WHITE WELL GOLD PROJECT

SURFACE WATER ASSESSMENT

Prepared for

MSP ENGINEERING

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1 INTRODUCTION

1.1 Background

MSP Engineering is assisting Lake Austin Mining Pty Ltd with pre-development planning of an open cut mine and processing operations at the White Well Gold Project. The site is located approximately 30km east of the town of Cue (refer Figures 1 and 2). Cue is a gold mining and pastoral support centre for the surrounding region, located 650km north east of Perth in the Shire of Cue. The land is used mostly for stock grazing on pastoral leases, and is typically vegetated with mallee scrub. Other land uses include prospecting and mining explorations.

The existing mine site comprises an open pit and waste dump. It is planned to expand both of these facilities, along with a new waste dump, tails storage facility, ROM pad and processing facilities (refer Figure 3).

The proposed pit will involve the expansion of the existing pit by free-digging ore to a depth of around RL390m, i.e. around 90m below current ex-pit ground levels and trucking ore concentrate to Tuckabianna for processing.

1.2 Scope of Services

As part of the planning and approvals process, comments have been received from the DMP concerning additional information with respect to surface water aspects of the development.

This report is a desktop surface water study to assess the options and requirements for surface water management at the proposed infrastructure areas. The objective is to develop relevant surface water scenarios, and provide preliminary information on hydraulic and engineering parameters associated with surface water management features.

The report addresses the following:

- Definition and description of the impacting project area surface water catchments;
- Description of the surface hydrology of the project area and downstream environment;
- Discussion of the surface water quality characteristics (where information is available);
- A description of the flooding characteristics of the area;
- Diversion drain assessment including peak flow rates (20, 50, 100 and PMP), flow velocities and erosion potential;
- Abandonment bund assessment with respect to location outside the potential zone of instability, potential ponding issues (trapped low points) around the bund and the feasibility of diverting trapped areas away from the pit crest;
- Drainage management for the haul roads and diversion channels, to minimize environmental impacts;
- Discussion of potential for dust suppression water to contaminate soil, groundwater and surface water.

2 HYDROLOGY

2.1 Climate Zones

Western Australia has three broad climate divisions. The northern part has a dry tropical climate, generally receiving summer rainfall in a wet season lasting from December to March. The south-west corner has a Mediterranean climate, with long, hot summers and mild wet winters.

The remaining areas are typically arid land or desert climates. The project area is located in the arid areas in the Murchison – East Gascoyne region of the State.

2.2 Temperature

The region has an extreme temperature range, up to around 45 degrees Celsius (°C) during the summer, and dropping to around 0°C in winter (Bureau of Meteorology climate station at Cue - Site Number 007017). Mean monthly maximum temperatures at Cue range from 38°C in January to 18°C in July, while mean monthly minimum temperatures range from 23°C in January to 7°C in July (BOM, 2016).

2.3 Rainfall

The nearest rainfall gauging station (BOM) is also at Cue. The annual average rainfall is 235mm (1895 to 2016). Variability is high with recorded annual rainfall varying between 73mm (1940) and 558mm (1975). Annual average rainfall at Meekatharra (110km north-east) is similar at 239mm.

Generally, the wet months are January to March when thunderstorms can produce heavy localised falls in short periods. February is typically the wettest month with an average rainfall of 29mm. Tropical lows or weakening tropical cyclones can sometimes bring widespread rain. The highest daily rainfall recorded was 119mm on 22 February 1975.

2.4 Rainfall Intensity

Intensity-Frequency-Duration (IFD) data is required to characterise the storm intensities in the area under consideration. IFDs are generally provided by techniques in ARR (Australian Rainfall and Runoff, Institution of Engineers, 1987).

The IFD data is characterised by the 2 year and 50 year ARI rainfall intensities (from which other intensities are derived). By way of example, the 2 year ARI rainfall intensity for the White Well area is 16mm in 1 hour, 34mm in 12 hours, and 50mm in 72 hours. The corresponding 50 year ARI rainfall intensities are 38mm, 95mm and 158mm respectively. The 100 year rainfall intensities are 43mm, 112mm and 187mm.

New IFD design rainfalls have been produced as part of an ARR revision project, typically about 0-15% greater at this site.

Information on storms exceeding the 100 year ARI event is not available in ARR, but by extrapolation, approximate estimates can be made as follows:

- 1,000 year ARI rainfall - 155mm (12hrs) and 290mm (72 hrs);
- Probable Maximum Precipitation - 290mm (12hrs) and 450-500mm (72 hour).

2.5 Evaporation

The mean annual Class A pan evaporation rate at Meekatharra is 4,068mm (Department of Agriculture, 1987). The monthly average evaporation rates at Meekatharra vary between 135mm in June (4.5mm/day) and 585mm in January (18.9mm/day).

3 EXISTING ENVIRONMENT

3.1 Regional Surface Water Hydrology

The proposed project is located within the Murchison River catchment, and more locally within the Lake Austin sub-catchment (Lake Austin is about 30km south west). The general direction of surface flow is north and then north-westerly towards Nallan Creek, 25km away. Nallan Creek is around 45km long, and drains into the north east end of Lake Austin.

Stream flow in the region correlates with rainfall. The smaller flow channels typically flow for a short duration, and cease soon after rainfall passes. In the larger river channels which drain the larger catchments, runoff can persist for much longer following major rainfall events. Average annual volumetric runoff is expected to be about 3-4% of average rainfall.

3.2 Flooding Characteristics of the Area

The project area is impacted from the south by a catchment of approximately 6.4km2. The local flowpaths (at the head of the catchment) have relatively steep average bed gradients of around 1%, and drain mainly in a north direction towards the mining area. The water courses typically do not have incised creek beds, but a shallow sheet flow regime typically prevails.

The general direction of local surface flow is northerly through the site, before turning in a north-westerly direction towards Nallan Creek.

3.3 Flood Estimation Methods

The relevant surface water catchments impacting the mine are shown on Figure 4. There is no readily available stream flow gauging data in this area upon which flood estimates may be made directly. Peak stream flow discharges from ungauged catchments can be estimated using empirical techniques (such as the new ARR "RFFE 2015 MODEL" recommended in ARR). "RAFTS" was also used to estimate flows:

- RAFTS is a nonlinear rainfall / runoff program, using design rainfall data derived from ARR (or actual storm events). The program calculates flood flows (hydrographs) by simulating rainfall over a catchment with time, removing losses to calculate the rainfall excess runoff, and then routing this runoff through the model reaches. The catchment area of interest was divided into sub-catchments with routing links between. The RAFTS 'pern' or surface roughness factor affects the storage factor and was set at 0.045. The older 1987 IFD data was used as existing inputs to the model has been previously calibrated using this data;
- The "RFFE 2015 Model" requires the region name (Pilbara), Region code (6), and latitude / longitude at the catchment centroid and outlet (27.402 deg / 118.182 deg and 27.386 deg / 118.192deg respectively). This model uses the newer IFD data. However the distance of the nearest gauged catchment in the database is 366km away and ARR warns "Results have lower accuracy and may not be directly applicable in practice".

3.4 Flood Estimates

At the downstream end of the site, the 10 year flow was estimated as 1.5m^3/s and 3m^3/s in RAFTS and the RFFE 2015 Model respectively. The 100 year flows were estimated as 8m^3/s by each model. Both outputs were therefore similar, but the RAFTS outputs were generally preferred as the model requires customising for each application, and is considered more accurate than generic catchment calculations that are based on correlating data for a number of catchments.

On this basis, the adopted flows are shown in Table 1.

Table 1: Estimated Peak Flows (6.4km^2 Catchment)

Average Recurrence Interval (years)	Flow (m^3/s)
2	0.2
5	0.7
10	1.5
20	3
50	5
100	8
1,000	17
10,000	28
100,000	41
PMP	56

As a general guide, the 20, 50, 100 and PMF peak flow rates may be estimated as a percentage of the 100 year flow as follows:

- 20 year AR flow 38%;
- 50 year AR flow 63%;
- 100 year AR flow 100%;
- PMF 8 x 100 year AR flow.

3.5 Existing Surface Water Quality

There is no published water quality data for the project area. However, consistent with surface water quality in other catchments following rainfall events, it is expected that surface water run-off would generally be of non-saline quality, though turbid.

4 SURFACE WATER MANAGEMENT IN OPERATIONAL PIT

4.1 General

The 6km x 1.5km tenement area has elevations ranging from about RL515m on the south side to RL475m at the north end. The proposed pit will be about 1km long, along a shallow drainage, and up to about 200m wide. The pit will be impacted by shallow sheet flow from the south. Various options to manage the water course are discussed below as follows:

- Managing the creek through the pit;
- Creek diversions (west and east, excavated trapezoidal channels around pit);
- Flood retention structure upstream of pit;
- External catchment flows into pit.

4.2 Managing the Creek through the Pit

This option would require the pit to be partially or fully backfilled to the surface as part of pit staging, allowing the watercourse to be diverted and re-diverted as required across (a) the undisturbed areas and then (b) the backfill areas. However the long narrow footprint of the pit in the direction of flow precludes this option.

4.3 Creek Diversions (Excavated Trapezoidal Channel around Pit)

This option (Figure 5) consists of two diversions routing the upstream impacting catchment around each side of the pit.

The eastern diversion consists of a channel excavation along the eastern side of the operational pit bund, routing the upstream impacting catchment, cutting off impacting flows from the eastern side, and directing them to the north.

The western diversion consists of a diversion routing the upstream impacting catchment around the west side of the pit, cutting off impacting flows from the western side, and directing them to the north.

4.4 Flood Retention Structure

This option consists of a flood retention structure to protect the pit from floods by storing flood water upstream. The retention structure would consist of an embankment up-gradient of the pit. The required embankment fill volumes could be formed mainly of waste materials.

In the flat terrain, upstream catchments would be diverted across to the embankment. The dam embankment would include a spillway (on natural ground at one end). The capacity of the dam below the spillway invert would match the design volume of the flood event. Spillway overflows would enter the pit and need to be addressed in the mine plan. The design storage capacity would be designed to account for the life of the pit, the cost of the retention structure, and the cost of pit pump out and mining delays should the retention structure spill and water enter the pit, etc.

Water retained would evaporate, infiltrate into the groundwater and seep into the pit, be used opportunistically at the site, or be disposed of.

4.5 Allow External Catchments to Flow into the Pit

4.5.1 General

The pit stormwater management system and flood storage capacity should ideally accommodate the 100 year ARI 72 hour rainfall event (a common industry practice). Durations <72 hours result in lower total inflow volumes, and durations >72 hours have reduced rainfall intensity, and an inflow rate which would typically allow adequate time to mount a dewatering response to remove flood water.

The design 100 year 72 hour rain event in this location is about 190mm. The 10 year ARI 72 hour rain event is about 100mm, and the 2 Year event about 50mm.

The probability that a 100 year ARI event would occur during a 10 year mine life is about 10%, so there is a 90% chance that a storm of this severity would not occur within the mine life. There is a 63% chance that the 10 year event would occur within the mine life.

