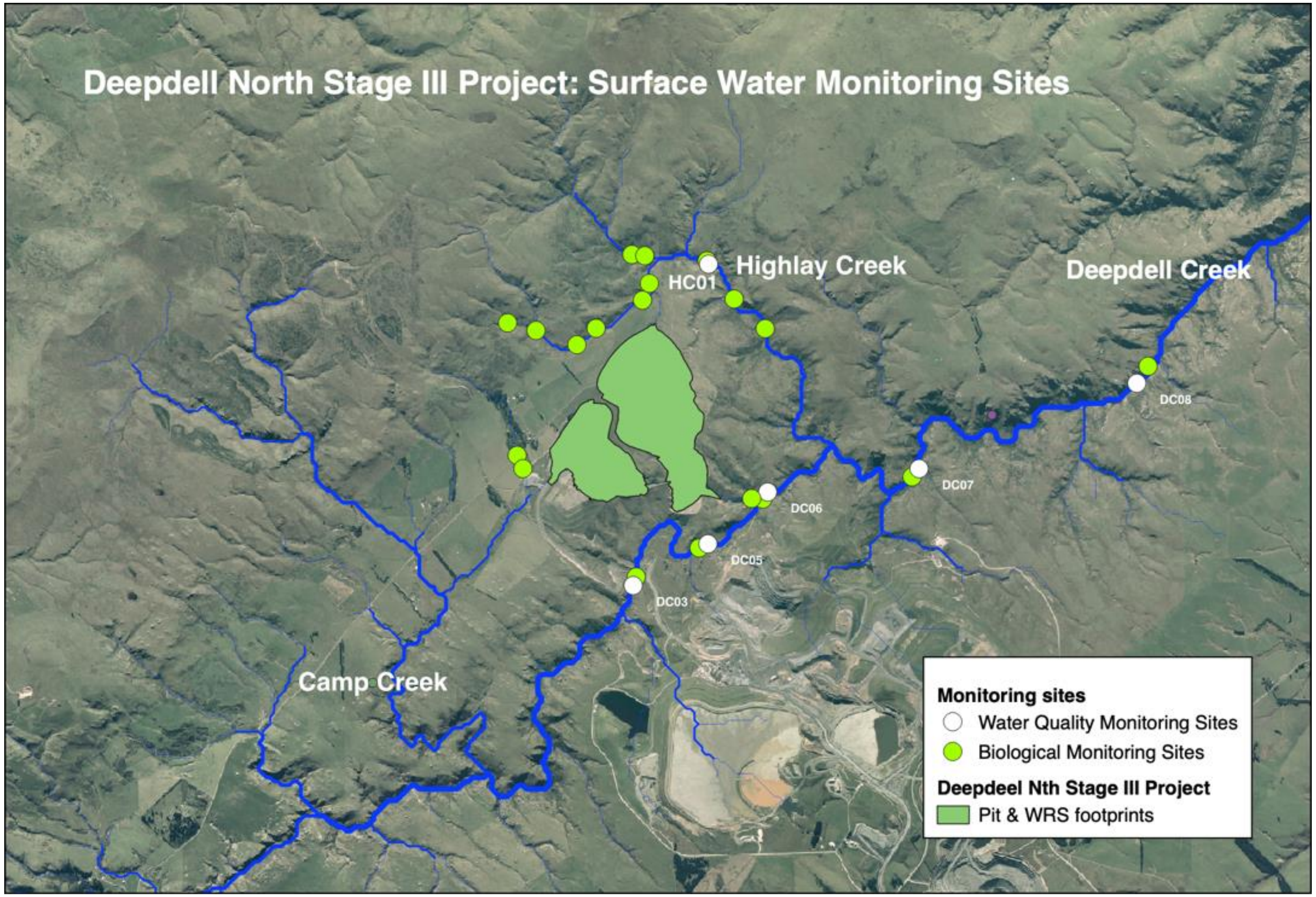

Figure 5 Aerial map showing surface water monitoring sites and biological survey sites in relation to the proposed Deepdell North Stage III Project.

3. Catchment physical & biological descriptions

3.1 General

Part of the proposed Deepdell East Waste Rock Stack is situated in the Highlay Creek catchment (figures 1 and 4). Runoff and seepage from the WRS area will flow into Highlay Creek and a small tributary of Highlay Creek. Depending on how the WRS is contoured, the southern side could also potentially drain to the headwaters of Camp Creek.

The Deepdell North Stage III Pit and Deepdell South Backfill footprints lie within the Deepdell Creek catchment and surface water from these sites would flow into Deepdell Creek via the existing Deepdell North Silt Pond and the Deepdell South Silt Pond.

Routes for flow of 'clean' water and 'dirty' drainage water from the project areas are shown in Figure 4.

Descriptions of individual sub-catchments are described in Thorsen (2019).

3.2 Highlay Creek catchment

3.2.1 Physical description

Highlay Creek is a third order tributary of Deepdell Creek (Figure 1). Its headwaters are in the vicinity of Highlay Hill, starting at elevations up to approximately 750m above sea level. The catchment drains steep slopes with several small tributaries that join upstream of Horse Flat Road. Below Horse Flat Road the creek flows in a south-easterly direction through a 2km long gorge before entering Deepdell Creek on its true left.

The area of catchment within the Project footprint consists largely of gently sloping land, with shallow ephemeral gully systems, and watercourses that may have once had a natural channel but since been channelled to divert surface flows. The gullies and watercourse drain to small tributaries of Highlay Creek located outside of the Project footprint. The watercourses are likely to be ephemeral in their upper reaches and have intermittent flow in their lower reaches, or at least carry very little surface flow in drier months of the year, given the very small size of their watersheds.

Surrounding land is a mixture of open pasture and matagouri with tussock grasses and native shrubs surrounding the watercourses (see Thorsen 2019). Cattle, deer and sheep graze much of the area.

Surface waters in the general area of the Project were inspected in February 2018 and September 2019. In the Highlay Creek catchment, under summer conditions, surface flow in small tributaries of the upper catchment (upstream of the project footprint) was minimal and barely covered the bed of the gully. Stock trampling was evident at many sites along the gully, often resulting in pugging and surface mud, although remnant native stream-side vegetation was present in most places. Tracks where stock had crossed the creek areas were common. Schist gravels, large rocks and occasional bedrock were common, often covered with moss. Bedrock often created short, steep waterfalls although the movement of water over these was more of a slow trickle than a steady flow. Further downstream, as gullies joined, surface flow increased to an estimated 0.1 – 0.15 L/sec (Figure 6 left).

Figure 6 Left: Highlay Creek tributary upstream of the Project footprint, upper reach over bedrock, with an estimated flow of 0.1 – 0.15 L/sec. Right: True left gully in section with no flow. February 2018.

In its lower reaches, but still upstream of the Project footprint (see Figure 4), this tributary of Highlay Creek remains confined within a small, narrow gully (Figure 7). In this reach, the tributary is bordered by open pasture with open stock access to the creek, and a ford for a farm access track. The creek channel appears to have been historically modified in places, with contoured banks on both creek banks confining the channel (Figure 7, top). The creek in this reach contains large beds of grasses, *Juncus* and the introduced grass *Glyceria fluitans*. Note that *Glyceria fluitans* is on Biosecurity New Zealand's Schedule of Prohibited Plant Species. Wetland habitat is also present characterised by diffuse flow through a poorly defined channel choked with grass-like species. Some riffle habitat is present where the channel is incised, but the majority of the surface flow is through grass beds.

Still further downstream, about 250-300 metres upstream of the confluence with Highlay Creek, the tributary remains in a confined channel that is grazed to the water's edge (Figure 7, bottom).

The gully that would receive runoff and seepage water from the northern part of the WRS is described by Thorsen (2019) as a shallow ephemeral drainage system and seepage habitat. These gullies are contained within farmed land and stock have access to them.

Severe pugging was observed in them during the September 2019 site inspection (Figure 8, top).

Figure 7 Lower reaches of the tributary of Highlay Creek potentially receiving runoff and seepage from the Deepdell East Waste Rock Stack. In the top photo (February 2018), this section of the channel looks to have been engineered in the past. In the bottom photo (September 2019), further downstream, the channel is open with grazing to the edge. The gully with seepage water can be seen in the lower left of the photo.

The tributary joins Highlay Creek approximately 450 metres upstream of Horse Flat Road ford. The Highlay Creek reach upstream of Horse Flat Road is bordered by open areas of pasture grass with isolated patches of *Coprosma* and matagouri that completely shade the creek (Figure 9). Stock presence is evident throughout the area, although stock numbers appeared low when the site was inspected in February 2018 and September 2019. The creek has been modified in places by historic mining activities, with stone walls concentrating river flows through chutes. Instream habitat is dominated by riffles, with few runs and pool sections. Bed substrate is dominated by small boulders and cobbles with gravels and fine sediment deposits in slower flowing areas.

Figure 8 Top: Heavily pugged upper reaches of a gully that drains part of the proposed Deepdell East WRS. Bottom: Lower reaches of the same gully system just upstream of the confluence with the Highlay Creek tributary shown in Figure 7.

The middle reaches of Highlay Creek, in the vicinity of the Horse Flat Road ford, are bordered by *Coprosma* and matagouri away from the banks, with generally open sections of pasture and isolated *Carex* along the creek edges (Figure 9). The creek is generally very open with limited shading. Instream habitat is dominated by riffles, with few runs and pool sections. Bed substrate is dominated by small boulders and cobbles with gravels and fine sediment deposits in slower flowing areas. Some extensive sections of bedrock are present. The creek forms a well-defined, confined channel with a bed of large cobbles and occasional large slabs of bedrock.

Figure 9 Highlay Creek middle reach in the vicinity of the Horse Flat Road ford.

In April 2013, a site was surveyed approximately 750 m downstream of the Horse Flat Road ford (NZTM E 1399031 N 4976644). This section of Highlay Creek is narrow (0.5 – 1.0 m wide) and bordered by matagouri and other native shrubs away from the banks, with sections of pasture and isolated tussocks, *Carex* and rushes along the creek edges (Figure 10). The channel is mainly open although shaded in places by overhanging vegetation. Stock have access to the watercourse. At the survey site the creek is dominated by riffles, with occasional short run and pool sections. The water level appeared to be lower than normal and water depths ranged from 0.10 – 0.15 m in the riffles. The bed substrate is dominated by small boulders and cobbles with gravels and fine sediment deposits in slower flowing areas including within vegetation on the channel edges.

Figure 10 Highlay Creek survey site, April 2013.

In general, the quality of habitat in Highlay Creek is superior to that in its tributary that would be potentially affected by runoff and seepage from the proposed WRS. Aquatic habitat is of similar quality in the middle and upper reaches of Highlay Creek.

3.2.2 Highlay Creek water quality

As noted above, part of the proposed WRS (18.8ha) will drain towards Highlay Creek. There has been no regular water quality monitoring of Highlay Creek until recently. Previous spot readings collected during previous surveys in summer found reasonably low water temperatures (for summer), good dissolved oxygen levels (all readings above 9 mg/L) suitable for sensitive fish species, relatively low conductivity levels indicative of low nutrient enrichment, but increasing with distance down the catchment (Table 1). GHD (2019) report that 17 samples taken from Highlay Creek at site HC01 (Figure 5) had a median sulphate concentration below 10 g/m^3 and a maximum recording of 70 g/m^3. The median Nitrate-N value was 0.09 g/m^3 and the maximum reading was 0.49 g/m^3. Current and projected increases in nitrate and sulphate are discussed further below in Section 5.

Table 1 Water quality in Highlay Creek, February 2011.

Site	pH	Temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)	Conductivity (µS/cm)
Highlay Creek - upper reaches	8.11	13.7	10.42	100.3	53.2
Highlay Creek tributary	7.83	17.0	9.05	93.2	65.8
Highlay Creek - middle reaches	8.54	15.8	9.83	98.8	65.7

3.2.3 Stream biota

Benthic communities

In support of a proposed Highlay Creek Storage dam, aquatic communities within the Highlay Creek area were surveyed in February 2011. The approach taken was to sample representative habitats throughout the area. Refer to Appendix One for descriptions of sampling techniques.

Periphyton communities in the upper reaches of Highlay Creek have been previously found to include diatoms (e.g., *Synedra*, *Encyonema*, *Melosira*, *Cymbella*, and *Gomphoneis*) and cyanobacterial mats (*Oscillatoria / Phormidium*). Small areas of the felt-like mats of *Vaucheria* have also been observed. These algal communities are found in a wide range of conditions, from pristine headwater streams to more enriched lowland locations.

The February 2018 survey of Highlay Creek found a significant algae bloom in the creek in the vicinity of the Horse Flat Road ford (Figure 11). A sample of the algae was identified in the lab to be *Melosira varians*, a filamentous diatom, found throughout New Zealand in slow to medium flowing open lowland streams. It can dominate the periphyton community in moderately enriched situations, although it is reported as both a "clean water species" and "moderately polluted water species" in Cassie (1989).

Not surprisingly, algal abundance appears to be higher in open areas where sunlight can reach the creek bed, providing more suitable conditions for growth. Algal communities present in the creek are commonly found throughout New Zealand in a range of conditions, with the filamentous algae typically found in open, unshaded situations.

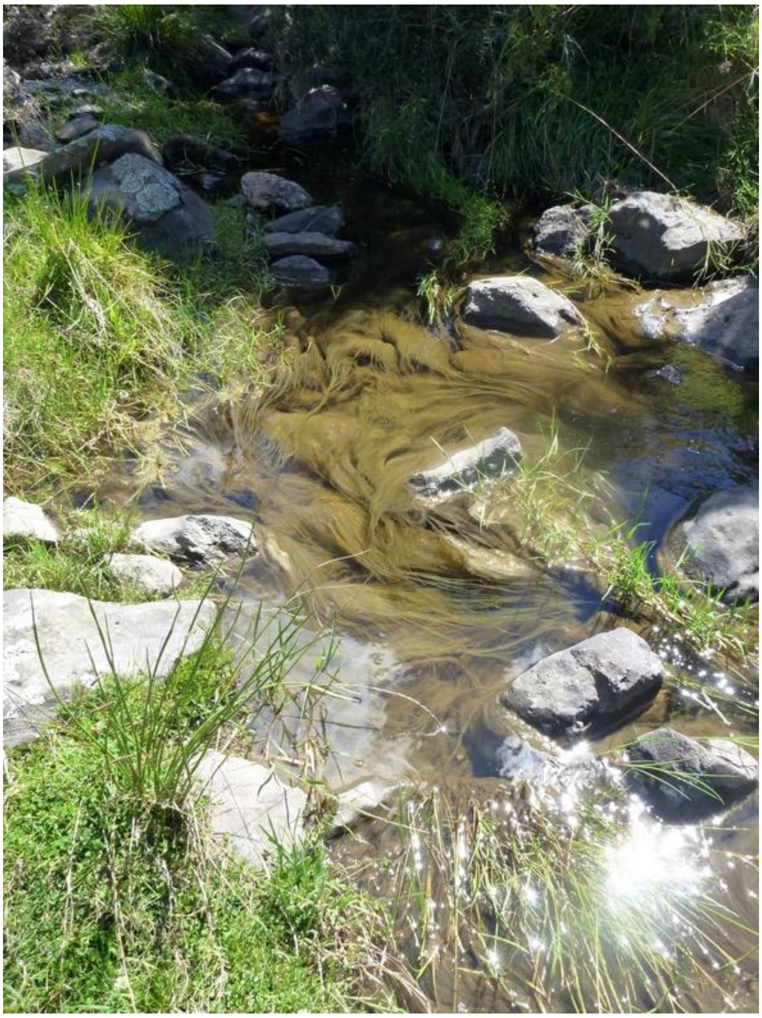

*Figure 11 Algae bloom (*Melosira varians*) in Highlay Creek just upstream of the Horse Flat Road ford, February 2018.*

Benthic invertebrate surveys of Highlay Creek catchment in February 2011 found a total of 32 invertebrate taxa. *Deleatidium* mayflies and *Potamopyrgus* snails (Figure 12) were numerically abundant at all sites (Appendix One). 'High quality' taxa were also present, including *Stenoperla* stonefly larvae. Invertebrate community health index scores were calculated using tolerances developed for hard-bottomed habitats for the upper and middle reaches of Highlay Creek, and soft-bottomed habitats for the tributary of Highlay Creek (Appendix One). The average hard-bottomed and soft-bottomed MCI and SQMCI score was indicative of 'fair' water quality, using Stark's narrative categories (Table A1.2).

Figure 12 Potamypyrgus antipodarum *snails on stones surface of Highlay Creek, February 2018.*

A survey of Highlay Creek downstream of the Horse Flat Road ford in April 2013 found and identified 20 invertebrate taxa from six benthic samples (Appendix One). *Deleatidium* mayflies numerically dominated the community. *Neozephlebia* mayflies, the megalopteran *Archichauliodes*, *Potamopyrgus* snails, oligochaete worms, and the caddisflies *Aoteapsyche* and *Polyplectropus* species were also common. MCI scores were indicative of 'good' or 'excellent' habitat quality (using Stark and Maxted's (2007) narrative terminology). The SQMCI and average QMCI scores were both indicative of 'excellent' habitat quality (Appendix One).

Surveys of the Highlay catchment in February 2018 found similar macroinvertebrate communities to that found in the February 2011 surveys (Appendix One). A total of 41 taxa were found from three sites, with beetle taxa being more diverse relative to the lower creek. Community health was good in the upper tributaries (SQMCI scores of 6.9 and 7.0) and indicative of good water quality, although MCI scores suggested doubtful quality (MCI scores of 111 and 108).

Crayfish (*Paranephrops zealandicus*, Figure 13) have been observed throughout the Highlay Creek catchment, having been recorded at all survey sites. *Paranephrops zealandicus* has been classified as 'At Risk – Declining' using New Zealand Threat Classification System (NZTCS) criteria (Townsend *et al.* 2008), with criteria C (1/1) (very large population and low to high ongoing or predicted decline, >100,000 mature individuals, predicted decline 10 70

%) and the qualifier 'Partial Decline' (Grainger *et al.* 2014).

Figure 13 Crayfish and crayfish eggs from Highlay Creek.

Overall, macroinvertebrate communities are relatively healthy throughout Highlay Creek, with communities dominated by sensitive mayflies and *Potamopyrgus* snails. Invertebrate communities were of poorer quality in the tributary that would receive runoff and seepage water from part of the Project's proposed WRS.

3.2.4 Fish communities

NZFFD records for surface waters draining the Macraes Gold Project area are presented in Figure 14.

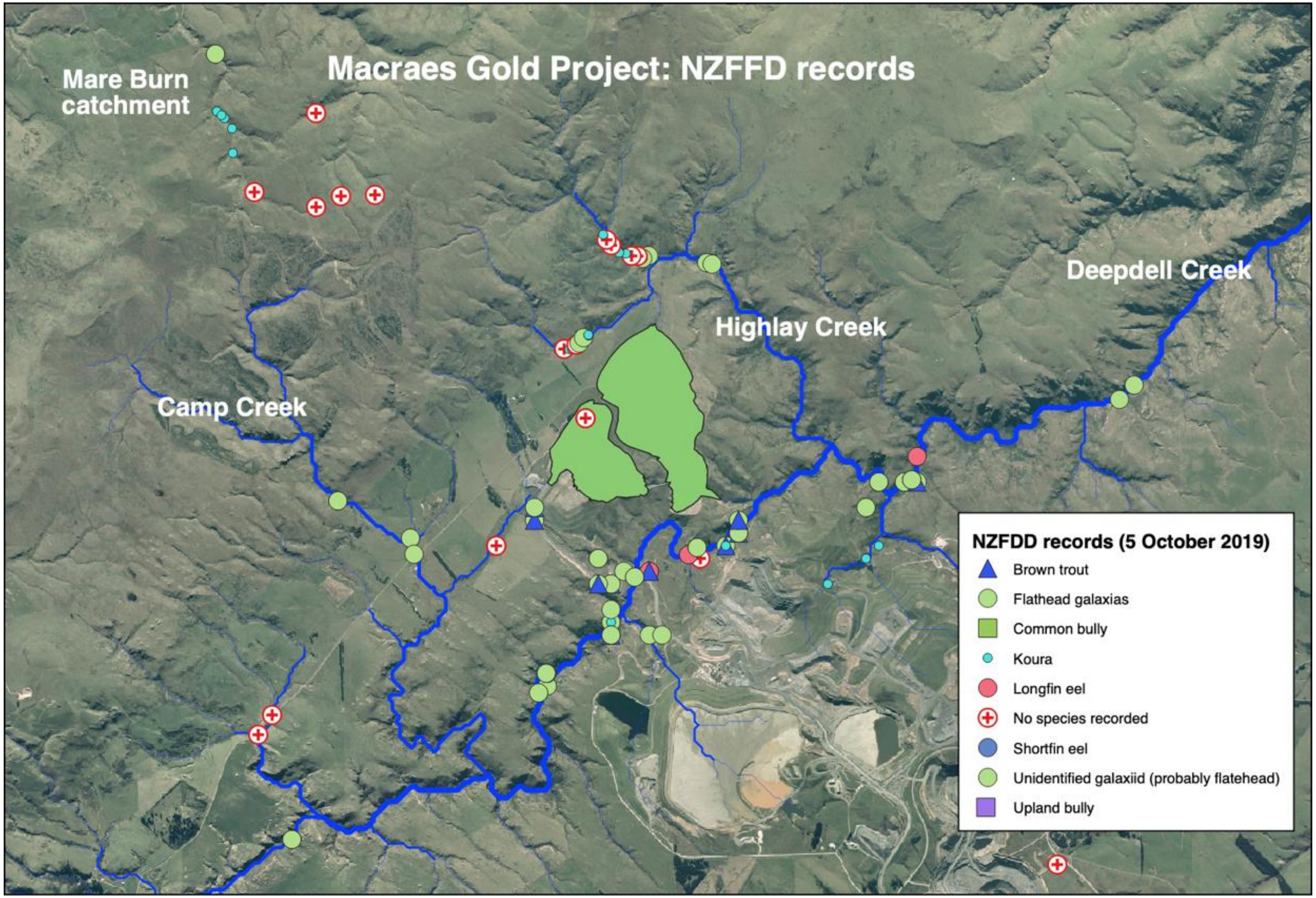

Figure 14 NZ freshwater fisheries database records for receiving waters surrounding the Macraes Gold Project (accessed 5 October 2019).

Up until 2006, there was only one confirmed NZFFD record of a fish survey in Highlay Creek, undertaken as part of a survey throughout the Macraes area by DOC. The survey included a site in Highlay Creek in January 2006 and was undertaken at the Horse Flat Road ford. The survey recorded Flathead galaxias, ranging in length from 22 to 93mm (data sourced from the NZFFD).

The February 2011 survey undertaken on behalf of OceanaGold found flathead galaxias throughout Highlay Creek and in the lower section of the tributary that would receive runoff and seepage from the new waste rock stack (Table 2). Abundance was similar at both sites surveyed in Highlay Creek, indicating an abundant population probably present throughout the creek. Only one galaxiid was caught in the Highlay Creek tributary.

Table 2 Number of fish (length range in mm), Highlay Creek catchment, February 2011.

Site	Flathead galaxias (*Galaxias depressiceps*)
Highlay Creek - upper reaches	19 (36–81mm)
Highlay Creek tributary	1 (45mm)
Highlay Creek - middle reaches	19 (36–81mm)

Flathead galaxias were also captured in lower Highlay Creek in April 2013. Fish were common, with seven individuals caught and several others observed, but not caught. Individuals ranged in length from 60 to 88 mm, indicating an absence of juveniles. A lack of juveniles may have been related to the low flows in the creek at the time, with smaller fish having temporarily moved into less confined habitats elsewhere to avoid larger individuals.

Numerous adults and sub-adult galaxiids were observed and caught in the February 2018 survey at the Horse Flat Road ford. No fish were found in the headwaters of the tributary that would receive runoff and seepage water from the proposed WRS. These headwaters are steep and carried very little water in late summer. Some gullies had no surface flow.

The Department of Conservation surveyed sections of the Highlay Creek catchment in May 2018 (Jack 2018). Ten g-minnow traps were placed in the second order tributary in a section just upstream of the Project's proposed WRS, and another ten traps were placed in the mainstem of Highlay Creek just downstream of the confluence of the second order tributary, but still upstream of the WRS area (Figure 5). The Highlay Creek tributary traps captured two adult flathead galaxias (89 and 92 mm long), along with 14 adult and juvenile koura. The Highlay Creek mainstem traps captured two Taieri flathead galaxias (47 and 75 mm long) and 10 adult koura.

A further 8 baited minnow traps were set in the second order tributary overnight by Ryder Environmental in September 2019, downstream of Jack's (2018) traps (Figure 5). No flathead galaxias or Koura were captured in this early spring survey. Water temperature was very cold.

3.3 Camp Creek

3.3.1 General

Camp Creek is a major tributary of Deepdell Creek. Its catchment is situated upstream of the OceanaGold's mining operations, on the true left (Figure 1). Camp Creek headwaters are set in the vicinity of the Sister Peaks, at an elevation of 737m above sea level. The catchment drains steep slopes and the creek flows in a south-easterly direction to a plateau at approximately 500m elevation near Horse Flat Road. Below Horse Flat Road the creek enters a 3km long gorge before entering Deepdell Creek on its true left.

In 2011, OceanaGold gained consents to construct a storage dam in the Camp Creek catchment. The purpose of the storage dam is to augment flows in lower Deepdell Creek to guarantee adequate dilution of future leachate from the waste rock stacks and tailings impoundment.

3.3.2 Description of surface waters associated with the Project

Several small watercourses associated with the Camp Creek catchment are situated within or adjacent to the proposed Project footprint. The mid reaches of a modified watercourse that runs close to and parallel to the existing haul road (Figure 15) will be surrounded by the Project footprint. Within the proposed Project footprint area, the watercourse below Horse Flat Road has been straightened (Figure 16, top left) and flows into a cut-off drain that has been constructed around the upper perimeter of the existing waste rock stack (Figure 16, top right). It then discharges into a small ponding area on the northern side of the haul road (Figure 17, top). Discharge into the upper Camp Creek catchment is then via a small culvert under the haul road (Figure 17, top).

This small tributary in the Camp Creek catchment was surveyed by Ryder Consulting in the general vicinity of the haul road in October 2010 (Ludgate, Ryder & Dale 2011), as a part of Macraes Gold Project Phase III investigations (and prior to the establishment of the haul road and other mining activities in this area of the catchment). At that time, the tributary was described as having a low gradient, bordered by pasture grasses and with unrestricted stock access (Figure 16, bottom). Very little water was present in the channel with only occasional sections having visible surface water. Some areas are dominated by wet areas of soft sediment with pasture grasses and tussocks. Beds of *Glyceria fluitans* were present throughout the channel.

This watercourse was inspected again in September 2018 . The channel is willow-infested (Figure 16, top left) down as far as the cut-off drain, and significant cover of algae covered with iron-staining bacterial flocs were present in September (Figure 17, bottom). The bed was also clogged with willow branches and willow roots.

This watercourse will not be physically modified by the Project and will continue to drain to the Camp Creek catchment under the Project design.

A man-made pond is located on between Horse Flat Road and the existing waste rock stack. It discharges into a cut-off drain which runs for approximately 460 metres before reaching the confluence of the modified watercourse described above (Figure 16 top right). Approximately 100 metres of its lower section will be lost due to pit infrastructure.

The pond is fed by a small catchment (currently in pasture) that contains several gullies that potentially support ephemeral watercourses (Figure 23). The pond will be surrounded by the Deepdell North Pit to the east and additional pit infrastructure to the west (towards Horse Flat Road). These gullies will be lost to the new pit and some stockpile area. The loss of these ephemeral watercourses is estimated at 450 metres.

The cut-off drain into which the pond flows into will be converted to a drain for the diversion of 'dirty' drainage water to the existing Deepdell North Silt Pond (Figure 4) and will cease flowing towards the Camp Creek catchment. The loss of this highly modified intermittent flowing drain is estimated at approximately 360 metres.

3.3.3 Stream biota

The aquatic ecology of Camp Creek is similar to that found elsewhere in the Macraes area. The quality of benthic macroinvertebrate communities is variable, but generally healthy throughout, with some degradation in community health in the small tributaries that flow through farm land.

3.3.4 Benthic invertebrates

Thirty four invertebrate taxa were identified at the Camp Creek monitoring site CC02 in 2018 (Appendix One). The most taxonomically diverse group was trichopterans (caddisflies), following by dipterans (true flies) and plecopterans (stoneflies). Overall taxonomic diversity and diversity of EPT taxa were similar in summer and winter, however densities were lower in winter, due mainly to a reduction in snail abundance, which typically dominate the invertebrate fauna at site CC02. Invertebrate health index scores (QMCI) in summer 2018 were indicative of 'fair' quality conditions, while in winter the higher average score was indicative of 'good' quality conditions, using the narrative terminology of Stark and Maxted (2007).

The October 2011 survey found macroinvertebrate communities were relatively healthy throughout Camp Creek, however communities in the middle and lower reaches were generally of higher quality than those upstream of Horse Flat Road. Invertebrate communities in the tributaries such as the one adjacent to the haul were expected to be dominated by low quality taxa more typical of those found in soft bottomed habitat (Ludgate, Ryder & Dale 2011).

3.3.5 Fish

Flathead galaxias are present throughout Camp Creek with higher abundance in the lower and middle reaches. Some longfin eel are also present in the lower and middle reaches of Camp Creek, however eels have not been found further upstream.

Old NZFFD records from 1996 and 1987 recorded brown trout, koura and an unidentified galaxiid (most likely flathead galaxias) in the tributary beneath what is now the haul road, but no fish captured a further 300-400 metres downstream (Figure 15). In September 2019, four baited minnow traps were set overnight in deeper water within the tributary below Horse Flat Road (Figure 15). No fish or crayfish were captured.

The October 2010, a survey by Ryder Consulting included the tributary of Camp Creek at Golden Point Road, and was at a similar location as the Fish and Game Otago NZFFD record described above. However, habitat in the creek was described as very poor, with low water clarity and no suitable habitat for fish. Ludgate, Ryder & Dale (2011) concluded that the brown trout, flathead galaxias and crayfish found in the area by Fish and Game are probably no longer present due to local changes in habitat.

Figure 15 Aerial map showing the location of the modified watercourse adjacent to the haul road described in section 5.1.1. The thick light blue line indicates the watercourse flow path from top of the aerial down to the left towards Camp Creek (piped under the culvert. The finer dark blue lines are imported REC shape files. Note that fish and koura records for the tributary running through the middle of the map pre-date (1991-1987) the existing haul road and adjacent waste rock stacks.

Figure 16 Camp Creek tributary within the Project footprint. Top left: willow infested, channelled section immediately below Horse Flat Road (September 2019). Top right: Cut-off drain that receives tributary water and flows towards the haul road culvert (September 2019). Bottom: Same tributary in October 2010 looking downstream from Golden Point Road.

Figure 17 Top: Ponded area between the cut-off drain and haul road. Note the haul road culvert in upper centre of the photo. Bottom: Flocs of iron-staining bacteria over filamentous algae in the Camp Creek tributary downstream of Horse Flat Road.

3.4 Deepdell Creek catchment

The Deepdell North Stage III Project includes backfilling the existing Deepdell South Pit and creating a new pit on a rehabilitated rock stack (Figure 2). These areas border land that drains into Deepdell Creek (figures 1 and 4). The section of Deepdell Creek that would potentially receive runoff and seepage water from this land, and the discharge of Highlay Creek water, has been monitored at several sites (Figure 5) for many years, and thus the creek environment in this area is well understood.

3.4.1 General habitat

Deepdell Creek in the vicinity of the Project is contained within a confined channel that is surrounded by relatively steep-sided land throughout most of its length (figures 3 and 18). Riparian vegetation is dominated by pasture grasses, broom and matagouri, with occasional tussocks and *Carex* sedges along the edges. Shading is common due to the steep topography and overhanging riparian vegetation. Stock and pig disturbance is evident in places.

Figure 18 Aerial view of Deepdell Creek looking downstream (right of photo), with the Deepdell South Pit in the upper left corner.

