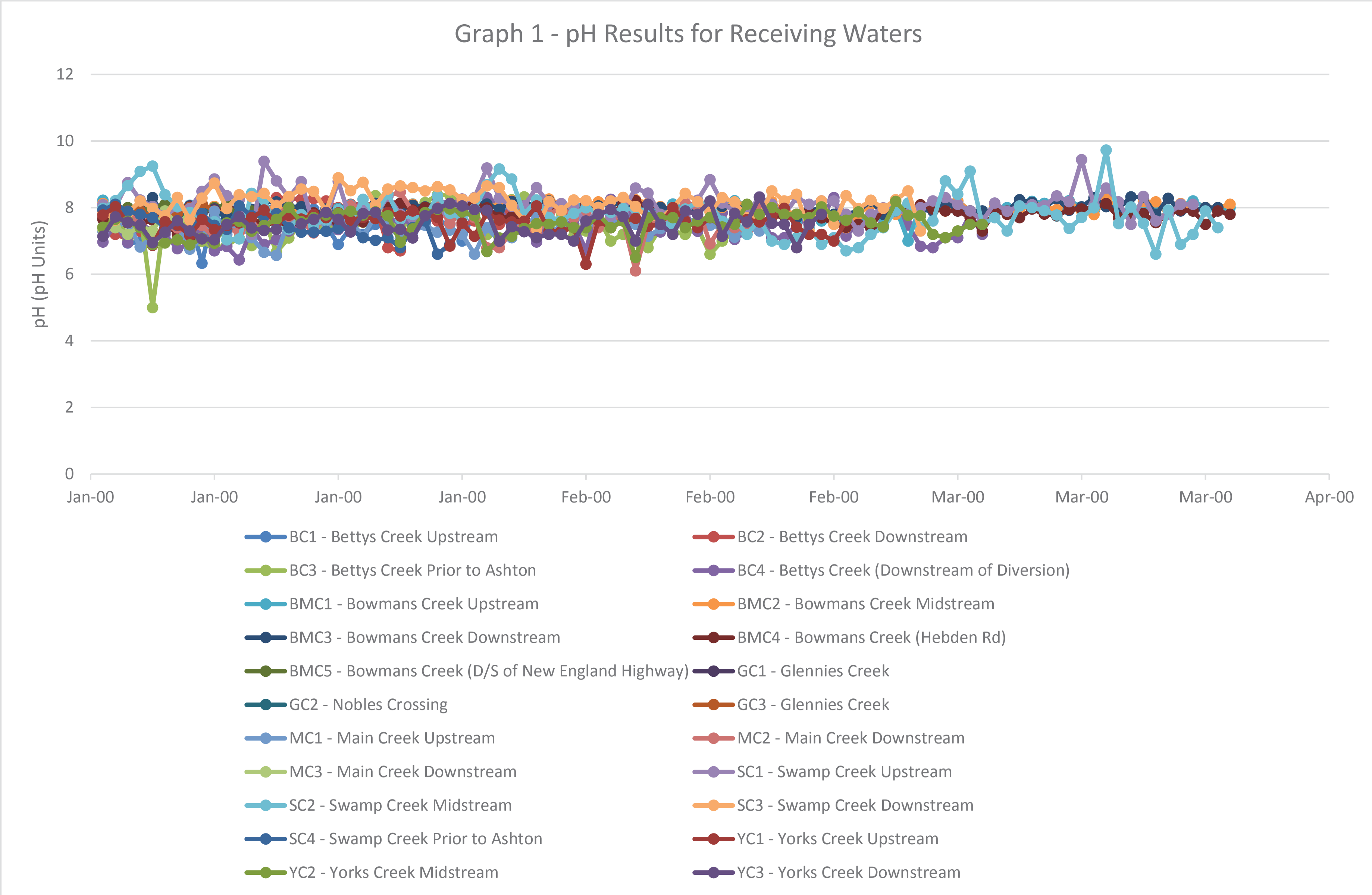
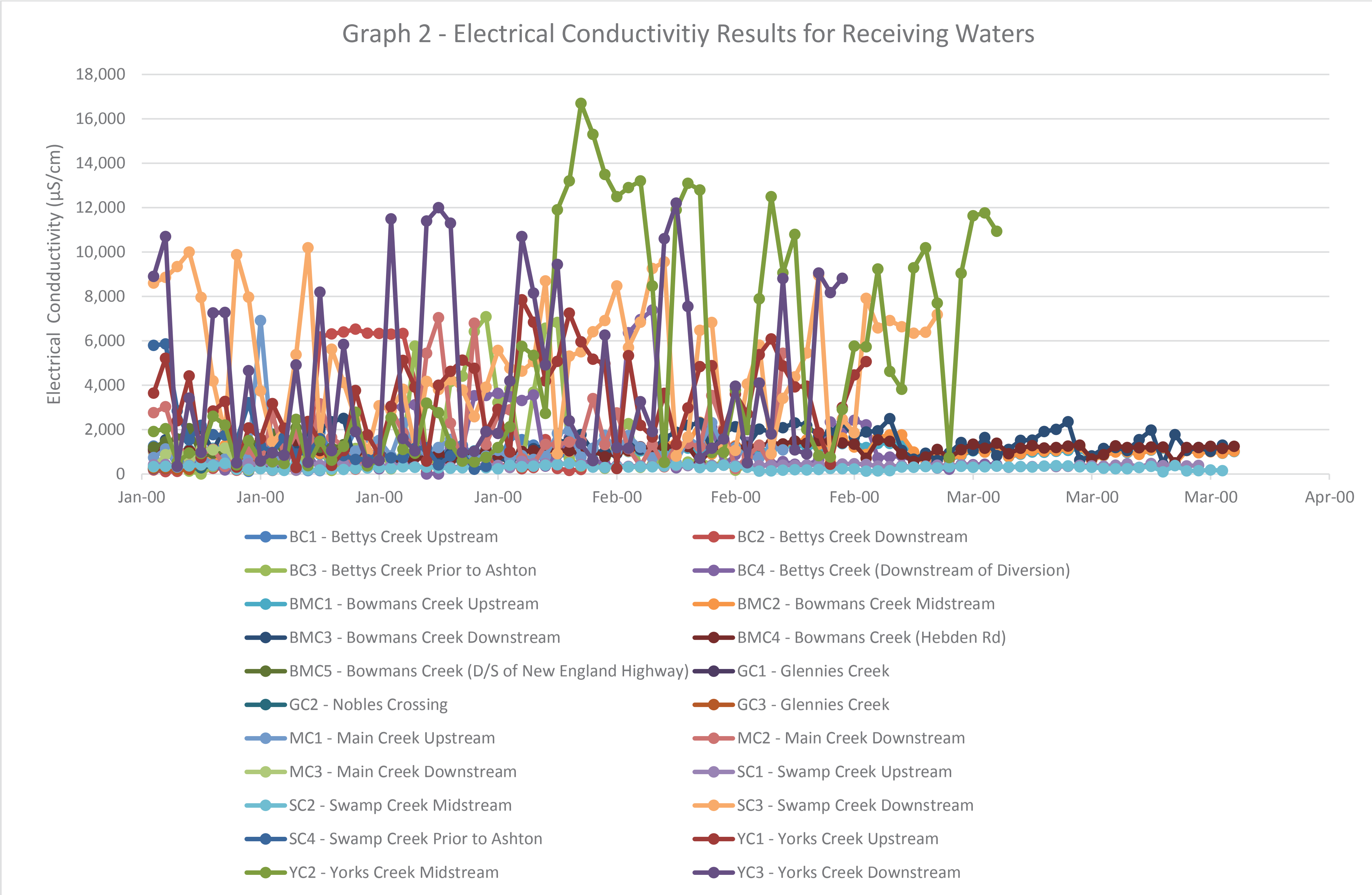
Integra Underground Mine Water Management System Layout