Typically the pit shell will store any surface water inflows, but the impact that the flood water has on mining largely depends on the provisions made for flood storage. Flooded plant and equipment or production loss due to a flooded mining face may be critical. General mine stormwater management strategies include ascertaining flood storage requirements for every stage of pit development, setting aside areas and prior workings in the lower parts of the pit to ensure that sufficient flood storage capacity is available to minimise disruption risk to operations (while leaving some upper mine areas available for work in the event of flooding).

4.5.2 Pit Footprint Only

The final pit outline (direct rain catchment) is 21ha, and the flood volume would therefore be in the order of 12,000m^3 for a 10 year rain event. This water could be removed in 1 week @ 20L/s pump out rate, by way of example. The 100 year flood volume would be about 25,000m^3 with pump out times of 2 weeks @ 20L/s. The volume of water that accumulates in the pit is managed by dewatering equipment within the pit and the volume increases as the pit staging unfolds i.e. as the pit gets bigger. A pit base can potentially have more than one low point at any point in time, where water would separately pond.

4.5.3 Pit Footprint Plus External Catchments

If most external catchments (say 6km^2) are directed to run into the pit from the east, the surface water catchment increases to 620ha, and the 10 year flood volume would then be in the order of 350,00m^3. This water could be removed in 2.6 months @ 50L/s, or about 1.3 months @ 100L/s.

The 100 year flood volume would be about 750,000m^3 with pump out time 6 months @ 50L/s and 3 months @ 100L/s.

4.6 Summary of Pit Options

Managing the creek through the narrow pit is not practical. The flood retention structure has the disadvantage that water would need to be stored upstream of the pit (with potential seepage and pit slope stability and safety issues downstream) and also leaves a significant catchment downstream unprotected.

Allowing external water to enter the pit (where it will be dewatered), along with the associated wet season pit management measures is economic in terms of capital expenditure (i.e. no external surface water protection works required), but the relatively large catchment cut off may generate large volumes of water into the pit, with possible geotechnical issues and loss of production during pump out times.

It is therefore proposed that once the water courses have been cut off by the development of the pit, both the eastern and western diversions be adopted. It is noted that relatively minor channels are required.

5 SURFACE WATER MANAGEMENT – GENERAL

5.1 General

General surface water management (refer to Figures 3 and 4) includes:

- A pre-existing 300m long pit exists in the shallow valley, with water diverted around the east side, and an existing waste dump lies on the western side of the valley;
- The proposed pit down the centre of the valley along the flow path will subsume the existing pit. A flow diversion around the west and east sides of the pit is proposed;
- The proposed waste dump is located on the east side of the valley, on slightly higher ground. The dump will generally drain west towards the pit, and east towards the tenement boundary. It is also noted that the waste dump footprint has a trapped low point on its south-east side, this part of the dump will need to be managed to allow water through the footprint until the TSF is built (and this problem is eliminated);
- The tails storage facility (TSF) is located in the south-east corner of the dump, on gently sloping ground draining towards the waste dump. Run-off from the external surfaces of the TSF will be trapped at the dump face;
- Topsoil stockpile storage is located at the north end of the site, across the valley drainage path. It is recommended that this storage be moved away from the main drainage path (as shown on Figure 5);
- The main infrastructure (ROM, process plant, laydown area, admin area, process water pond) will be located on the eastern side of the valley and generally drain towards the pit. A diversion (channel and bund combination) across the south end of the site will divert upstream catchments away from this infrastructure and into the main water course through the site. Upstream sheet run-off will be diverted with minor bund / channel diversions;
- A haul road will run between the pit and the waste dump over about 1.5km, accessing the pit and waste dump at several ramp locations, and connecting to the ROM pad. The haul road is located just outside the proposed pit bund;
- The magazine and explosive facility is located on the western side of the valley near the existing waste dump. Minor bunding will divert external sheet run-off around.

5.2 Water Quality and Dust Suppression

Salinity is the measure of total mineral constituents or dissolved salt (TDS) in water. Water resources are classified as fresh, marginal, brackish or saline on the basis of TDS as follows:

- Fresh (good quality) <500mg/L;
- Marginal 500-1,500mg/L;
- Brackish 1,500-5,000mg/L;
- Saline >5,000mg/L.

Groundwater in the region is 'stock quality' water suitable for mining and pastoral activities. The desirable maximum concentration of TDS for sheep is about 5,000mg/L and beef cattle 4,000mg/L. Groundwater salinity (refer "Groundwater Investigations in Palaeo-valleys in the Murchison Region", Pauline English, AusGeo News, March 2013) ranges from fresh to highly saline, 650–130,000mg/L TDS. Some potable supplies are present, and the Water Corporation supplies water to Cue township via bores. At the other extreme, hypersaline groundwater was found at >100m depth down-gradient from Lake Annean (45km north of the White Well mine) indicating leakage from the evaporatively concentrated playa lake brine pool (in contrast to Lake Austin 35km south of the mine where this leakage did not occur).

Typically however, water quality was mostly in the 1,100–4,600mg/L range. The water quality at the mine site is reported to be <5000mg/L (i.e. "brackish").

It is considered that there is no risk to local non-saline drainages and vegetation degeneration in using brackish water for dust control on roads; and no potential to contaminate the soil, groundwater and surface water. Regular water quality testing of the water supply will be undertaken and water would not be used on the roads if it was saline.

6 DIVERSIONS

6.1 Typical Surface Water Diversions

Infrastructure should lie outside 100 year ARI floodplains where possible. However, when there is interruption to existing surface water flow patterns, surface water diversion can be required. Diversion structures carry flood waters via a flow path different from the natural water course, back into the original water course at a point downstream, or another water course (less desirable).

Diversions consist of earth bunds and excavated channels, built with an appropriate freeboard (e.g. 1-2m when protecting a pit). They are generally constructed using cut-to-fill (by excavating the channel on the upstream side as fill for the bund on the downstream side).

There are no strict criteria for selecting the level of flood protection. One criterion is to allow a probability of exceedance of 20% over the LOM. For a 10 year mine life, a 40-50 year ARI level of protection is therefore suggested. A 100 year protection level has a 10% chance of being exceeded. Aside from direct flooding issues, the 5-10 year flow event is suitable for collection diversions to direct runoff to sedimentation basins.

Earth flood bunds typically consist of a trapezoidal shaped mound with side batters of 1V:2.5-3H. If excess material is available, the batters can be flattened for further stability. The bund crest width should be commensurate with the height of the bund and impacting flows, generally wider with increased height.

Excavated open (trapezoidal) diversion channels typically have side batters of 1V:2H.

6.2 West Operational Diversion

This diversion (Figure 5 can consist of a cut-to-fill operation with a combination channel and bund as follows (dimensions assume a fully excavated channel with the pit bund acting as free board):

- Impacting catchment 3.6km^2;
- Flow 4.5m^3/s (100 year ARI);
- Average longitudinal grade 0.5%, channel base width 4m,
- Flow depth 0.75m, velocity 1.2m/s.

6.3 East Operational Diversion

As for the west diversion, the east operational diversion (Figure 5) is characterised as follows:

- Impacting catchment 1.8km^2;
- Flow 2.3m^3/s (100 year ARI);
- Average longitudinal grade 0.5%, channel base width 2m;
- Flow depth 0.6m, velocity 1.0m/s.

6.4 South Diversion

This operational diversion (Figure 5) is located to the south of the site and protects mine infrastructure from sheet flow from above. Nominally, this diversion will consist of a combination channel and bund, as follows:

- Impacting catchment 1.3km²;
- Flow 1.6m³/s (100 year ARI);
- Average longitudinal grade 0.5%;
- Flow depth 0.5m, channel base width 3m, velocity 0.8m/s on a channel;
- Flow depth 0.3m, velocity 0.5m/s against a bund.

6.5 Flood Bund Materials

Earth flood bunds should be built to an engineering specification using competent materials and soil materials should be characterised to ensure suitability. Embankments are typically watertight construction for stability reasons, and are commonly homogeneous (i.e. not zoned). Generally the most suitable materials available at the site are used (selected mine waste, or other excavations). The materials should contain 20-30% clay and rocks <75mm size.

By comparison, an abandonment bund preferentially consists of freely draining rockfill.

6.6 Erosion Protection

If bund or channel materials are loose or disturbed (such as uncompacted and loose fine-grained materials), the critical shear stress would be (a very low) ~5-10Pa.

If the bund or channel materials are compacted in an engineering manner, then the critical shear stress increases greatly to about 60-80Pa (for fine-grained / sandy clay material), and materials are far more erosion resistant.

In velocity terms, maximum velocities before scour would occur in unprotected soils is about 1.2-2m/s for clays, up to about 1.5m/s for sand, and higher for rocky material. If the channel soil has good vegetative cover, the permissible velocity can be increased.

If materials used for surface water diversions are fine-grained and potentially dispersive, then compaction should be provided for all surfaces exposed to flows.

Generally, it is not considered necessary to rock armour an operational embankment or channel against velocities of up to 2m/s for the design event (although this is subject to operational experience and additional armour can be applied as required).

For a closure operational embankment (abandonment bund), then the bund materials should comprise sufficient rock armour and toe protection to provide erosion resistance in the PMF flows. Permanent closure channels should be avoided, but if required should consist of oversize rock armour.

By comparison, an abandonment bund preferentially consists of freely draining rockfill.

7 EROSION AND RUNOFF

7.1 General Principles

The landscape can be subject to heavy rainfall, with the risk of erosion and sedimentation on disturbed or degraded lands. The potential for erosion and sedimentation offsite is increased by vegetation and topsoil removal, mining activities, spoil stockpiling and general construction activities, generating coarse and suspended sediment that can adversely affect water quality and ecological systems downstream.

Generally environmental approvals for projects that involve land disturbance require adherence to surface water protection principles. The general objective for hydrological processes is to maintain the hydrological regimes of surface water to protect existing and potential uses, and maintain ecosystems.

7.2 Potential Surface Water Impacts

The main surface water impacts relate to sediment laden run-off from waste dumps and stockpiles. General surface water impacts include the interruption to surface water flow patterns and reduction of surface water runoff volume or water quality in the environment downstream - these can potentially have an impact on downstream dependent vegetation communities.

The storage and spillage of chemicals and hydrocarbons can also adversely impact water quality downstream. The pooling of water and growth of invasive vegetation in low-lying areas should also be eliminated.

7.3 Mitigation of Impacts

Engineering surface water controls should be assessed for each sub-catchment / drainage area to prevent sediment (and other contaminants) from entering natural flow paths. Surface water management includes diversion and dispersion mechanisms, and erosion & sedimentation controls (i.e. sediment basins). Potential mitigation measures include:

- Construction on or near natural flow paths planned for the dry season where practicable;
- Limiting clearing, retaining adequate buffer zones between disturbed areas and natural drainage lines;
- Diversion of surface water flows around structures, into water courses downstream;
- Prevention of clean water mixing with disturbed, dirty runoff;
- Minimisation of disturbance due to vehicle movements, use existing tracks;
- Dishing of waste to landforms in the centre, to dissipate runoff by evaporation and seepage, and to reduce runoff and erosion down the batter faces. Appropriate batter slopes, contour drains, etc. to provide effective water management;
- Storage of chemicals, hydrocarbons, etc. away from, or bunded off from, external surface water flows;
- Roads constructed with a camber and table drains with regular ‘turnouts’ to discharge the water into the surrounds. Roads and earthworks induce erosion because they concentrate external overland flow, as well as from rain falling directly on the road surface. Haul roads catch surface

run-off at the safety bunds which is then released at strategic points through the bunds and into the environment;

- The capture of all sediment laden surface water runoff from any disturbed (operational) area (stockpiles, roads, process areas). Run-off is captured by bunding the perimeter of infrastructure areas and directly to sedimentation basins;
- The placement of sedimentation basins downstream of all disturbed areas.