In summer, the flow in Deepdell Creek can drop significantly, however even under these low flow events, the creek is punctuated with deep, very slow moving sections (Figure 19 left). Small riffle and run sections are also present (Figure 19 right). In riffle and run sections the substrate is dominated by cobbles with gravels and occasional boulders. Softer sediment is present in the slow moving glides and pools. These habitats support significant macrophyte cover, particularly in the warmer months and following periods of stable flow (Figure 20). Algae growth can be significant also.

Figure 19 Examples of pool (left) and riffle (right) habitat in Deepdell Creek in the vicinity of the Deepdell North project area.

Figure 20 Submerged macrophytes including Myriophyllum*, Deepdell Creek, February 2018.*

3.4.2 Water quality

Deepdell Creek typically has a pH above 7 and relatively high conductivity (average of 546 µS/cm). Dissolved inorganic nitrogen levels are elevated (particularly nitrate, average of

0.54 mg/L at DC07) and concentrations in Deepdell Creek at DC08 over the period 2018-2019 peaked at 0.6 mg/L, but generally much lower. Nitrate concentrations in the Shag River at Loop Road were slightly less than 0.5 mg/L over the same period. Although no recent phosphorus monitoring data are available, past monitoring suggests there is sufficient dissolved phosphorus in Deepdell Creek to promote algae and plant growths. Water clarity is generally very good under average and low flow conditions.

3.4.3 Benthic biota

Biological surveys of Deepdell Creek and tributaries were first undertaken in 1987 (Dungey 1988). Following on from these initial surveys, aquatic monitoring has been undertaken on a quarterly basis in Deepdell Creek since 1990 as part of resource consent monitoring for the Macraes Mine (e.g., OFGC 1990, Bioresearches 1991, Ryder 1995, Ludgate and Goldsmith 2004, 2006, 2007, Ludgate 2008, Ryder Consulting 2009a, Ryder Consulting 2010). This monitoring has included surveys of fish (since 1990), benthic macroinvertebrate (since 1991) communities and plant and periphyton cover.

The most recently completed analysis of Deepdell Creek monitoring data (March 2019) found the invertebrate community composition at monitoring sites DC03, DC05 and DC07 to be dominated by snails (particularly *Potamopyrgus antipodarum* but also *Physa*), chironomid larvae and various Trichoptera, with lessor contributions from small crustaceans, mayflies and worms. This assemblage is broadly similar to that observed in recent years. Benthic invertebrate health index scores are typically indicative of 'poor' to 'fair' water quality using the narrative terminology of Stark and Maxted (2007). This ranking reflects the dominance of taxa (e.g., snails) that are relatively insensitive to poor water quality and habitat conditions (although see further below in relation to nitrate toxicity). Koura have been observed at sites DC03, DC05 and DC07.

Flathead galaxiids are by far the dominant fish in Deepdell Creek, and site DC07, located downstream of the Highlay Creek confluence, typically supports a large population (Figure 19). In the most recently completed fish survey of Deepdell Creek (February 2017), 32 galaxiids were caught at DC07, 11 at DC05 and 27 at DC03.

3.4.4 Fish communities

Electric fishing was undertaken at two Deepdell Creek monitoring sites in late summer 2018 and at all sites in winter 2018. The community at each site was dominated by galaxiids in the 40-50 mm size class. At DC07 in summer, 61 galaxiids were caught, ranging in size from 38 to 90 mm long (Figure 21). Freshwater crayfish were also caught during electric fishing at DC07.

The highest populations of galaxiids in winter 2018 were found at DC01 and DC02, followed by DC03 and DC05 (Figure 21, Table 3). The population estimate for DC01 was the highest since 2014, and estimates for all sites except DC07 and DC08 were higher than 2017 estimates. Natural annual fluctuations in the galaxiid population are expected, and relate to variations in reproduction, food availability and physical habitat. Error associated with sampling efficiency and model assumptions also affect population estimates. With the sampling being undertaken in winter 2018, rather than the usual summer monitoring period, variation when compared to previous sampling results is also expected.

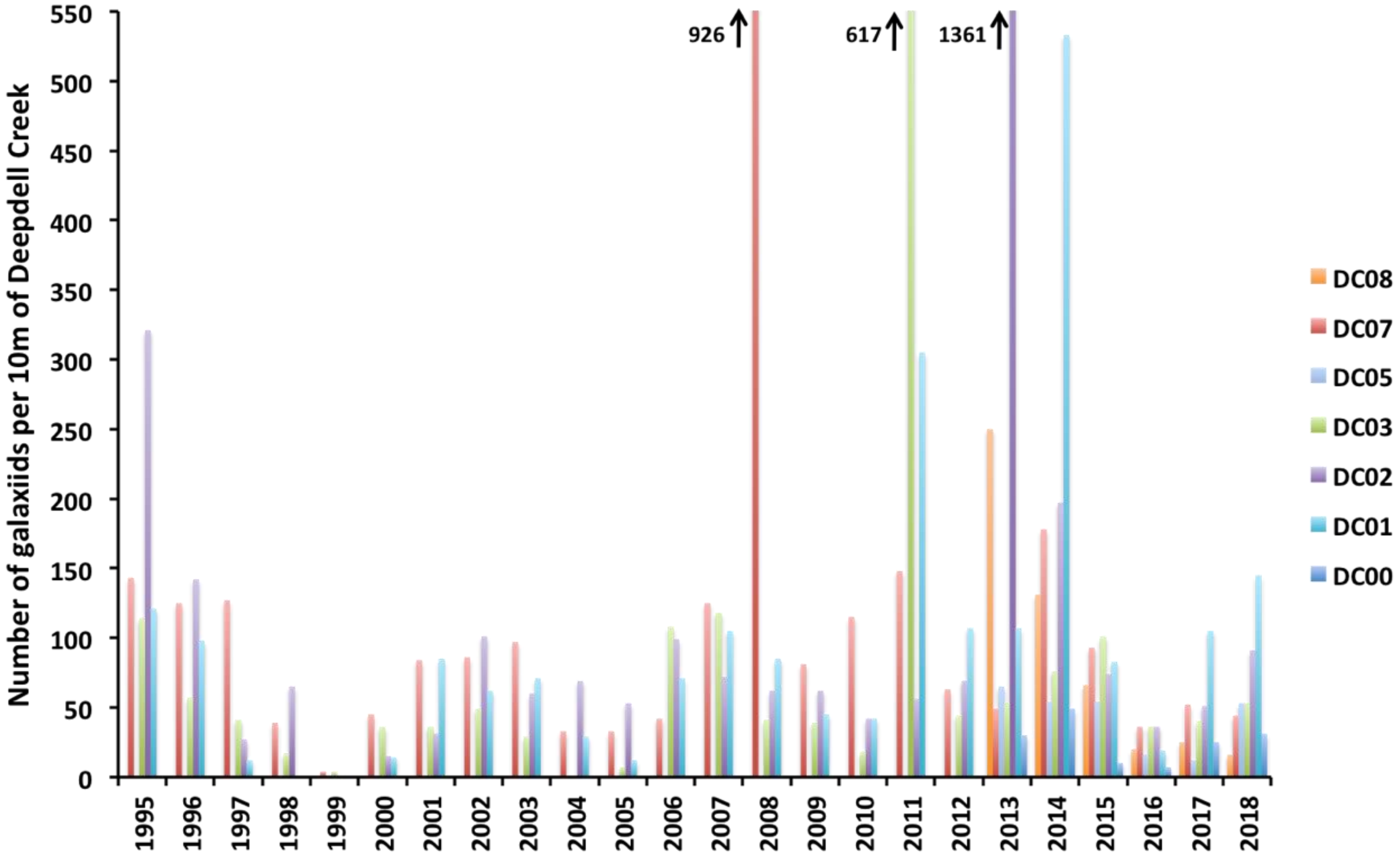

Figure 21 Number of flathead galaxiids (per 10 m reach) found in summer surveys of Deepdell Creek, 1995 to 2018. Summer sampling in each year, except winter 2018.

Table 3 Results of fish surveys and fish population estimates, Deepdell catchment sites, 1998-2018. – = unable to be sampled due to low flows. Note 2018 data is from fishing undertaken in winter 2018.

Year	Downstream of mine operations								Upstream of mine operations					
	DC08		DC07		DC05		DC03		DC02		DC01		DC00	
	Count	Pop'n estimate	Count	Pop'n estimate	Count	Pop'n estimate	Count	Pop'n estimate	Count	Pop'n estimate	Count	Pop'n estimate	Count	Pop'n estimate
1990														
1991			30	-			19	-	62	-	45	-		
1992			43	-			15	-	37	-	68	-		
1993			56	-			15	-	48	-	105	-		
1994			21	-			2	-	38	-	30	-		
1995			155	143			55	114	126	321	72	121		
1996			84	125			43	57	115	142	88	98		
1997			47	127			52	41	37	27	14	12		
1998			42	39			14	17	37	65	7	*		
1999			3	4			3	4	-	-	-	-		
2000			15	45			13	36	5	15	7	14		
2001			40	84			20	36	20	31	24	85		
2002			81	86			25	49	48	101	38	62		
2003			53	97			25	29	62	60	41	71		
2004			27	33			6	*	34	69	13	29		
2005			18	33			4	7	35	53	7	12		
2006			21	42			35	108	43	99	18	71		
2007			38	125			50	118	57	72	35	105		
2008			70	926			26	41	62	62	62	85		
2009			31	81			20	39	28	62	27	45		
2010			58	115			10	18	14	42	16	42		
2011			37	148			46	617	14	56	32	305		
2012			32	63			42	44	43	69	76	107		
2013	29	250	33	49	24	65	22	53	69	1361	70	107	24	30
2014	57	131	105	178	39	54	49	76	131	197	108	533	39	49
2015	29	66	53	93	45	54	70	101	66	74	70	83	7	10
2016	9	20	26	36	16	16	26	36	28	36	14	19	5	7
2017	15	25	32	52	11	12	27	40	33	51	78	105	15	25
2018	14	16	31	44	48	53	22	53	70	91	76	145	24	31

4. Significance of existing aquatic values

4.1 Natural values

According to the Otago Regional Council (ORC) Regional Plan: Water for Otago (2004), Deepdell Creek contains significant natural values including the absence of aquatic pest plants and significant habitat for galaxiids (Table 4). The ORC Water Plan identifies that some tributaries of the Taieri River contain significant habitat for flathead galaxiids, and this has been confirmed by our current and previous assessments in the Macraes Flat area.

There are no values listed in the regional water plan for Camp Creek or Highlay Creek, however it is expected that the values present in Deepdell Creek would also be relevant for these creeks.

Table 4 Natural values for Deepdell Creek. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Deepdell Creek	No aquatic pest plants Presence of indigenous fish species threatened with extinction	Significant habitat for flathead galaxias

4.2 Non-migratory galaxiids

Flathead galaxiids are common and widely distributed in the Highlay Creek catchment and to a lesser extent in Camp Creek. Headwaters of both creeks drain small catchments, are very steep and carry little surface water under normal summer flow conditions. Indeed, some sections of the Highlay Creek catchment were dry in the February 2018 inspection despite recent rain. Further downstream, where channels are more creek-like in appearance and have stony beds, fish are more common, despite significant algae and plant growth smothering the bed in places. However, it has been our experience that fish can be quite common amongst significant periphyton growths in creeks of the Macraes Flat area.

Flathead galaxiids are common in the mainstem of Deepdell Creek and monitoring over many years has indicated that the population is large and resilient to algae blooms, disturbance (e.g., large floods and stock damage) and drought conditions (Table 3).

Flathead galaxiids found in the Shag River, Waikouaiti River, and Taieri River catchments are all being managed as *Galaxias depressiceps* K Taieri flathead galaxias. The threat status of New Zealand freshwater fish was updated in 2018 (Dunn *et al.* 2018). The Taieri flathead galaxias has been classified by the Department of Conservation as 'Threatened – Nationally Vulnerable', with criteria C (3) (moderate population, with population trend that is declining, total area of occupancy ≤ 100 ha (1 km^2), predicted decline 10–50%) and the qualifiers 'Conservation Dependent' and 'Data Poor' (Dunn *et al.* 2018). The geographic range of this species has decreased substantially in the last 150 years, since the introduction of invasive fish species (e.g., brown trout) and its distribution is now highly fragmented (Department of Conservation 2004, Jones 2014, NIWA 2013) (Figure 22).

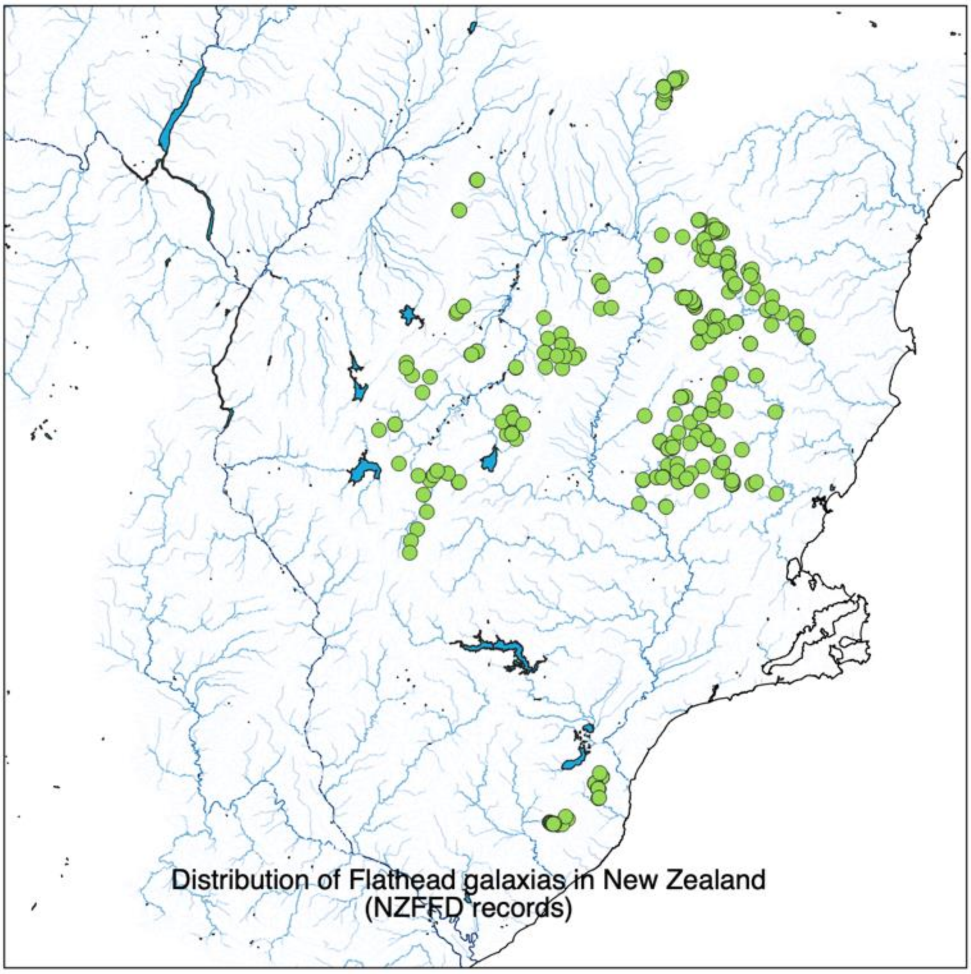

*Figure 22 Map showing the known national distribution of flathead galaxias (*Galaxias depressiceps) using NZFFD records.

4.3 Other fish species

Brown trout and longfin eel have occasionally been caught in Deepdell Creek since regular monitoring commenced in the 1990s, however they are uncommon. This is probably due to limited access from downstream populations (Deepdell Creek often flows underground in a short section near monitoring site DC08) and frequent low flows in summer provide limited habitat availability. Longfin eel are classified by the Department of Conservation as 'At Risk – Declining' (Dunn *et al.* 2018).

4.4 Freshwater crayfish

Freshwater crayfish or koura (*Paranephrops zealandicus*) are widely distributed throughout the Highlay Creek catchment and in the mainstem of Deepdell Creek, and they are generally common in many of the small streams of the Macraes Flat area. They are also likely to widespread in the Camp Creek catchment. Their relatively high abundance in these creeks is surprising given that habitat appears limited by a lack of flow and wetted area at times, particularly during late summer and into autumn. A lack of predators (trout and birds – both restricted by a lack of suitable foraging habitat and, in the case of trout, upstream passage) and good cover amongst the schist slab substrate may in part explain the success of crayfish at Macraes.

4.5 Benthic macroinvertebrates

Approximately sixty benthic invertebrate taxa have been identified from three benthic invertebrate surveys of the Highlay Creek catchment (Ludgate *et al*. 2011, Ryder Consulting 2013, this report). This is a relatively high number by New Zealand standards, but reflects the sampling effort in the catchment. Scarsbrook *et al.* (2000) found 18 was the national median number of taxa per site based on 66 sites located throughout New Zealand. The most recent survey (February 2018) of the Highlay catchment found the number of taxa per site ranged between 17 and 25 (Appendix One).

Benthic invertebrate habitat is variable in the Highlay Creek catchment, ranging from small seepages through to creeks. Habitat is widely affected by algal blooms and stock damage. No taxa we have identified are uncommon, and most are commonly found throughout large areas of the country.

The benthic invertebrate community of Deepdell Creek is similar to that of Highlay Creek, but composition varies between sites and seasons, often influenced by climate, flow history and local physical habitat features. Again, as for Highlay Creek, most taxa in Deepdell Creek are common and found throughout the country.

5. Potential effects on freshwater ecology associated with the Project

5.1 Stream habitat - General

5.1.1 Within the Project footprint

The proposed Deepdell North Stage III Project will result in some loss of shallow ephemeral drainage systems and small seepage habitat in the Highlay Creek catchment (see Figure 23 of this report and Figure 2 of Thorsen 2019). Arguably, some of this habitat may be intermittent in character than ephemeral (as shown in Figure 23), however, based on (wet) September observations, it is difficult to distinguish where watercourses change from being ephemeral to intermittent. It is unlikely that they carry surface flow during warmer months of the year. A rough estimate using maps of the proposed project area and GIS tools indicates that approximately 350 metres of ephemeral seepage watercourses and 130 metres of possibly intermittent watercourse would be lost in the Highlay Creek catchment. Because they are small, very shallow surface water systems at best, and appear to be largely ephemeral in nature, they do not support fish or typical stream invertebrate habitat and associated communities. Further, given that they lie within farmed land, and historically stock have had direct access to this habitat, they are also likely to be a source of nutrients, sediment and faecal pathogens to watercourses located further downstream. Inspections of some of these areas in September 2018 found them to be heavily modified and subject to considerable pugging from stock (Figure 8). Consequently, other than some very minor flow contribution, it is considered that these drainage networks provide little to support downstream stream communities of the Highlay Creek tributaries or Highlay Creek itself. 'Clean' water will be diverted downstream of the proposed silt pond (Figure 4). The establishment of a silt pond in this part of the catchment may potentially help improve downstream water quality relative to the current situation.

Populations of Taieri flathead galaxiids are present throughout Highlay Creek catchment, but not in gullies that would be inundated by the proposed Deepdell East Waste Rock Stack. Galaxiid populations are present in the Highlay Creek tributary into which these gullies drain into and in Highlay Creek itself. Streams in Highlay Creek catchment that support fish and crayfish populations cannot be regarded as pristine. They are subject to physical disturbance through stock trampling and support nuisance algae growths. However, they obviously have characteristics that are favourable to these species. One of the likely key features responsible for robust crayfish and galaxiid populations in Highlay Creek catchment is the lack of predatory species, in particular brown trout.

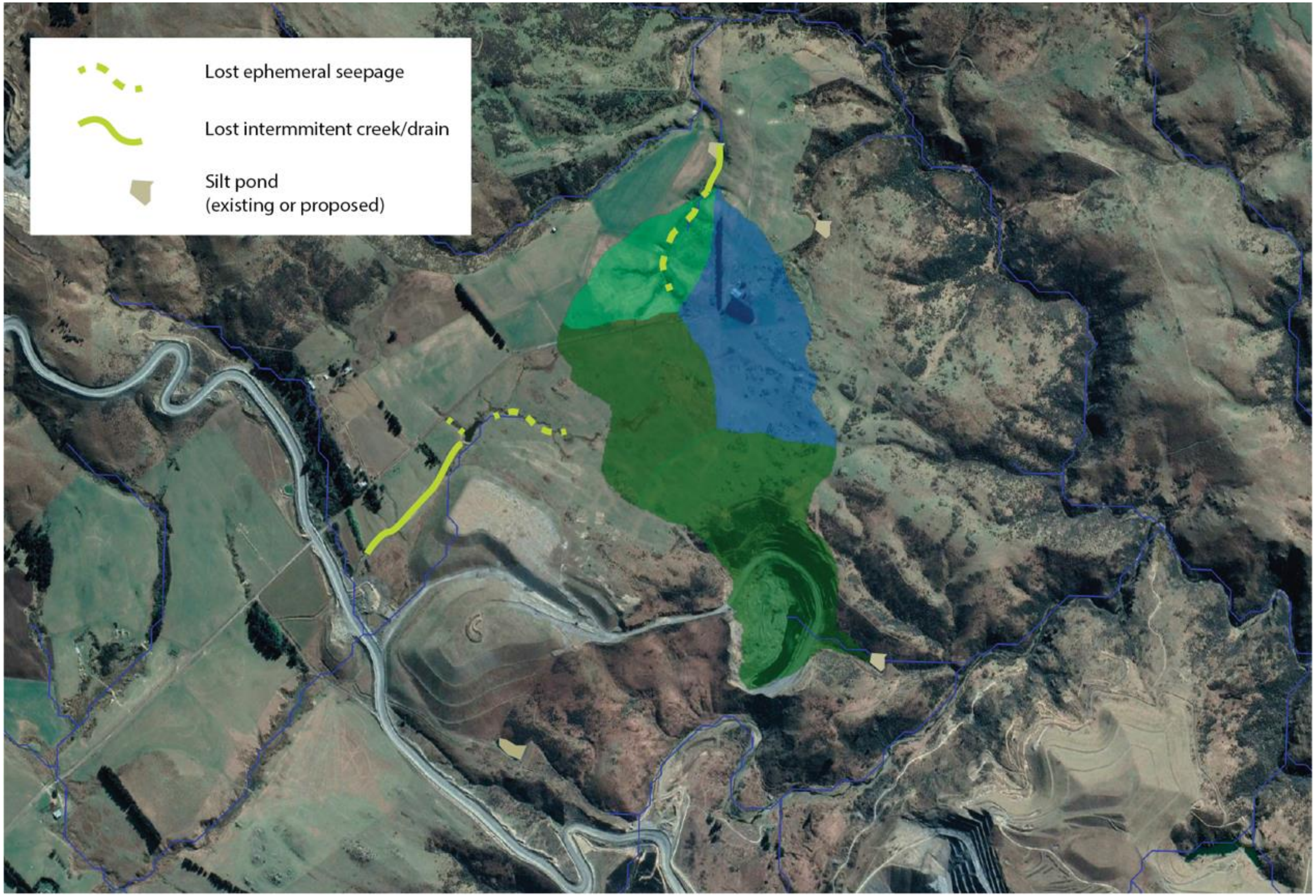

Figure 23 Map showing locations and approximate extent of surface water habitat loss associated with the Deepdell North Stage III Project.

The existing watercourse adjacent to the haul road that drains into the Camp Creek catchment appears devoid of fish, and it is possible the watercourse flows intermittently, which would limit habitat potential even further. Although no fish or crayfish were captured in September, it is possible that crayfish may still be present in the system, given the habitat observed in September 2019. Crayfish were found in the general vicinity as part of a Fish & Game surveys around 1987-1996. Under the proposed Project, this modified watercourse would not be affected, however approximately 480 metres of an intermittently flowing cut-off drain, located between the confluence with the above watercourse and the man-made pond to east of Horse Flat Road, would be lost to pit infrastructure (figures 23 and 24). Although highly modified and likely to carry little flow even in the cooler months of the year, it potentially may provide some crayfish habitat if surface water persists throughout all year-round. New drains are proposed to divert 'clean' water away from the mine footprint, and sections of these could be constructed in a way that provided habitat for crayfish (see section 6.1).

An estimated 450 metres of gullies that may support ephemeral watercourses will be lost due to the new pit and associated mine earthworks. These gullies are currently in grazed catchments and are unprotected. They do not support fish habitat.

Figure 24 Centre of photo is looking upstream to the cut-off drain that receives from the man-mdae pond that lies east of Horse Flat Road. The modified watercourse within the Camp Creek catchment that flows parallel to the haul road enters from the left.

The mainstem of Deepdell Creek is also a stronghold for flathead galaxiids and a large population exists in the reach downstream of gullies draining the Deepdell South Pit and the Highlay Creek confluence.

There will be no physical disturbance to Deepdell Creek as a result of the Project. Provided that the project does not exacerbate low flows, sediment load and water quality, downstream crayfish and fish populations should be unaffected by the Project. Sediment and water quality are discussed further below.

5.2 Sediment mobilisation

Mining disturbs the land, removes vegetation and soil cover, and so increases the risk of fine sediment discharges to watercourses further down the catchment. Fine sediment is already present in tributaries of Highlay Creek, and also present in the mainstem of Highlay Creek and in slow runs and pools in Deepdell Creek. Excessive fine sediment cover is usually detrimental to stream communities, particularly if flow variability is insufficient to regularly flush excess material away. Measures to avoid the introduction and downstream transport of sediment are therefore necessary. Such measures are routinely employed by OceanaGold at the Macraes Mine, but are worth re-emphasising here.

Specific erosion and sediment control measures will need to include:

- Manage surface water runoff around the pit, waste rock stacks and haul road with diversion drains and silt control dams. Permanent silt ponds should be located as close as possible to the disturbed area to minimize effects on downstream aquatic habitats. Sediment control should be installed prior to any disturbance within each catchment area. Any silt pond in the Highlay Creek catchment should be situated well upstream of Highlay Creek mainstem and in any tributary that supports fish. Existing silt ponds associated with the Deepdell South Pit should be assessed to ensure they are appropriately sized for any expansion associated with the Project and in particular to avoid additional transport of fine sediment to Deepdell Creek.

- Shoulders of waste rock stacks should have benches designed to control runoff.

- Install perimeter surface water drains around waste rock stacks to ensure runoff is conveyed to the base of gullies without erosion. Such drains may need to be lined where necessary and energy dissipation provided at high energy locations.

- Surface water and groundwater collected in the pit during operations may need to be pumped out to a water sump and used for dust control. Any surplus water may need to be discharged to watercourses via silt ponds. Water quality testing of this water is recommended prior to discharge to ensure it meets water quality guidelines that protect stream biota.

- Ensure any catchment runoff associated with the Project is directed into the tributaries they currently feed. This will help minimise any potential effect on downstream crayfish and crayfish communities. At best, ensure that low flows are not exacerbated.

5.3 Water quality

Nitrate and sulphate have been identified as two water quality parameters that have increased in downstream receiving water environments due to the effects of the mining operations at Macraes. The nitrate and sulphate character of Deepdell Creek and the Shag River is discussed in the report prepared by GHD for the Deepdell North Stage III Project (GHD 2019).

The project will result in these two contaminants reaching Deepdell Creek and Highlay Creek via silt ponds and consequently some level of treatment can be expected as a result of flow retention and sediment deposition. Potential ecological effects of these contaminants in these two creeks can be expected to be similar given they have similar freshwater communities and drain catchments with similar physical and land use characteristics. Camp Creek will receive clean water only.

5.3.1 Sulphate

Golder (2011) reported that sulphate concentrations would likely exceed receiving water resource consent limits seasonally at the Macraes Gold Project, with a risk of increasing over time due to the delayed release associated with geochemical reactions of waste rock material. In recent years, OceanaGold OGL has initiated changes in its waste rock stack construction and management in order to better control sulphate in seepage. Sulphate leaches from waste rock stacks over time and recent consenting processes associated with the Macraes Gold Project have considered the effects of sulphate on local surface water quality and ecology.

Sulphate concentrations have been monitored in Deepdell Creek for a number of years now, as have fish populations. Both sulphate concentrations and flathead galaxiid fish population estimates are presented in Figure 25 for the period 1990 to 2018 (note regular fish monitoring of Deepdell Creek commenced in 1995). The data for sulphate in Figure 25 show that concentrations have increased from 2006 onwards. Fish population estimates over that period have not altered relative to pre-2006 estimates. While the population varies widely from year to year, the post 2006 median population estimate of 87 fish/10m^2 compares closely to the pre-2006 estimate of 64 fish/10m^2.

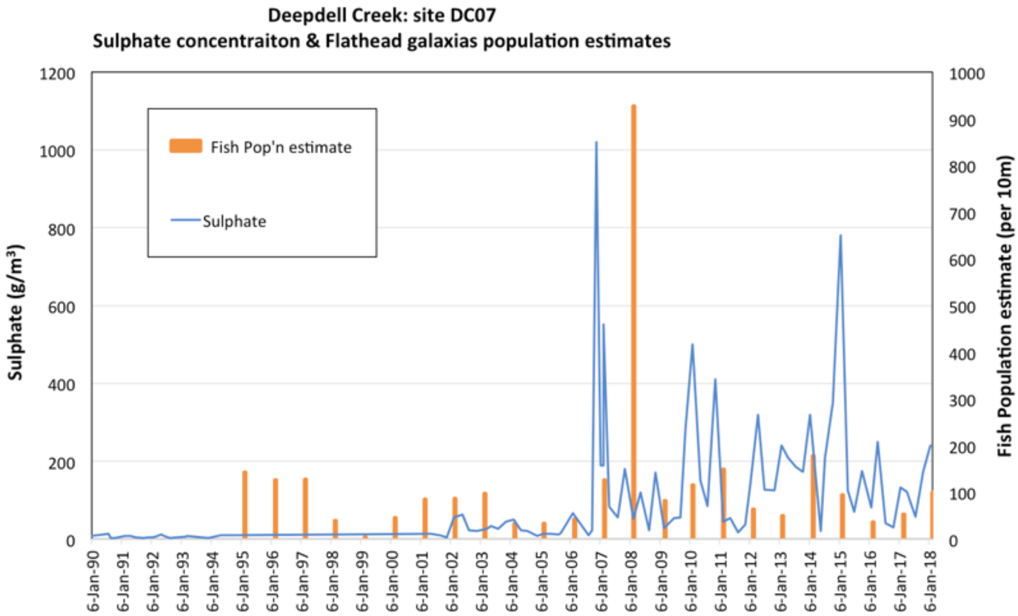

Figure 25 Flathead galaxiid population estimates (per 10 m reach) and sulphate concentrations over time at Deepdell Creek site DC07, 1990 to 2018.

Elevated levels of sulphate in recent years have not resulted in changes to the typical fish population or size classes found in Deepdell in late summer, with the median population estimate in recent years slightly higher than that prior to sulphate levels increasing at DC07.

Recently, toxicity testing has been conducted using Taieri flathead galaxias (OceanaGold 2018). The most sensitive stages of the flathead galaxias (eggs and larvae) were exposed to a range of concentrations of Macraes mine waste rock seepage diluted with Mare Burn creek water over a 50 day period. The principal constituent of seepage is sulphate and the testing used sulphate concentrations ranging from 100 to 3,000 mg/L. No impact was identified on ova. There was no evidence of a toxicity effect during any of the egg development stages. Eggs that developed fungus appeared to have been unfertilised and were distributed across the test concentrations. Actual mortally effects did not occur until sulphate concentrations of between 1,640 and 1,920 mg/L. No effects were observed at 1000 mg/L sulphate, which OceanaGold has proposed as a compliance limit for Deepdell Creek.

GHD (2019) predict that sulphate values will increase in Deepdell Creek (DC08) from the baseline condition over time to a median of 100 to 200 g/m^3 (seasonal variation). This prediction aligns with the gradual increase in sulphate concentrations in waste rock stack seepage, however concentrations will remain consistently under the current compliance limit. For the Shag River downstream of the Deepdell Creek confluence (at Loop Road), the predicted median sulphate concentration is also predicted to stay within compliance over the 40 year time period run in the model (GHD 2019). Modelling did identify potential to exceed the 95th percentile guidance values for sulphate from 2045 onwards, but with a low probability of occurrence.