FIGURE 5

GRAPHS


Graph 1 - pH Results for Receiving Waters
pH (pH Units)
0
2
4
6
8
10
12
Jan-00
Jan-00
Jan-00
Jan-00
Feb-00
Feb-00
Feb-00
Mar-00
Mar-00
Mar-00
Apr-00
BC1 - Bettys Creek Upstream
BC2 - Bettys Creek Downstream
BC3 - Bettys Creek Prior to Ashton
BC4 - Bettys Creek (Downstream of Diversion)
BMC1 - Bowmans Creek Upstream
BMC2 - Bowmans Creek Midstream
BMC3 - Bowmans Creek Downstream
BMC4 - Bowmans Creek (Hebden Rd)
BMC5 - Bowmans Creek (D/S of New England Highway)
GC1 - Glennies Creek
GC2 - Nobles Crossing
GC3 - Glennies Creek
MC1 - Main Creek Upstream
MC2 - Main Creek Downstream
MC3 - Main Creek Downstream
SC1 - Swamp Creek Upstream
SC2 - Swamp Creek Midstream
SC3 - Swamp Creek Downstream
SC4 - Swamp Creek Prior to Ashton
YC1 - Yorks Creek Upstream
YC2 - Yorks Creek Midstream
YC3 - Yorks Creek Downstream


Graph 2 - Electrical Conductivitiy Results for Receiving Waters
Electrical Condductivity (µS/cm)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-00
Jan-00
Jan-00
Jan-00
Feb-00
Feb-00
Feb-00
Mar-00
Mar-00
Mar-00
Apr-00
BC1 - Bettys Creek Upstream
BC2 - Bettys Creek Downstream
BC3 - Bettys Creek Prior to Ashton
BC4 - Bettys Creek (Downstream of Diversion)
BMC1 - Bowmans Creek Upstream
BMC2 - Bowmans Creek Midstream
BMC3 - Bowmans Creek Downstream
BMC4 - Bowmans Creek (Hebden Rd)
BMC5 - Bowmans Creek (D/S of New England Highway)
GC1 - Glennies Creek
GC2 - Nobles Crossing
GC3 - Glennies Creek
MC1 - Main Creek Upstream
MC2 - Main Creek Downstream
MC3 - Main Creek Downstream
SC1 - Swamp Creek Upstream
SC2 - Swamp Creek Midstream
SC3 - Swamp Creek Downstream
SC4 - Swamp Creek Prior to Ashton
YC1 - Yorks Creek Upstream
YC2 - Yorks Creek Midstream
YC3 - Yorks Creek Downstream

APPENDIX A

Water Quality Results

Appendix A
Water Quality Results

Table A-1
Summary of pH Results for Receiving Waters

Monitoring Location	Samples	Non-Detects	Minimum	Median	Maximum
BC1 - Bettys Creek Upstream	36	0	6.3	7.6	8.2
BC2 - Bettys Creek Downstream	37	0	6.7	7.7	8.3
BC3 - Bettys Creek Prior to Ashton	52	0	5	7.4	8.4
BC4 - Bettys Creek (Downstream of Diversion)	72	0	6.4	7.5	8.3
BMC1 - Bowmans Creek Upstream	92	0	7	8.0	8.2
BMC2 - Bowmans Creek Midstream	92	0	7.4	8.0	8.3
BMC3 - Bowmans Creek Downstream	91	0	7.5	8.0	8.3
BMC4 - Bowmans Creek (Hebden Rd)	92	0	7.1	7.8	8.2
BMC5 - Bowmans Creek (D/S of New England Highway)	17	0	7.4	7.9	8.1
GC1 - Glennies Creek	10	0	7.6	7.9	8.1
GC2 - Nobles Crossing	10	0	7.6	7.9	8.1
GC3 - Glennies Creek	10	0	7.6	7.9	8.1
MC1 - Main Creek Upstream	54	0	6.6	7.4	8.0
MC2 - Main Creek Downstream	54	0	6.1	7.6	8.5
MC3 - Main Creek Downstream	8	0	7.2	7.4	7.9
SC1 - Swamp Creek Upstream	89	0	7.2	8.1	9.4
SC2 - Swamp Creek Midstream	91	0	6.6	7.8	9.7
SC3 - Swamp Creek Downstream	67	0	7.3	8.2	8.9
SC4 - Swamp Creek Prior to Ashton	29	0	6.6	7.4	8.1
YC1 - Yorks Creek Upstream	61	1	6.3	7.6	8.1
YC2 - Yorks Creek Midstream	72	1	6.5	7.6	8.2
YC3 - Yorks Creek Downstream	58	0	6.8	7.5	8.3