8 SEDIMENTATION BASINS

8.1 General

Sediment basins are located at low points (Figure 5) and constructed by forming earth bunds. Specific consideration can be given to discharge water quality (an 'outcome based' criterion is indicated in Figure 6, for example), but typically only target particle size and design inflow are used for sizing.

A basin can typically consist of one of two forms;

- Dam-like structures located downstream, each commanding larger areas of the site prior to discharge. These consist of embankments (across an existing water course) and forming a storage area upstream (refer Figure 7 and 8). They typically collect more clean run-off than would otherwise be the case, but the larger surface area required is usually readily attained;
- Smaller more localised rectangular "turkeys nest" type of structure (refer Figure 9) for specific facilities not otherwise protected, targeting the collection of dirty water runoff only.

A basin has a permanent pool settling zone above, and a sediment storage zone below, each with a minimum depth typically of 0.6m (overall 1.2m).

The inlet and discharge points are at opposite ends of the basin to prevent flow short-circuiting, with a minimum aspect ratio of 3:1 (length: width) recommended. Internal baffles can be used to increase the flow path and distribute dirty water through the basin to increase retention time and treatment of the water.

The basin may be configured as a wet or dry basin:

- A dry basin (refer Figure 7) is preferred and drains through a 'control' outlet (such as an overflow pit / pipe system). Captured water discharges downstream over a day or so, and the basin is therefore normally dry. Flood flows pass through the basin and over a spillway;
- A wet basin (refer Figure 8) does not have a 'control' outlet, hence the basin is normally full. Water is contained within the trap, and remains there to slowly infiltrate and evaporate (or be used on site). A spillway passes flood flows downstream.

The capacity of the emergency spillway depends on how long the basin is required, but for a longer term basin is typically the 100 year ARI capacity. Where practical, the spillway should be excavated through natural ground (bypassing the main dam structure, Figure 7 and 8), reducing scour protection requirements. Water spilling over the containing embankment itself requires more formal methods of scour protection, as shown in Figure 9 for example.

8.2 Sizing of Sedimentation Basins

Water quality capture and treatment devices are not expected to treat all flow, but rather focus on smaller more frequent run-off events. The surface area at the top water level in the basin is designed to match the settling velocity of the target particle size with the rate of flow (based on the duration and ARI of the storm considered). The target particle size can be based on the particular sediment characteristics of the site, but is typically silt size (2 - 60um) – larger particles are assumed to be captured in the pond, while smaller particles mostly stay in suspension and wash out of the basin.

The pond surface area increases rapidly as the target particle size become smaller. 100% capture of fine silt requires 45,000m^2 top surface water area per m^3/s of design inflow. Medium silt requires 4,100m^2 per m^3/s, and coarse silt 450m^2 per m^3/s.

Mine sites consist of large areas of disturbed cleared areas. Various design flows can be used (0.25-20year ARI flows), but a significant 5 year ARI rain event in conjunction with 100% removal of 50um particles is proposed - this is equivalent to 635m^2 water surface area per m^3/s of inflow, and results in a manageable pond size. The proposed basin at the north end of the site requires a top surface area of 445m^2 minimum (Q5 0.7m^3/s x 635), with a minimum water depth at the basin wall of 1.2m.

9 MAINTENANCE OF WATER MANAGEMENT STRUCTURES

9.1 General Principles

Effective erosion, sedimentation and water quality control is required to minimise adverse water quality and sedimentation impacts on downstream waterways and adjacent environs. Soil and water issues will be identified, planned, managed and monitored during the mine life to minimise adverse impacts.

Project activities such as fuel and chemical storage, and handling activities can also affect local flowpaths. The commitment is to carry out activities in a manner that conforms to relevant regulatory and legislative requirements, by ensuring that controls are properly implemented, and are regularly monitored and audited to assess their effectiveness. Changes to the stipulated controls will be instigated if they are not achieving their objectives.

The objective is to ensure integration of all erosion, sedimentation and water quality issues (including groundwater and site wastewater) during the mining period to minimise erosion and off-site sedimentation, and minimise impact of construction activities on downstream water quality.

9.2 Performance Goals

The performance goals of surface water management include:

- Prevent degradation of the surrounding environment through the application of best management practices and innovation;
- No decrease in downstream water quality;
- All water discharged from the site to comply with discharge limits;
- Sediment deposited offsite kept to a minimum;
- Work areas kept to the minimum area necessary for safe working operations to minimise exposed surfaces.

9.3 Environmental Controls and Mitigation Measures

The implementation of various environmental control measures can reduce the risk of environmental aspects. Impacts may relate to the extent of disturbance and excavation, proposed work procedures and specific environmental control measures for activities which require more detailed attention (e.g. clearing and grubbing; topsoil stripping and stockpiling; waterway crossings, chemical storage and use; refuelling operations, water monitoring methods, etc).

9.4 Inspection, Auditing & Monitoring

Site inspections or informal visual checks will take place regularly to ensure appropriate mitigation measures and controls are implemented, and that they are operational and effective. Such site inspections can include event based inspections prior to predicted rainfall events, following significant rain events, and prior to extended site shutdowns.

The outcomes of inspections, monitoring, and audits facilitate the identification of problems and recurring issues or areas for improvement.

10 GENERAL GUIDELINES POST-CLOSURE

10.1 General

The objective of Mine Closure Plans is to ensure an effective planning process is in place throughout the life of mine, so closure is achieved in an environmentally sustainable manner and without unacceptable liability to the State.

Decommissioning involves minimising sterilisation of ore reserves and rehandling of waste materials.

In particular, it includes rehabilitation of areas disturbed by the project works such as of disturbed areas, old roadways, site compounds etc. and blending with the natural landform and reducing visual impact.

10.2 Land Disturbance and Rehabilitation

Mining is a temporary land use and therefore rehabilitation objectives should be consistent with the projected future land use. Post-mining landforms consist of unconsolidated materials, dispersive, and erodible materials combined with steep and / or long slopes, which give rise to high erosion risks and in turn a reduction in water quality downstream. Rehabilitation strategies contribute to maintenance free closure over the long term and should be integrated with mine development planning and operations to minimise environmental impacts and maximise rehabilitation success.

The objective is to rehabilitate disturbed areas to safe and stable landform containing endemic plant communities that approximate those that existed prior to disturbance. These areas should be free draining, non-polluting and visually compatible with surrounds, with mining tenements relinquished for alternative land use (such as pastoralism and heritage conservation). In particular, rehabilitation requires surface water management on reconstructed landforms to eliminate erosion gullying, loss of surface material and other factors affecting surface stability and revegetation.

General mine closure water principles include:

- Surface and groundwater hydrological patterns / flows not adversely affected;
- Surface and groundwater levels, and water quality reflect original levels and water chemistry;
- No long term reduction in the availability of water to meet local environmental requirements i.e. a desire that base-flows be maintained.

10.3 Pit Abandonment Bund

At closure, the pit bund must be upgraded or enhanced into an abandonment bund which is constructed outside the area designated as the potentially unstable pit edge zone (dependent on the extent of weathered (oxidised) rock and unweathered (unoxidised) rock in the pit wall). The location of the abandonment bund is shown on Figures 10, 11 and 12, and includes the zone of instability plus 10m allowance as per DMP requirements.

The minimum DMP requirements for an abandonment bund are 2m high, 5m wide at base, and wherever possible, constructed from unweathered, freely draining rockfill. An abandonment bund can be enhanced (wider crest and flatter batter slopes) and used as a flood bund, noting that water would seep through when flowing against the outer edge.

It may be necessary to remove the pre-existing waste dump from the designated unstable zone i.e. leaving a gap through which the bund can run.

10.4 Pit – Post Closure

10.4.1 General

A more detailed assessment of post-closure surface water will be completed. It is understood that no backfill of the pit is proposed. The three post closure options are to (a) allow surface water to enter the pit, (b) permanently divert water around the pit requiring rehandling of the pre-existing dump, and (c) permanently divert water around the pit and the pre-existing dump.

10.4.2 Option 1 Permanent Flow into Pit (Figure 10)

Generally the pit will be impacted from surface flows from three sides. The abandonment bund will act as a barrier to prevent substantial flows entering the pit.

However, on the western side, the abandonment bund alignment intersects the pre-existing waste dump preventing further diverted flow north. Impacting flows from the western diversion, otherwise trapped at the intersection of the bund and the existing dump, would enter the pit at this location through a gap in the abandonment bund (if the existing dump is cleared away from the designated unstable zone and a gap is made between the waste dump and the bund to allow passage of surface water, then this latter provision for entry into the pit would not be required – refer Option 2).

Where surface water is directed to the pit edge, it is necessary to prevent an upstream migrating nick point from forming as the watercourse over the long term readjusts its grade. Surface inflows would be directed to the pit edge, to a spill point located preferably at indurate rock level. Less hardened or consolidated material would need to be protected for a long life with overdesigned rock armour, including batter armouring to ensure no outflanking. Alternatively a substantial (overdesigned) rock armoured chute is required from bed level to the base of the pit, able to accept any flow up to the Probable Maximum Flood without failure.

The abandonment bund can be used as a permanent flood bund with a substantial rock armoured toe, graded continuously downstream and directing flows around both sides of the pit.

The flood bund and toe / drain would be protected for long life with rock armour to accept any flow up to the PMF (~40m^3/s around the western side and ~16m^3/s around the eastern side). Flow depths in the PMF at the abandonment bund would be up to 1m, with velocities 1m/s.

The pit would act as a termination point for entering flows.

10.4.3 Option 2 Permanent Flow Diversion around the Pit (Figure 11)

The second option is to maintain water flow around the pit, by cutting a flood corridor between the existing waste the dump and the abandonment bund (as shown on Figure 11). This option may require rehandling of the toe of the existing waste dump in order to create the required flow path. Note that the final pit shell footprint is still being defined, and there is the potential that the final pit footprint will leave sufficient space between the existing waste dump and the pit crest for both an abandonment bund and drainage channel to be created. This option again utilises the abandonment bund as a permanent flood bund.

10.4.4 Option 3 Permanent Flow Diversion around the Pit (Figure 12)

The third option is to realign the armoured abandonment bund / flood bund, extended around the north of the existing waste dump to maintain water flow around the pit.

However the outfall back to the watercourse channel at the north-east corner of the existing waste dump is steep (10%), and a rock armoured channel would be required adjacent to the flood bund to direct these flows back into the original watercourse.