5.3.2 Nitrate

The GHD (2019) report notes that investigations by OceanaGold have determined that unburnt ammonium nitrate from explosives and source rock are sources of nitrate to receiving waters draining the mine site. GHD (2019) undertook further modelling to predict the potential changes in receiving water nitrate concentrations based on the development of Deepdell North Stage III Project proceeding as summarised in section 1 of this report.

Nitrate nitrogen is a nutrient that is necessary for algae and macrophyte (plant) growth. In excessive concentrations in freshwater, it can result in nuisance growths of these plant forms, particularly if sufficient phosphorus is also available for growth (along with other factors such as sufficient temperature and water clarity for light penetration). At even higher concentrations, nitrate can be toxic to aquatic life to various degrees.

5.3.3 Nitrate toxicity

The 2014 National Policy Statement for freshwater (updated 2017) contains attribute bands for nitrate toxicity. These are presented as concentration bands and are accompanied by a narrative description of each band, as set out in Table 5.

An obvious question to be asked in this report is, are there nitrate-sensitive species in the Deepdell catchment and if so, what is an appropriate attribute state for their protection?

The three aquatic species identified in the catchment are freshwater crayfish (koura), longfin eel and the flathead galaxias, of which the latter species has a relatively narrow geographical distribution (Figure 22). Longfin eel are widely distributed throughout New Zealand and are very uncommon in the Deepdell Creek catchment. This catchment does not appear to be favourable to them and any protection afforded to them is likely to be met by that provided for other species, as described below.

The Taieri flathead galaxiids have not been tested specifically for sensitivity to nitrate. However, the waste rock stack seepage described above that focused on sulphate toxicity most likely contained elevated levels of nitrate also, given the seepage leachate was sourced from areas known to contain high nitrate. This can be seen in Table 6, which are laboratory test results for Back Road Waste Rock Stack seepage leachate collected between May and September 2018. This leachate was used in toxicity testing described above. A sulphate limit of 1,000 mg/L, which testing showed to have no effect on flathead galaxias eggs and larvae, is equivalent to a nitrate-N concentration of approximately 7-8 mg/L N, going by the ratios of sulphate to nitrate in Table 6. This range is below the NPS-FW National Bottom Line concentration identified in Table 4.

Table 5 Nitrate (Toxicity) attribute states from the 2014 NPS-fW (updated 2017).

Value (and component)	Ecosystem Health (water quality)	
Freshwater Body Type	Rivers	
Attribute Unit	**NO_3-N** mg/L (milligrams nitrate-nitrogen per litre)	
Attribute band and description	**Numeric Attribute State**	
	Annual Median	Annual 95th Percentile
A High conservation value system. Unlikely to be effects even on sensitive species.	≤1.0	≤1.5
B Some growth effect on up to 5% of species.	>1.0 and ≤2.4	>1.5 and ≤3.5
C Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.	>2.4 and ≤6.9	>3.5 and ≤9.8
National Bottom Line	**6.9**	**9.8**
D Impacts on growth of multiple species, and starts approaching acute impact level (ie risk of death) for sensitive species at higher concentrations (>20 mg/L).	>6.9	>9.8

Note: This attribute measures the toxic effects of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes will be more stringent.

Table 6 Laboratory test results for Back Road Waste Rock Stack seepage leachate collected between May and September 2018. (source: OceanaGold 2018).

Date	**Sulphate** (mg/L)	**Nitrate-N** (mg/L)	**Ammoniacal-N** (mg/L)	**Hardness-Total** (mg/L as $CaCO_3$)
2-May-18	2,500	21	<0.01	3,000
1-Jun-18	2,900	20	<0.01	3,400
1-Jul-18	2,900	21	0.25	3,300
1-Aug-18	3,000	21	0.23	3,400
1-Sep-18	3,000	24	<0.10	3,600

Hickey (2013) described toxicity testing for another galaxias species (the inanga or *Galaxias maculatus*) and the ubiquitous, yet relatively sensitive *Deleatidium* mayfly, which is relatively common in Deepdell Creek and Highlay Creek. The chronic mayfly test was for a 20 day exposure and measured survival of the larvae. A no observed effect concentration (NOEC[1]) sensitivity values for *Deleatidium* was 20.3 mg/L NO_3-N in low hardness (soft) water (40 mg/L $CaCO_3$). A geometric mean value of 11.2 mg/L NO_3-N was calculated for inanga from the low and medium hardness water NOEC values and used by Hickey for

[1] The NOEC is the highest measured continuous concentration of an effluent or a toxicant that causes no observed effect on a test organism. NOEC is determined by a statistical test comparison with control concentrations.

guideline derivation.

Only one reference to nitrate toxicity testing using koura has been identified. That work was reported on by Hickey (2018). He found that the third most sensitive New Zealand native species to nitrate were juvenile koura, which were measured over a 60 day test on one occasion. The most sensitive thresholds[2] were growth at 2.2 and 2.3 mg/L NO_3-N for length and weight respectively, with a survival threshold of 17.4 mg/L NO_3-N (i.e., approximately 8x above the growth threshold).

Hickey (2018) found the most sensitive invertebrate species was the New Zealand snail (*Potamopyrgus antipodarum*), which is abundant in Deepdell Creek. Long-term (31-40 day) chronic tests were used and a range of endpoints measured. The most sensitive endpoint was for morbidity (averaged 1.9 mg/L NO_3-N), followed by growth (2.3 mg/L NO_3-N), and a reproduction endpoint of 8.6 mg/L NO_3-N. The survival threshold averaged 15.5 mg/L NO_3-N (i.e., approximately 8x safety factor for the survival threshold above the morbidity threshold). The long-term 50% survival value averaged 56 mg/L NO_3-N (range 16.8 to 194 mg/L NO_3-N) (Hickey 2018).

Hickey (2018) also noted a that a number of studies had identified water hardness as a factor affecting both acute and chronic nitrate toxicity in some species. For example, chronic toxicity studies with *Potamopyrgus antipodarum* showed a decrease in sensitivity as hardness increased for both survival and morbidity endpoints (Hickey 2016). Hardness is high in Macraes waste rock stack seepage (Table 5).

Given all of the above, for toxicity purposes, applying the NPS-FW Band B would appear to provide ample protection for the aquatic community in the Deepdell Creek catchment. The Attribute Band B values for nitrate (and ammonia) are:

- Nitrate-N g/m3 (NO3-N) – Annual median [>1.0 and ≤2.4] and Annual 95th percentile [>1.5 and ≤3.5]
- Ammoniacal-N g/m3 (NH4-N) – Annual median[>0.03 and ≤0.24] and Annual 95th percentile [>0.05 and ≤0.40]

The narrative description for the NPS-FW B Band is "*95% species protection level: Starts impacting occasionally on the 5% most sensitive species*". Hickey (2013) described this level of nitrate management as "*very good*" and for *"Environments which are subject to a range of disturbances from human activities, but with minor effects*".

5.3.4 Nitrate as a nutrient for algae and plant growth

The Regional Water Plan for Otago contains water quality schedules that are relevant to nitrate concentrations that are aimed to curb the development of nuisance algae and macrophyte (aquatic plant) growth. The NPS-FW contain attribute states that provide

[2] Measuring EC10 and LC10 values (the effect concentration or lethal concentration for a 10% effect).

guidance to manage the effects of nitrate toxicity, and are thus set at considerably higher levels than management for the protection against nuisance algae and plant growths. It is important to note that ammoniacal nitrogen is also potentially toxic to freshwater aquatic life and has an NPS-FW attribute state of its own. However, ammoniacal nitrogen concentrations in the Deepdell catchment do not appear to be anywhere near at a level that may cause toxic effects to aquatic life.

The Otago Regional Plan: Water (RPW) Schedule 15 describes the characteristics of good water quality in lakes and rivers along with numerical water quality limits and targets for waterbodies across Otago. The targets and limits specified in this table are to protect against nuisance plant growth as opposed to protection against toxicity.

Table 7 below sets out the numerical water quality limits/targets for receiving water groups (RWGs) in the Shag River catchment. The limits/targets in Schedule 15 are not limits/targets that apply to any potential discharge, but rather set out the long-term water quality objectives for receiving waters. These limits/targets apply as 5-year, 80th percentiles when flow is below the median flow at the relevant flow reference site. That is, 80% of values collected when flows are at or below the median flow at the appropriate flow reference site over a 5-year period should be below the Schedule 15 limit.

Table 7 Numerical limits and targets for good water quality in rivers in the Shag River catchment from Schedule 15 of the Otago Regional Plan: Water. RWG = receiving water group, NNN = nitrate-nitrite nitrogen, DRP = dissolved reactive phosphorus.

RWG	**NNN** (mg/L)	**DRP** (mg/L)	**Ammoniacal nitrogen** (mg/L)	***E. coli*** (cfu/100 mL)	**Turbidity** (NTU)	**Catchment**
2	0.075	0.01	0.1	260	5	Shag

Currently, Deepdell Creek does not meet the Schedule 15 target concentration for nitrate-nitrite nitrogen, and, not surprisingly, would not do so if the NPS-FW B-Band (or A-Band) was adopted to protect the river ecosystem against nitrate toxicity. The Regional Plan Water Schedule 15 targets are not consistent with the NPS attribute bands for nitrate toxicity, and require much lower levels of nitrate to manage nuisance algae and plant growths. A concentration target of under 0.075 mg/L to achieve this seems overly ambitious for the Deepdell catchment given current concentrations are almost an order of magnitude higher.

Given a highly significant reduction in typical nitrate concentrations in the creek are unlikely, it is recommended that focus on managing phosphorus losses to water be given greater attention in the catchment. Both nitrate and dissolved phosphorus are necessary to stimulate algae and plant growth. The pathway for phosphorus to reach surface waters is primarily via overland flow (and direct through stock access to water), whereas nitrate can reach surface waters via subsurface seepage and groundwater.

This is not to say that management of waste rock stacks at Macraes will be not required to avoid adverse effects on freshwater ecology, but rather dual nutrient management be considered.

5.4 Accidental contaminant spills

The presence of construction machinery in and around waterways always presents a risk of contaminants (e.g., diesel, lubricants) entering watercourses with the potential to harm aquatic life. These issues can be addressed by way of an appropriate on-site contaminant management plan. As a general rule, any possible contaminants stored on site should be kept away from watercourses and bunded. Refuelling of machinery should also take place away from watercourses. Such measures are routinely employed by OceanaGold at the Macraes mine and should be replicated for the Deepdell North Stage III Project.

5.5 Nuisance aquatic weed/algae introduction

Machinery and personnel involved in construction can potentially transfer nuisance weeds/algae (e.g., *Didymosphenia geminata* - didymo) to local watercourses. Didymo has been recorded in the Shag River catchment, but has not been recorded in the Taieri River catchment, and we have not found it during our more recent surveys. While didymo has not been recorded in the Taieri River catchment, and many watercourses within the mining area may not be suitable for didymo establishment, if didymo was to enter these streams it may be able to travel downstream to establish at more suitable locations in the lower Taieri River. To address this, OceanaGold complies with notices and guidelines issued by Biosecurity New Zealand regarding didymo, and will continue this practice.

6. Recommended mitigation & monitoring

6.1 Loss of crayfish and fish habitat & water quality

No stream habitat that supports fish populations are proposed to be disturbed or lost as a part of the Deepdell North Stage III Project. Gullies draining parts of the Highlay Creek catchment that would be lost due to the Deepdell East Waste Rock Stack are very small, heavily impacted, probably ephemeral (potentially intermittent in the lower section) and do not support stream communities (including crayfish). The estimated length of this habitat that would be lost is approximately 480-500 metres, of which approximately 130 metres of this may have intermittent flow. Provided the measures described above in section 5 relating to sediment mobilisation and runoff, and the management of contaminants and machinery, are appropriately addressed, effects on stream populations located further downstream are not anticipated. A proposed silt pond (Deepdell East Silt Pond 1) could potentially be suitable for crayfish and riparian planting around the margins would further enhance habitat potential. Additional mitigation for direct physical effects on crayfish and fish habitat and their populations for loss of these habitats is not considered necessary.

The loss of approximately 380 metres of a cut-off drain that may potentially support some koura could be replaced by constructing an equivalent length of drain to divert 'clean' water around the western side of Project footprint near the haul road and into Camp Creek (see Figure 4). To be of net benefit to koura and other aquatic life, the drain, or sections of it, would need to maintain a permanently submerged bed (it need not be flowing continually, although some turnover of water is desirable) and be of sufficient quality to ensure adequate dissolved oxygen levels. Koura are found in most substrate types, often associated with abundant refuge (e.g. woody vegetation and riparian plant cover). Higher densities are associated with substrate that they can burrow in (e.g., clay) with overhanging riparian vegetation. Habitat could also be enhanced by planting tussocks or other overhanging vegetation along the margins and creating shelter through placement of schist slabs and woody debris on the bed.

Potential water quality effects have been described above. Applying the NPS-FW Band B attribute state for nitrate would appear to provide ample protection for the aquatic community in the Deepdell Creek catchment with respect to nitrate toxicity.

OceanaGold propose to construct a freshwater dam in the Camp Creek catchment (operating by January 2022) to provide a base flow to Deepdell Creek to manage and effectively mitigate sulphate concentrations in Deepdell Creek and in the Shag River as far as the confluence with McCormicks Creek (GHD 2019). It is anticipated that this will also act to mitigate nitrate concentrations. It is recommended that this dam also be assessed for potential to provide periodic flushing flows down Deepdell Creek to remove nuisance algae and plant biomass that may accrue over summer stable low flow periods. Additional stream shading may also reduce the need to reduce instream nitrogen.

6.2 Spills and sediment management

Recommended mitigation measures to avoid effects on downstream ecosystems due to accidental spills and sediment losses have been identified above in section 5.

6.3 Contaminants and nuisance weed/algae introduction

To ensure didymo and nuisance weeds are not introduced or spread it is recommended that, wherever possible, equipment and other items to be used in or near waterways are first inspected and if necessary cleaned prior to use. Such measures are already in place with existing consent conditions associated with the Macraes Gold Mine and should continue for the Deepdell North Project.

6.4 Monitoring

Regular monitoring of fish and invertebrate populations in Deepdell Creek and Highlay Creek should continue as a check against potential effects on freshwater biota due to potential changes in water quality. Regular nitrate and phosphorus monitoring should commence in Highlay Creek and at the existing Deepdell Creek monitoring sites if it hasn't already done so.

Investigating the potential to provide effective flushing flows from the Camp Creek dam is recommended.

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Appendix One: Benthic macroinvertebrate data

Field collection

Benthic macroinvertebrates were sampled using either a Surber sampler or a qualitative kick-net sampler with a 500 µm diameter mesh, following Ministry for the Environment's 'Protocols for sampling macroinvertebrates in wadeable streams' (Stark *et al.* 2001). Samples were preserved in 70% ethanol and returned to the Ryder Consulting laboratory for processing.

Laboratory analysis

For kick-net samples, macroinvertebrate samples were processed for species identification and relative abundance using the semi-quantitative protocols outlined in Stark *et al.* (2001). Protocol 'P1: Coded abundance' was used, which is summarised briefly below.

Samples were passed through a 500 µm sieve to remove fine material. Contents of the sieve were then placed in a white tray for observation. Each taxon present in a sample was assigned to one of five coded abundance categories using the codes established by Stark (1998) (Table A1). Up to 20 individuals representative of each taxon were removed from each sample to confirm their identification under a dissecting microscope (10-40x). Identifications were carried out using keyed guidelines from Winterbourn *et al.* (2006).

Table A1 Coded abundance scores used to summarise semi-quantitiative macroinvertebrate data (after Stark 1998).

Abundance (in sample)	Coded Abundance	Weighting factor
1 - 4	Rare (R)	1
5 - 19	Common (C)	5
20 - 99	Abundant (A)	20
100 - 499	Very abundant (VA)	100
> 500	Very very abundant (VVA)	500

Benthic macroinvertebrate community health was assessed by determining the following characteristics:

Number of taxa: A measurement of the number of distinct taxa present which provides an indication of community diversity.

Number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, and percentage of EPT taxa (% EPT taxa): These insect groups are generally dominated by pollution sensitive taxa.

In stony bed rivers, these indexes usually increase with improved water quality and increased habitat diversity.

Macroinvertebrate Community Index (MCI) (Stark 1993): The MCI uses the occurrence of specific macroinvertebrate taxa to determine the level of organic enrichment in a stream. Taxon scores are between 1 and 10, 1 representing species highly tolerant to organic pollution (e.g., worms and some dipteran species) and 10 representing species highly sensitive to organic pollution (e.g., most mayflies and stoneflies). A site score is obtained by summing the scores of individual taxa and dividing this total by the number of taxa present at the site. These scores can be interpreted in comparison with national standards (Table 2). For example, a low site score (e.g., 40) represents ‘probable severe pollution’ and a high score (e.g., 140) represents very ‘clean’ conditions.

$$MCI = \left(\frac{\text{Sum of taxa scores}}{\text{Number of scoring taxa}}\right) \times 20$$

Semi-quantitative MCI (SQMCI) (Stark 1998): The SQMCI uses the same approach as the MCI but weights each taxa score based on how abundant the taxa is within the community. Abundance of all taxa is recorded using a five-point scale (i.e., rare = 1-4 animals per sample, common = 5-19, abundant = 20-99, very abundant = 100-499, very very abundant = >500). As for MCI, SQMCI scores can be interpreted in the context of national standards (Table A2).

$$SQMCI = \frac{\text{Sum of (Taxa coded abundance x Taxa score)}}{\text{Sum of coded abundances for sample}}$$

Quantitative Macroinvertebrate Community Index (QMCI) (Stark 1985): This method was used for analysing community health in samples collected with a Surber sampler. Similar to the SMCI, the QMCI assigns taxa scores based on their sensitivity to organic pollution. However, unlike the SMCI, the QMCI takes into account the abundance of each taxa collected in a sample and weights each sample score accordingly. Sample scores range between 0 and 10. A score of 1 represents ‘poor’ conditions and 10 represents ‘excellent’ conditions (Table A2).

$$QMCI = \sum_{i=1}^{i=S} \frac{(n_i \times a_i)}{N}$$

Where S = the total number of taxa in the sample, n_i is the number of invertebrates in the ith taxa, a_i is the score for the ith taxa, and N is the total number of invertebrates for the entire sample.

Table A2 *Interpretation of macroinvertebrate community index values from Boothroyd and Stark (2000) (Quality class A) and Stark and Maxted (2007) (Quality class B).*

Quality Class A	Quality Class B	MCI	SQMCI	QMCI
Clean water	Excellent	> 120	> 6.00	> 6.00
Doubtful quality	Good	110 - 119	5.00 – 5.99	5.00 – 5.99
Probable moderate pollution	Fair	80 - 99	4.00 – 4.99	4.00 – 4.99
Probable severe pollution	Poor	< 80	< 4.00	< 4.00

Macroinvertebrate taxa in samples collected from Highlay Creek, February 2011.

			Highlay Creek				
			Upper reaches		Middle reaches		Tributary
TAXON	MCI score	MCI-sb score	1	2	1	2	1
COLEOPTERA							
Elmidae	6	7.2	A	A	C	A	
Ptilodactylidae	8	7.1		C			
CRUSTACEA							
Ostracoda	3	1.9	A	A	C	VA	A
Paracalliope fluviatilis	5	5.5					C
Paranephrops zealandicus	5	8.4			R		R
DIPTERA							
Aphrophila species	5	5.6	R				
Austrosimulium species	3	3.9	R		A	C	C
Empididae	3	5.4	R				
Maoridiamesa species	3	4.9	A			C	
Mischoderus species	4	5.9		R			
Orthocladiinae	2	3.2	VA	A	A	A	C
Paralimnophila skusei	6	7.4					C
Tanypodinae	5	6.5	C	C			
Tanytarsini	3	4.5		C		C	
Zelandotipula species	6	3.6		R			
EPHEMEROPTERA							
Deleatidium species	8	5.6	VA	VA	VA	VA	A
MEGALOPTERA							
Archichauliodes diversus	7	7.3	C	A	A		
MOLLUSCA							
Gyraulus species	3	1.7					VA
Potamopyrgus antipodarum	4	2.1	VA	VA	VVA	VA	VVA
Sphaerium novaezelandiae	3	2.9					C
NEMATODA	3	3.1	R				
OLIGOCHAETA	1	3.8	A	C	C	C	A
PLECOPTERA							
Stenoperla species	10	9.1		R			
Zelandobius species	5	7.4	C	A	C		
Zelandoperla species	10	8.9		R		C	
TRICHOPTERA							
Aoteapsyche species	4	6.0	C	VA	VA	VA	
Hudsonema amabile	6	6.5			C	C	
Hydrobiosis umbripennis group	5	6.7	R	C	R	C	
Oxyethira albiceps	2	1.2	C		C	C	C
Polyplectropus species	8	8.1	A			A	A
Psilochorema species	8	7.8	R			R	
Zelolessica species	10	6.5		C			
Number of taxa			19	18	14	16	13
Number of EPT taxa			7	7	6	8	3
% EPT taxa			33	46	50	44	3
MCI score			89	112	87		
SQMCI score			4.6	5.2	4.5		
MCI-sb score						95	86
SQMCI-sb score						4.8	4.0

Benthic macroinvertebrate communities at the Highlay Creek survey site, April 2013. Quantitative Surber samples (Samples 1 – 5) and one composite qualitative kicknet sample (Kicknet). Surber sample data presented as number of invertebrates per sample. Kicknet sample data presented as coded abundance categories from Stark (1998).

		Highlay Creek					
TAXON	**MCI score**	1	2	3	4	5	Kicknet
COLEOPTERA							
Elmidae	6	1		1	2		R
COLLEMBOLA	6					1	
CRUSTACEA							
Paranephrops zealandicus	5	1				1	
DIPTERA							
Aphrophila species	5			2			
Orthocladiinae	2			1	1		
Tanypodinae	5		2	1			R
EPHEMEROPTERA							
Deleatidium species	8	197	86	113	128	123	V A
Neozephlebia scita	7	8	4	9	2	4	C
Zephlebia species	7			2	1		R
MEGALOPTERA							
Archichauliodes diversus	7	10	10	11	3	1	C
MOLLUSCA							
Potamopyrgus antipodarum	4	20	4	2	2	21	C
OLIGOCHAETA	1	2	12		3	16	C
PLECOPTERA							
Stenoperla species	10					1	
Zelandoperla species	10	1					
TRICHOPTERA							
Aoteapsyche species	4	2	1	5	2	7	C
Olinga species	9					1	
Polyplectropus species	8			1			C
Psilochorema species	8	1			1		R
Pycnocentria species	7	1			1		R
Pycnocentrodes species	5	1					
Number of invertebrates (per sample)		245	119	148	146	176	-
Number of invertebrates (per m^2)		6125	2975	3700	3650	4400	-
Number of taxa		12	7	11	11	10	12
Number of EPT taxa		7	3	5	6	5	7
% EPT		86	76	88	92	77	-
MCI score		120	103	115	111	122	120
QMCI score		7.5	7.0	7.5	7.6	6.7	-
SQMCI score		-	-	-	-	-	7.3
Average QMCI score		7.3					-

Macroinvertebrate taxa from kicknet samples collected from Highlay Creek and Deepdell Creek, February 2018.

		Highlay Creek			Deepdell Creek 1
TAXON	**MCI score**	**Trib. A**	**Trib. B**	**Horse Flat Road ford**	
ACARINA	5		R		
COLEOPTERA					
Elmidae	6	C	C	C	
Hydraenidae	8	C	R		
Ptilodactylidae	8		R		
Scirtidae	8	R	R		
Staphylinidae	5	R			
CRUSTACEA					
Ostracoda	3			C	VA
Paracalliope fluviatilis	5				C
Paraleptamphopus species	5	R			
Paranephrops zealandicus	5		R		
DIPTERA					
Austrosimulium species	3			C	R
Corynoneura scutellata	2			R	
Ephydridae	4			R	
Nothodixa species	4	C			
Orthocladiinae	2		R	C	R
Paradixa species	4	R	R		
Polypedilum species	3	R			
Stratiomyidae	5		R	R	
EPHEMEROPTERA					
Coloburiscus humeralis	9				R
Deleatidium species	8	VA	VA	VA	
HEMIPTERA					
Microvelia macgregori	5		R	R	R
Sigara species	5			R	
LEPIDOPTERA					
Hygraula nitens	4				R
MECOPTERA					
Nannochorista philpotti	7	R			
MEGALOPTERA					
Archichauliodes diversus	7			R	
MOLLUSCA					
Gyraulus species	3			R	VA
Physa / Physella species	3			R	VA
Potamopyrgus antipodarum	4	A	A	VVA	VVA
Sphaeriidae	3	R		C	A
NEMATODA	3			C	
OLIGOCHAETA	1	R	R	C	C
PLATYHELMINTHES	3			R	
PLECOPTERA					
Spaniocerca species	8	R			
Zelandobius species	5			C	
TRICHOPTERA					
Aoteapsyche species	4		R	A	A
Hudsonema alienum	6	A	C		
Hudsonema amabile	6			R	VA
Hydrobiosella species	9	R			
Hydrobiosidae early instar	5			R	
Hydrobiosis umbripennis group	5	R	C		
Neurochorema species	6	R			
Oxyethira albiceps	2			A	C
Psilochorema species	8		R	R	R
Pycnocentrodes species	5			C	R

Macroinvertebrate taxa in samples collected from Camp Creek, October 2010. 'VVA' = very, very abundant, 'VA' = very abundant, 'A' = abundant, 'C' = common, and 'R' = rare.

		Camp Creek					
		Upstream of Horse Flat Road		Middle reaches		Lower reaches	
TAXON	**MCI score**	**1**	**2**	**1**	**2**	**1**	**2**
COLEOPTERA							
Elmidae	6	C	R	A	A	A	C
Scirtidae	8			C		C	
CRUSTACEA							
Ostracoda	3		C				
DIPTERA							
Aphrophila species	5	C			A	C	R
Austrosimulium species	3	A	VA		C	A	R
Ceratopogonidae	3						R
Maoridiamesa species	3					A	R
Orthocladiinae	2		A	C	C	A	A
Tabanidae	3					R	
Tanypodinae	5				C		R
Zelandotipula species	6		R				
EPHEMEROPTERA							
Deleatidium species	8	VVA	VA	VVA	VVA	VVA	VA
HEMIPTERA							
Sigara species	5				R		
MEGALOPTERA							
Archichauliodes diversus	7				C	R	R
MOLLUSCA							
Potamopyrgus antipodarum	4	A	A	A	C	VA	C
Sphaerium novaezelandiae	3				R		
OLIGOCHAETA	1	VA	VA	A	A	A	C
PLECOPTERA							
Zelandobius species	5		A	C	A	C	C
Zelandoperla species	10		C			C	
TRICHOPTERA							
Aoteapsyche species	4		C	C	C	A	C
Hudsonema alienum	6		R				
Hudsonema amabile	6			R		C	
Hydrobiosis umbripennis group	5	C				A	
Oxyethira albiceps	2		C				R
Polyplectropus species	8		R				
Psilochorema species	8		R	R	C		
Pycnocentria species	7			C	C		
Pycnocentrodes species	5	A		A	C	R	C
Number of taxa		8	15	12	16	17	15
Number of EPT taxa		3	8	7	6	7	5
% EPT		60	49	86	84	50	84
MCI score		93	101	107	98	100	84
SQMCI score		6.5	4.0	7.4	7.3	6.6	6.3
Average MCI score		97		102		92	
Average SQMCI score		5.3		7.3		6.5	

Macroinvertebrate taxa from kicknet samples collected from Camp Creek (CC02) and Deepdell Creek, February 2018.

Summer 2018			**DC07**					**DC00**					**CC02**				
TAXON	**MCI score**	**NG01**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	5	1											1				
COLEOPTERA																	
Dytiscidae	5												1				
Elmidae	6													1	1	1	
Hydraenidae	8							1					1			10	1
Staphylinidae	5												1				
COLLEMBOLA	6	1										1					
CRUSTACEA																	
Ostracoda	3		2	33	93	9		6	2	26	46			1	1	1	
Paracalliope fluviatilis	5	148	5	9	69	45	1	4	1				5	2			2
DIPTERA																	
Aphrophila species	5																1
Austrosimulium species	3						1	2									
Ceratopogonidae	3														1		
Chironomidae	2		3	12	34	21	9	2	2	11	28	2	21	73	1	2	4
Limonia species	6	1															
Mischoderus species	4												1				
Muscidae	3			2													
Psychodidae	1												1				
Sciomyzidae	3						1										
EPHEMEROPTERA																	
Deleatidium species	8	2	1	3	2	1	1	378	47	96	97	42	9	31	6	45	31
HEMIPTERA																	
Microvelia macgregori	5			1			2					5					
MEGALOPTERA																	
Archichauliodes diversus	7		1			1	4							1	2		
MOLLUSCA																	
Gyraulus species	3		59	9	22	18	78	1		6	17						
Physa / Physella species	3	1	11	16	21	25	17	6	4	7	40	4					
Potamopyrgus antipodarum	4	458	934	465	540	271	348	509	55	103	590	74	898	539	552	515	201
Sphaeriidae	3		2			1	1	2	1		2						
NEMATODA	3													1			
NEMERTEA	3		2		1	1	1										
ODONATA																	
Xanthocnemis zealandica	5								1	1	3						
OLIGOCHAETA	1	5	1	15	17	23	6	20	4	3	18	3	1	2	11		
PLECOPTERA																	
Austroperla cyrene	9													1	1		
Spaniocerca species	8	1															
Stenoperla species	10												1	1	1	3	
Zelandobius species	5						1			1			4	6	5	8	8
TRICHOPTERA																	
Hudsonema amabile	6	2	3	3	25	20	15	15	1		2		1	1			1
Hydropsyche - Aoteapsyche group	4		250	35	41	14	150	2				3	25				
Olinga species	9					3							10	1	4	4	4
Oxyethira albiceps	2		12	12	26	7	7	7	5	3	9	1	10	64		8	6
Paroxyethira species	2		1							1			1	1	2		
Polyplectropus species	8	1			1						4			16	1		
Psilochorema species	8		1	1		2	3	2	1				4	2		2	1
Pycnocentria species	7		1	1	5	3	4						26	11	3	128	18
Pycnocentrodes species	5		1	3	4	11							119	24	22	176	84
Number of invertebrates		621	1290	620	901	476	650	957	124	258	856	135	1141	779	614	903	362
Number of taxa		11	18	16	15	18	19	15	12	11	12	9	21	20	16	13	13
QMCI score		4.3	3.9	3.8	3.8	3.9	3.9	5.5	5.3	5.2	4.2	5.2	4.2	4.0	4.1	4.9	4.8

Macroinvertebrate taxa from kicknet samples collected from Camp Creek (CC02) and Deepdell Creek, August 2018.