All results presented in pH units and rounded to one decimal place
Results presented for the period 2009 to July 2017 (inclusive)

Table A-2
Summary of Electrical Conductivity Results for Receiving Waters

Monitoring Location	Samples	Non-Detects	Minimum	Median	Maximum
BC1 - Bettys Creek Upstream	36	0	121	904	2,000
BC2 - Bettys Creek Downstream	37	0	103	257	6,530
BC3 - Bettys Creek Prior to Ashton	52	0	4	477	7,090
BC4 - Bettys Creek (Downstream of Diversion)	72	2	178	531	7,390
BMC1 - Bowmans Creek Upstream	92	0	360	1,010	1,410
BMC2 - Bowmans Creek Midstream	92	0	334	1,010	2,340
BMC3 - Bowmans Creek Downstream	91	0	339	1,260	2,510
BMC4 - Bowmans Creek (Hebden Rd)	92	0	503	1,110	1,540
BMC5 - Bowmans Creek (D/S of New England Highway)	17	0	773	1,209	2,080
GC1 - Glennies Creek	10	0	241	297	751
GC2 - Nobles Crossing	10	0	232	307	749
GC3 - Glennies Creek	10	0	207	364	748
MC1 - Main Creek Upstream	54	0	151	868	6,920
MC2 - Main Creek Downstream	54	0	215	1,320	7,040
MC3 - Main Creek Downstream	8	0	328	978	1,247
SC1 - Swamp Creek Upstream	89	0	173	386	567
SC2 - Swamp Creek Midstream	91	0	102	306	500
SC3 - Swamp Creek Downstream	67	0	566	5,070	10,200
SC4 - Swamp Creek Prior to Ashton	29	0	212	969	5,860
YC1 - Yorks Creek Upstream	61	1	252	3,220	7,850
YC2 - Yorks Creek Midstream	72	1	363	2,730	16,700
YC3 - Yorks Creek Downstream	59	0	343	2,400	12,200

All results presented in μS/cm and rounded to the nearest whole number
Results presented for the period 2009 to July 2017 (inclusive)

Table A-3
Summary of Total Suspended Solids Results for Receiving Waters

Monitoring Location	Samples	Non-Detects	Minimum	Median	Maximum
BC1 - Bettys Creek Upstream	36	11	1	10	258
BC2 - Bettys Creek Downstream	37	5	1	12	234
BC3 - Bettys Creek Prior to Ashton	52	5	1	20	382
BC4 - Bettys Creek (Downstream of Diversion)	72	12	5	17	912
BMC1 - Bowmans Creek Upstream	92	34	1	8	100
BMC2 - Bowmans Creek Midstream	92	10	1	13	414
BMC3 - Bowmans Creek Downstream	91	15	1	15	183
BMC4 - Bowmans Creek (Hebden Rd)	92	22	2	11	69
BMC5 - Bowmans Creek (D/S of New England Highway)	17	0	1	6	64
GC1 - Glennies Creek	10	9	16	16	16
GC2 - Nobles Crossing	10	8	8	16	23
GC3 - Glennies Creek	10	4	5	12	14
MC1 - Main Creek Upstream	54	2	6	43	1,060
MC2 - Main Creek Downstream	54	4	2	18	1,990
MC3 - Main Creek Downstream	8	0	2	9	168
SC1 - Swamp Creek Upstream	89	20	2	8	42
SC2 - Swamp Creek Midstream	91	21	2	12	76
SC3 - Swamp Creek Downstream	67	10	5	17	260
SC4 - Swamp Creek Prior to Ashton	29	0	4	19	98
YC1 - Yorks Creek Upstream	61	13	1	12	263
YC2 - Yorks Creek Midstream	72	25	2	10	1,000
YC3 - Yorks Creek Downstream	59	17	2	14	1,030