10.5 Waste Rock Dump

Waste dumps are usually the landforms most prone to erosion post open pit mining. Geomorphic principles should be applied in the design of stable landforms over the long term. These principles dictate drainage density and size of catchments, and slope angles – the incorporation of natural slope features that emulate slopes that are in equilibrium with local conditions of rainfall, soil type, and vegetation cover.

It is understood that the final surface of the waste dump will be constructed to be self-draining.

10.6 Assessment of Runoff Loss to the Downstream Environment

The White Well development lies within the Nallan Creek catchment. The runoff volume is likely to decrease from areas containing pits and waste dumps due to the reduction in catchment area from the infrastructure footprints and catchments blocked or trapped by these works.

Note that during the operational period, runoff volumes from infrastructure areas such as roofs, hardstands and access roads may increase from concentration and redirection of flows. The runoff volumes from infrastructure other than pits and dumps are generally considered to remain effectively unchanged (neutral).

Post closure, only pit and waste dump areas have been considered to contribute to non-recovered runoff volume. On this basis, runoff volume losses have been assumed as follows:

- 100% loss of runoff volume from pit areas;
- 50% loss of runoff volume from waste dump developments.

As such the pit footprint is $0.2km^2$, and the waste dump about $0.5km^2$. This is an effective reduction in contributing catchment area of $\sim 0.5km^2$, or <0.1% of the Nallan Creek catchment (total catchment area approximately $1{,}000km^2$ at Nallan Salt Lake or $3{,}000km^2$ at Austin Lake). Assuming the reduction in catchment area is directly proportional to the reduction in runoff volume, there is a <0.1% potential reduction in runoff volumes.

If the flow from upstream external catchments terminates in the pit (Closure Option 1), the overall effective reduction in contributing catchment area is <1% of the Nallan Creek catchment.

In a semi-arid to arid climate, with very flat surface grades, low rainfall and uncommon and intermittent surface flow with large natural seasonal variations, these losses would not be environmentally significant.

Within the mining lease area of 6km², the local scale effects on riparian vegetation downstream would be more significant, and be part of the subsequent rehabilitation objectives for the area.

10.7 Monitoring

Completion criteria are agreed standards to be achieved on particular aspects of the project. Progressive assessment against these criteria can demonstrate the relative success of rehabilitation in achieving desired outcomes, and whether the rehabilitation end point has been reached. Rehabilitation performance criteria include post-closure land use objectives, landform stability, ground water protection, and revegetation targets. Where possible, completion criteria should be developed from actual rehabilitation trials and site experience to ensure that rehabilitation methods are effective, durable and achievable.

Completion criteria should be flexible to adapt to changing circumstances, time based (trend) so rehabilitation development can be assessed as to whether it is progressing well towards a defined end point, and designed to allow effective reporting and auditing to determine the endpoint and allow sites to be relinquished.

11 SUMMARY

The proposed White Well Gold Project is located approximately 30km east of Cue. The pit will have a proposed mining life of 10 years. The surface water management plan for the project development is summarised in Figure 5. The White Well development lies within the Nallan Creek catchment.

Drainages flow north and north west towards the Nallan Creek system. Flood protection of infrastructure should be provided at the 40-50 year protection level minimum based on a 10 year LOM. General collection drains to direct rainfall runoff to sedimentation basins may be designed for a 5-10 year ARI flow event.

The best method of water management is to locate infrastructure away from significant creeks and avoid the need for diversion works where possible. Otherwise surface water diversion is required when there is interruption to existing surface water flow patterns. A combination of bunds and excavated channels with an appropriate freeboard is required to carry flood waters around infrastructure via a flow path different from the natural water course. Earthworks diversions are generally constructed using cut-to-fill (by excavating the channel on the upstream side to provide fill for the associated bund on the downstream side).

The proposed pit lies along the watercourse. As shown in the surface water management plan, the watercourse will be cut off by the development of the pit. Options for pit closure include allowing water to enter the pit at a hard spill point or rock armoured chute to the bottom of the pit. Two diversion options around the pit are possible, one requires re-handling of part of the existing dump, the other a substantial realignment of the abandonment / flood bund to the west and an additional rock armour chute down the hill on the northern side of the existing dump.

It is proposed that external water be permanently diverted around both sides of the pit using the abandonment bund as the basis of a flood bund for a permanent diversion.

The landscape can be subject to heavy rainfall, and there is a risk of erosion and sedimentation on disturbed or degraded landscapes. The general objective is to maintain the hydrological regimes of surface water so that existing and potential uses, including ecosystem maintenance, are protected. Erosion mitigation measures are required, with sediment basins to be located at low points to trap and treat flow prior to discharge, and preferably fitted with a control structure to allow stored water to slowly pass downstream. One large basin is proposed downstream of the site. Storage areas (chemicals, hydrocarbons, etc) will be located away from, or bunded off from, external surface flows.

Monitoring during the life of mine is recommended to ensure the proposed surface water management measures are effective in maintaining the hydrological regimes in the downstream environment. Furthermore, mine closure planning needs to consider if any alterations of the surface water management plan are required post-mining / post-closure.

The pit and waste dump footprint areas, and catchments blocked or trapped by the pit and dump areas, are likely to decrease runoff volume into the creek. The total catchment loss is estimated as approximately 0.5km². This reduction in runoff volumes in a widely variable rainfall regime in a very large catchment would be environmentally insignificant.

FIGURES

N

0 200 400

Kilometers

Scale: 1:10,000,000 @A3

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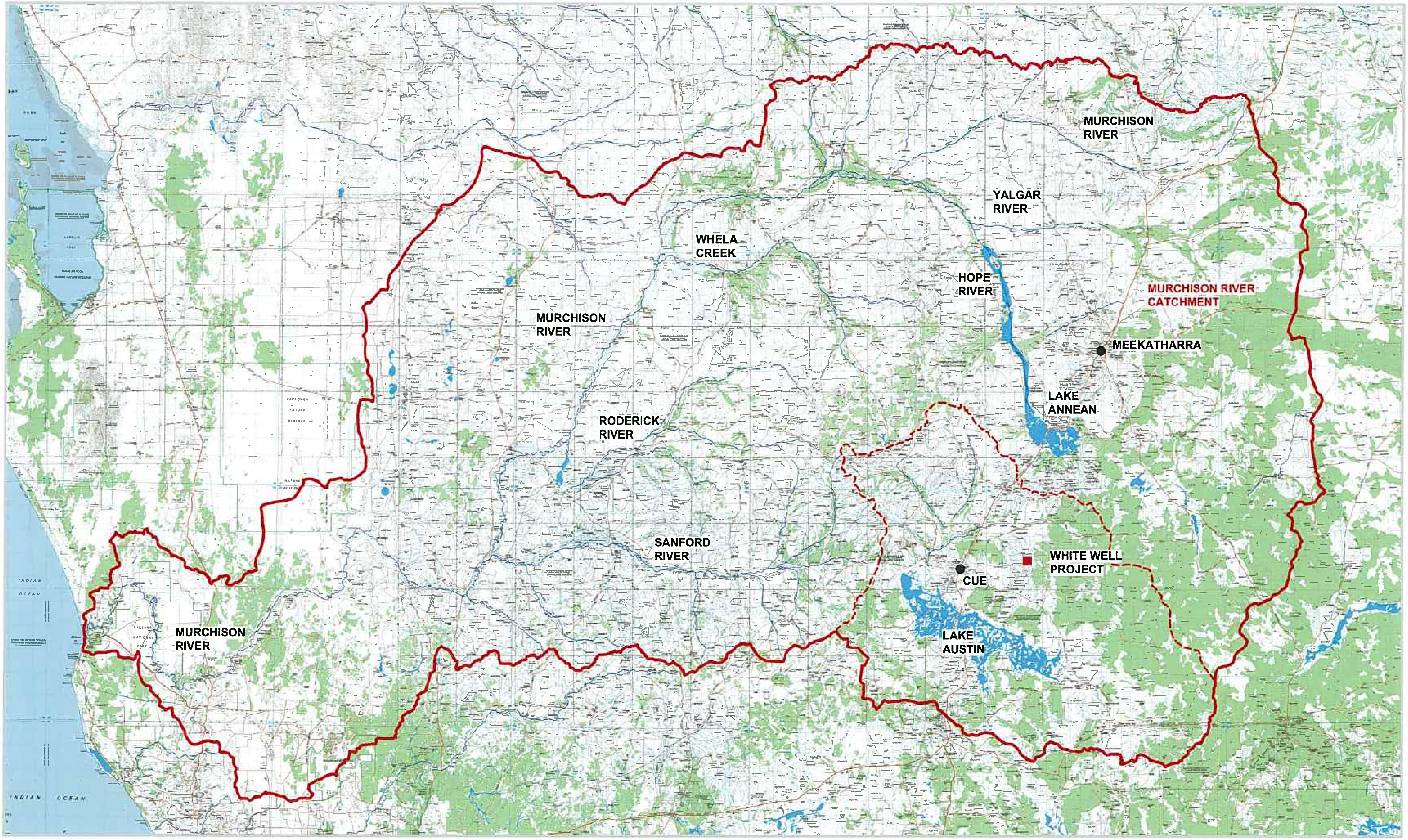
FIGURE 1

REGIONAL LOCATION PLAN

Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure1



LOCATION MAP

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Kilometres

Scale: 1:1,500,000 @A3

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LEGEND

- Regional Catchment
- Regional Sub-Catchment
- Project Location
- Regional Drainage