Winter 2018		DC02					DC01					DC00					CC02				
TAXON	**MCI score**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	5					1															
COLEOPTERA																					
Berosus species	5			1																	
Elmidae	6		1						1	1						1	1	1	2	2	6
Hydraenidae	8																3	7	9	7	5
Scirtidae	8																				
Staphylinidae	5						1														
COLLEMBOLA	6																				
CRUSTACEA																					
Ostracoda	3	3	2				2		2	4		1		2	8						
Paracalliope fluviatilis	5						1		1	1					1			4		1	6
Paraleptamphopus species	5																				
DIPTERA																					
Aphrophila species	5	1	1		3	1		1			1		1		1		1	1			
Austrosimulium species	3	2	17		6	4	16	13	13	4	9	7	7		1	12					
Ceratopogonidae	3																				
Chironomidae	2	10	10	10	14	16	58	111	83	29	40	18	56	6	23	16	3	16	5	4	7
Empididae	3						2														
Ephydridae	4																				
Hexatomini	5																				
Limonia species	6						1														
Mischoderus species	4																				
Muscidae	3												1								
Paradixa species	4																				
Paralimnophila skusei	6																				
Stratiomyidae	5																				
EPHEMEROPTERA																					
Ameletopsis perscitus	10																1				
Deleatidium species	8	216	230	185	227	351	348	348	808	438	224	204	313	119	216	111	50	49	87	151	55
Neozephlebia scita	7							2													
HEMIPTERA																					
Microvelia macgregori	5																				
HIRUDINEA	3																				
MEGALOPTERA																					
Archichauliodes diversus	7	3				2		15	3	2	2						1	1	1		3
MOLLUSCA																					
Gyraulus species	3														3						
Physa / Physella species	3				1										2						
Potamopyrgus antipodarum	4	38	14	23	19	54	49	104	30	82	39	127	196	23	240	45	90	208	78	157	49
Sphaeriidae	3														1						
NEMATODA	3																				
NEMATOMORPHA	3																				
NEMERTEA	3																				
ODONATA																					
Xanthocnemis zealandica	5																				
OLIGOCHAETA	1	5	2	2	3	6	11	51	12	30	9	11	67	2	14	5	2	4	2	3	
PLATYHELMINTHES	3																				
PLECOPTERA																					
Acroperla species	5																		1	4	1
Stenoperla species	10																5		2	2	
Zelandobius species	5			1	1	1	2	1	2	5			1	1	1		10	6	8	5	1
Zelandoperla species	10																	1			
TRICHOPTERA																					
Hudsonema alienum	6																				
Hudsonema amabile	6	4	1	2	3			2		5		2									
Hydrobiosidae early instar	5					3	1		4	2	1							1			
Hydrobiosis umbripennis group	5							2		1			3							1	
Hydropsyche - Aoteapsyche group	4	1		2	2		1	6	3	1	1	1	1			1		10	2		1
Oeconesidae	9																				
Olinga species	9																7	7	9	9	4
Oxyethira albiceps	2				2	1	1	2	1	2					2						
Polyplectropus species	8																8				
Psilochorema species	8	1	1	1	2	2	2	2	3	4	1			1	1		1	1	4	3	1
Pycnocentria species	7																	9	4		4
Pycnocentrodes species	5	37	9	14	8	10	4	8	4	1	3				2		36	46	58	65	71
Number of invertebrates		321	288	241	291	452	500	668	970	612	330	371	646	154	516	191	219	372	272	414	214
Number of taxa		12	11	10	13	13	16	15	15	17	11	8	10	7	15	7	15	17	15	14	14
QMCI score		6.8	7.1	7.1	7.0	7.0	6.5	5.6	7.1	6.7	6.4	6.0	5.4	7.0	5.5	6.0	5.6	4.8	5.9	5.8	5.7

Macroinvertebrate taxa from Surber samples collected from Deepdell Creek, March 2019.

March 2019	**DC08**					**DC07**					**DC05**					**DC03**				
Taxon	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	1																			
CNIDARIA																				
Hydra species												1								
COLEOPTERA																				
Elmidae						1														
Hydraenidae	1																			
COLLEMBOLA		1			1		1						1					1		
CRUSTACEA																				
Ostracoda					1	4		4	26	3					4		7	7	3	4
Paracalliope fluviatilis	1		2		1	200		5	47	11		5	7		30		2	3	2	5
DIPTERA																				
Austrosimulium species							1					1	2	1	1				1	
Chironomidae		3	16	1	1	13	41	24	100	25	7	46	27	12	34	68	730	190	507	880
Ephydridae			1	1					1	3										
Muscidae	5	3	11	8		22	10	3	13	15	4	2	13		5		3	3	13	14
EPHEMEROPTERA																				
Deleatidium species			9	4		1	3	4	2	1	17	87	13	23	35	19	130	116	95	156
HEMIPTERA																				
Saldidae					1															
Microvelia macgregori											7							2		
MEGALOPTERA																				
Archichauliodes diversus				1		2		2				6		2			5			1
MOLLUSCA																				
Gyraulus species		1	1	1	2		1	15	7	2		2		1	3					
Physa / Physella species	2	2	14	6	17	70	5	120	280	4	2	39	6	6	64	1	5	6	11	12

March 2019			**DC08**					**DC07**					**DC05**					**DC03**		
Taxon	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Potamopyrgus antipodarum	4	45	11	31	40	2480	39	980	1640	28	87	1040	300	210	395	42	265	133	39	320
Sphaeriidae						20	1	9	10			4		1						
NEMERTEA						2		1				1	1		1					
OLIGOCHAETA	3		2	1		1360	13	40	480	17	5	24	160	10	34	1	7	21	4	8
PLATYHELMINTHES						3		1				2	1		9					
PLECOPTERA																				
Zelandoperla species														1						
TRICHOPTERA																				
Hudsonema amabile			1	1		2		2	3	1	4	11		1	5	2	3	11	4	9
Hydrobiosidae early instar						3	1	3			2	3			7		11	2		
Hydrobiosis species						4	3		9		1	11	7	5	5	2	25	14	6	20
Hydropsyche - Aoteapsyche group		38	41	77	2	129	330	180	64	17		24	34	20	10	5	5	1	22	131
Oxyethira albiceps		2	1	2		40	5	56	235	29	19	53	49	51	122	4	6	67	90	43
Psilochorema species				1		8	2	3	12	6		8	2	3	12	1	19	12	4	15
Pycnocentria species						4		3											2	
Pycnocentrodes species					2	7		10	1	1		1		1	5	2	11	5	6	10

P

APPENDIX P

Traffic Assessment Report

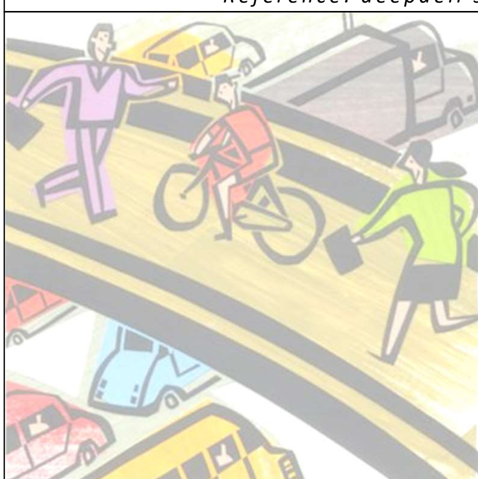
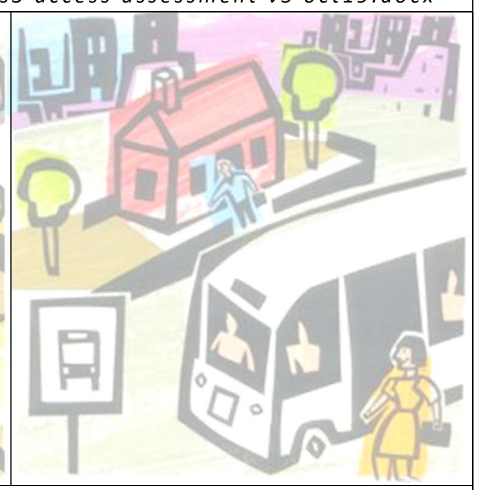
Macraes Goldmine
Deepdell North Stage 3
Traffic & Pedestrian Access Management

prepared by: **Tim Kelly Transportation Planning Ltd**

for: **OceanaGold Corporation**

October 2019

Reference: deepdell s3 access assessment v5 oct19.docx

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Contents

1 Background & Scope

1.1 Background

The OceanaGold Corporation has been operating the Macraes Open Pit goldmine in Otago since 1990.

The operation involves the progressive relocation of mining activity to new areas and backfilling of exhausted pit areas. Such relocation can impact upon established public vehicular and pedestrian access routes and controls are necessary to maintain this accessibility in a way which ensures the safety of the public and site employees.

OceanaGold is now seeking consents to enable mining operation in the Deepdell North Stage 3 (**DDN3**) area and some changes to public access are necessary to ensure continued safety.

1.2 Scope

The purpose of this document is to identify and assess the necessary arrangements for continued public accessibility in this area during the DDN3 operations. Compliance with the relevant provisions of the Waitaki District Plan (**WDP**) is also addressed.

This document forms part of an Assessment of Environment Effects (**AEE**), which in turn supports the application for resource consent to be lodged with the Waitaki District Council (**WDC**).

1.3 Objectives

The objectives of the arrangements described by this document are:

- to ensure the safety of members of the public when in the vicinity of mining operations;
- to ensure the safety of mining employees;
- to prioritise public accessibility over the movement of mine-operated vehicles, within reasonable constraints;
- to ensure the efficient movement of mine-related vehicles;
- to provide for continued public access to non-operational areas, subject to safety requirements being guaranteed; and
- to comply with the requirements of the district plan and all relevant local and national standards.

2 Existing Situation

2.1 Location

The Macraes Open Pit is located 35 kms driving distance from State Highway 1 (**SH1**) at Palmerston.

The location of the area to which the application relates is shown by **Figure 2.1.**

2.2 Road Environment

Golden Point Road

Golden Point Road provides access from Macraes Road to the Macraes Open Pit, processing plant and administrative complex.

The intersection of Golden Point Road with Macraes Road is priority controlled, with movements from Golden Point Road subject to 'Stop' controls.

From this intersection, Golden Point Road runs over a distance of 590m in a north-westerly direction to an uncontrolled intersection. This section is sealed, with two-lanes, narrow shoulders and is subject to a 70 km/hr speed limit for most of its length.

The Macraes Back Road runs north-east from the intersection and provides access to a number of mine support services (this was originally Golden Point Road prior to its diversion to accommodation the mine activity).

Golden Point Road continues towards the west – after 620m a priority intersection provides access to the OceanaGold administrative complex. Beyond this point, Golden Point Road continues, swinging to the north and descending to a priority intersection after a further 2.2kms.

From this location, the sealed road continues to the processing plant. Golden Point Road continues as an unsealed single carriageway - a sign indicates that this is the route to the Golden Point Historic Area. After 1.06kms the mine haul road is reached where a manned crossing provides access to the remainder of the route to the Golden Point Historic Area, a further 1.06kms.

Golden Point Road continues to Horse Flat Road on an alignment which is mostly occupied by the mine haul road – approximately 500m to the SE of Horse Flat Road, Golden Point Road takes a route further to the SW, intersecting with Horse Flat Road 240m from the haul road crossing.

Golden Point Road is a public road between Macraes Road and Horse Flat Road, though is maintained by OceanaGold. Any public access through the haul road section is managed by OceanaGold, as described below. There is little reason for any members of the public to use Golden Point Road for through access purposes.

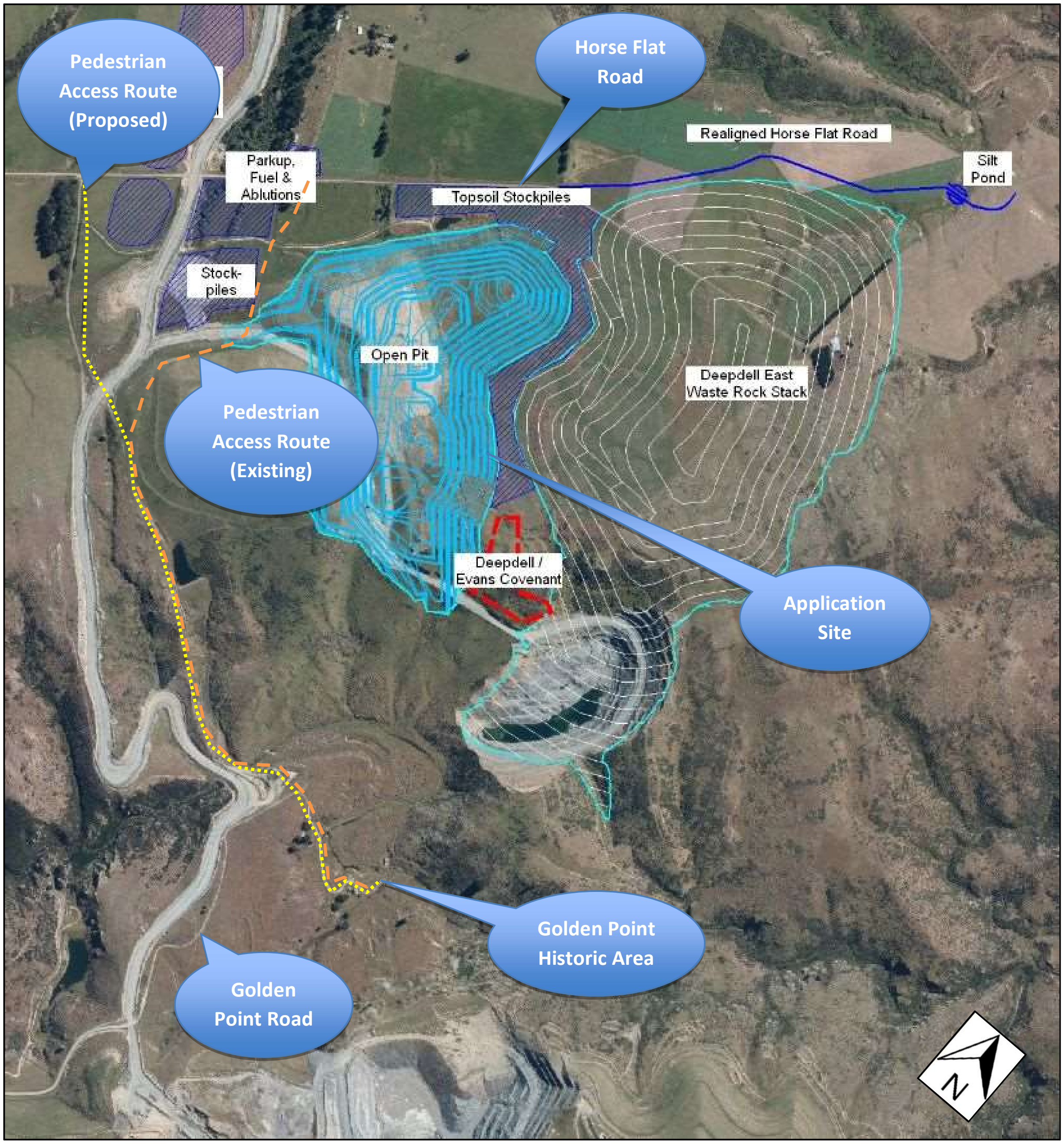

Figure 2.1: Location Plan *(Source: OceanaGold)*

Note: Pedestrian access route alignments are approximate only

Horse Flat Road

Horse Flat Road is a no-exit road which runs for 6.8kms in a NE direction from an intersection with Macraes Road and the Hyde – Macraes Road, located 6.6kms from the Macraes Road / Golden Point Road intersection. The intersection with Golden Point Road is reached after 5.1kms and the haul road crossing after 5.3kms. Horse Flat Road is unsealed with a single carriageway and provides access to a small number of residential properties / farms and a small quarry operated by OceanaGold. While the speed limit on Horse Flat Road is 100km/hr, the standard of road means that achievable speeds are considerably lower.

Paper Roads

There are a number of 'paper roads' in this area. These are legal roads which have not been formed, most likely identified in the past as being required to provide access within this area but prior to the mining operation. Their relevance to this assessment is that the public has a right to use such public roads on foot, cycle, horses or vehicles (although in many cases the topography and/or lack of formation may preclude such use).

If such use would place the public and/or mining operations at risk, a legal road 'stopping' process is the preferred option to effectively close the paper road. Where this is necessary, an alternative route is provided to maintain public accessibility. This is discussed further in **Section 3** in relation to the proposed activity.

Traffic Volumes

Recorded traffic volumes are not available for Golden Point Road or Horse Flat Road.

The southern section of Golden Point Road between the administration building and the haul road carries a small number of mining-related vehicle movements and an occasional vehicle wishing to access the Golden Point Historic Area.

Horse Flat Road is understood to carry less than 30 vehicle movements a day, these being associated with the Highlay quarry and the residential dwellings / farms.

The volume of haul road traffic activity is addressed below.

Crash History

The crash history for the existing roads in this area for the ten-year period since January 2009 has been obtained from the database maintained by the New Zealand Transport Agency (**NZTA**).

Over this period, two minor incidents have been recorded in the general area of the mine, both of which occurred on Macraes Road and have been unrelated to the mining operations.

No incidents have been reported on either Golden Point Road or Horse Flat Road.

By law, only those crashes involving personal injuries are required to be reported. Accordingly, it is possible that a number of other non-injury crashes may have occurred which have not been included in these records.

2.3 Site Operation

General Description

In 2013, OceanaGold obtained consents to enable the excavation of the Coronation Pit area on the ridgeline to the north of Horse Flat Road.

After blasting, ore from the Coronation Pit is transported to the existing processing plant by means of ore transporter vehicles using a haul road having a width of approximately 25m. After descending from the Coronation Pit area, the haul road crosses Horse Flat Road 240m from the Golden Point Road intersection, then continues south to meet with a haul road from the Deepdell area before generally following the alignment of Golden Point Road.

Approximately 5,000 tonnes of ore is transported each day from the pit to the processing plant. Each ore transporter carries 100 tonnes of ore, typically resulting in around 50 return movements (100 one-way movements) over an eight-hour period 8am – 4pm. In any one hour, the number of one-way ore transporter vehicle movements is 10 – 15.

Public Access Management - Vehicular

The current haul road alignment to the south of Horse Flat Road is located on private land owned by OceanaGold. As this does not follow the road reserve, public access to this road can be and is lawfully restricted for safety reasons. Public road connections between Horse Flat Road, the Golden Point Historic Area and the Golden Point Road (south) exist as paper roads only and have not been formed.

Any crossing or use of the haul road by public vehicles is subject to procedures which are detailed in Traffic Management Plans (**TMP**s). These procedures include:

- any public vehicles along Horse Flat Road are required to wait at a gate until clearance is confirmed by mine personnel at the haul road crossing;
- any public vehicles wishing to access the Golden Point Historic Area from Golden Point Road (south) are required to cross the haul road - this crossing is permanently (24/7) staffed with access gates and upon arrival of a public vehicle, radio communications are used to stop any ore transporters in the area before the public vehicle proceeds through the crossing; and
- the use of radio communications ensures that all mine personnel have an awareness of any public vehicles or individuals which are within the operating mine area.

TMPs are subject to annual renewal and require approval from the Council.

Once mining operations are complete in this area, the intention is that the haul road will be formed and vested as public road.

Public Access Management - Pedestrian

A public walking route between Horse Flat Road and the Golden Point Historic Area was provided as part of the Coronation / Coronation North consent.

This is an unformed pedestrian access, which was originally defined with a series of blue marker pegs along the alignment identified as Pedestrian Access Route (Existing) by **Figure 2.1**.

This avoided the active mine area and the requirement for any pedestrian arriving by vehicle along Horse Flat Road to firstly pass through the controlled haul road crossing ensured that mine personnel were aware of their presence in the area. This is to be realigned, as described in **Section 3**.

3 Proposed Activity

3.1 General Description

The activity for which consent is now sought is excavation of the DDN3 area, located to the south of Horse Flat Road and east of Golden Point Road.

The proposed activity at Deepdell will gradually replace that which is currently occurring at the Coronation Pit, with an expected overlap period of around 12 months.

3.2 Material Volume, Timing

The area of the proposed excavation is 38 hectares and is expected to result in the movement of 57m tonnes of material.

Waste rock material will be transported to the Deepdell South backfill (a previously disturbed open pit area) or the Deepdell East Waste Rock Stack (**WRS**).

Site establishment works are expected to commence in October 2020, with the first ore being extracted within a few months. Mining operations are expected to be complete in November 2022.

The operating hours of mining operations and associated vehicle movements will be unchanged.

3.3 Road Access

A new 25-30m wide haul road will be extended into the open pit area from the existing haul road to the south of Horse Flat Road.

A haul road to the Deepdell South backfill waste rock disposal area is not required as this currently exists. A haul road will be formed to the Deepdell East WRS along the northern perimeter of the excavation area (and broadly parallel to Horse Flat Road).

The establishment of the Deepdell East WRS will require a realignment of Horse Flat Road from a point slightly under 800m NE of the current haul road crossing, as shown by **Figure 2.1**. Instead of heading ENE and then turning N over a distance of 1.1kms, the road will instead take a more direct alignment towards the NE, a distance of 0.97kms.

3.4 External Vehicular Activity

As the DDN3 activity will replace that currently taking place at the Coronation Pit, there will be no material change to staffing numbers or vehicular activity on the external road network.

3.5 Public Access Control - Vehicular

The arrangements for the control of public vehicle movements from Golden Point Road (south) to the Golden Point Historic Area and along Horse Flat Road will remain the same.

Although not formed, an application will be made to legally stop the existing paper road to the south of Horse Flat Road. As described in **Section 2**, it is intended that once mining operations are completed in this area, the haul road will be formed and vested as public road, providing for vehicular access between Horse Flat Road, the Golden Point Historic Area and the southern (public) section of Golden Point Road.

3.6 Public Access Control to Golden Point Historic Area - Pedestrian

The Deepdell proposal will result in a significant increase in the number of mine vehicles crossing the existing pedestrian route between Horse Flat Road and the Golden Point Historic Area.

Accordingly, an alternative pedestrian access route has been developed (shown as Pedestrian Access Route (Proposed) by **Figure 2.1**). This leaves Horse Flat Road from a point a short distance to the SW of the haul road crossing (avoiding a requirement for vehicles to cross the haul road).

There will be single crossing of the haul road by the pedestrian access route. It is proposed to manage safety associated with this crossing, by:

- fencing the approaches with normal stock fences leading into deer fences as the haul road is approached;
- fences to have signage identifying that entry into the mining area outside of the fences is prohibited;
- each side of the haul road crossing will have a locked gate with a call box and instructions (e.g. a 'push to talk' arrangement);
- the pedestrian will push the button, linking to the Minestar control room and advise their request to cross the haul road;
- the Minestar controller will then notify the pit supervisor who will drive to the crossing;
- mine traffic in the area will be halted then the pedestrians will be escorted across the road; and
- once the crossing is completed the gates will be locked and normal haulage will resume.

These measures, which will be encapsulated into a TMP, will ensure the safety of pedestrians and are considered to be appropriate in the context of very low levels of pedestrian activity in this area (there has been little or no utilisation of the existing pedestrian access route in recent years).

3.7 Public Access Control between Horse Flat Road and Matheson Road

The DDN3 proposal does not affect public accessibility between Horse Flat Road and Matheson Road (this is currently being addressed as part of the separate Coronation and Coronation North consenting processes).

4 Assessment of Effects

The only potential 'effects' arising from the proposal relate to public accessibility and safety.

4.1 Public Accessibility

Golden Point Historic Area

The Golden Point Historic Area will continue to be accessible by vehicle from both the southern part of Golden Point Road (and Macraes Road), and from Horse Flat Road.

Pedestrian access to the Golden Point Historic Area will continue to be provided from Horse Flat Road.

In both cases, the 'effect' of the proposal upon the ability of the public to access the Golden Point Historic Area, relative to the existing situation, will be negligible.

Horse Flat Road

The low number of non-mine vehicle movements along Horse Flat Road will continue to be subject to a controlled crossing of the haul road.

The realignment of Horse Flat Road to the NE of the haul road will have no tangible effect upon road users (the stopping of the existing alignment will follow the construction and availability of the new alignment, ensuring that access is retained).

Again, the 'effect' of the proposal upon the ability of the public to use Horse Flat Road, relative to the existing situation, will be negligible.

Matheson Road – Horse Flat Road

As noted in **Section 3.7**, the DDN3 proposal will not affect public accessibility between Horse Flat Road and Matheson Road.

4.2 Safety

The control of any points where public access routes cross mine operational areas will continue to be subject to TMPs which stipulate the detailed arrangements for such aspects as warning signage, gate control, radio communications, etc.

All TMPs are subject to the approval of the Council, ensuring the safety of the measures proposed.

As indicated above, an outcome of these procedures is that the mine is aware of any members of the public who may be in the area. In this manner, relevant mine staff can be alerted to their presence, further ensuring that the public are not placed in any danger as a result of mine operations.

Accordingly, the proposals will not result in any 'effects' upon the safety of either members of the public or mine personnel.

5 District Plan Provisions & Compliance

5.1 Operative District Plan

Relevant Plan & Status

The relevant plan is the Waitaki District Plan (**WDP**), which became operative in May 2010.

While a process of reviewing the WDP is currently underway, this a draft plan has yet to be notified and as such has no legal 'weight' for the purposes of this assessment.

The application site lies within the 'Macraes Mining' zone.

All of the public roads in this area are classified as 'local roads' in the roading hierarchy defined by the plan.

5.2 Compliance with Macraes Mining Zone Rules (WDP Part III, Section 6)

Section 6.2 of the WDP draws attention to a need to comply with the district-wide rules in relation to Transport / Car Parking.

There are no other specific transportation rules which apply to this zone.

5.3 Compliance with District Wide Transport Objectives (WDP Part II, Section 6)

Objective 1 is *'to promote the efficient use of the District's existing and future transportation resource and of fossil fuel usage associated with transportation, and the maintenance and improvement of access, ease and safety of all vehicular, cycle and pedestrian movements'.*

Objective 2 is to *'avoid or mitigate adverse effects on the surrounding environment as a result of transport'.*

The only relevant issue associated with the application relates to ensuring continued and safe accessibility to the Golden Point Historic Area by public vehicles (from Golden Point Road and Horse Flat Road) and on foot (from Horse Flat Road). The assessment above describes how this will be achieved in a manner which will ensure the on-going safety of the public and mine employees.

5.4 Compliance with District Wide Transport / Car Parking Rules (WDP Part III, Section 12)

Section 12.2.1 defines a number of standards relating to provision for parking and loading. The large area of the Macraes mining site means that there are no problems or issues arising from compliance with these standards.

Vehicle Access

Rules at 12.2.2 (a) require the provision of legal access to all lots with a complying vehicle crossing, with a drivable surface between the carriageway and road access lot and provision of an access space on the lot.

The DDN3 proposal will not change the location of the haul road crossings with either Golden Point Road or Horse Flat Road, though there may be some change in intensity of use as activity shifts between areas. Accordingly, the proposal will not give rise to any issues of compliance with these requirements.

Formation and Sealing of Vehicle Crossings

Rules at 12.2.2 (b) relate only to crossings of sealed roads and so are not relevant to either Golden Point Road or Horse Flat Road.

Location of Vehicle Crossings with Frontage in Relation to Intersections of Roads

Rules at 12.2.2 (c) seek to ensure the provision of a safe separation distance of any crossing from an intersection. This is not relevant in the context of the remote crossings of either Golden Point Road or Horse Flat Road.

Length of Vehicle Crossings

Rules at 12.2.2 (d) define a maximum crossing length for non-residential activities of 9m. This is exceeded by the haul road crossings, which are around 25m to accommodate the large haulage vehicles. There is no adverse effect of this non-compliance, as the purpose of the rule is primarily to ensure the safety and convenience of pedestrians.

Minimum Distance Between Vehicle Crossings

Rule 12.2.2 (e) requires a minimum separation distance of 7m between crossings on the same road frontage. This is easily achieved.

Maximum Number of Vehicle Crossings

Rule 12.2.2 (f) requires that no site is to have more than 4 vehicle crossings plus 1 vehicle crossing per km for site with over 4km of frontage. It is unclear whether the site as a whole has more than 4 vehicle crossings. Regardless, the intent of the rule is to ensure that vehicle turning movements are controlled to fewer points where safety can be controlled – in the case of the DDN3 proposal, there will be no change to the number of vehicle crossings and safety will be ensured.

Sight Distance from Vehicle Crossings

Rule 12.2.2 (g) defines sight distance requirements at vehicle crossings based upon the legal speed limit. As indicated in **Section 2.2**, the legal speed limit on Golden Point Road is 70 km/hr (requiring a sight distance of 95m) and on Horse Flat Road it is 100 km/hr (requiring a sight distance of 195m).

It is unlikely that the requirement is met on Horse Flat Road, but there are no associated adverse effects because achievable speeds on these roads are considerably lower than the legal speed limits, the crossings are controlled by gates and few, if any, vehicles are making turns at these crossing points. Further, any potential interaction of public and mine-operated vehicles is minimised through the use of radio communications and procedures defined through TMPs.

Vehicle Orientated Commercial Activities

Rules 12.2.2 (h) defines further sight-distance requirements for sites generating over 60 vehicle movements per day with vehicle access to non-arterial roads. The same comments as for 12.2.2 (g) above apply.

5.5 Summary

The district-wide transportation rules are primarily focussed upon controlling the effects of more traditional activities in urban and rural areas, and do not fit well with the nature of the Macraes mining activities.

The DDN3 proposal will not result in any changes to the location of operation of existing haul road crossings of public road, though some change in the intensity of use is likely.

Procedures for the control of public vehicle movements in the vicinity of the haul road crossings are clearly defined in TMPs approved by WDC. These are heavily focussed upon ensuring the safety of the public and mine employees and have operated well for a number of years.

As a result, any areas of non-compliance with the WDC rules are ‘technical’ in nature and will not be associated with any adverse effects in terms of the safe or efficient operation of the public road network in this area.

6 Conclusions

OceanaGold is seeking consents to enable mining operation in the Deepdell North Stage 3 (**DDN3**) area. This will result in some changes to the location and intensity of mine-related activity and vehicle movements in the wider area.

The existing mining area currently includes the Golden Point Historic Area, which attracts occasional public visitation. In addition, there are a number of ‘paper’ roads in this area, which members of the public are legally entitled to utilise for access purposes.

The over-riding objective for OceanaGold is to ensure the continued high safety standards which have applied to date for both the public and mine employees. At the same time, it is seeking to maintain the ability of the public to access the Golden Point Historic Area and utilise routes across this area.

A package of measures is proposed to achieve both safety and accessibility. This package will:

- maintain the ability of the public to access the Golden Point Historic Area by car from both Golden Point Road and Horse Flat Road;
- maintain an ability for the public to access to Golden Point Historic Area on foot from Horse Flat Road;
- ensure the mine operator is aware of the movement of any members of the public in this area;
- ensure that the Council is aware of access arrangements through a continued requirement for the review and approval of Traffic Management Plans; and
- ensure compliance with the relevant requirements of the district plan.

On the basis of the transportation issues addressed by this assessment, it is recommended that consent be granted for the Deepdell proposal.

APPENDIX Q

Economic Assessment

MACRAES GOLD PROJECT – DEEPDELL NORTH PROJECT
ASSESSMENT OF ECONOMIC EFFECTS

Mike Copeland
Brown, Copeland & Co Ltd
8 October, 2019

1. INTRODUCTION

1.1 Macraes Gold Project commenced operations in 1990 following the granting of initial consents in 1988. In 1992, 1997, 2000, 2001, 2002, 2004 and 2006 further consents were issued in relation to various expansions in both the rate of production and physical elements of the mine (pits, waste rock stacks and storage facilities for tailings and process water).

1.2 In 2011, OceanaGold (New Zealand) Limited (OceanaGold) sought and was granted an extension to the consented life of the Macraes Gold Project. The extension, called the Macraes Phase III Project, is expected to take the consented mine life through to 2020, instead of the mine closing as previously proposed in 2012. Under the Macraes Phase III Project, production at the Fraser's underground mine has continued in parallel with the open pits. The Macraes opencast mining operations were to be scaled back towards the end of the mine's life (i.e. in 2019 and 2020).

1.3 In 2013 OceanaGold sought and was granted another extension to the life of the Macraes Gold Project. The Coronation Project was expected to add approximately 1 year to the overall Macraes Gold Project's mine life. In other words, rather than the Macraes opencast mining operations being scaled back in 2019 and 2020 as was previously proposed, this was to be delayed until 2020 and 2021. The year 2019 would see a continuation of the same level of economic activity at the site as was proposed previously for the period 2015 to 2018 (inclusive) under the Macraes Phase III Project.

1.4 In 2016 OceanaGold sought and was granted a further extension called the Coronation North Project. This extension was to add 3 full years to the operational life of the mine – i.e. in terms of the economic effects of the Project the operating life of the mine was to continue at current levels into the years 2020, 2021 and 2022, with the scaling back of activities and rehabilitation push back to 2023 and 2024.

1.5 Currently consented activities are now (October, 2019) expected to allow mining operations to continue at current levels into 2023, with the scaling back of activities and rehabilitation now expected in 2024 and 2025. A further extension of the Macraes Gold Project is now proposed called the Deepdell North Stage III Project (the Project). The estimated duration of the operation and rehabilitation activities of the Project will be approximately 1 year, with the Project effectively adding an additional full year to the operational life of the mine – i.e. in terms of the economic effects of the Project the operating life of the mine will continue at current levels into the year 2024, with the scaling back of activities and rehabilitation pushed back to 2025 and 2026. Further exploratory drilling may result in the operational life of the mine being further extended but that is uncertain at this time.