All results presented in mg/L and rounded to the nearest whole number
Results presented for the period 2009 to July 2017 (inclusive)
Non-detections have been assessed at limit of reporting (i.e. 1 mg/L to 5 mg/L) for summary statistics

Table A-4
Summary of Total Dissolved Solids Results for Receiving Waters

Monitoring Location	Samples	Non-Detects	Minimum	Median	Maximum
BC1 - Bettys Creek Upstream	36	0	228	544	1,040
BC2 - Bettys Creek Downstream	37	0	141	313	4,380
BC3 - Bettys Creek Prior to Ashton	52	0	2	460	4,990
BC4 - Bettys Creek (Downstream of Diversion)	72	2	181	455	4,930
BMC1 - Bowmans Creek Upstream	92	0	292	557	843
BMC2 - Bowmans Creek Midstream	92	0	216	587	1,450
BMC3 - Bowmans Creek Downstream	91	0	208	733	1,610
BMC4 - Bowmans Creek (Hebden Rd)	92	0	304	625	861
BMC5 - Bowmans Creek (D/S of New England Highway)	17	0	469	740	1,300
GC1 - Glennies Creek	10	7	172	195	242
GC2 - Nobles Crossing	10	7	172	216	253
GC3 - Glennies Creek	10	2	123	272	398
MC1 - Main Creek Upstream	54	0	157	698	3,930
MC2 - Main Creek Downstream	54	0	180	807	4,170
MC3 - Main Creek Downstream	8	0	294	638	732
SC1 - Swamp Creek Upstream	89	0	164	232	710
SC2 - Swamp Creek Midstream	91	0	136	211	497
SC3 - Swamp Creek Downstream	67	0	486	3,200	6,570
SC4 - Swamp Creek Prior to Ashton	29	0	257	707	3,670
YC1 - Yorks Creek Upstream	61	1	308	1,890	4,600
YC2 - Yorks Creek Midstream	72	1	252	1,590	9,900
YC3 - Yorks Creek Downstream	59	0	320	1,570	7,790

All results presented in mg/L and rounded to the nearest whole number
Results presented for the period 2009 to July 2017 (inclusive)

Table A-5
Summary of Water Quality Results for the Portal Sump

Monitoring Parameter	Samples	Non-Detects	Minimum	Median	Maximum
pH (pH unit)	67	0	7.1	7.7	8.5
Electrical Conductivity (µS/cm)	67	0	1,590	8,620	9,800
Total Dissolved Solids	67	0	831	5,200	6,090
Total Hardness as CaCO3	67	14	101	854	1,080
Dissolved Calcium	67	8	14	96	187
Dissolved Magnesium	67	8	16	142	191
Dissolved Sodium	67	8	296	1,700	2,240
Dissolved Potassium	67	8	4	14	25
Dissolved Chloride	67	63	771	1,540	1,720
Silicon as SiO2	67	8	4	13	17
Sulfate as SO4	67	15	14	1,165	1,780
Total Petroleum Hydrocarbons (µg/L)	67	59	140	2,125	73,520
Biochemical Oxygen Demand	67	55	3	6	39
E. coli (CFU/100mL)	67	66	280	280	280
Enterococci sp. (CFU/mL)	67	57	1	73	220
Thermotolerant Coliforms (CFU/100mL)	67	67	0	0	0
Total Iron	67	11	0.07	0.4	4
Total Alkalinity as CaCO3	67	8	208	932	1,160
Free Chlorine	67	15	274	1,480	2,440
Sodium Adsorption Ratio	67	9	11	25	38
Total Phosphorus as P	67	63	0.02	0.1	0.2

All results presented in mg/L and rounded to the nearest whole number unless otherwise stated
Results presented for the period 2012 to July 2017 (inclusive)