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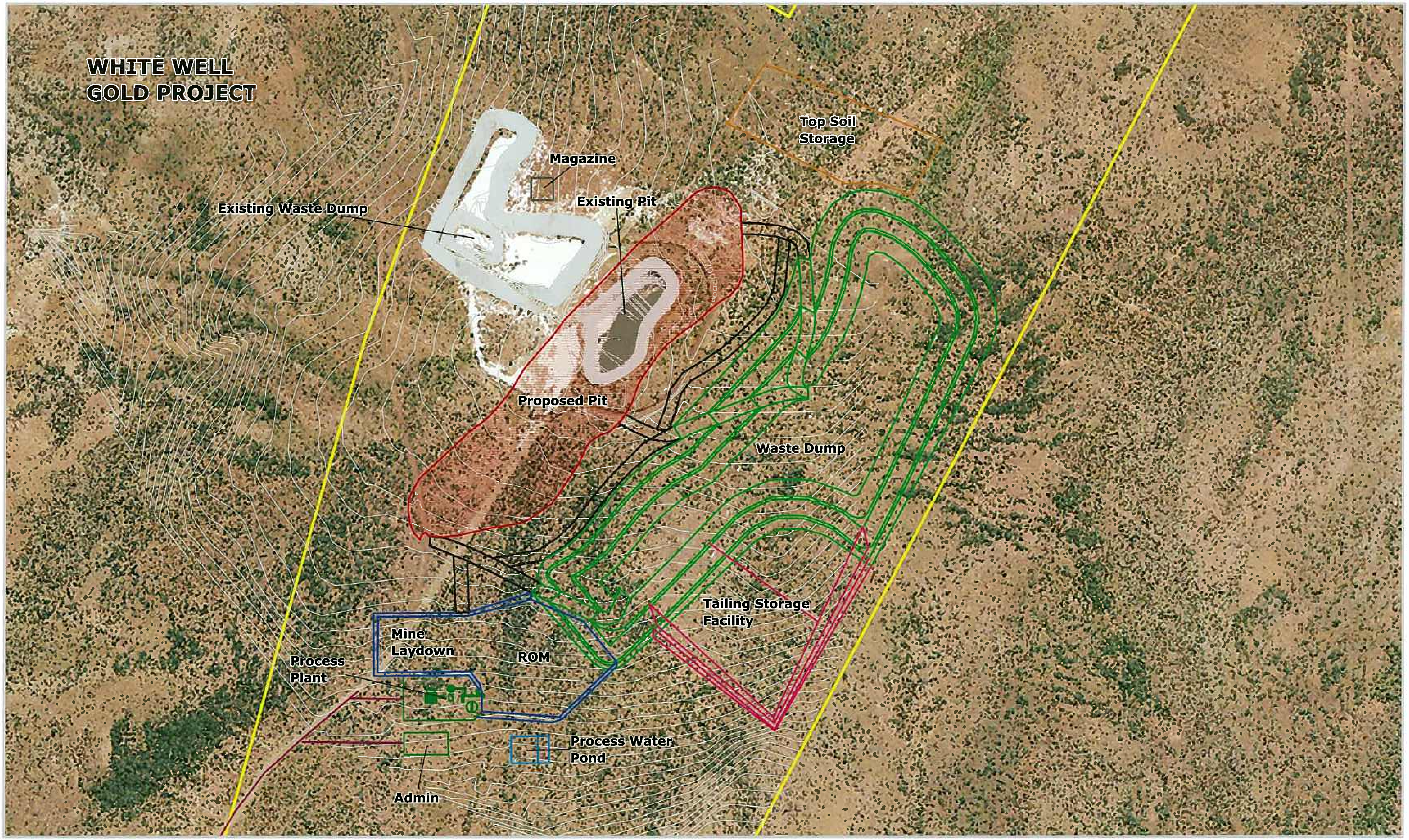
FIGURE 2

REGIONAL CATCHMENT & SUB-CATCHMENT

Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure2



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Meters

Scale: 1:8,000 @A3
GDA 1994 Zone 50

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LEGEND

- Lease Boundary
- Haul Road
- Main Access Road

Note:
- 0.5m Contour Interval Shown

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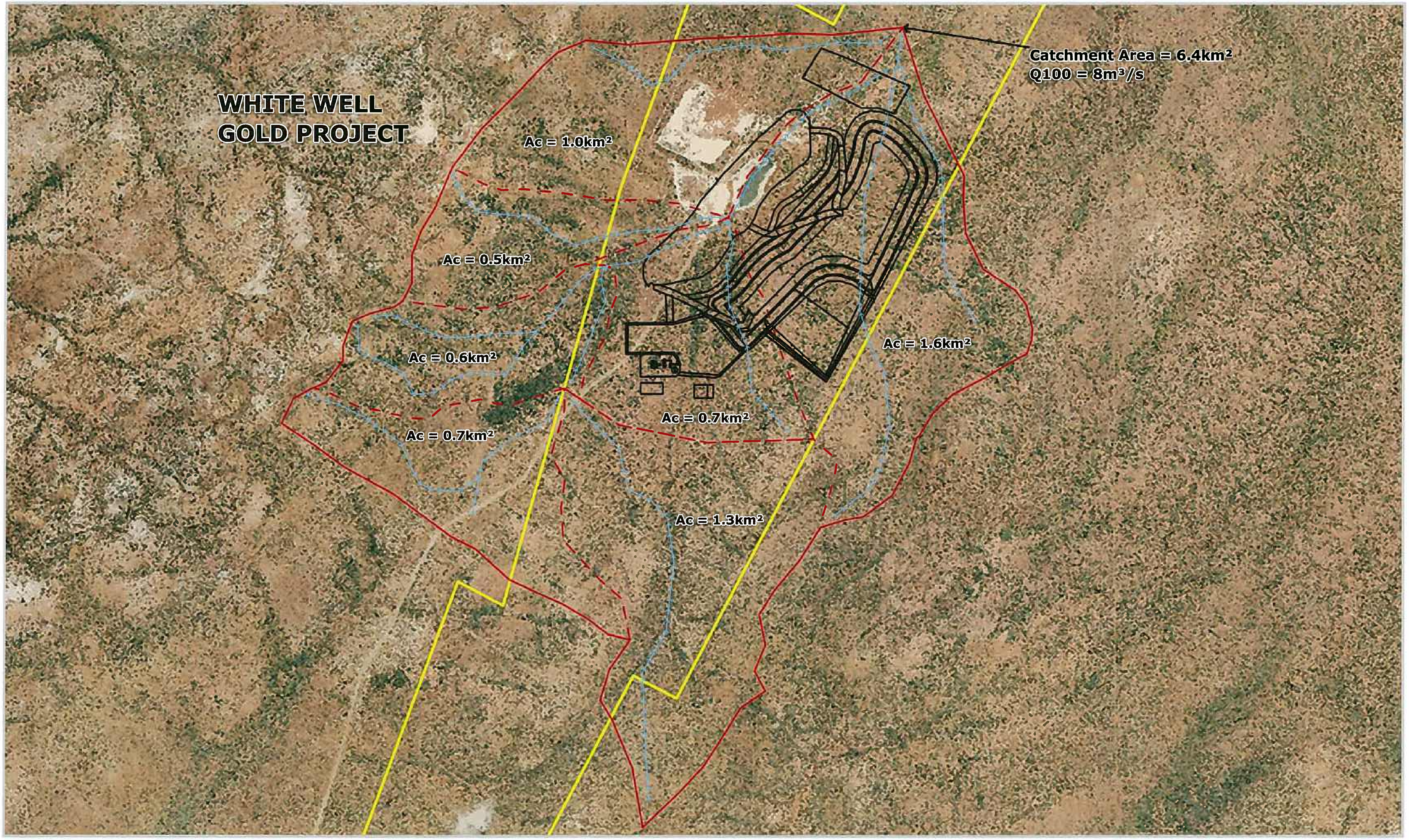
FIGURE 3

GENERAL LAYOUT

Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure_3



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Meters
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LEGEND

- Lease Boundary
- Proposed Mine Infrastructure
- Catchment Boundary (Pre-Development)
- Sub-Catchment Boundary (Pre-Development)
- Flow Paths (Pre-Development)

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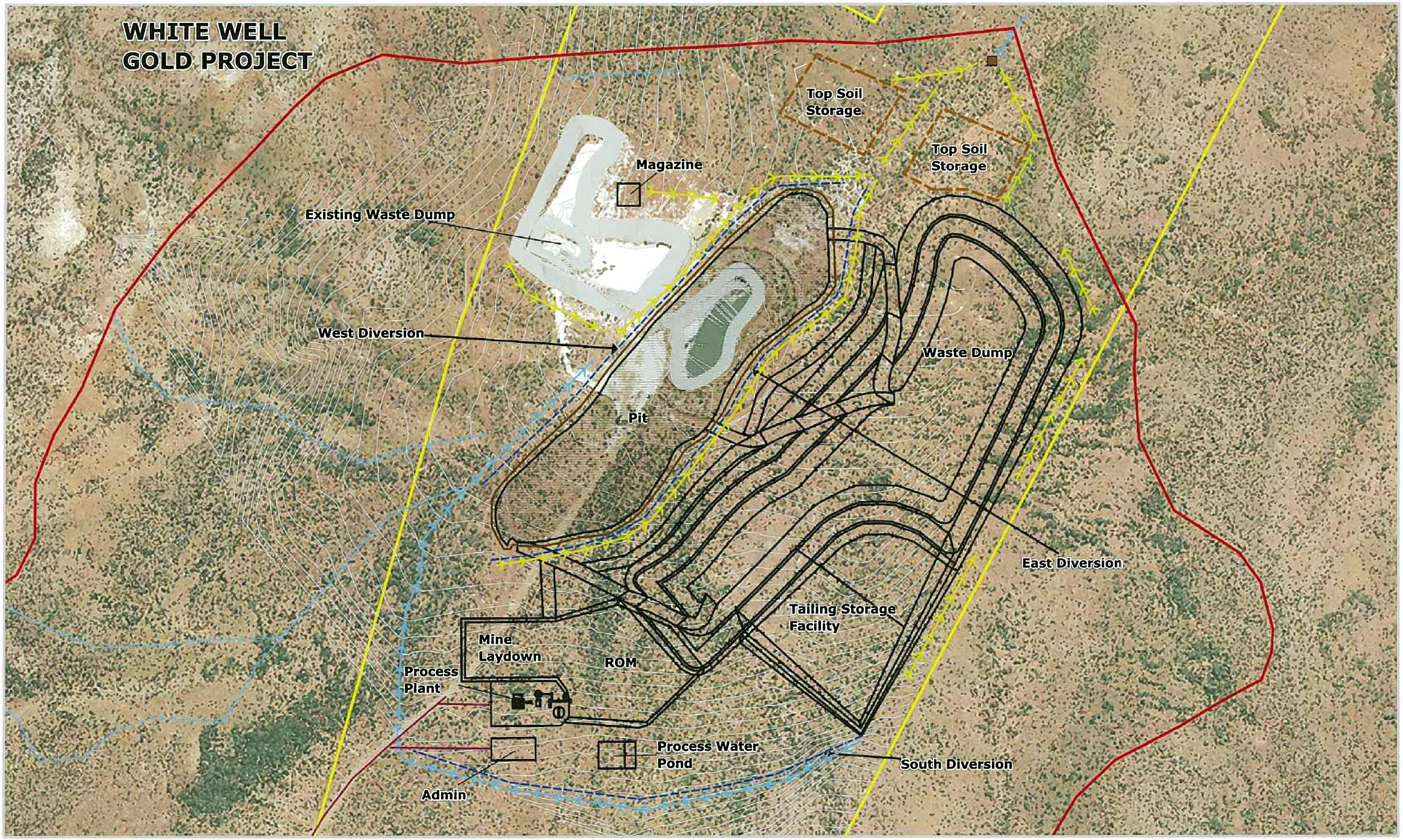
FIGURE 4

SURFACE WATER CATCHMENTS

Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure_4



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Meters

Scale: 1:8,000 @A3

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Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure_4

LEGEND

- Lease Boundary
- Mine Infrastructure
- Catchment Boundary
- Proposed Sedimentation Basin
- Proposed Diversion Drain
- Dirty Water
- Clean Water

Note:
- 0.5m Contour Interval Shown
- Top soil storage to be located to facilitate main site drainage