1.6 A report[1] covering the past, current and projected future economic effects of the Macraes Gold Project was appended to the Assessment of Environmental Effects (AEE) for the Macraes Phase III Project, whilst reports[2] on the future economic effects of the Coronation Project and Coronation North Project were appended to the AEEs for those projects. The purpose of those reports was to consider the additional national, regional and local area economic effects of the Macraes Phase III and the Coronation Projects respectively.

1.7 The purpose of this current report is to consider the national, regional and local area economic effects of a proposed further 1 year extension of the mine's life as a consequence of the Deepwell North Project.

1.8 This report is divided into 5 parts (in addition to this introductory section). These cover:

(a) A description of the key economic drivers of the Waitaki District, Dunedin City and Otago regional economies;

(b) A consideration of the relevance of economic effects under the Resource Management Act (RMA);

(c) The additional national, regional and local economic benefits of the Project extending the life of the mine by 1 year;

(d) Potential economic costs of the Project extending the life of the mine by 1 year; and

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[1] *Macraes Phase III Project Assessment of Economic Impacts;* Appendix 19 to the Assessment of Environmental Effects for MPIII; Mike Copeland, Brown, Copeland & Co Ltd; April 2011. See also Statement of Evidence of Michael Campbell Copeland in the matter of an application by Oceana Gold (New Zealand) Limited for the resource consents for the Macraes Phase III Project; 16 September 2011.

[2] *Macraes Gold Project – Coronation Project Assessment of Economic Impacts;* Appendix 2 to the Assessment of Environmental Effects for the Coronation Project; Mike Copeland, Brown, Copeland & Co Ltd; March 2013; and *Macraes Gold Project – Coronation North Project Assessment of Economic Impacts;* Appendix 2 to the Assessment of Environmental Effects for the Coronation North Project; Mike Copeland, Brown, Copeland & Co Ltd; April 2016.

(e) Some overall conclusions.

2. THE WAITAKI DISTRICT, DUNEDIN CITYAND OTAGO REGIONAL ECONOMIES[3]

Geographical Extent of the Project and its Economic Effects

2.1 The site of the existing Macraes Gold Project is located largely within the Waitaki District, which in turn is one of the districts within the Otago region. However the Coronation and Coronation North Projects extend the mining activities over the local authority boundary into Dunedin City[4]. Also the employees at the mine reside in a number of centres stretching from Oamaru to Dunedin. Therefore in this report the "local" economic impacts are assessed for an area identified as north-east Otago, which includes the Waitaki District and the nearby north Dunedin City towns of Waikouaiti, Hyde and Middlemarch. The wider regional economic impacts are assessed for the Otago region which includes the local sub-region of north-east Otago, the rest of Dunedin City and the other districts which make up the Otago region.

Population

2.2 Data from Statistics New Zealand show that the population of the Waitaki District in 2006 was estimated at 20,700 and by 2018 had grown to 22,300 – i.e. an increase of 7.7%. Dunedin City's population has grown from 122,300 in 2006 to 130,700 in 2018, an increase of 6.9%. Over this same period Otago's population has grown from 199,800 to 229,200, an increase of 14.7%, whilst New Zealand's population has grown by 16.7%.

2.3 Statistics New Zealand is forecasting relatively slow growth in Waitaki District's and Dunedin City's population over the next 25 years. Its 'medium'[5] population projections have the Waitaki District's population increasing to 24,100 by 2043 – i.e., a gain of 1,800 or 0.3% average annual growth over the period 2018-2043. Dunedin City's[6] population is projected to grow to 136,500 by 2043, up by 5,800 or average annual growth of 0.2% over the period 2018-43. For Otago, the population is projected to grow to 256,100 by

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3 Data in this section from Statistics New Zealand.

4 Although the processing of all ore still occurs at the mine's processing plant within the Waitaki District.

5 Statistics New Zealand produces high, medium and low projections corresponding to different assumptions about fertility, morbidity and migration. The projections also incorporate information about the existing age structure of the population within each district. The projections do not incorporate assumptions about the likely economic performance of different industries within each sector.

6 I.e. as defined by Statistics New Zealand's boundaries – the city centre itself, the surrounding suburbs and the hinterland stretching up to the southern boundary of the Waitaki District and the eastern boundary of the Central Otago District.

2043 – i.e. a gain of 26,900 or 0.4% average annual growth over the period 2018-2043. The comparative figures for New Zealand show a projected increase in population averaging 0.8% per annum over the same 25 year period.

Employment

2.4 Statistics New Zealand 2018 industry employment data highlight the Waitaki District's reliance on the primary sector. The agriculture (forestry and fishing)[7] industry group accounted for 1,500 jobs or 15.1% of the labour force against a national percentage share for this industry group of only 5.4%. Agriculture accounts for 1,433 jobs or 14.5% of the labour force. This reliance on the agricultural sector is further illustrated by 1,600 jobs (16.2% of the Waitaki District labour force) in the manufacturing sector being in the food manufacturing industry group.

2.5 Other significant sectors within the Waitaki labour force are retail trade (1,100 jobs or 11.1% of the total labour force), accommodation and food services (850 jobs or 8.6% of the total labour force), healthcare and social assistance (750 jobs or 7.6% of the total labour force) and construction (710 jobs or 7.2% of the total labour force). Total employment in the Waitaki District grew by 6.5% over the period 2006 to 2018, as compared to employment growth for New Zealand of 17.9%.

2.6 For Dunedin City, the key sectors are healthcare and social assistance (9,100 jobs in 2018 or 15.5% of the total labour force), education and training (7,600 jobs or 12.9% of the total labour force), retail trade (6,400 jobs or 10.9% of the total labour force), accommodation and food services (5,000 jobs or 8.5% of the total labour force), construction (4,600 jobs or 7.8% of the total labour force) and manufacturing (3,850 jobs or 6.5% of the total labour force). Total employment in Dunedin City grew by only 3.7% over the period 2006 to 2018. This was largely due to manufacturing sector employment reducing by 38.5% from 6,100 in 2006 to only 3,850 in 2018.

2.7 For the Otago region as a whole, employment data suggest the most significant sectors are tourism with the accommodation and food services industry group[8] having 14,300 jobs in 2018 or 12.4% of the region's workforce), retail trade (12,100 jobs or 10.5% of the

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7 The forestry and fishing labour force within the Waitaki District is estimated to be only about 12 employees.

8 The accommodation and food services industry group is only a proxy for the tourism sector. It provides goods and services as well to customers who are not tourists, whilst tourists purchase goods and services from other industry groups.

region's workforce), healthcare and social assistance (12,000 jobs or 10.4% of the region's workforce), education and training (10,300 jobs or 9.0% of the region's work force), construction (9,800 jobs or 8.5% of the region's workforce), , manufacturing (9,300 jobs or 8.1% of the region's workforce) and agriculture, forestry and fishing (8,900 jobs or 7.7% of the region's workforce).Total employment in the Otago region grew by 17.4% over the period 2006 to 2018.

2.8 Therefore the Macraes Gold Project has helped to diversify the Otago regional economy and especially the Waitaki District economy and the north-east Otago sub-region, which remain heavily dependent upon agriculture and the processing of agricultural products. The ability of the mine to help offset periodic downturns in the agricultural sector was identified in the 1996 Brent Wheeler & Co. Ltd survey of local businesses in Palmerston and Waikouaiti.[9] The Macraes Gold Project has also helped to sustain Dunedin City's economy through the location of OceanaGold's head office in Dunedin and the city's businesses providing goods and services to the mine, its employees and other businesses supplying the mine. The Project also provides some diversity to the Dunedin City economy, although in proportionate terms the Project has greater impact in the smaller and less diversified north-east Otago sub-region.

3. ECONOMICS AND THE RMA

Community Economic Wellbeing

3.1 Economic considerations are intertwined with the concept of the sustainable management of natural and physical resources, which is embodied in the RMA. In particular, Part 2 section 5(2) refers to enabling "*people and communities to provide for their social, economic and cultural well being*" as a part of the meaning of "*sustainable management*", the promotion of which is the purpose of the RMA.

3.2 As well as indicating the relevance of economic effects in considerations under the RMA, this section also refers to *"people and communities"* (emphasis added), which highlights that in assessing the impacts of a proposal it is the impacts on the community and not just the applicant or particular individuals or organisations, that must be taken into account. This is underpinned by the definition of *"environment"* which also extends to include people and communities.

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9 See *The Economic Impacts of the Macraes Gold Project*; Brent Wheeler & Co. Ltd; December 1996.

3.3 The Project will enhance the social and economic well being of the residents and businesses of both Waitaki District and Dunedin City by retaining levels of expenditure, employment and incomes for a further year.

Economic Efficiency

3.4 Part 2 section 7(b) of the RMA notes that in achieving the purpose of the Act, all persons *"shall have particular regard to ... the efficient use and development of natural and physical resources"* which include the economic concept of efficiency[10]. Economic efficiency can be defined as:

"*the effectiveness of resource allocation in the economy as a whole such that outputs of goods and services fully reflect consumer preferences for these goods and services as well as individual goods and services being produced at minimum cost through appropriate mixes of factor inputs*"[11].

3.5 More generally economic efficiency can be considered in terms of:

(a) Maximising the value of outputs divided by the cost of inputs;

(b) Maximising the value of outputs for a given cost of inputs;

(c) Minimising the cost of inputs for a given value of outputs;

(d) Improving the utilisation of existing assets; and

(e) Minimising waste.

3.6 The Project is consistent with the efficient development and use of resources in that it will prolong the life of the existing Macraes gold mining operations for a further year utilising existing infrastructure, plant and equipment. Also the Project will retain the critical mass of the local communities in north-east Otago.

Economic Growth and Employment

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10 See, for example, in *Marlborough Ridge Ltd v Marlborough District Council* [1998] NZRMA 73, the Court noted that all aspects of efficiency are "*economic*" by definition because economics is about the use of resources generally.

11 Pass, Christopher and Lowes, Bryan, 1993, *Collins Dictionary of Economics* (2nd edition), Harper Collins, page 148.

3.7 Section 32A 2(a) of the RMA requires reports prepared under the Act to:

> *"Identify and assess the benefits and costs of the environmental, economic, social and cultural effects that are anticipated from the implementation of the provision, including the opportunities for:*
>
> *Economic growth that are anticipated to be provided or reduced; and*
>
> *Employment that are anticipated to be provided or reduced."*

3.8 This section of the RMA highlights that economic costs and benefits and economic growth and employment effects are relevant under the RMA. The Deepdell North Project will contribute economic growth and employment opportunities within the north-east Otago sub-region and the Otago region.

Viewpoint

3.9 An essential first step in carrying out an evaluation of the positive and negative economic effects of a development project is to define the appropriate viewpoint that is to be adopted. This helps to define which economic effects are relevant to the analysis. Typically a district or wider regional viewpoint is adopted and sometimes even a nationwide viewpoint might be considered appropriate.

3.10 For the proposed Deepdell North Project extending the life of the Macraes Gold Project it is appropriate to consider the north-east Otago economic impacts given the likely economic impacts for local residents and businesses, where north-east Otago is defined to include the Waitaki District (including Macraes Flat, Oamaru, Dunback and Palmerston) and the northern part of Dunedin City (including Waikouaiti, Hyde and Middlemarch). It is also appropriate to consider the impacts on metropolitan Dunedin (i.e. the city centre and surrounding suburbs)[12] and the wider Otago regional and national level economic impacts.

3.11 OceanaGold 2019 data on the residence of their own staff (i.e. excluding contractors) engaged on site at Macraes Flat shows that out of a total of 571 - 252 (44.1%) reside in metropolitan Dunedin, 85(14.9%) reside in Palmerston, 57 (9.9%) reside in Waikouaiti, 47 (8.2%) reside in Oamaru, 16 (2.8%) reside in Middlemarch, 5 (1.2%) reside in Waitati

12 Since this will be the area to benefit most from the additional economic activity generated by the Project.

and Warrington, 2 (0.4%) reside in Macraes Flat and 107 (18.8%) reside elsewhere within the Waitaki District or Dunedin City. Another 22 staff work in the Macraes Dunedin Office. It is likely most, if not all, of these staff reside in metropolitan Dunedin.

3.12 There are also private or financial costs and benefits associated with the Project. If consents are granted, and OceanaGold gives effect to those consents by proceeding with the proposed Deepdell North Project, then it can be assumed that these private or financial costs and benefits have been responsibly and properly analysed and that from the viewpoint of those with money at risk, the expected financial benefits exceed the expected costs. Accountability for accuracy of the financial analysis clearly rests with OceanaGold and ultimately the net financial benefits OceanaGold might receive from the Project are not directly relevant to the assessment of effects under the RMA. The focus of this report is therefore on the wider economic effects on parties other than OceanaGold and its customers. Economists refer to such effects as “externalities”[13].

4. ECONOMIC BENEFITS OF THE DEEPDELL NORTH PROJECT[14]

Retention of Employment, Wages and Salaries and Other Expenditure

4.1 The Deepdell North Project will add approximately 1 year to the overall Macraes Gold Project’s mine life. This will mean the reduction in economic activity within north-east Otago, metropolitan Dunedin and the Otago region as the mining operations are wound down will be delayed a year. This implies an additional year of full opencast mining activity in 2023, with the curtailing of production for the mine’s last two years of operation now being in years 2024 and 2025, instead of 2023 and 2024.

4.2 For north-east Otago – i.e. the Waitaki District (including Macraes Flat, Oamaru, Dunback and Palmerston) and the northern part of Dunedin City (including Waikouaiti, Hyde and Middlemarch) - there will be the retention for an extra year of 235 jobs for local residents[15] at the Macraes Flat site, wage and salary payments to these employees of $23.1 million and other expenditure in the local economy of $19.9 million. For the Otago region there will be the retention for an extra year of 547 jobs, wage and salary

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[13] Defined as the side effects of the production or use of a good or service, which affects third parties, other than just the buyer and seller.

[14] Data in this section provided by OceanaGold unless otherwise stated.

[15] As at March 2016, 440 jobs in total on site but reduced by 41.7% to account for the employees who reside in metropolitan Dunedin. See footnote 11.

payments to these employees of $54.5 million and other expenditure of $48.9 million. These are the direct economic impacts of the Project.

4.3 In addition to these direct economic impacts there are indirect impacts arising from:

(a) The effects on suppliers of goods and services provided to the Project (i.e. the “forward and backward linkage” effects); and

(b) The supply of goods and services to employees of OceanaGold and its contractors and to those engaged in supplying goods and services to OceanaGold and its contractors (i.e. the “induced” effects). For example, there will be additional jobs and incomes for employees of supermarkets, restaurants and bars as a consequence of the additional expenditure by these employees.

4.4 District and regional multipliers can be estimated to gauge the size of these indirect effects. The size of the multipliers is a function of the extent to which a districtor regional economy is self-sufficient in the provision of a full range of goods and services and the district’s proximity to alternative sources of supply.

4.5 District multipliers typically fall in the range of 1.5 to 2.0[16] and conservatively taking the low point of 1.5 implies total north-east Otago economic impacts of the Project (i.e. direct plus indirect impacts) for 2023 of:

(a) 353 retained jobs;

(b) $34.7 million in retained wages and salaries; and

(c) Retained other expenditure of $29.9 million.

4.6 Regional multipliers are higher than district multipliers because a region is more self sufficient in the provision of goods and services. The 1996 Brent Wheeler & Co. Ltd report referred to in the 2011 Brown, Copeland report, produced Otago regional multipliers for gold mining of 2.24 for expenditure, 3.66 for employment and 2.67 for wages and salaries. In 2001 updated multipliers of 1.67 for expenditure, 2.45 for

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16 For example, employment and income multipliers estimated for the construction and operation of the proposed new Holcim cement plant at Weston in the Waitaki District ranged between 1.58 and 1.93 for employment and 1.46 and 1.58 for incomes. (See Environment Court Evidence of Michael Copeland in Holcim New Zealand Limited v Waiareka Valley Preservation Society and others, November 2008.)

employment and 2.71 for wages and salaries were estimated (see also 2011 Brown, Copeland report). Conservatively a regional multiplier of 2.0 has been assumed for employment, incomes and expenditure. The estimated total regional economic impacts (i.e. direct plus indirect impacts) for 2023 of:

(a) 1,094 retained jobs;

(b) $109.0 million retained wages and salaries; and

(c) Retained other expenditure of $97.8 million.

4.7 A 2017 KPMG report covering the economic, social and environmental contribution of OceanaGold to New Zealand states that in 2016 the Macraes Gold Project contributed almost $84 million (0.88%) to the Otago region's GDP. This was almost 1.5 times the grape growing and wine production industry, 90% of the forestry and logging industry, more than double the value of the wool industry and approximately 5 times the contribution of the fishing and aquaculture industry.[17] The Deepdell North Project will extend this contribution for a further year.

4.8 It is expected that north-east Otago and metropolitan Dunedin will be the principle location of Otago suppliers to the Project and its employees. Also metropolitan Dunedin is the location of OceanaGold's head office activities. Therefore for metropolitan Dunedin (i.e. the city centre and surrounding suburbs) the economic impacts will be largely the difference between the Otago regional economic impacts and those estimated for north-east Otago. On this basis the direct plus indirect economic impacts of the Project for metropolitan Dunedin in 2023 are estimated to be:

(a) 741 retained jobs;

(b) $74.3 million retained wages and salaries; and

(c) Retained other expenditure of $67.9 million.

[17] OceanGold's Contribution to New Zealand. KPMG; September, 2017.

4.9 In addition the Government will continue receiving royalty payments foran extra year estimated to be worth about $3.1 million, whilst the New Zealand economy will benefit from higher gross domestic product (GDP) and exports.[18]

Economic Benefits from Increased Economic Activity

4.10 As indicators of levels of economic activity, economic impacts in terms of increased expenditure, incomes and employment within north-east Otago, metropolitan Dunedin and the Otago region are not in themselves measures of improvements in economic welfare or economic wellbeing. However, there are economic welfare enhancing benefits associated with increased levels of economic activity. These relate to one or more of:

(a) Increased economies of scale: Businesses and public sector agencies are able to provide increased amounts of outputs with lower unit costs, hence increasing profitability or lowering prices;

(b) Increased competition: Increases in the demand for goods and services allow a greater number of providers of goods and services to enter markets and there are efficiency benefits from increased levels of competition;

(c) Reduced unemployment and underemployment[19] of resources: To the extent resources (including labour) would be otherwise unemployed or underemployed, increases in economic activity can bring efficiency benefits when there is a reduction in unemployment and underemployment. The extent of such gains is of course a function of the extent of underutilised resources within the local economy at the time and the match of resource requirements and those resources unemployed or underemployed within the local economy; and

(d) Increased quality of central government provided services: Sometimes the quality of services provided by central government such as education and health care are

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18 Two earlier studies have identified the significance of the Macraes Gold Project to New Zealand's GDP and exports – see *Contribution of OceanaGold to the New Zealand Economy*; Infometrics Ltd; August 2010; and *The Value of Gold. The National Economic Benefit of GRD Macraes Gold Mining in New Zealand*; NZ Institute of Economic Research; 15 July, 2003. See also *Macraes Phase III Project Assessment of Economic Impacts;* Appendix 19 to the Assessment of Environmental Effects for MPIII; Mike Copeland, Brown, Copeland & Co Ltd; April 2011.

19 Underemployment differs from unemployment in that resources are employed but not at their maximum worth; e.g. in the case of labour, it can be employed at a higher skill and/or productivity level, reflected in higher wage rates.

a function of population levels and the quality of such services in a community can be increased if increased economic activity maintains or enhances population levels.

4.11 It is reasonable to presume that the retention for an extra year of economic activity (i.e. employment, incomes and other expenditure) within north-east Otago, metropolitan Dunedin and the Otago region as a consequence of the Project would give rise to one or more of these four welfare enhancing economic benefits for the local and regional communities. For example, retaining population in north-east Otago helps underpin local school rolls. Data provided by OceanaGold indicates that in 2011 the children of OceanaGold staff and permanent contractors at Macraes Flat made up:

(a) 41% of pupils at East Otago High School (72 out of 175);

(b) 38% of pupils at Palmerston Primary School (49 out of 126);

(c) 33% of pupils at Waikouaiti Primary School (27 out of 82);

(d) 33% of pupils at Flag Swamp Primary School (3 out of 9);

(e) 22% of pupils at Karitane Primary School (6 out of 27);

(f) 35% of pupils at Macraes Moonlight Primary School (6 out of 7); and

(g) 28% of children at pre-school institutions in North-East Otago (74 out of 269).

4.12 Since then local school rolls have changed – the current school rolls are approximately East Otago High School (135), Palmerston Primary School (114), Waikouaiti Primary School (80), Flag Swamp Primary School (8), Karitane Primary School (31), Macraes Moonlight Primary School (18) and Strath Taieri Primary School (51), However the children of OceanaGold staff and permanent contractors continue to underpin these school rolls. The local community benefits from better quality educational services as a consequence of the Macraes Gold Project providing a workforce, whose dependants increase the rolls at local schools and pre-schools.

Increased Diversity for the North-East Otago, Metropolitan Dunedin and Otago Regional Economies

4.13 As noted in Section 2 of this report, the Waitaki District economy is primarily driven by the agricultural sector and agricultural product processing and this is also the case for the north-east Otago area which includes the Waitaki District plus the towns of Waikouaiti, Hyde and Middlemarch and surrounding countryside.

4.14 The Project will extend the period of time the Macraes Gold Project will provide greater diversity and balance to the north-east Otago economy, retaining employment opportunities and incomes less dependent upon returns to the agricultural sector, helping to strengthen the local economy's resilience to agricultural commodity price cycles. This greater diversity is reinforced by the contribution the Macraes Gold Project makes to tourism in north-east Otago (see next section).

4.15 This is also the case for metropolitan Dunedin and at the regional and national levels, although to a lesser extent because these economies are already more diversified and less dependent upon agriculture and agricultural product processing.

Contribution to Tourism

4.16 The Macraes Gold Project mine tour is a major reason why tourists visit Macraes Flat. Extending the life of the mine by a year will extend the period that the local economy will benefit from the direct and indirect impacts of tourism activity linked to the mine's operation.

Increased Rates Revenue for Waitaki District Council

4.17 In 2018/19 rates paid by OceanaGold to the Waitaki District Council totalled about $513.000 (excluding GST) representing about 1.6% of the Council's total rates income in the financial year 2018/19.[20] Because of economies of scale it is likely that the rates paid by the Macraes Gold Project will be greater than the increase in Council's costs as a consequence of gold mining operations on the site as compared to pastoral farming. From the perspective of the Waitaki District Council and other ratepayers in the District, this broadening of the rating base provides the opportunity for a greater range of Council provided services or a reduction in the rates burden for other ratepayers. The Deepdell North Project will extend this contribution from OceanaGold by a year.

4.18 In addition OceanaGold pay around $50,000 in rates to the Otago Regional Council and $8,000 in rates to the Dunedin City Council. However at these levels it is unlikely that there is a significant surplus for other ratepayers from economies of scale.

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20 Total rates income for 2018/19 was $31,835,000. Source: Waitaki District Council Annual Plan 2019/20.

Community Sponsorship Programmes

4.19 In recognition of the important role the community plays in helping the Macraes Gold Project realise its potential, the company provides financial support to a number of initiatives at the community level. From the start of 2018 to the present time (i.e. in the last 21 months), $285,000 has been distributed to community groups covering community, educational and health initiative activities ($99,900 in 2018 and $185,100 to the end of September, 2019). In November 2014 the Macraes Community Development Trust was also formed as part of a revised rehabilitation strategy for the Macraes area. Funds to the value of $2.25 million previously committed for the completion of the Heritage Art Park were redirected to the Trust. The purpose of the Trust is to support initiatives that assist future growth and development options for the Macraes community when mining ceases.

Other Socioeconomic Benefits

4.20 The Macraes Gold Project also contributes to the “social fabric” of the north-east Otago community via staff, contractors and their families belonging to service clubs, sports clubs and other voluntary organizations. As well as fulfilling leadership roles and making other contributions within the community, the Project staff, contractors and their families help provide the critical mass to underpin these organizations’ ongoing sustainability.

4.21 In addition the Macraes Gold Project has on-site 59 emergency response personnel, who respond to community emergencies as and when required. The places of residence of these staff are Dunedin (28), Waikouaiti (6), Palmerston (4), Oamaru (3) and elsewhere in the Otago region (18). Appendix 1 to this report list the incidents the OceanaGold’s emergency response team has attended for the wider community during the last 21 months – i.e. in 2018 and the first nine months of 2019 up to the end of September.

4.22 The Macraes Gold Project emergency response team are also an official co-response unit (CRU) for the St John Ambulance southern region. As such it is dispatched as a first response unit by the ambulance communications centre. In this capacity it is responsible for an area that includes all of the Macraes-Hyde road between SH85 and SH67, SH85 up to Morrisons and Dunback, the Nenthorn Valley, Middlemarch and Hyde.

5. POTENTIAL ECONOMIC COSTS OF THE DEEPDELL NORTH PROJECT

Lost Agricultural Production

5.1 Lost agricultural production is not an external cost of the Project. The productive value of the land in alternative uses was internalised into the cost structure of the Project – in other words OceanaGold when purchasing the land had paid a price reflective of future net returns from alternative uses for the land. Such costs are not costs to be borne by the wider community.

5.2 In terms of reduced economic activity within north-east Otago (and the Otago region) from a reduction in agricultural use, the direct and indirect economic impacts of gold mining operations at the site will significantly outweigh any reductions in economic activity from any displaced farming. In a report, *Contribution of OceanaGold to the New Zealand Economy*; Infometrics Ltd; August 2010, and the New Zealand Institute for Economic Research report for OceanaGold in 2011 the contribution to GDP of the Macraes Gold Project is shown to be substantially larger than the alternative of dairy farming at the site.[21]The reports found that the value of production equated to $3 million per hectare at that time and that it would take 767 years of dairy production on an equivalent area of land to match the revenue earned by the mine from 1990-2010.

Utilities

5.3 Externality costs can arise when utilities provided by central or local government (e.g. roads, water supply, storm water and flood control systems and wastewater disposal) are not appropriately priced. In the case of the Deepdell North Project no such externality costs will arise. The Project will be completely self-sufficient with respect to water supply, wastewater disposal and storm water and flood control systems. In addition to road user charges, and roading costs payable as part of the annual rates, OceanaGold will continue to be responsible for maintenance of key sections of local roads adjacent to the mine, as already required under conditions of consent for the Macraes Gold Project and these payments are to continue for 4 years after mine closure.

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[21] See also *Macraes Phase III Project Assessment of Economic Impacts;* Appendix 19 to the Assessment of Environmental Effects for MPIII; Mike Copeland, Brown, Copeland & Co Ltd; April 2011.

Local Road Congestion Costs

5.4 An analysis of the traffic effects of the proposed development has concluded that the proposed access arrangements will readily accommodate the volumes of vehicles envisaged and that the traffic generated during the Deepdell North Project will be safely and efficiently accommodated within the adjacent road network.[22]

6. CONCLUSIONS

6.1 Since its start-up in 1990, the Macraes Gold Project has been, and continues to be, a significant contributor to levels of employment, incomes and expenditure for north-east Otago, metropolitan Dunedin and the Otago region. At a national level, the Macraes Gold Project has made, and continues to make a considerable contribution to Government revenues, GDP and exports. The proposed Deepdell North Project will extend mining operations at Macraes Flat for approximately 1 year, enabling these positive economic impacts to continue for a longer period.

6.2 In particular the Project will enhance the economic well being of the north-east Otago, metropolitan Dunedin and Otago communities by:

(a) Maintaining significant levels of local and regional employment, incomes and expenditure for an additional year;

(b) Maintaining population levels in north-east Otago, thereby maintaining the quality of some central government provided services;

(c) Extending the period of time for the local economy to benefit from greater diversity and resilience;

(d) Extending the period of time the mine and its workforce will contribute to local community activities and socioeconomic benefits.

6.3 The Project will improve resource use efficiency by retaining economic activity and population in north-east Otago, metropolitan Dunedin and the Otago regionfor an additional year, enabling increased economies of scale in the local provision of goods

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22 Macraes Goldmine Deepdell North Stage 3 Traffic & Pedestrian Access Management; Tim Kelly Transportation Planning Ltd; October 2019.

and services. It will also assist in reducing unemployment and underemployment of labour and other resources.

6.4 The Project will not give rise to economic externality costs.

Appendix 1

OGL Macraes Emergency Response Team Attendances 2018/2019 (to end September, 2019; i.e. 21 month period)

2018

02 Jan	Public	Member of public with head injuries in Hyde.
03 Feb	A&P	Sound Tech, head laceration
03 Feb	A&P	15 mth old baby, reaction to bee stings
21 Feb	Public	Tourists rolled car in floodwaters at Katiki Straight.
01 Oct	Dunback	Police request for assistance with body recovery at accident.
22 Oct	Maheno	Medical assist. Cardiac, patient deceased.
10 Nov	Macraes	Public injured leg after falling on stone steps
21 Nov	Dunback	assisted to remove silt Dunback Bowling Green
25 Nov	Macraes	Public cut foot with Angle Grinder cutting disk. Dressed. Sent to A&E.

2019

09 Jan	Nenthorn	MVA. Failed to take corner and hit rock.
16 Jan	Katiki	MVA. Tyre blew, car off road. Non injury.
2/3 Feb	Palmerston	East Otago A&P show
19 Feb	Dunback	Member of public with grinding grit in the eye
07 Mar	Peddies	locate and mark hotspots after vegetation fire
13 Mar	Dunback	Tree down on road to mine
14 Mar	Nenthorn	Child with burns to body and face
19 Mar	Macraes	Person fallen from bicycle
02 Jun	Waitaki Bridge	Fatal MVA, car vs 3 x motorbikes
12 Jun	Nenthorn	Member of public suffering from asthma attack.
06 Sep	Redbank	Member of public suffering diabetic event

Source: OceanaGold.

R

APPENDIX R

Erosion and Sediment Control Report

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EGL Ref: 8529

OCEANA GOLD (NEW ZEALAND) LTD
MACRAES GOLD PROJECT
DEEPDELL NORTH STAGE III
EROSION AND SEDIMENT CONTROL REPORT

Prepared for:

11 November 2019

Oceana Gold (New Zealand) Ltd
P O Box 5442
Dunedin
OTAGO

CONTENTS

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DEEPDELL NORTH STAGE III
EROSION AND SEDIMENT CONTROL REPORT

1.0 INTRODUCTION

Oceana Gold (New Zealand) Ltd (OceanaGold) operates the gold mine, known as the Macraes Gold Project (MGP), at Macraes Flat in East Otago. The mine is located between Middlemarch and Palmerston as shown in Figure 1. Gold extraction from the current mining operation involves mining of open pits and underground (Frasers Underground). Associated with the MGP are waste rock stacks (WRS) for disposal of pit overburden material and tailings storage facilities for disposal of tailings.

The Deepdell North Stage III project is located on the northern side of Deepdell Creek as shown in Figures 2 and 3. The project involves the following:

- Re-mining of an extension of the Deepdell North Pit located immediately south of Horse Flat Road, to be known as Deepdell North Stage III Pit.
- Construction of a new waste rock stack, to be known as Deepdell East Waste Rock Stack, immediately south of Horse Flat Road. This will include backfill of the existing Deepdell South Pit.
- Partial realignment of Horse Flat Road

There is an existing haul road between the Coronation North Project to the north and the MGP Process Plant located on the southern side of Deepdell Creek. The haul road is on the western side of Deepdell North Stage III project (refer Figure 3) and will provide access to the new pit and WRS. No significant length of new haul road will therefore be required for the project other than a short length to access Deepdell East WRS.

Details of the proposed Deepdell North Stage III Project comprises:

- Deepdell North Stage III Pit will produce 3.5Mt of ore and 53.3Mt of waste rock. The new pit comprises an extension to the existing Deepdell North Pit (Stage 2). The footprint will be 38ha of which 18.7ha was previously disturbed by mining.
- Deepdell East WRS comprises backfilling of the existing Deepdell South Pit and will approximately re-establish the original ground contours, before constructing the rest of the WRS to the north. At the northern extent of the WRS, the toe crosses Horse Flat Road and the road is to be realigned. Overall the WRS has a footprint of 70.8ha (of which 57.6ha will be new disturbance) and a storage capacity of 21.6Mm^3.

The new Deepdell North Stage III project will require erosion and sediment control throughout the life of the project. Mining is due to start in October 2020 with the first ore produced in November 2020. The project completion date is November 2022.

This report outlines the proposed concepts for managing erosion and sediment control to support the Assessment of Environmental Effects (AEE) for consents for Deepdell North Stage III. It identifies the practises and procedures to minimise erosion and sedimentation associated with the project, and the treatment of runoff prior to discharge. Operation Management Plans (OMP) will be prepared prior to construction commencing.

Extensive site-specific experience managing erosion and sediment exists with the operations team at MGP. Past erosion and sediment control measures have been designed for the site-specific nature of the ground conditions, topography and rainfall, and scale of earthworks. These controls have been effective elsewhere on the MCP and are expected to be effective for Deepdell North Stage III Pit and Deepdell East WRS also. This performance will be monitored and reviewed and if necessary additional measures exist in practice that can be implemented to minimise any effects on the downstream environment.

The purpose of this report is to provide information on the proposed erosion and sediment control approach and mitigation so that the Otago Regional Council (ORC) can be confident that any effects from activities will be no greater than minor. The intention is to develop an appropriate OMP for the elements of Deepdell North Stage III following procurement of resource consents. It is recommended that Deepdell North Stage III is subject to detailed design and preparation of construction drawings and specifications prior to construction. The OMP can form part of this documentation.

All plans, grid references and geological orientations referred to in this report are to mine north, which is approximately 45 degrees anti-clockwise from true north.

2.0 OPERATION MANAGEMENT PLAN

The OMP will be developed for the individual elements of Deepdell North Stage III following procurement of the consents. The OMP will follow the erosion and sediment control principles embodied in the Environment Canterbury's Erosion and Sediment Control Toolbox and Guidelines (Ref.1,7), applied to suit the site-specific conditions and experience.

The erosion and sediment control aspects of the OMP, for the MGP, needs to consider the nature, scale and practicalities of placement of the rockfill in the WRS. Onsite practices for the stripping and management of rockfill placement have resulted in little sediment laden water, with little cleaning of the silt ponds (also known as sediment retention ponds) required, primarily because the waste rock, once placed, acts as a natural filter for sediment. The most important part of the works is the stripping of the loess soils to key in the rock stack on to the rock foundation. Limiting exposure of the loess to rainfall and runoff is an important aspect of the OMPs to be prepared. However, staging of the works along with controls can be effective to achieve good water quality for discharge. Similar practices should be applied with improvements included where possible and necessary using the range of tools in the Environment Canterbury Toolbox (Ref.1).

The OMP will detail the design of specific erosion and sediment control devices, responsibilities for implementation, construction details and standards, construction timetable, maintenance, monitoring and reporting procedures, response to storm events and contingency measures.

3.0 SITE AND PROJECT DESCRIPTION

Deepdell North Stage III is located on a relatively flat plain running east west, which is approximately 1km wide. Deepdell Creek meanders down the southern side of the plain and is incised about 130m lower. The northern side of the plain comprises a mountain range rising up about 200m.

The existing Deepdell South Pit is located on the southern edge of the plain as shown in Figure 3 and extends partway down the steep slope to Deepdell Creek at between about 1v:4h to 1v:1.3h. The existing Deepdell South Pit is to be backfilled and merges with the waste rock to be placed north of the pit, on Horse Flat, to form the proposed Deepdell East WRS. On Horse Flat, a local high point lies beneath the centre of the WRS with ground sloping to the east, west and south. To the west of the WRS, the ground slopes relatively gently at approximately 1v:30h to 1v:15h. To the east the ground also slopes relatively gently at 1v:30h to 1v:10h which steepens into the gully side slopes of approximately 1v:3h, down to Deepdell Creek. The northern toe of the WRS approaches the toe of the mountain range/hills to the north of Horse Flat.

The new Deepdell North Stage III Pit is north west of the existing Deepdell South Pit and located over the central southern area of the plain, immediately south of Horse Flat Road, east of the existing haul road and west of the Deepdell East WRS as shown in Figure 3. This area has been previously mined in part for Deepdell North Pit Stage I and II. The new pit is to be excavated deeper and extended further than the previous pit.

All stormwater runoff from Deepdell North Stage III project will drain via a series of gullies and ephemeral streams to Deepdell Creek, that forms part of the Shag Catchment.

The catchment divide for stormwater runoff is along the top of the northern hills/mountain range (refer Figure 2). All stormwater runoff from the Deepdell North Stage III project will therefore drain via a series of creeks to Deepdell Creek, that forms part of the Shag Catchment.

4.0 SITE SUBSOIL CONDITIONS AND EROSION POTENTIAL

From the geological map (GNS, Geological Map 19, Waitaki), experience at the MGP, and site mapping the soils on the site consist of a sequence of:

- Topsoil;
- Loess (silt) that is typically 0.3 to 0.5m thick. However, in localised areas of the WRS on Horse Flat, the loess has been found to be up to 4m. These soils are fine and erodible if subject to rainfall or concentrated seepage;
- colluvium (gravel sized rock with some sand/silt) located near the base of slopes;
- The underlying bedrock at the location of the Deepdell North Stage III project comprises Haast Schist of the Rakaia terrane, formed during Early and Middle Jurassic regional metamorphism. The Haast Schist in this area has abundant Quartz veining which generally runs either parallel to local lineation's within the schist rocks or along the strike of the schistosity. The well foliated schist generally dips towards the mine south east (true east) at an average angle of about 20°. From observations of rock outcrops, test pits and relevant experience in the area, the underlying bedrock is anticipated to be at shallow depth on the steeper slopes (typically less than 1m) and up to about 5m depth on the more level plain.

Waste rock will be predominantly overburden material from Deepdell North Stage III Pit and disposed of in the Deepdell East WRS. It comprises schist rockfill varying from gravel to boulders (typically 10mm to 0.5m). Plate 7 and 8 show the rockfill.

The surficial soils that blanket the site are erodible (i.e. loess). The waste rock is coarse in nature and is low risk with respect to erosion and sediment loads.

5.0 EXISTING EROSION AND SEDIMENT CONTROL

OceanaGold has been operating the MGP for about 30 years. Management of erosion and sediment control has been an important part of the operation and has followed the principles of diverting clean water, minimising disturbed areas by reducing footprints, staging works to minimise open areas and surface water runoff, and treating sediment laden runoff before discharge. These principles align with the those prepared by Environment Canterbury (Ref.1, 7).

Runoff from pits and associated haul roads generally collects in the base of the pits and is pumped to the Process Plant, where practical, or used for dust control. Excess water that cannot practically be pumped to the Process Plant is discharged via silt ponds, provided it meets the required environmental discharge conditions. Runoff and seepage water from the WRSs reports to silt ponds. Water is decanted and either discharged downstream to existing watercourses, pumped back to the Process Plant or used for dust control.

The MGP has a water deficit and water is pumped from the Taieri River to make up the shortfall for the operation of the Process Plant. This is advantageous for sediment control in that excess water does not have to be released from site. Photographs of existing silt ponds (Clydesdale, Deepdell North, Deepdell South, Frasers West and Murphy’s Creek) are shown in Plates 1-5 respectively.

Erosion and sediment control for the development of the existing Coronation WRS is managed by earth bunds, to contain and minimise concentrated runoff in disturbed areas, and downstream silt ponds. All rainfall falling within the existing Coronation North Pit is contained within the pit and used for dust suppression or discharged to a downstream gully when conditions allow.

The existing Coronation Haul Road down to Horse Flat Road, and west of Deepdell North Stage III, includes regular silt traps down the side of the road to collect the stormwater runoff and silt. The general control of stormwater runoff from disturbed areas within the Coronation North Project was set out in EGL's Erosion and Sediment Control report (Ref.4) and similar measures are proposed for Deepdell North Stage III. To date we are not aware of any significant discharge of silt to the downstream environment and the current measures appear to be operating satisfactorily.

The existing erosion and sediment control practice at the MGP includes:

- Cleanwater drains to divert run-on and clean water away from disturbed areas;
- Silt ponds to allow time for settlement of suspended solids associated with runoff from disturbed areas;
- Diversion drains to divert runoff from disturbed areas to silt ponds;
- Staged stripping of WRS footprints to minimise disturbed areas, particular of loess soils, before rockfill is placed which provides detention and minimises runoff;
- Steep gullies are not stripped beneath WRSs, except in the base of gullies at the toe of the WRSs, which minimises disturbed areas and leaves a buffer that acts to intercept sediment from areas stripped above;

- Stripping of topsoil and loess soils is undertaken in dry weather conditions, generally over summer months:
- Management of water on the working surface of the WRSs including profiling of the WRS to prevent runoff from discharging over the outside shoulder and excavation of soak pits to allow surface runoff to soak into the waste rock (which acts to filter out fines);
- Placement of coarser rock in gullies which act as underdrains for natural water courses;
- Progressive rehabilitation of WRS and TSF embankments consisting typically of 0.3m of oxidised waste rock and 0.2m of topsoil and grassing to minimise bare areas;
- Shoulders of the WRS will form slopes up to about 1V:3H to minimise erosion of the rehabilitation layer;
- Monitoring of discharges as required by consent conditions;
- Regular inspections of silt ponds and diversion drains to check condition and undertake maintenance if required.

Silt ponds have been constructed at the MGP in advance of placement of waste rock in WRSs or construction of TSFs. In all cases the silt ponds have been created by construction of embankment dams across gullies with ephemeral streams immediately downstream of the disturbed areas.

Typically, the dams have been zoned embankments consisting of a central core of low permeability fill with rockfill shoulders. The low permeability fill has either been sourced locally from loess and/or colluvium with overburden material from the pits or weathered rock sourced close to the pond. The rockfill has been sourced from pit overburden material or locally less weathered rock close to the ponds.

The design criteria for the silt ponds has changed with time. The initial silt pond in Maori Tommy Gully, downstream of the Mixed Tailings Impoundment TSF, was designed to store the runoff from a 2 year - 7 day storm event from a 150ha catchment, allowing for pump back to the Process Plant at 162m^3/hr. Other smaller silt ponds associated with the initial project development were designed to store the runoff from either a 10 year -1 hour or 2 year - 1 hour storm. Runoff was calculated with runoff coefficients that varied between 0.6 and 0.7 depending on whether the catchments were undisturbed or disturbed. The spillway for the Maori Tommy Silt Pond was designed to pass the 100 year flood event while the smaller ponds that had limited life were designed to pass the 10 year flood event.

Silt ponds designed later in the life of the project for WRSs were designed according to the criteria summarised in Table 1.

Table 1. Silt Pond Design Criteria

No.	Criteria
1.	Storage sufficient to contain at least the initial 24 hour rainfall from a 2 year rainfall event (70mm rainfall).
2.	Service and emergency spillways capable of passing flows from 10year and 100year return period rainfall events respectively
3.	Ponds provided with either pump-back facilities or a constricted flow outlet to decant impounded water. Pump or decant designed to recover the minimum live storage in no more than 5 days

4.	Dam, spillway and associated structures designed, constructed, operated and maintained for the life of the dam in accordance with the general principles of New Zealand Society of Large Dams (NZSOLD) Dam Safety Guidelines (Ref.3)

In the past the 24 hour rainfall from a 2 year event has been estimated as 70mm of rainfall. The latest High Intensity Rainfall Database Version 4 (HIRDS v4) estimates this to be equal to 44mm of rainfall, well below this past design value, however, it is recommended that 70mm is continued to be used for sizing ponds, that are similar to those previously constructed, which allow for greater detention before discharge.

If ponds are equipped with forebays, flow spreader bars, baffles, and floating decants as recommended by the Environment Canterbury Toolbox (Ref. 1) the latest HIRDs v4 estimate of 44mm of rainfall will be used.

For comparison the 2007 Environment Canterbury Erosion and Sediment Control Guidance (Ref. 7) indicates sediment retention ponds (silt ponds) are sized for a 10 hour rainfall from a 5 year rainfall event. For MGP area this is 41mm of rainfall, a lower value than proposed above for the resource consent condition in Table 1.

Storage volumes have typically been calculated using runoff coefficients (C) of between 0.32 and 0.70. Higher runoff coefficients have been adopted for small catchments. Experience is that a large proportion of rainfall either infiltrates or evaporates and that this is more significant for larger WRS and justifies lower runoff coefficients. The existing Murphy’s Creek silt pond was designed with a runoff coefficient of C=0.32 and operating experience indicates that this has been more than sufficient. The same runoff coefficient is proposed for the final catchments for the Deepdell North Stage III WRS and pit backfill.

The decant facility adopted for most silt ponds has been a perforated manhole structure as shown in Plate 6. This simple design has proven to work effectively at the MGP rather than floating decants which were tried in the early stage of the project but found to require considerably greater ongoing maintenance and prone to damage. The manhole also acts as the service spillway. The perforated holes have typically been set at a level which provides generous dead storage and water is sometimes drawn-down further by pumping for dust control. More recently a floating decant was used again for the silt pond for the construction of the Top Tipperary TSF embankment, and appeared to operate successfully during the short life of the silt pond. Where perforated manholes have been considered more recently a blanked flange has been formed in the manhole at the bottom of the live storage level to allow a floating decant to be added at a later stage, if required as indicated through monitoring and review of the OMPs during operation.

Experience to date is that stormwater runoff from the WRS is typically low in suspended solids. This is apparent in the small volumes of silt that have been collected in the existing silt ponds, and limited discharge of sediment downstream of the ponds . It is due to a combination of the low rainfall, the limited exposure of fine soils and the permeable nature of the waste rock in the WRS. This last factor is particularly important as the permeable nature of the waste rock results in a high proportion of rainfall infiltrating the WRSs. The runoff from the waste rock does not have a particularly high sediment load and as it drains through the waste rock most sediment is trapped and filtered out. The waste rock is typically end dumped in high lifts of about 10 to 20m height. This results in segregation with coarse rock at the base of each lift as shown in Plates 7 and 8 which acts as an underdrain beneath the WRS. High volumes of water can percolate through such material. The surface of the WRS is sloped away from the outside shoulder so that runoff flows back into the WRS working area where it infiltrates into the WRS as shown in the schematic in

Figure 4. Any surface water that collects on top of the WRS during rainfall is lost primarily through passive infiltration.

Infiltration of runoff into the WRSs has previously been encouraged, when necessary, by the digging of sumps if water begins to pond on the active fill surface.

The critical time for generation of sediment is at the initial stage of construction of the WRS. Typically, the foundations will be stripped, except where the ground is too steep and impractical. Until waste rock is placed over these exposed soils they can be moderately erodible. For the recent and ongoing Coronation WRS, runoff was also minimised by creating a series of earth windrows during stripping to increase the detention time within the disturbed areas and reduce the runoff velocity and concentration of stormwater. Steep gullies are not stripped beneath WRSs, except in the base at the downstream toe, minimising the disturbed area. Silt ponds were constructed in gullies downstream ahead of any areas being stripped. Once waste rock is placed then the potential for generation of sediment is significantly reduced because of the natural filtration of fines that occurs with seepage through the schist waste rock through the WRS.

OceanaGold has been operating the MGP for over 30 years. The existing erosion and sediment control practices have worked well throughout the life of the mine and no known issues have been identified. There has also been no need to remove silt from the existing silt ponds, confirming that the inflowing water has a low silt content.

6.0 DEEPDELL NORTH STAGE III EARTHWORKS

The areas of earthworks areas associated with the Deepdell North Stage III requiring erosion and sediment control are summarised in Table 2.

Table 2. Summary of Total Areas Requiring Earthworks

Area	Total Area (ha)
Deepdell North Stage III Pit	38
Deepdell East WRS	71

The earthworks areas in Table 2 are totals. The pit area will only be exposed for a short time at current ground level before it is lowered, with surface water runoff ending up at the base of the pit.

The WRS will be staged to minimise disturbed areas open at any one time. The backfilling of the Deepdell South Pit will be the first stage of the WRS. This area, which is lower than the Horse Flat area, is approximately 21ha. Once up to the Horse Flat level the WRS the first lift will be constructed after erosion and sediment control clean water diversion drains and bund and silt ponds are established. On Horse Flat stripping of a 30m width of surficial soils (loess and residual soil) to rock, around the toe of the WRS, provides a shear key for geotechnical stability in an earthquake. This stripping is to be promptly followed by placement of rockfill and rehab of the first bench.

In addition to the Pit and WRS there is an existing haul road to the west of Deepdell North Stage III providing access to the project with an existing haul road to the existing Deepdell North Pit (Stage 2) and Deepdell South Pit (refer Figure 3). The only new haul road for the project will be a very short length from the Deepdell North Stage III Pit to Deepdell East WRS.

It is noted that runoff from the new Deepdell North Stage III Pit will only require erosion and sediment control during the very early stages of development. At this stage of works, material is to be placed in the existing Deepdell South Pit. Runoff from this work can be managed with the existing Deepdell North Silt Pond. Once the pit reaches sufficient depth all the runoff will be contained within the pit and the water either used for dust suppression or pumped to Deepdell North Silt Pond for discharge to Deepdell Creek via the silt pond. Pumping can be managed to discharge to the pond when surface water from the WRS is low.

The backfilling of the Deepdell South Pit will be the first stage of the WRS. This area is approximately 21ha and can be managed by the Deepdell South Silt Pond and control of water within the lip of the pit. Water on the surface of the WRS can be directed to pond against the natural ground surface and infiltrate into the pit back fill. Most of the groundwater is unlikely to reach the south pit sediment pond rather infiltrating the ground and seeping through to Deepdell Creek. It will be possible to manage surface runoff in this way till the rockfill reaches a level where water naturally flows to the west and east. At this stage areas to the north will need to be opened up, with runoff ending up in new silt ponds in gullies to the east and in the Deepdell North Silt Pond.

Placement of waste rock on Horse Flat should establish a perimeter of waste rock, through staged undercut, placement of rockfill and rehab in those areas indicated to be early rehab areas on Figure 6. Catchment areas will be able to be managed with temporary diversion drains to event up load on each pond. Disturbed catchment areas will be able to be kept below approximately 20ha. With raising the working surface should be sloped inwards to allow water to pond in the centre and infiltrate the waste rock. Sumps through the tracked working surface will likely need to be dug. Detention of surface runoff can also be provided by earth bunds allow water to pond in different areas which are convenient for the operation.

7.0 PROPOSED EROSION AND SEDIMENT CONTROL PRACTICE

7.1. General

Prior to commencement of construction an OMP will be prepared. The Plan will be based on the OMP for the existing MGP, and will incorporate improvements where practical and necessary, such as the practices in the Environment Canterbury Erosion and Sediment Control Toolbox and Guidelines (Ref.1,7) and will include the specific erosion and sediment control measures:

- Cleanwater diversion drains and bunds to divert run-on water and clean water onsite away from dirty water. Temporary cleanwater diversion drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Any permanent cleanwater diversion drains or bunds will be designed for a 1 in 100 AEP storm with 0.25m freeboard. Where necessary (e.g. steeper ground, erosive soils) the drains will be lined (e.g. rockfill, geotextile) and energy dissipation will also be provided at high energy locations (i.e. at the bottom of steep sections of drain where velocities are high).
- Silt ponds will be established upfront using ponds similar to Deepdell North and South Silt Ponds. They will be sized for the site-specific design criteria (70mm of rainfall) reported above in Table 1, which is consistent with past resource consent conditions and which has been effective for other areas of the site. This criteria provides for more detention than the Environment Canterbury Guidelines (Ref. 1, 7). More modern silt ponds with forebays, flow spreader, baffles, floating decants and flocculant could be used,

however, lower rainfall levels consistent with the latest rainfall estimates would be more practical for sizing (44m of rainfall). Overall the OMP will include monitoring and review and additional measures can be implement if discharge water quality is not suitable. Decants using perforated manholes, similar to those currently on site is preferred. If a perforated manhole is used for the decant then it will be designed to allow for future attachment of a floating decant, if required. Primary and auxiliary spillways will be provided and designed to pass the flows from 10year and 100year return period rainfall events. Early rehab is to be promoted in areas indicated on Figure 6 to achieve less sediment laden runoff.

- Shoulders of the WRS will form slopes up to about 1V:3H to minimise erosion of the rehabilitation layer;
- Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds. Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard. Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

Comments on the proposed erosion and sediment controls for the Deepdell North Stage III Pit and WRS are discussed in more detail in the following sections.

7.2. Deepdell North Stage III Pit

During the initial clearing and excavation for the pit it is anticipated that some short term sediment control measures will be required together with clean water diversion drains. As the pit excavation progresses i.e. gets deeper, a stage will be reached where all the stormwater runoff from the disturbed area will report directly to the pit.

A clean water diversion drain is proposed to the north of the pit as on Figure 5 and 6. This directs clean runoff to a stream to the west, minimising the amount of water ending up in the pit.

During the operation of the pit the collected water will either be used for dust suppression or pumped to upstream of the existing Deepdell North Silt Pond. The silt pond was originally designed for the construction of the Deepdell Waste Rock Stack (referred to as Western WRS in Ref.6) with a design catchment of 22.25 hectares. Considering that the new pit has a footprint of 38 hectares and will contain stormwater runoff within the pit as it is deepened, it is considered that the existing silt pond has sufficient capacity for the disturbed area as the pit is developed. Clean water from the Deepdell North WRS will be diverted around this pond. The pond is also required for the Deepdell East WRS, however, the pit will be below the current ground surface before the Deepdell North Silt Pond is required. The existing silt pond is in good condition and suitable for re-use for the new pit.

7.3. Deepdell East Waste Rock Stack - South Pit Backfill

A temporary cleanwater diversion drain will be constructed immediately upstream of the pit backfill to minimise stormwater runoff entering the footprint of Deepdell South Pit Backfill. The lowest point of the existing pit is on the south western side. However, the existing pit holds water but does not overflow the pit. This means that the current inflow to the pit, plus direct rainfall, is less than that lost by evaporation and seepage through the rock. Consequently, the existing pit acts as a good detention pond. East of the low point, and on the southern side of the pit, is another gully draining down to Deepdell Creek with an existing silt pond referred to as Deepdell South Silt Pond (refer Figure 5). The silt pond was designed for a catchment of 20.5 hectares (Ref.5) which is similar to the area it may have to accommodate. However, it is likely that water from this catchment will infiltrate the ground via the pit back fill before reaching the silt pond, which is preferable. The silt pond is currently in good condition and suitable for re-use. Additional erosion protection should be added at the outlet of the discharge pipe to protect against erosion downstream of the silt pond. Should the water level in the pit rise, the low point of the lip is to the south west, which flows down to Deepdell Creek. Sediment retention will be able to be managed within the lip of the pit by locally adjusting the toe of the WRS and creating a decant and spillway. Once the upper backfill lifts have been constructed, rehabilitated and the surface cutoff drain formed to divert the clean surface stormwater runoff to the gully in which Deepdell South Silt Pond is located, the lower steepened slopes will be recontoured to final design slopes and rehabilitated.

When backfilling of Deepdell South Pit commences, the water level will be drawn down to enable backfill by pumping into the existing Deepdell South Silt Pond where it will discharge via the existing decant system to Deepdell Creek.

7.4. Deepdell East Waste Rock Stack – Horse Flat

There is a catchment of about 47 hectares upstream (north) of the Pit and WRS. It is intended to divert most of this upstream stormwater runoff to the east and west of the WRS using a cleanwater diversion drain as shown in Figure 5. Both will be to the existing natural drainage gullies and stream of Horse Flat, so it is not expected to increase normal flows in these overland flow paths. These measures will divert most of the upstream runoff away from the WRS and Pit.

Two silt ponds will be constructed downstream to the east of the WRS, the start of the natural drainage gullies. Catchment areas for each silt pond can be managed by introducing a diversion drain in the middle of the WRS on Horse Flat, directing water to the east, as shown on Figure 6. The silt ponds will be designed for a high runoff coefficient from the initial disturbed footprint as the WRS is progressively developed (i.e. C=0.6). They will also be designed for the ultimate disturbed catchment using a lower coefficient (C=0.32) to reflect the reduced runoff due to infiltration into the WRS and discharge via the coarser rock at the base of the WRS.

The west runoff will be diverted to the Deepdell North Silt Pond as shown on Figure 5 and 6, which will no longer be required for the pit once the pit level if below the existing ground surface.

The critical stages are the initial stripping and placing waste rock which will be carried out progressively starting around the perimeter of the site in the lower areas which drain into the natural gullies. These are areas indicated as early rehab areas on Figure 6. During this early stage temporary clean water diversion drains will be constructed upstream of the disturbed area to divert clean stormwater runoff away for the working area. Temporary erosion and silt control measures will also be implemented within the disturbed area to control stormwater runoff, as has successfully been carried out for the Coronation Project. This will typically comprise contour banks/bunds/windrows to control the concentration and velocity of stormwater runoff. Because it is not a high rainfall area the contour banks/bunds/windrows can also be used to contain stormwater runoff that is then lost through evaporation.

By a combination of keeping the upstream clean stormwater runoff away from the disturbed areas, containing and controlling stormwater within the disturbed areas by earth contour banks/bunds/windrows and progressively rehabilitating the completed areas of the WRS, this minimises the stormwater runoff that needs to be contained and treated in the silt ponds.

7.5. Preliminary Sizing of Ponds, Drains and Culverts

For the general erosion and sediment control measures proposed, the silt ponds, drains and culverts have been sized. Preliminary calculations are attached at the back of this report. Ponds, drains and culverts are labelled in Figure 7 and 8 in the Calculations.

The required live storage volumes are based on the specific runoff characteristics of each catchment. The live storage volume is the volume between the lowest decant level and the level of the primary spillway. The live volumes are indicated in Table 3. Also indicated is an estimate of the total volume, which includes dead and freeboard storage.

Table 3. Silt Pond Storage Volume Estimates

Silt Pond	Required Live Storage	Existing Live Storage	Existing Dead Storage	Estimated Total Storage Volume
DD North Silt Pond	10,900 m^3	11,000 m^3	7,400 m^3	23,000 m^3
DD South Silt Pond	4,460 m^3	4,600 m^3	800 m^3	7,400 m^3
DD South Pit Silt Pond	3,540 m^3	To be designed.	-	5000-7000 m^{3*}
DD East WRS Silt Pond 1	6,900 m^3		-	10,000-14,000 m^{3*}
DD East WRS Silt Pond 2	7,730 m^3		-	11,000-15,000 m^{3*}

*Volumes estimated using a ratio of 1.5 to 2.0 times the live storage, based on the North and South Silt Pond Ratios

The existing ponds have sufficient capacity to manage surface water runoff.

The Deepdell (DD) South Pit Silt Pond is formed by locally steepening the toe of the waste rock placed, to create the required volume against the lip of the pit. It is likely that this full volume won't be required, as the water will infiltrate into the permeable rock fill that will fill in the south pit, however, this volume will still be allowed for until performance is observed.

The Deepdell East Silt Ponds 1 and 2 will be designed to hold the required volumes and will be similar, to the North and South Silt Ponds, formed with small embankment dams across gullies.

The uphill clean water diversion drains are permanent where they are adjacent to the WRS and are therefore sized for a 1:100 AEP rainfall intensity. A culvert is required to pass the stormwater runoff beneath the western end of the Horse Flat Road realignment. This is also sized for a 1:100 AEP rainfall intensity and requires an internal diameter of 685mm. Where the clean water uphill diversion drain passes the Deepdell North Pit, the drains are sized for the temporary case of 1:20 AEP rainfall intensity as this surface water will be able to flow into the pit in the long term.

Where perimeter dirty water diversion drains are required, they are sized for both the temporary and permanent cases, as the runoff situation changes with the placement of the rock fill.

The dirty water diversion drain from the Deepdell East WRS to the Deepdell North Silt Pond was sized as a temporary drain and once the WRS is rehabilitated, could be directed into the Deepdell North Pit, which is to form a pit lake.

Drain sizes are summarised in Table 4.

Table 4. Surface Water Drain Sizes

Drain	Lining	Top Width	Depth	Base Width
Uphill Clean Water Cutoff Drain 1	Grass or geotextile	5.0m	0.7m	1.0m
Uphill Clean Water Cutoff Drain 2		4.25m	0.65m	1.0m
Uphill Clean Water Cutoff Drain 3		3.8m	0.6m	1.0m
Uphill Clean Water Cutoff Drain 4		2.75m	0.45m	0.5m
Uphill Clean Water Cutoff Drain 5		2.15m	0.35m	0.4m
Uphill Clean Water Cutoff Drain 6		2.4m	0.4m	0.5m
Uphill Clean Water Cutoff Drain 7	Geotextile and Rock, or Armco Flume	1.0m	0.2m	0.4m
Uphill Clean Water Cutoff Drain 8		1.1m	0.4m	0.25m
Perimeter Drain	Grass or geotextile	4.25m	0.65m	1.0m
Deepdell East WRS to North Silt Pond		4.25m	0.65m	1.0m

Velocities for drains on Horse Flat are generally less than 2m/s and well-established grass lining is likely sufficient to limit erosion. Geotextiles could be used if grass can not be established effectively, in combination with some rock lining.

Rock lining will be required for any diversion drains not cut into rock, where grades steepen down to the Deepdell North Silt and South Ponds, or where clean water cutoff drains head down slope towards Deepdell Creek. This may be required for Clean Water Cut Off Drains 7 and 8.

The road embankment across the existing gully at the eastern end of the Horse Flat Road Alignment requires a culvert. This was sized to pass a 1:100 AEP intensity and requires an internal diameter of 900mm.

8.0 SUMMARY AND CONCLUSIONS

OceanaGold propose to develop the Deepdell North Stage III project at the Macraes Gold Project. The project includes the new Deepdell East WRS immediately south of Horse Flat road which also includes the backfilling of the existing Deepdell South Pit near to Deepdell Creek. The waste rock will come from the existing Deepdell North Pit immediately west of the East WRS.

Operation Management Plans will be developed prior to construction to manage and control erosion and sediment associated with construction and operation of Deepdell North Stage III. Silt ponds together with water diversion and collection drains will be used for the erosion and sediment control for the WRS, pit backfill and pit. Runoff from the pit, once sufficiently deep, will be captured entirely in the base of the pit and either used for dust suppression or pumped to a gully upstream of an existing silt pond.

OceanaGold has been operating the Macraes Gold Project for 30 years. Existing erosion and sediment control practices have worked successfully, and similar practices are proposed for Deepdell North Stage III. Tools presented in Environment Canterbury Erosion and Sediment Control Toolbox and Guidelines (Ref.1, 7) can be included in the plans as practical and necessary, as indicated through monitoring and review of the erosion and sediment control for this specific project.

ENGINEERING GEOLOGY LTD

Report Prepared By

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MEngNZ

Report Reviewed By

J Yeats
CPEng

RERERENCES

1. Environment Canterbury Erosion and Sediment Control Toolbox (2019) https://www.esccanterbury.co.nz/resources/.

2. Auckland Regional Council. (1999) ‘Erosion and Sediment Control: Guidelines for Land Disturbing Activities in the Auckland Region’, ARC Technical Publication No.90.