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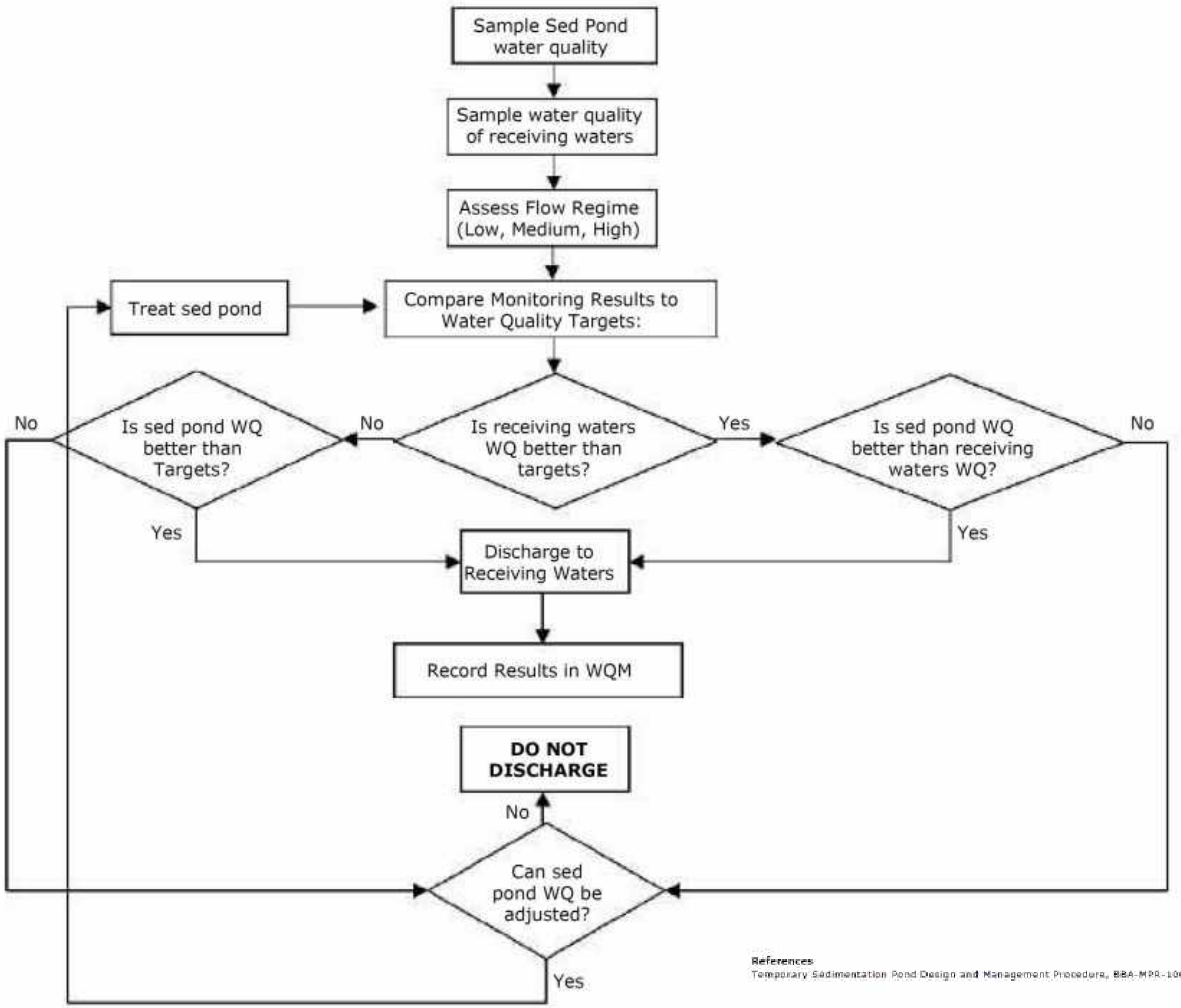
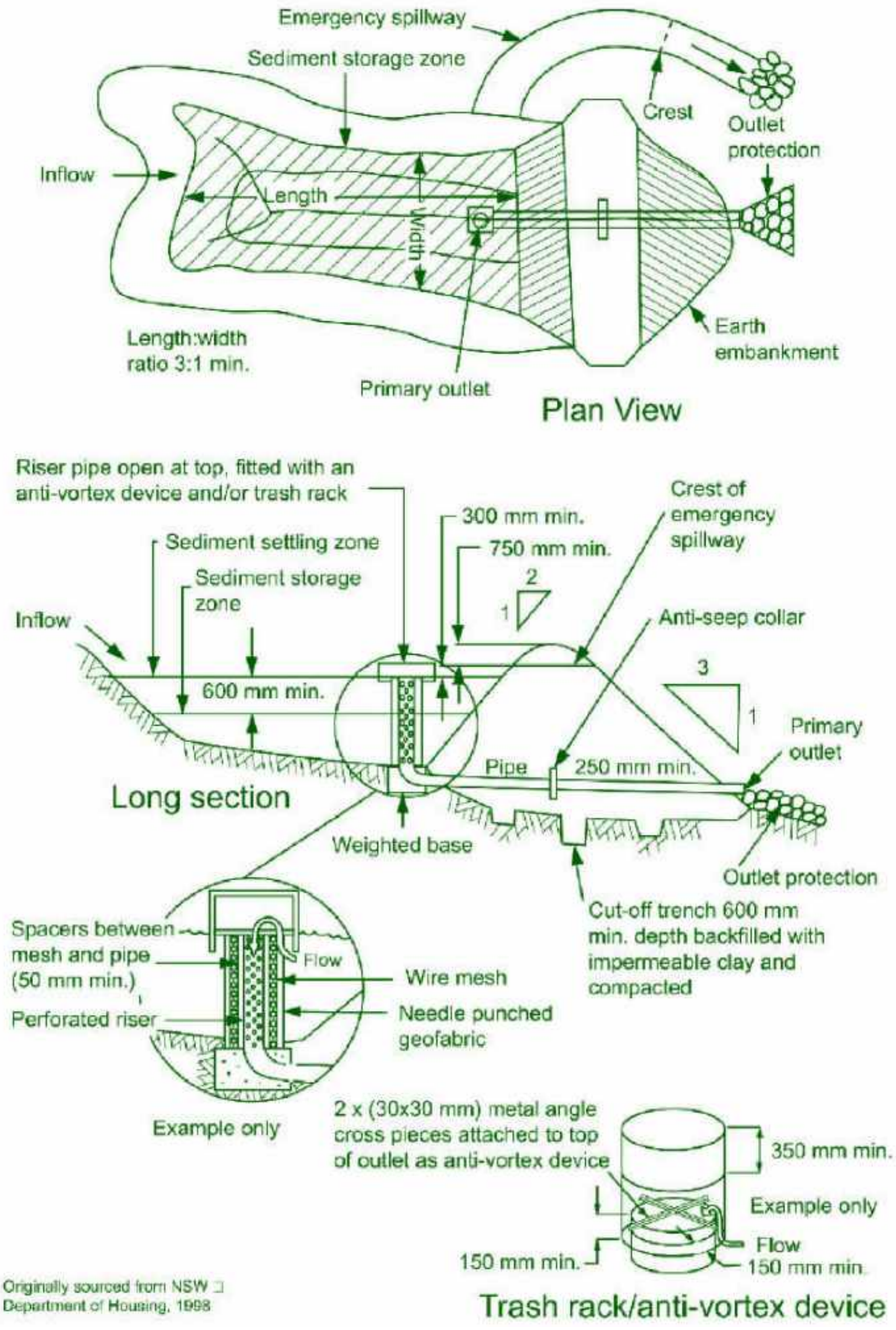
FIGURE 5