3. New Zealand Society on Large Dams. (2015) ‘New Zealand Dam Safety Guidelines’.

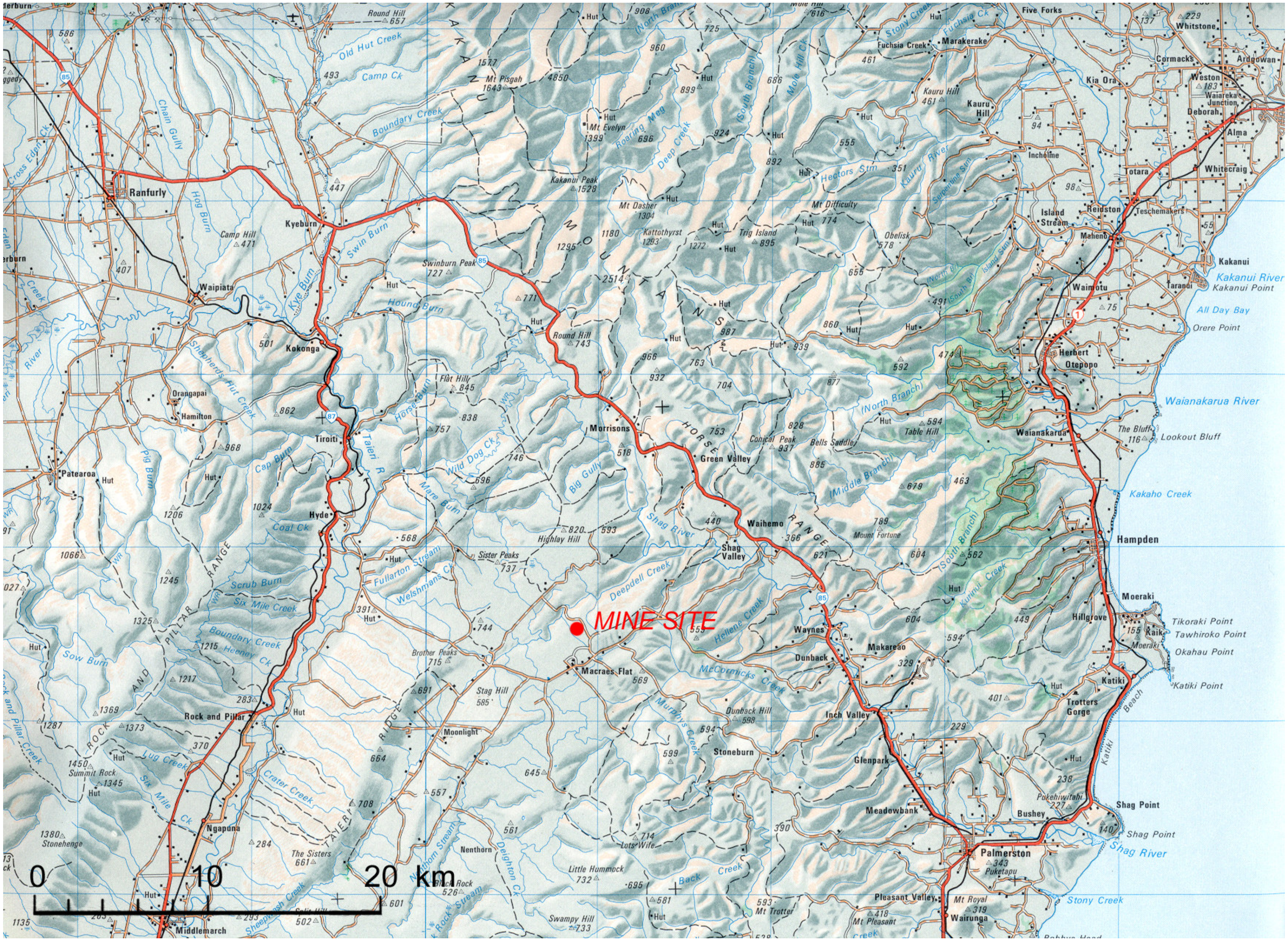
4. Engineering Geology Ltd (2016) 'Oceana Gold (New Zealand) Ltd, Macraes Gold Project, Coronation North Project, Erosion and Sediment Control', dated 3 May 2016, reference 7261.

5. Engineering Geology Ltd (2001) ‘GRD Macraes Ltd, Macraes Mine, Deepdell South Silt Pond, Design Report’ dated 13 December 2001, reference 4682.

6. Engineering Geology Ltd (2001) ‘GRD Macraes Ltd, Macraes Mine, Deepdell North Silt Pond, Design Report’ dated 27 October 2000, reference 1410.

7. Environment Canterbury. (2007) ‘Erosion and Sediment Control Guidelines for The Canterbury Region’

FIGURES



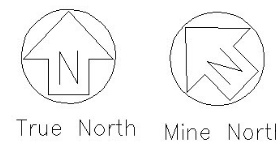


Figure 1

Source: NZMS Sheet 15 Waitaki.

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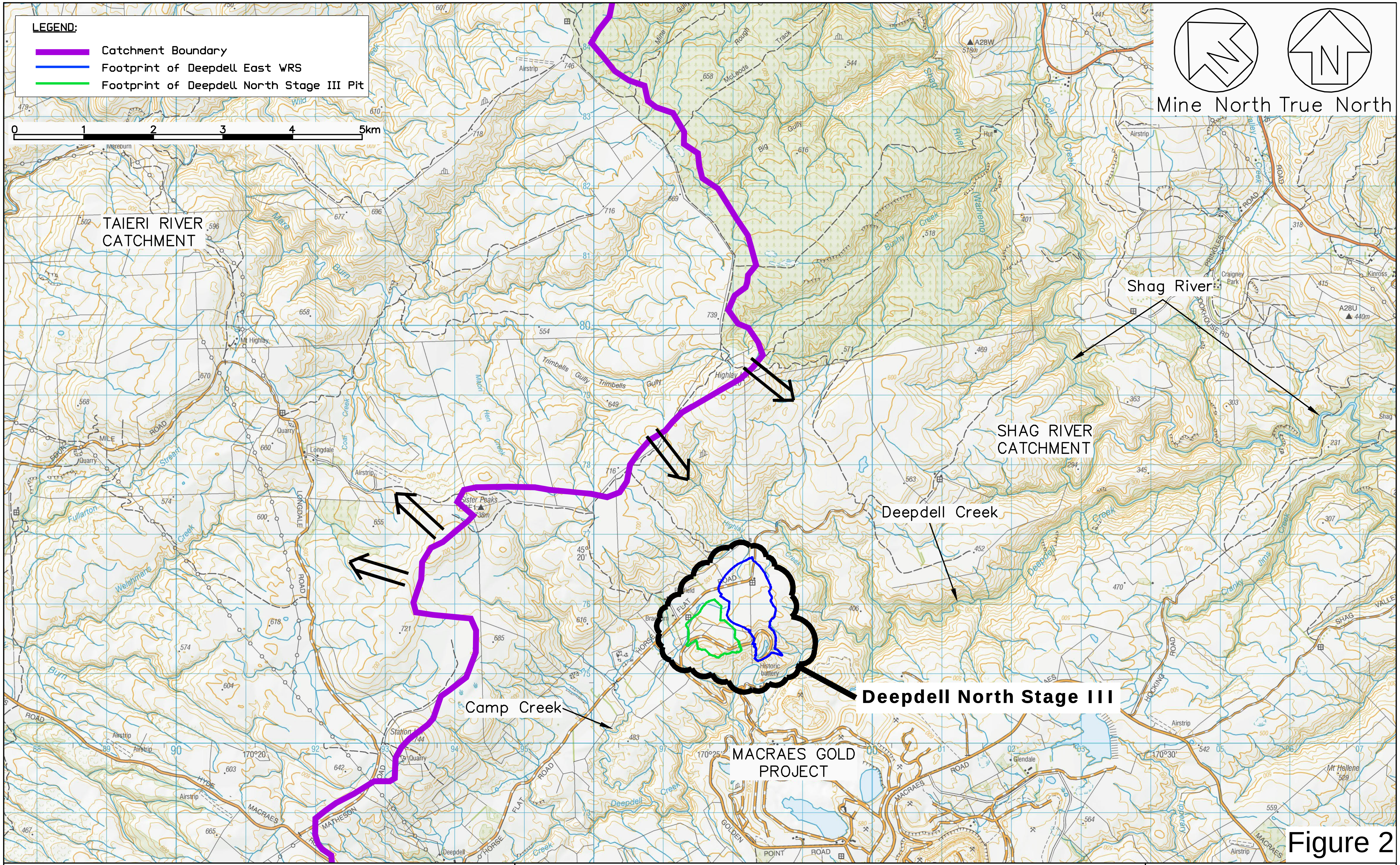
OCEANA GOLD (NEW ZEALAND) LTD
Macraes Gold Project
Locality Plan

Ref. No.: 1410
Date: 26 June 2002
Drawn: SP
File: local.grf



OCEANA GOLD NZ LTD
MACRAES GOLD PROJECT- Deepdell North Stage III
Site Plan

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Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany
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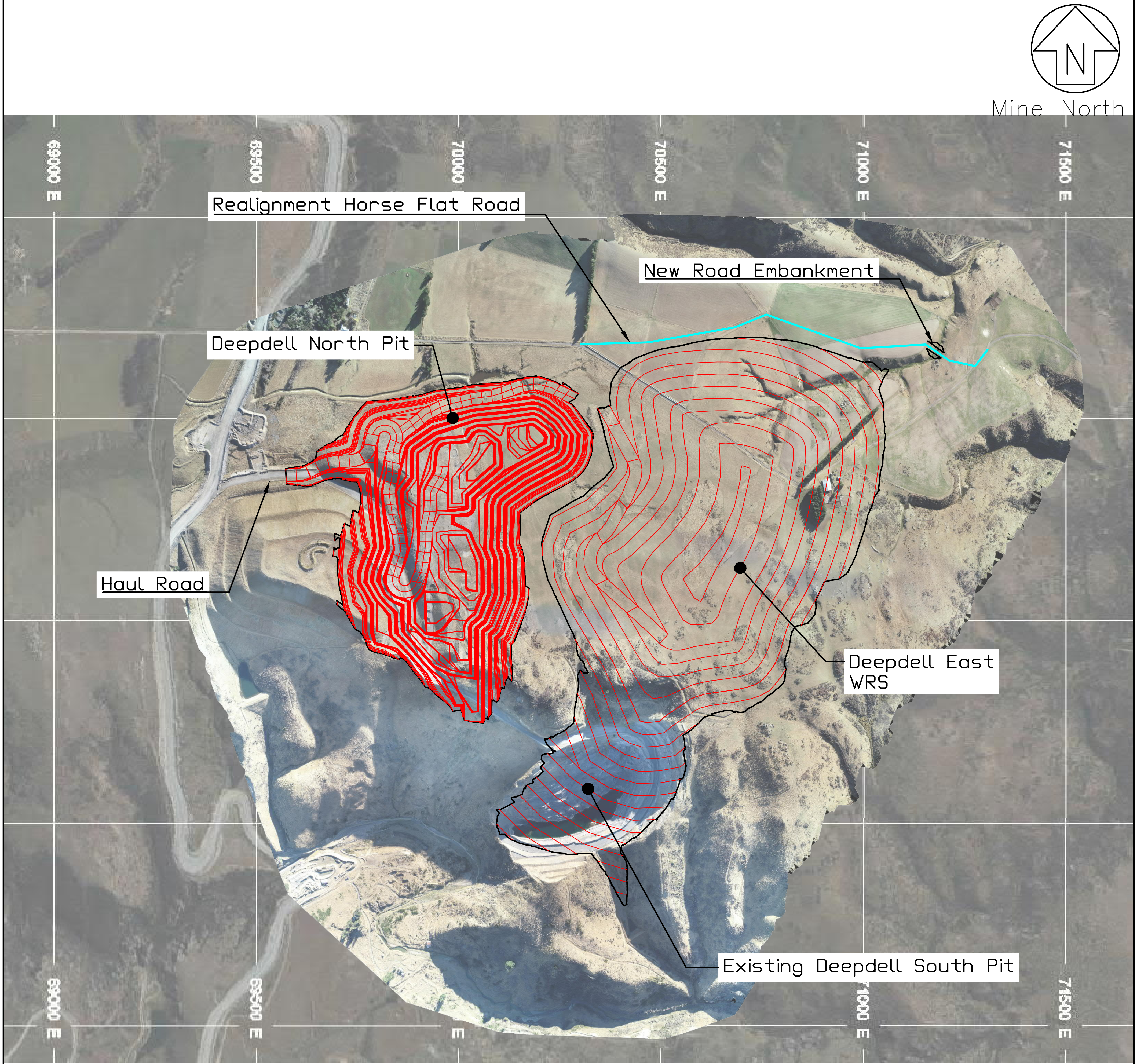
Drawing No.	8529-Fig 2
Date:	Aug 2019
Drawn:	NT
Scale:	1:50000 (@A3)
Filename:	8529-Fig2.dwg



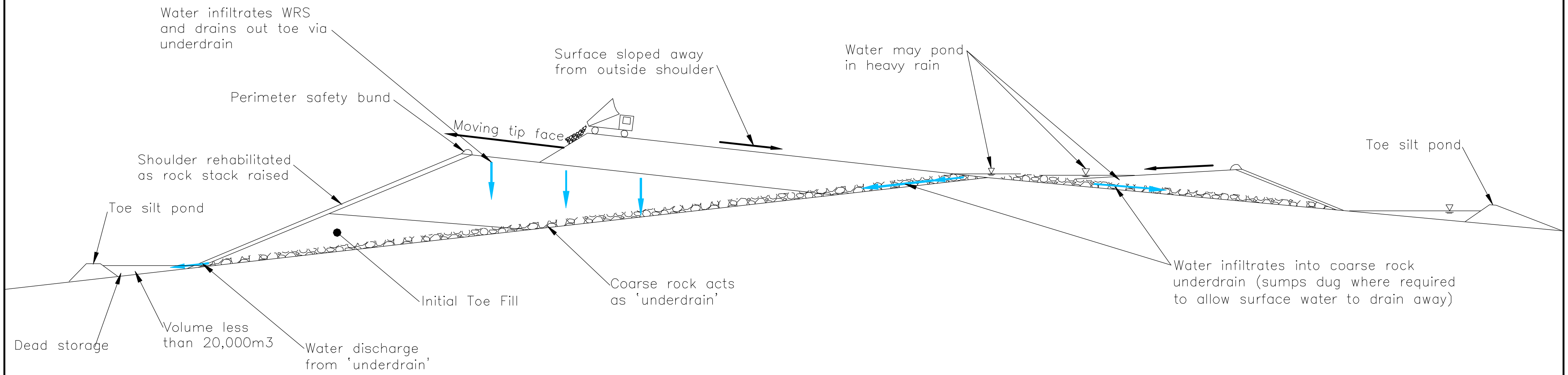
LEGEND:

Deepdell East WRS - Contours 10m Intervals

Deepdell North Stage III Pit - Contours 2.5m Intervals

Figure 3

ENGINEERING GEOLOGY LTD Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany Ph (09)486-2546, Fax (09)486-2556	OCEANA GOLD NZ LIMITED MACRAES GOLD PROJECT- Deepdell North Stage III *Waste Rock Stack Plan*	Drawing No. 8529-Fig3 Date: Aug 2019 Drawn: NT Scale: 1:10,000 (@A3) Filename: 8529-Fig3.dwg



Rock Stack – Schematic of Erosion and Sediment Control Features (Not to scale)

Figure 4

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OCEANA GOLD NZ LIMITED
MACRAES GOLD PROJECT- Deepdell North Stage III
Waste Rock Stack Schematic of Erosion and Sediment Control Features

Drawing No.	8529–Fig4
Date:	Oct 2019
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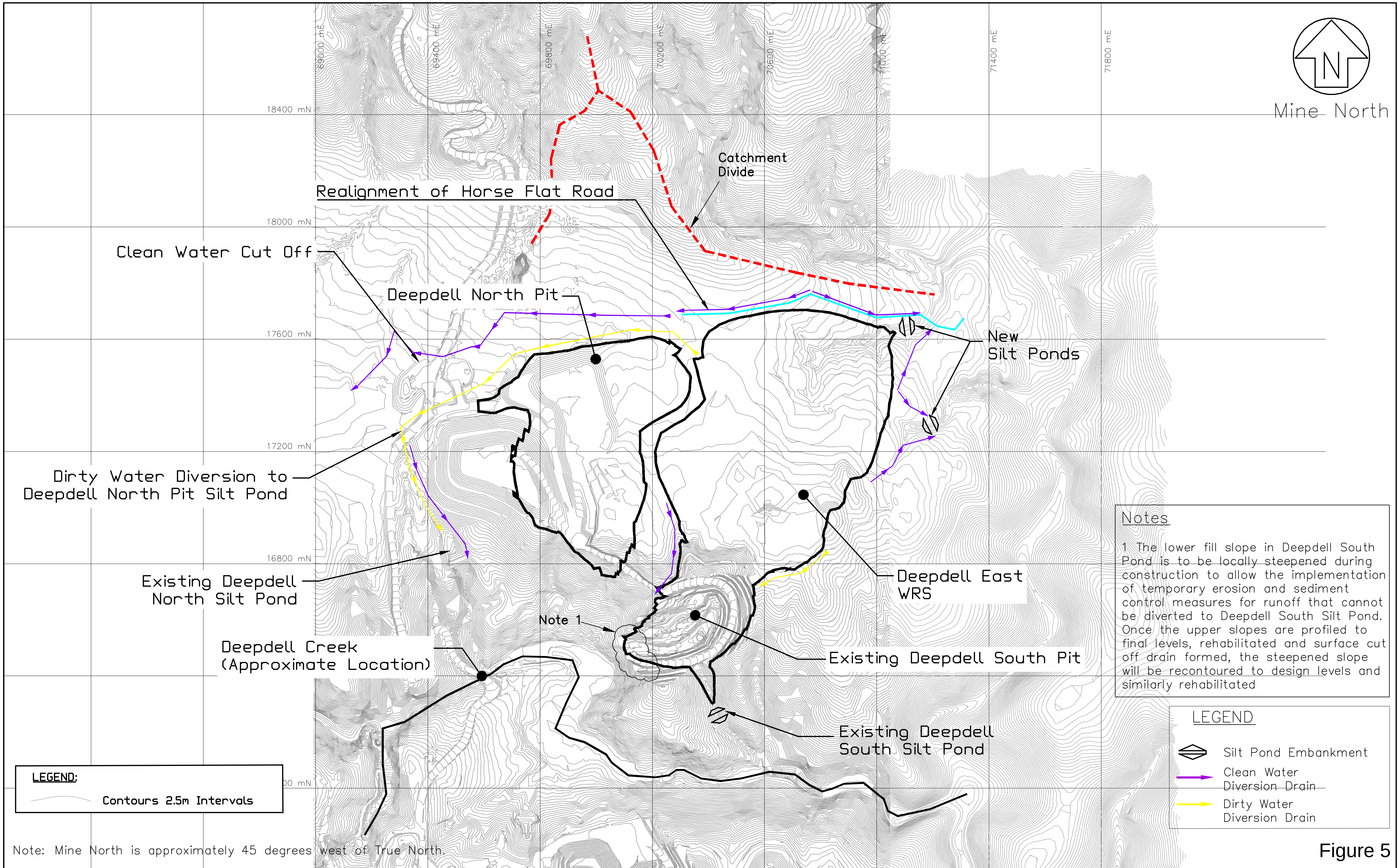

Figure 5

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OCEANA GOLD NZ LIMITED
MACRAES GOLD PROJECT-Deepdell North Stage III
Waste Rock Stack and Pit
Erosion and Sediment Control Overview

Drawing No.	8529-Fig5
Date:	Aug 2019
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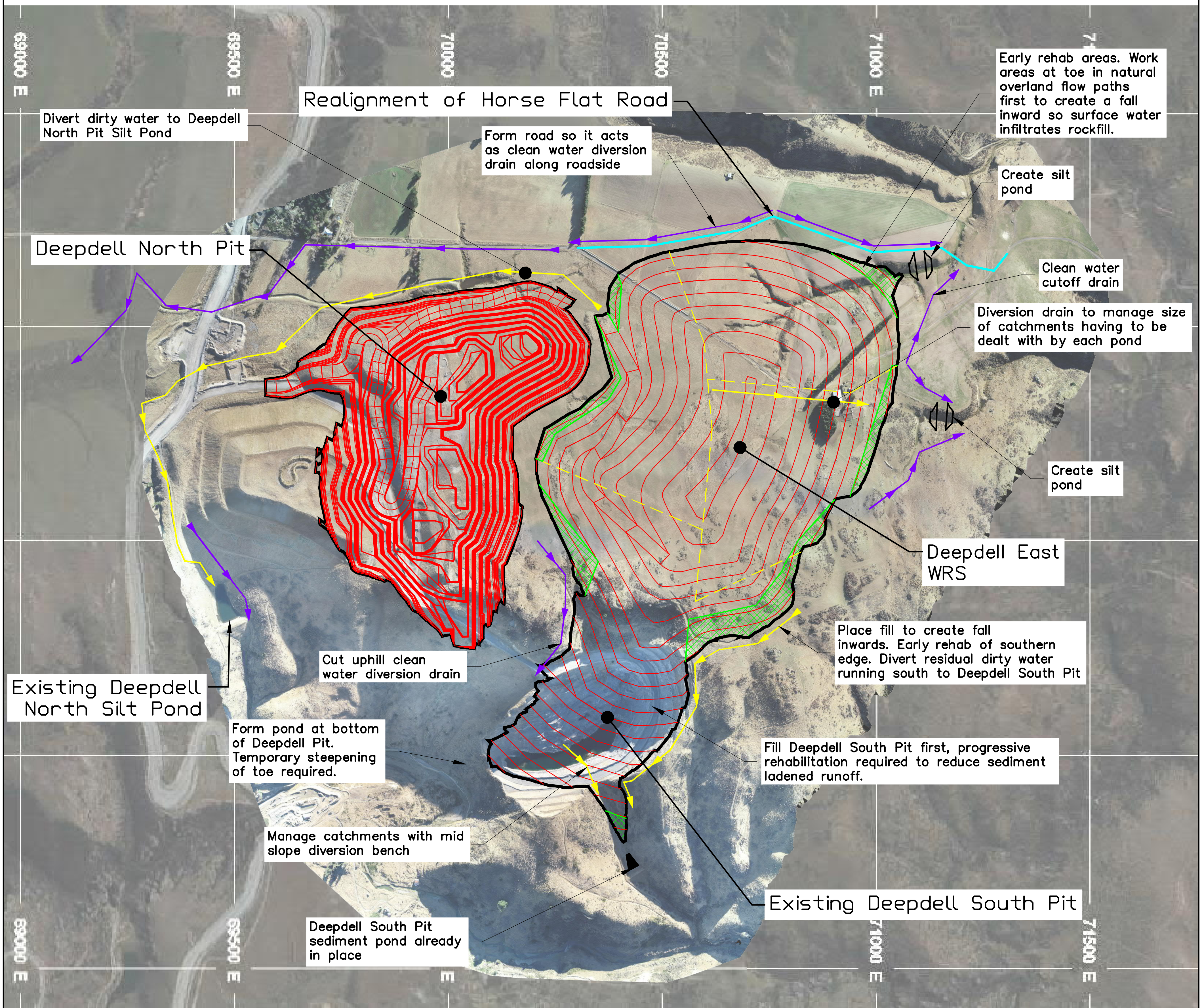
Mine North



LEGEND:

Deepdell East WRS - Contours 10m Intervals
Deepdell North Stage III Pit - Contours 2.5m Intervals

LEGEND

Silt Pond Embankment
Clean Water Diversion Drain
Dirty Water Diversion Drain
Early Rehabilitation Areas

Figure 6

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OCEANA GOLD NZ LIMITED
MACRAES GOLD PROJECT-Deepdell North Stage III
Waste Rock Stacks and Pit
Erosion and Sediment Control Features

Drawing No.	8529-Fig6 (RevA)
Date:	Jul 2019
Drawn:	NT
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PLATES

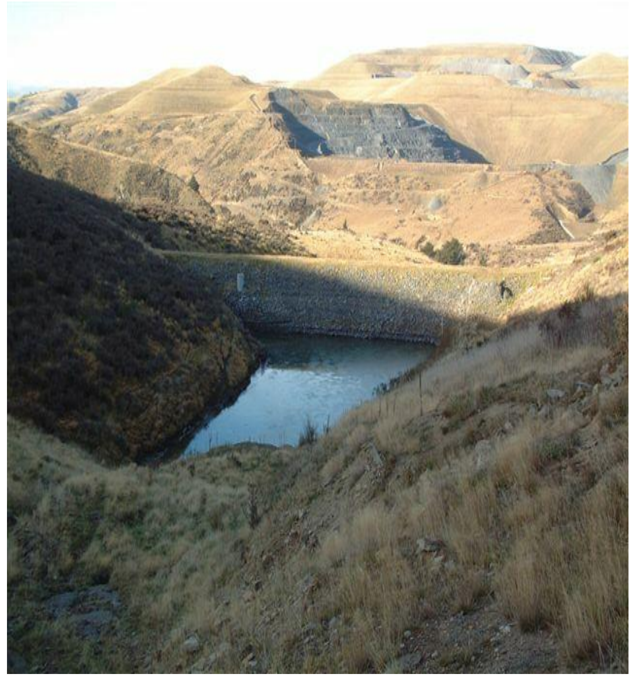


Plate 1. Clydesdale Silt Pond

Plate 2. Deepdell North Silt Pond

Plate 3. Deepdell South Silt Pond

Plate 4. Frasers West Silt Pond

Plate 5. Murphys Creek Silt Pond

Plate 6. Typical Silt Pond Decant Structure

Plate 7. Rock Stack Tip Face (initial lift)

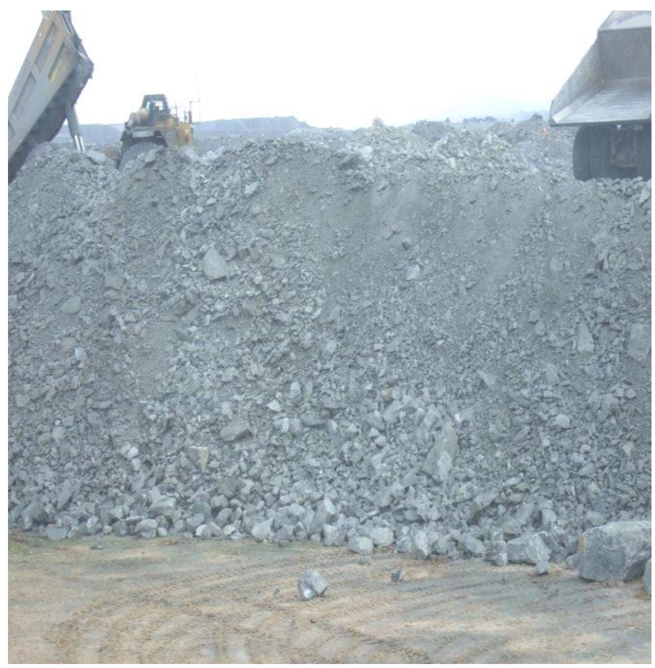
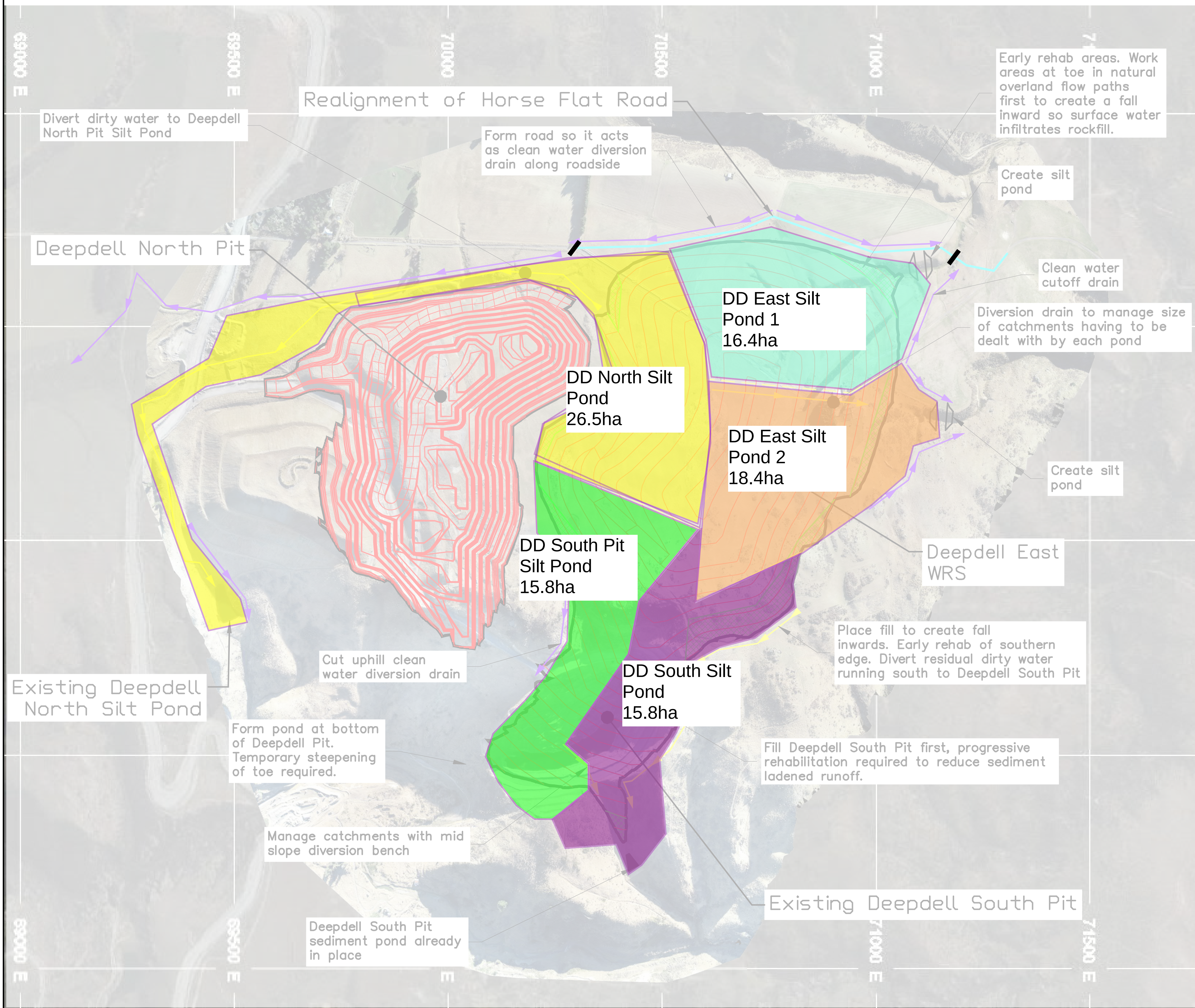


Plate 8. Rock Stack showing segregation of waste with coarse rock at base of lift

CALCULATIONS

Mine North



LEGEND

Silt Pond Embankment

Clean Water Diversion Drain

Dirty Water Diversion Drain

Early Rehabilitation Areas

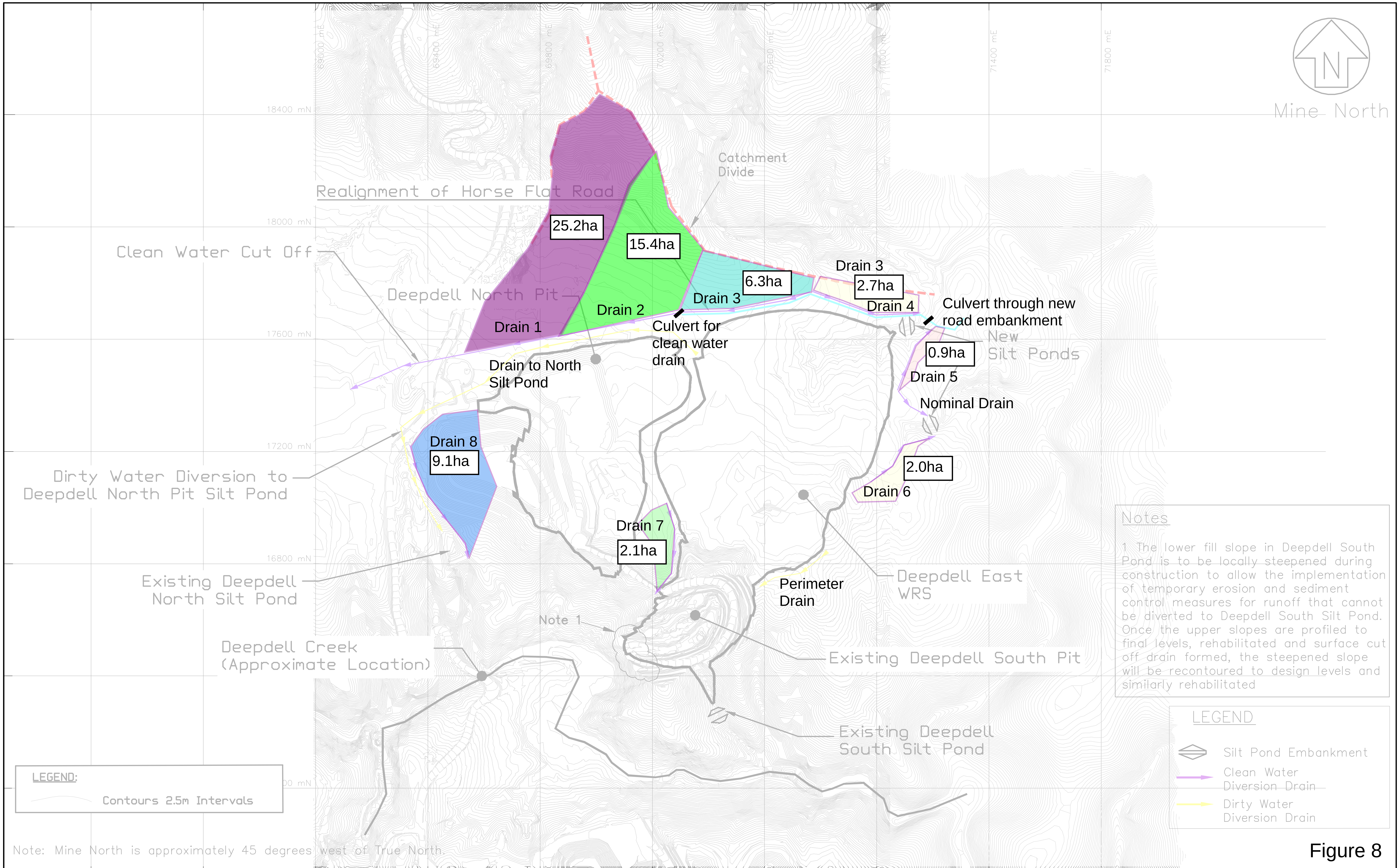
LEGEND:

Deepdell East WRS - Contours 10m Intervals

Deepdell North Stage III Pit - Contours 2.5m Intervals

Figure 7

ENGINEERING GEOLOGY LTD Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany Ph (09)486-2546, Fax (09)486-2556	OCEANA GOLD NZ LIMITED MACRAES GOLD PROJECT-Deepdell North Stage III Catchment Areas for Silt Pond Calculations	Drawing No. 8529-Fig Date: Jul 2019 Drawn: NT Scale: 1:10,000 (@A3) Filename: 8529-fig5.dwg



Note: Mine North is approximately 45 degrees west of True North.