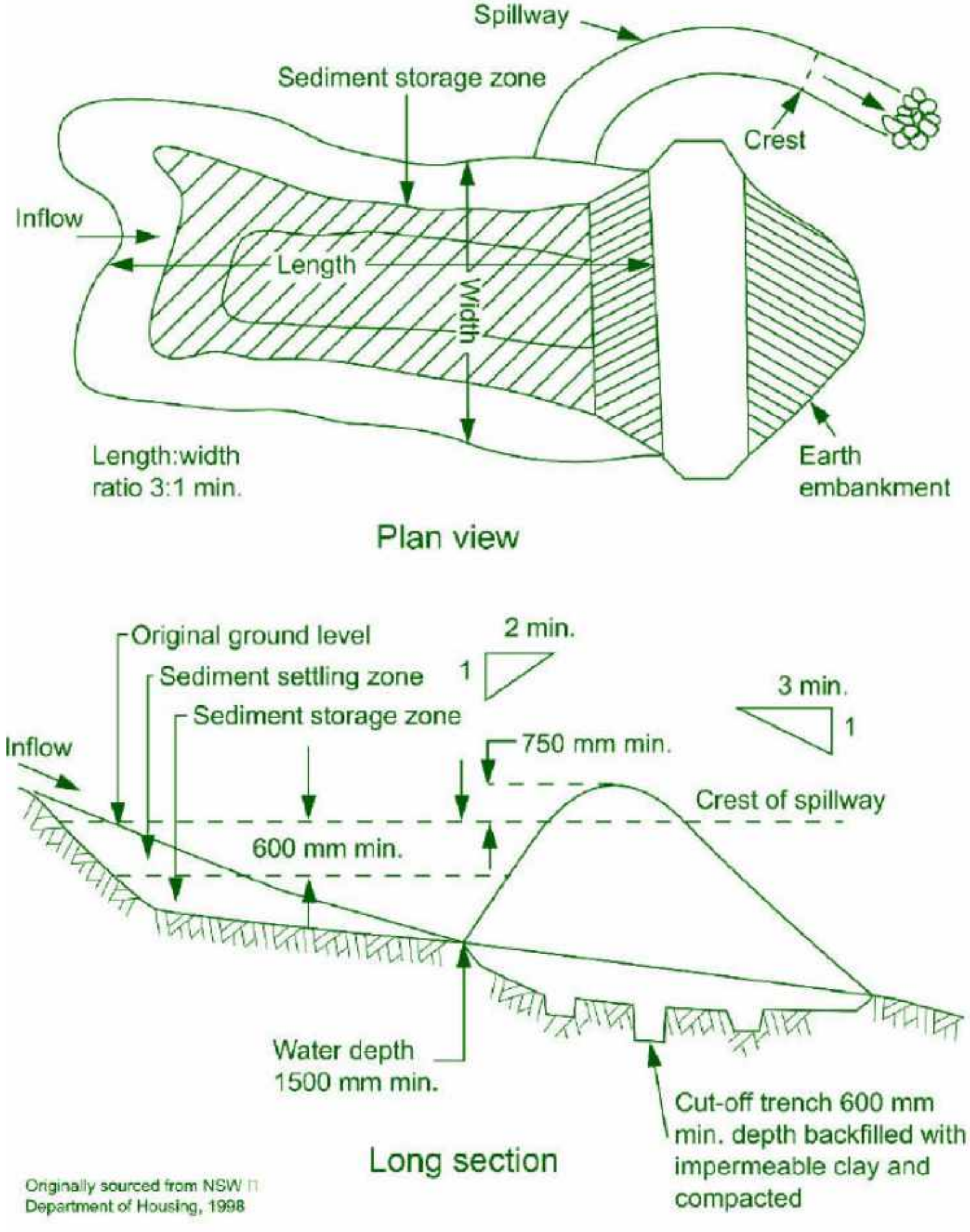
OPERATIONAL SURFACE WATER MANAGEMENT PLAN



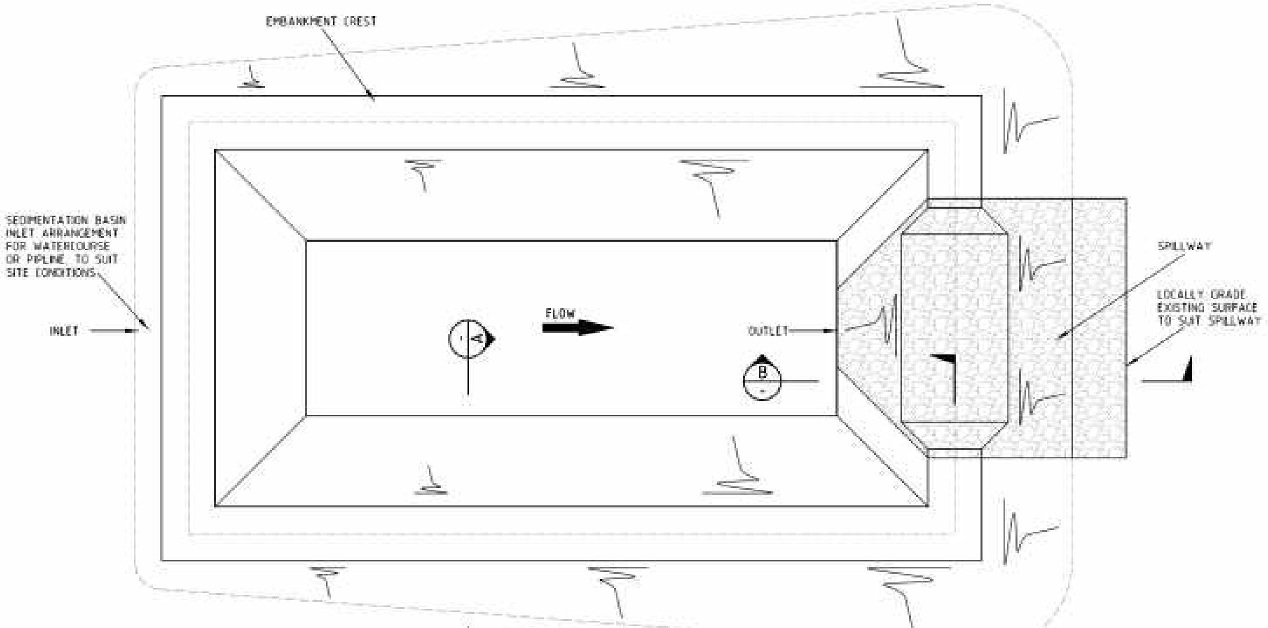
References
Temporary Sedimentation Pond Design and Management Procedure, BBA-MPR-1000-1400-0002, Bell Bay Alliance, 2008



TYPICAL DRY SEDIMENTATION BASIN WITH OUTLET FIGURE 7



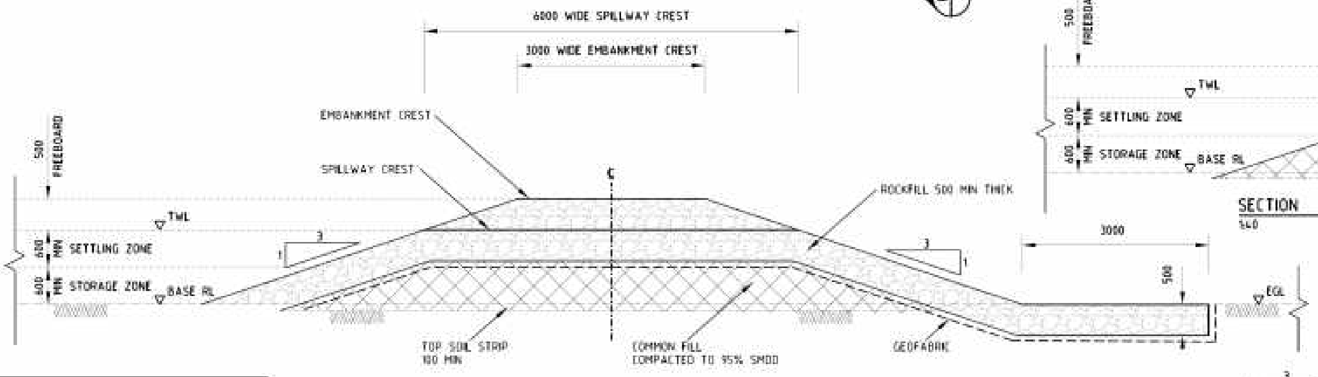
TYPICAL WET SEDIMENT BASIN FIGURE 8



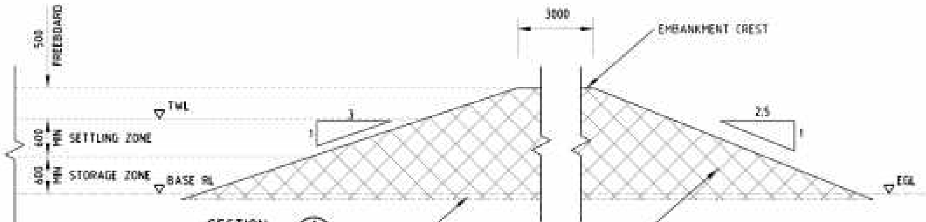
PLAN - SEDIMENTATION BASIN
NTS

GENERAL NOTES:

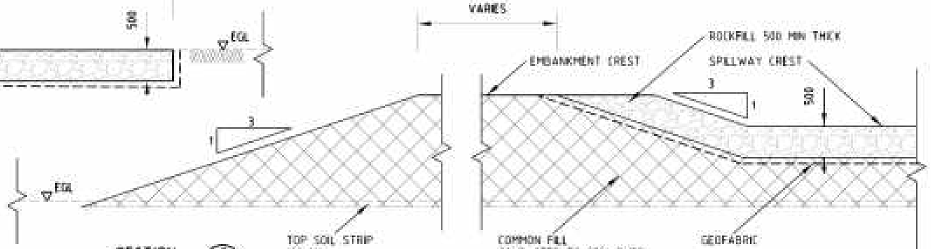
1. SEDIMENT BASINS ARE TYPICALLY CONSTRUCTED AS SMALL EARTHEN DAMS, SIMILAR TO "FARM DAMS".
2. BASINS TO BE CONSTRUCTED USING THE MOST SUITABLE AVAILABLE MATERIAL AT THE SITE, BUT ARE TYPICALLY LOCAL CLAYS, SANDS AND GRAVELS (SHOULD CONTAIN 20-30% CLAY WITH SAND, SILT AND SOME GRAVEL, AND NO ROCKS GREATER THAN 75mm SIZE).
3. THE MOST EFFICIENT SHAPE IS A LENGTH TO WIDTH RATIO OF 3:1 TO 8:1
4. THE INLET AND DISCHARGE POINTS TO BE LOCATED OPPOSITE FOR MAXIMUM INTERNAL FLOW LENGTH.
5. BAFFLES MAY BE USED, IF NECESSARY, TO PREVENT SHORT CIRCUITING.
6. AS THE BASIN FILLS WITH SEDIMENT, IT SHOULD NOT ENCOURAGE RE-ENTRAINMENT AND SCOUR OF SETTLED SEDIMENT.
7. THE REQUIRED BASIN TOP WATER SURFACE AREA (m^2) = 21 X Ac (CATCHMENT AREA IN HA). NOTE 25% VOLUMETRIC RUNOFF ASSUMED. THE AMOUNT OF RUNOFF CAN VARY WITH CATCHMENT CHARACTERISTICS.
8. FOR EMBANKMENT HEIGHTS UP TO 3m, SIDE SLOPES TO BE 3:1 (H : V) UPSTREAM AND 2.5 : 1 DOWNSTREAM OR FLATTER. MINIMUM CREST WIDTH 3m.
9. SEDIMENT BASINS, SPILLWAYS AND FREEBOARD MUST BE DESIGNED TO WITHSTAND PEAK RUNOFF FROM A DESIGN STORM IN THE WATERCOURSE (TYPICALLY 100 YEAR ARI EVENT FOR A LONG TERM BASIN).
10. THE INFLOW CHANNEL TO BE STABILISED SO THAT IT DOES NOT ERODE THE BASIN EMBANKMENTS.
11. THE CREST LEVEL FOR THE SPILLWAY SHOULD BE THE HIGHEST FEASIBLE (ALLOWING FOR FREEBOARD) TO MAXIMISE THE STORAGE VOLUME WITHIN THE BASIN WITHOUT CAUSING UNDUE BACKWATER IN THE INFLOW CHANNEL.
12. THE PRINCIPAL MAINTENANCE ACTIVITY FOR SEDIMENT BASINS IS THE REMOVAL OF SEDIMENT.
13. HYDROLOGY AND HYDRAULIC CHECKS TO BE CARRIED OUT BY QUALIFIED ENGINEER PRIOR TO CONSTRUCTION.



SECTION B
1:40

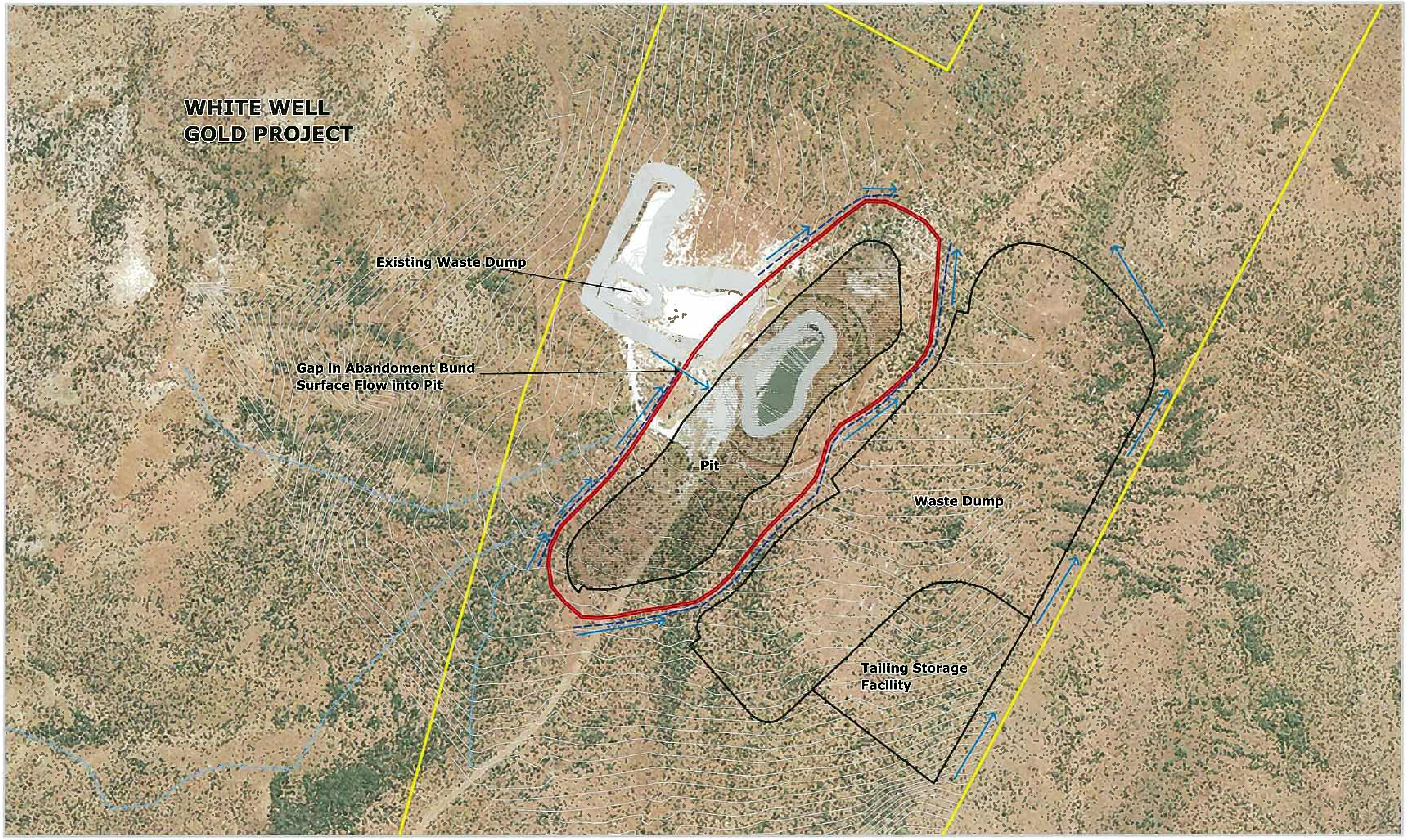


SECTION A
1:40



SECTION C
1:40

ROCKFILL CRITERIA (FACING CLASS)			
ROCK CLASS	ROCK SIZE (m)	ROCK MASS (kg)	MINIMUM PERCENTAGE OF ROCK LARGER THEN
RIPRAP	0.40	100	0
	0.30	35	50
	0.15	2.5	90



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0 200 400

Meters

Scale: 1:8,000 @A3

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Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure_10

LEGEND

- Lease Boundary
- Mine Infrastructure
- Abandonment Bund
- Proposed Diversion Drain
- Flow Path

Note:

- 0.5m Contour Interval Shown
- Operational Diversions Rehabilitated
- Gap in Abandoment Bund, Surface Flow into Pit

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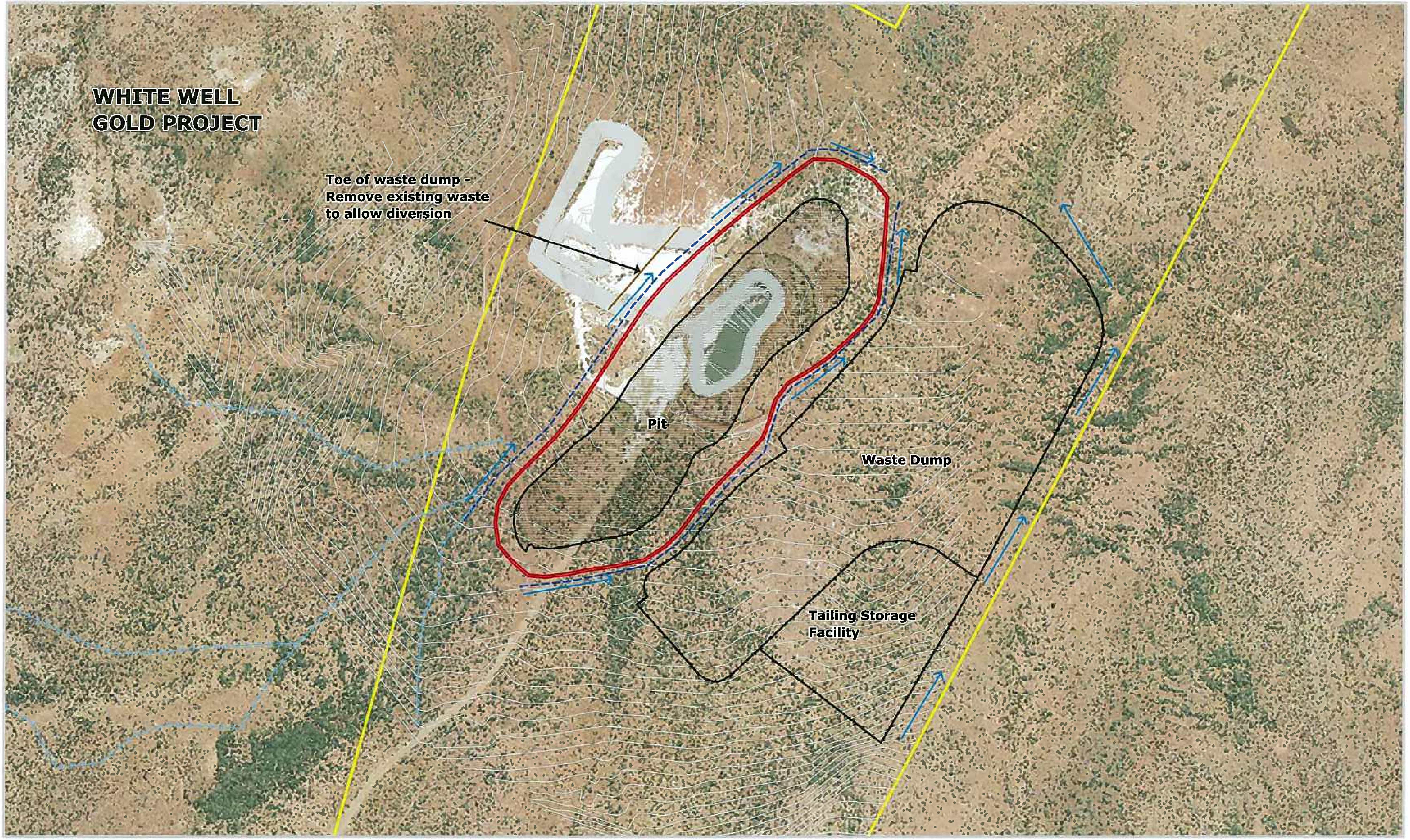
FIGURE 10

OPTION 1
POST-CLOSURE SURFACE
WATER MANAGEMENT



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Meters

Scale: 1:8,000 @A3

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Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure11

LEGEND

- Lease Boundary
- Mine Infrastructure
- Abandonment Bund
- Proposed Diversion Drain
- Flow Path

Note:

- 0.5m Contour Interval Shown
- Operational Diversions Rehabilitated

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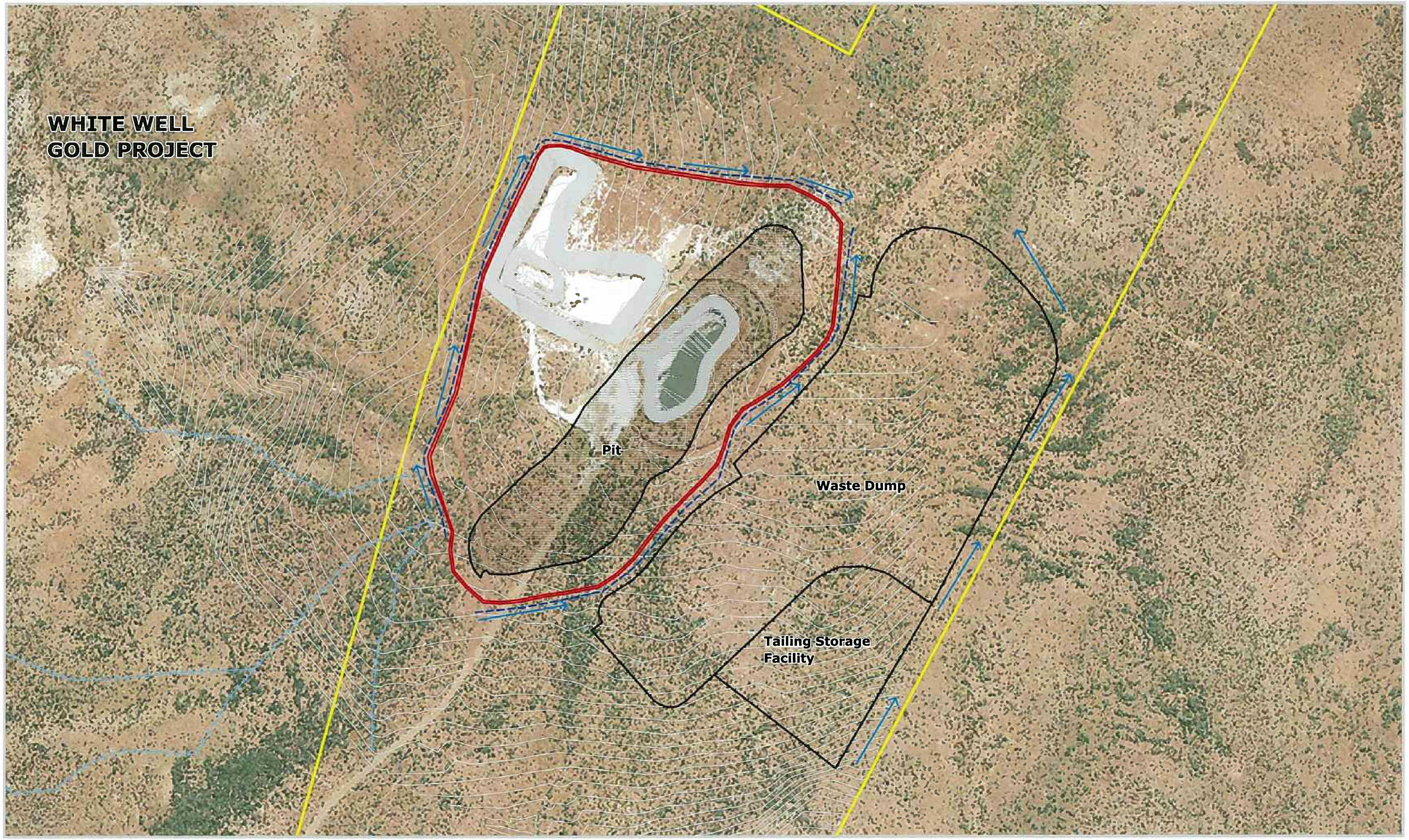
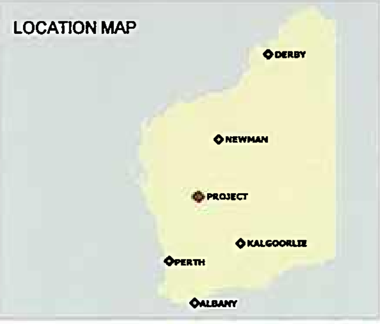
FIGURE 11

OPTION 2
POST-CLOSURE SURFACE
WATER MANAGEMENT



LOCATION MAP



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Meters

Scale: 1:8,000 @A3

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DATE:	13/05/2016	JOB NO:	2073B

LEGEND

- Lease Boundary
- Mine Infrastructure
- Abandonment Bund
- Proposed Diversion Drain
- Flow Path

Note:
- 0.5m Contour Interval Shown
- Operational Diversions Rehabilitated

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FIGURE 12

OPTION 3
POST-CLOSURE SURFACE
WATER MANAGEMENT

Location: F:\Jobs\2073B\Spatial_Data\MapInfo\Workspaces\002a_Figure12