Figure 8

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OCEANA GOLD NZ LIMITED
MACRAES GOLD PROJECT-Deepdell North Stage III
Catchment Areas for Diversion Calculations

Drawing No.	8529-Fig
Date:	Aug 2019
Drawn:	NT
Scale:	1:12,500
Filename:	8529-05.dwg

1) Deepdell South Silt Pond Required Storage Calcultation

Design rainfall $d_{rain} := 70\ mm$

Catchment area $Area := 15.8 \cdot 10^4\ m^2$

Runoff Coefficient

Rockfill area percentage $RF := 70\%$

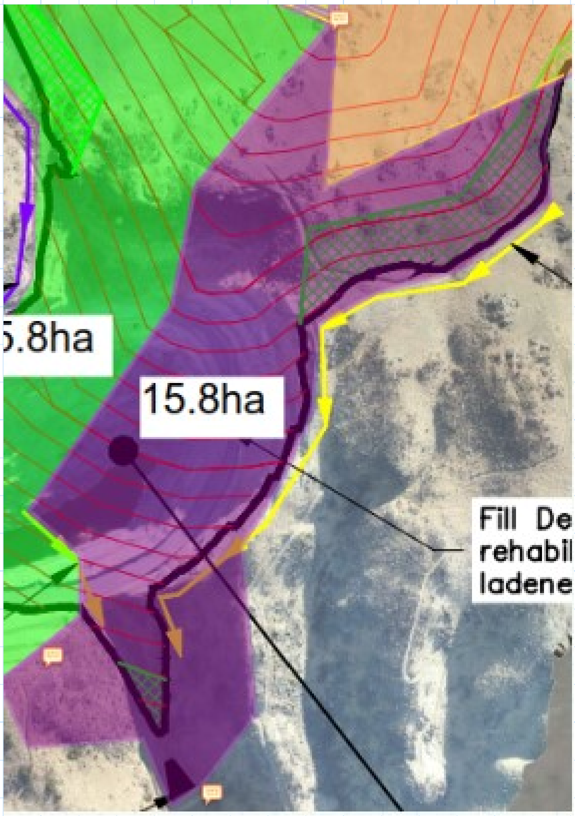
Rockfill runoff Coeff. $C_{ROCK} := 0.32$

Original/exposed ground $OG := 30\%$

Ground runoff Coeff. $C_{GROUND} := 0.6$

Runoff Coefficient $C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.404$

Live Storage Volume Req. $Vol := d_{rain} \cdot Area \cdot C_{Catchment} = \left(4.468 \cdot 10^3\right)\ m^3$



2) Deepdell South Pit Silt Pond Required Storage Calcultation

Design rainfall $d_{rain} := 70\ mm$

Catchment area $Area := 15.8 \cdot 10^4\ m^2$

Runoff Coefficient

Rockfill area percentage $RF := 100\%$

Assumes all water will flow over waste rock and been fit from infiltration

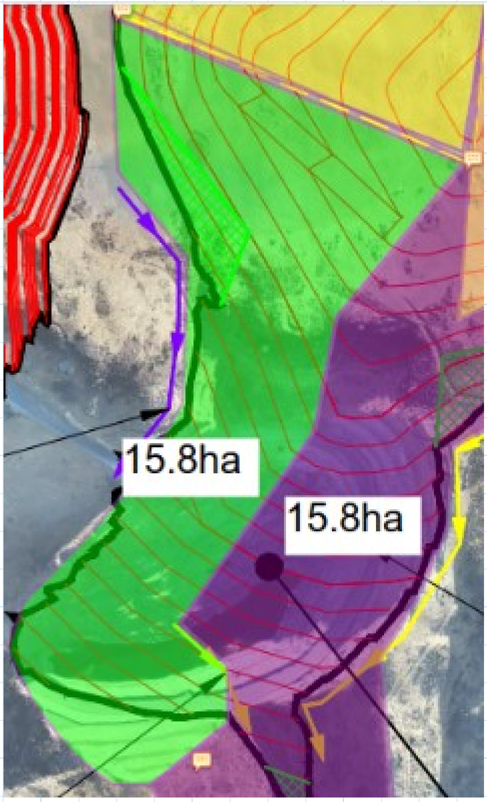
Rockfill runoff Coeff. $C_{ROCK} := 0.32$

Original/exposed ground $OG := 0\%$

Ground runoff Coeff. $C_{GROUND} := 0.6$

Runoff Coefficient $C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.32$

Live Storage Volume Req. $Vol := d_{rain} \cdot Area \cdot C_{Catchment} = \left(3.539 \cdot 10^3\right)\ m^3$



3) Deepdell East WRS East Silt Pond 1 Required Storage Calculation

Design rainfall $d_{rain} := 70\ mm$

Catchment area $Area := 16.4 \cdot 10^4\ m^2$

Runoff Coefficient

Rockfill area percentage $RF := 0\%$

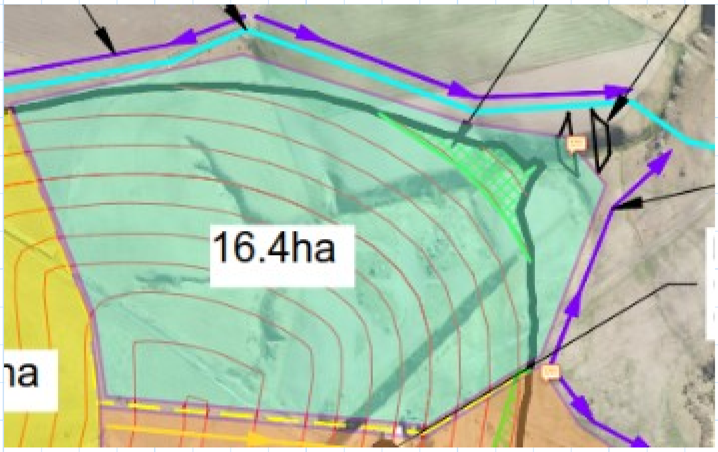
Rockfill runoff Coeff. $C_{ROCK} := 0.32$

Original/exposed ground $OG := 100\%$

Ground runoff Coeff. $C_{GROUND} := 0.6$

Runoff Coefficient $C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.6$

Live Storage Volume Req. $Vol := d_{rain} \cdot Area \cdot C_{Catchment} = \left(6.888 \cdot 10^3\right)\ m^3$



4) Deepdell East WRS East Silt Pond 2 Required Storage Calculation

Design rainfall $d_{rain} := 70\ mm$

Catchment area $Area := 18.4 \cdot 10^4\ m^2$

Runoff Coefficient

Rockfill area percentage $RF := 0\%$

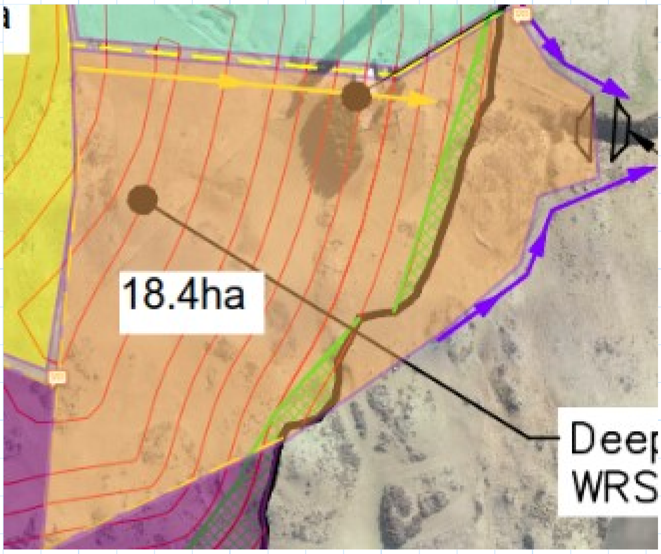
Rockfill runoff Coeff. $C_{ROCK} := 0.32$

Original/exposed ground $OG := 100\%$

Ground runoff Coeff. $C_{GROUND} := 0.6$

Runoff Coefficient $C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.6$

Live Storage Volume Req. $Vol := d_{rain} \cdot Area \cdot C_{Catchment} = \left(7.728 \cdot 10^3\right)\ m^3$



5) Deepdell North Silt Pond Require Storage Calculation

Design rainfall $d_{rain} := 70\ mm$

Catchment area $Area := 26.5 \cdot 10^4\ m^2$

Runoff Coefficient

Rockfill area percentage $RF := 5\%$

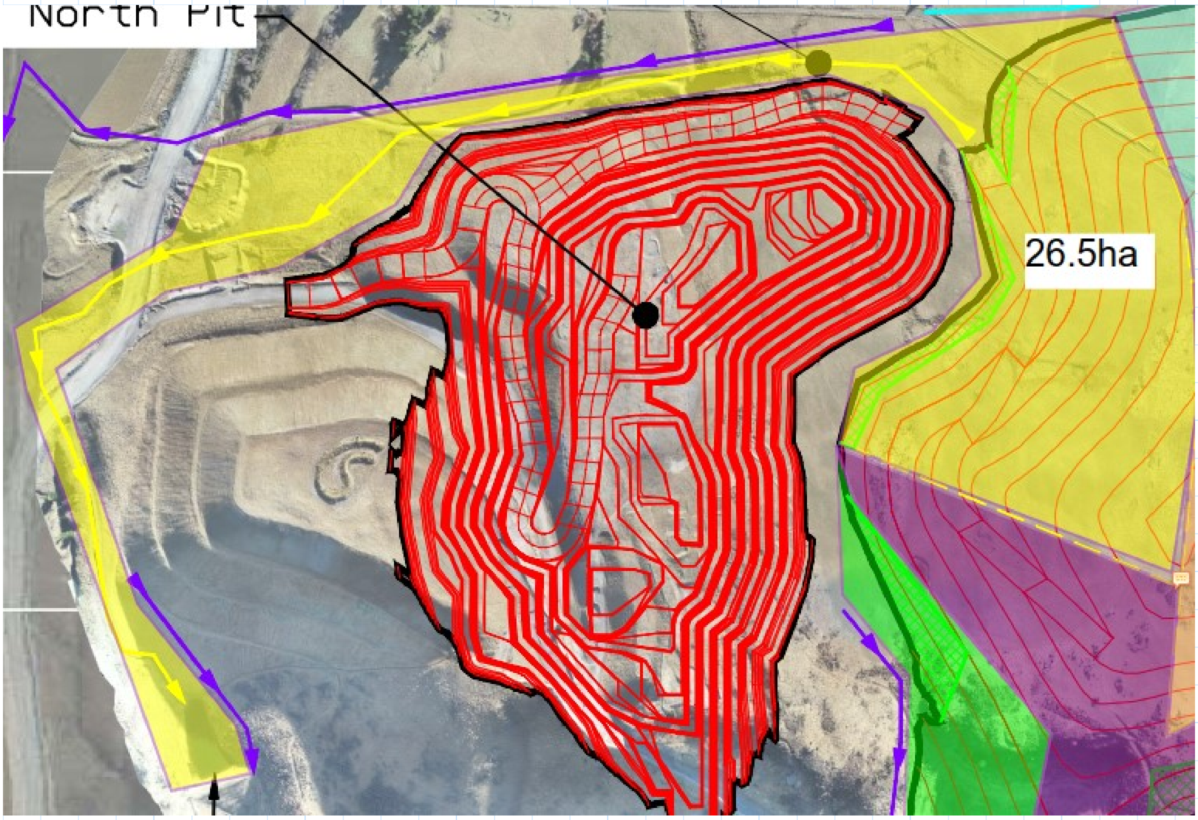
Rockfill runoff Coeff. $C_{ROCK} := 0.32$

Original/exposed ground $OG := 95\%$

Ground runoff Coeff. $C_{GROUND} := 0.6$

Runoff Coefficient $C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.586$

Live Storage Volume Req. $Vol := d_{rain} \cdot Area \cdot C_{Catchment} = \left(1.087 \cdot 10^4\right)\ m^3$



6) Inflow design volume for Horse Flat Road embankment culvert sizing

Catchment area

$Area := 20 \cdot 10^4\ m^2$

Catchment area beneath embankment is approximately 16.4ha, however, allow some additional area for uncertainty of final drainage condition and rainfall in gully between silt pond and culvert. Use 20ha

Flow for 1:20 AEP rainfall 10min intensity with C=0.6

$C := 0.6$

$i := 52\ \frac{mm}{hr}$

$Q := i \cdot C \cdot Area = 1.733\ \frac{m^3}{s}$

Flow for 1:100 AEP rainfall 10min intensity

Runoff Coefficient

Rockfill area percentage	$RF := 80\%$
Rockfill runoff Coeff.	$C_{ROCK} := 0.32$
Original/exposed ground	$OG := 20\%$
Ground runoff Coeff.	$C_{GROUND} := 0.6$
Runoff Coefficient	$C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.376$

$C := 0.38$

$i := 81.9\ \frac{mm}{hr}$

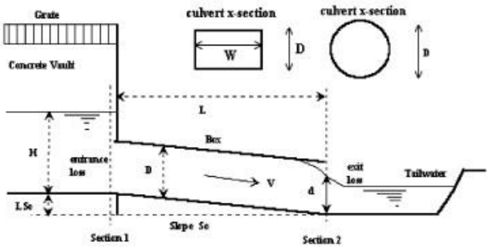
$Q := i \cdot C \cdot Area = 1.729\ \frac{m^3}{s}$

Use 1.7m3/s as design inflow

$1.7\ \frac{m^3}{s} = 60.035\ \frac{ft^3}{s}$

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: **Deepdell Stage 3**
Basin ID: **Horse Flat Road - 900mm ID Culvert**
Status:



Design Information (Input):

Circular Culvert:	Barrel Diameter in Inches	D =	35	inches
	Inlet Edge Type (choose from pull-down list)		Square End with Headwall	
	Number of Barrels	No =	1	
	Inlet Elevation at Culvert Invert	Inlet Elev =	0	ft. elev.
	Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Slope =	0.025	ft vert. / ft horiz.
	Culvert Length in Feet	L =	131	ft.
	Manning's Roughness	n =	0.015	
	Bend Loss Coefficient	K_b =	0	
	Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	1.28
Sum of All Loss Coefficients	K_s =	2.78
Orifice Inlet Condition Coefficient	C_d =	0.86
Minimum Energy Condition Coefficient	KE_{low} =	-0.0422

Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
0.00	-2.30	0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
1.00	-2.30	5.70	49.97	**5.70**	Min. Energy. Eqn.	INLET
2.00	-2.30	18.80	55.14	**18.80**	Regression Eqn.	INLET
3.00	-2.30	35.10	60.09	**35.10**	Regression Eqn.	INLET
4.00	-2.30	49.30	68.54	**49.30**	Regression Eqn.	INLET
5.00	-2.30	60.40	76.03	**60.40**	Regression Eqn.	INLET
6.00	-2.30	69.50	82.86	**69.50**	Regression Eqn.	INLET
7.00	-2.30	77.40	89.17	**77.40**	Regression Eqn.	INLET
8.00	-2.30	84.60	95.08	**84.60**	Regression Eqn.	INLET
9.00	-2.30	91.30	100.60	**91.30**	Orifice Eqn.	INLET
10.00	-2.30	97.20	105.85	**97.20**	Orifice Eqn.	INLET
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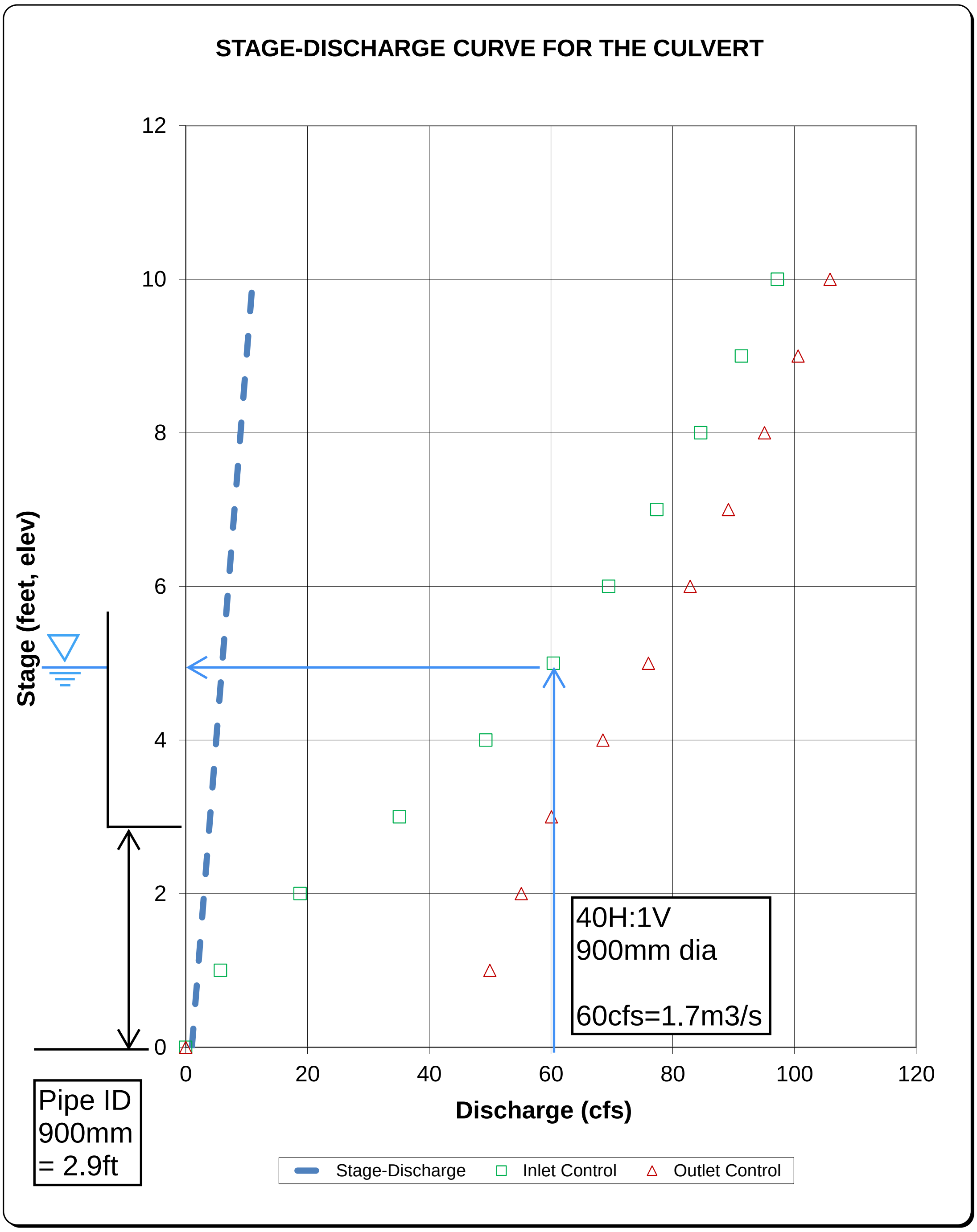
CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

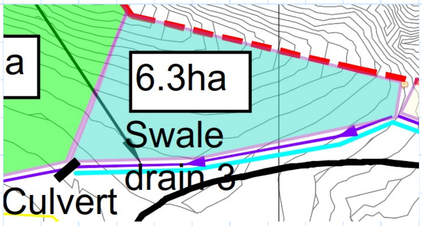
Project: Deepdell Stage 3
Basin ID: Horse Flat Road - 900mm ID Culvert



7) Inflow design volume for Horse Flat Road western (Swale Drain 3) culvert sizing

Catchment area

$Area := 6.3 \cdot 10^4 \ m^2$



Flow for 1:100 AEP rainfall 10min intensity

$C := 0.6$

$i := 81.9 \ \frac{mm}{hr}$

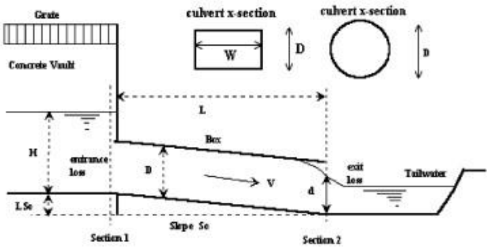
$Q := i \cdot C \cdot Area = 0.86 \ \frac{m^3}{s}$

Use 0.86m3/s as design inflow

$0.86 \ \frac{m^3}{s} = 30.371 \ \frac{ft^3}{s}$

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: **Deepdell Stage 3**
Basin ID: **Horse Flat Road - 685mm ID Culvert**
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = 27 inches

Inlet Edge Type (choose from pull-down list) — Square End with Headwall

Number of Barrels	No =	1	
Inlet Elevation at Culvert Invert	Inlet Elev =	0	ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Slope =	0.02	ft vert. / ft horiz.
Culvert Length in Feet	L =	50	ft.
Manning's Roughness	n =	0.015	
Bend Loss Coefficient	K_b =	0	
Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	0.70
Sum of All Loss Coefficients	K_s =	2.20
Orifice Inlet Condition Coefficient	C_d =	0.86
Minimum Energy Condition Coefficient	KE_{low} =	-0.0316

Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
0.00	-0.30	0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
1.00	-0.30	4.80	14.58	**4.80**	Min. Energy. Eqn.	INLET
2.00	-0.30	14.60	20.35	**14.60**	Regression Eqn.	INLET
3.00	-0.30	24.60	28.49	**24.60**	Regression Eqn.	INLET
4.00	-0.30	31.80	35.66	**31.80**	Regression Eqn.	INLET
5.00	-0.30	37.50	41.66	**37.50**	Regression Eqn.	INLET
					Invalid Entry	
					Invalid Entry	
					Invalid Entry	
					Invalid Entry	
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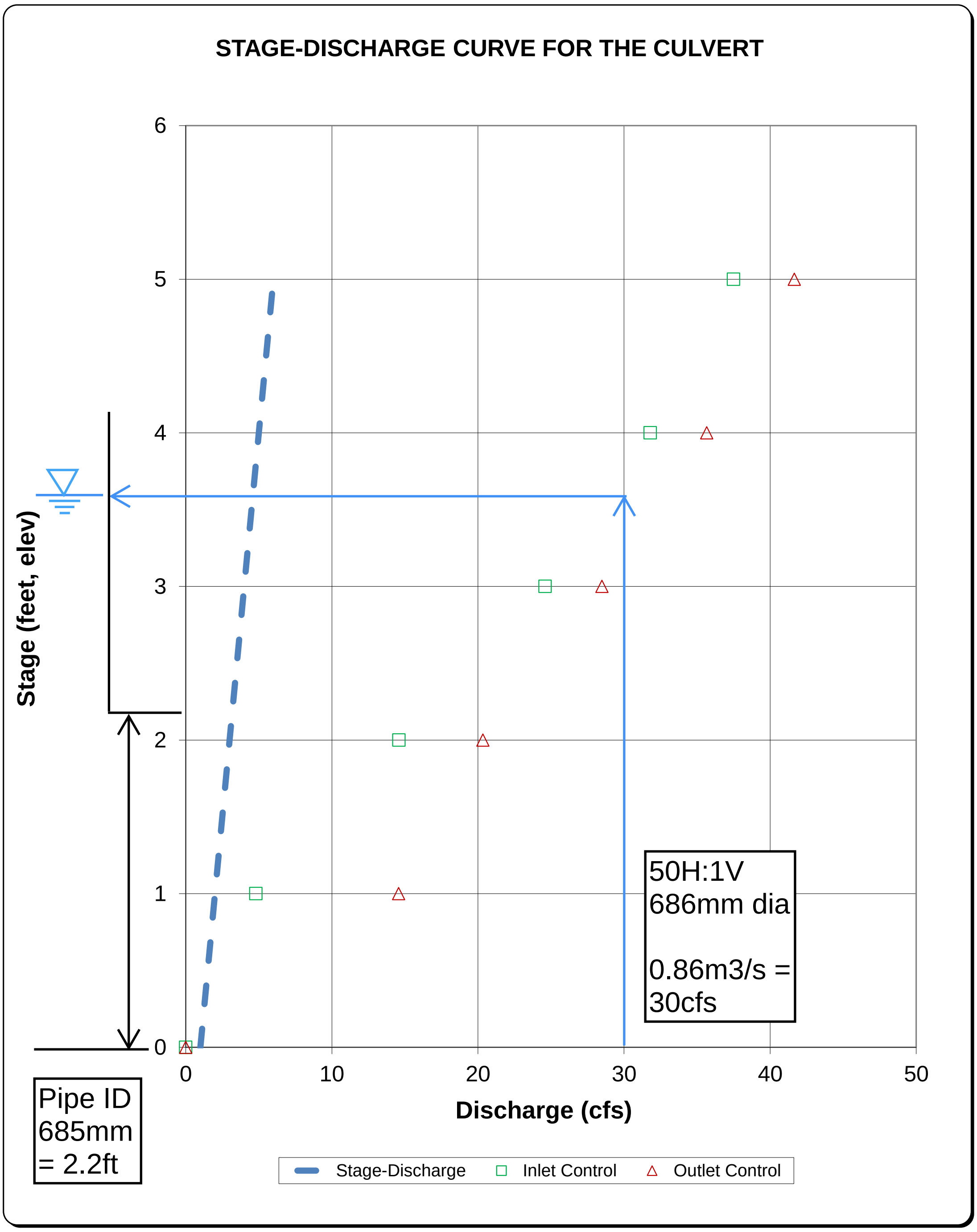
Processing Time: 01.03 Seconds

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Deepdell Stage 3
Basin ID: Horse Flat Road - 685mm ID Culvert



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Temporary Swale Drain 1

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Temporary

Drain is temporary as water can run into pit at closure

Catchment area	=	469000	m^2
30 min intensity from a 1:20 AEP storm	=	0.485	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	2.275	m^3/s

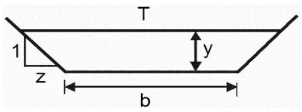
Bottom Width
b(L)= 1.0 m

Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined
And Full Flow Capacity

Bottom Slope H V
S_0= 0.02 50 to 1 Ratio i.e. 1V to 100H

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth
y(L)= 0.5 m

Wetted Area
P= 3.693 m

Top Width
T= 3.5 m

Area
A= 1.125 m2

Hydraulic Radius
R_h= 0.305 m A/P

Hydraulic Depth
Dh= 0.321 m A/T

Flow Velocity
V= 2.13 m/s

$$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$$

Flow Capacity (Flux)
Q= 2.40 m3/s

$$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$$

Channel Conveyance (Metric Units)
K= 16.9723

$K = (\phi/n)\ A\ R_h^{2/3}$ phi=1

Froude Number
Fr 1.201508

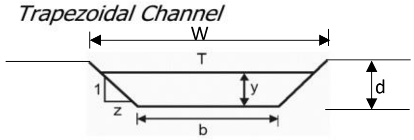
$$Fr = \frac{V}{\sqrt{gD}}$$

Where:
V = Water velocity
D = Hydraulic depth (cross sectional area of flow / top width)
g = Gravity
When:
Fr = 1, critical flow,
Fr > 1, supercritical flow (fast rapid flow),
Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	1.0	m
d	0.750	m
Side Slopes z	2.5	H
Top width, W	4.75	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Temporary Swale Drain 2

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Temporary

Drain is temporary as water can run into pit at closure

Catchment area	=	217000	m^2
20 min intensity from a 1:20 AEP storm	=	0.596667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	1.295	m^3/s

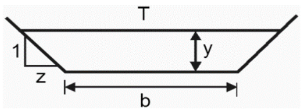
Bottom Width
b(L)= 1.0 m

Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined And Full Flow Capacity

Bottom Slope
S_0= 0.02 H 50, V to 1, Ratio i.e. 1V to 100H

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth
y(L)= 0.4 m

Wetted Area
P= 3.154 m

Top Width
T= 3 m

Area
A= 0.8 m2

Hydraulic Radius
R_h= 0.254 m A/P

Hydraulic Depth
Dh= 0.267 m A/T

Flow Velocity
V= 1.89 m/s

$$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$$

Flow Capacity (Flux)
Q= 1.51 m3/s

$$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$$

Channel Conveyance (Metric Units)
K= 10.68029

$$K = (\phi/n)\ A\ R_h^{2/3}$$ phi=1

Froude Number
Fr 1.167318

$$Fr = \frac{V}{\sqrt{gD}}$$

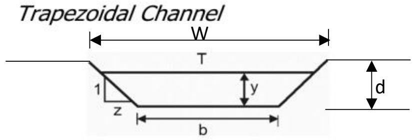
Where:
- V = Water velocity
- D = Hydraulic depth (cross sectional area of flow / top width)
- g = Gravity

When:
- Fr = 1, critical flow,
- Fr > 1, supercritical flow (fast rapid flow),
- Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	1.00	m
d	0.650	m
Side Slopes z	2.5	H
Top width, W	4.25	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Permanent Swale Drain 3

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.

Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.

Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

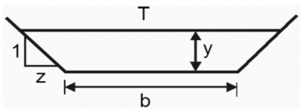
g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Permanent

Catchment area	=	63000	m^2
Max Intensity from a 1:100 AEP storm	=	1.365	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	0.860	m^3/s

Bottom Width					
b(L)=	1.0	m			
Side Slope					
z:1=	2.5				
Manning's n					
n=	0.03		Assumes Unmowed Grass Lined		
			And Full Flow Capacity		
Bottom Slope			H	V	
S_0=	0.02		50	to 1	Ratio i.e. 1V to 100H

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth		
y(L)=	0.31	m

Wetted Area			
P=	2.669	m	
Top Width			
T=	2.55	m	
Area			
A=	0.55025	m2	
Hydraulic Radius			
R_h=	0.206	m	A/P
Hydraulic Depth			
Dh=	0.216	m	A/T

Flow Velocity				
V=	1.64	m/s	$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$	
Flow Capacity (Flux)				
Q=	**0.90**	**m3/s**	$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$	
Channel Conveyance (Metric Units)			$K = (\phi/n)\ A\ R_h^{2/3}$	phi=1
K=	6.39697			
Froude Number				
Fr	1.130017			

$$Fr = \frac{V}{\sqrt{gD}}$$

Where:

V = Water velocity

D = Hydraulic depth (cross sectional area of flow / top width)

g = Gravity

When:

Fr = 1, critical flow,

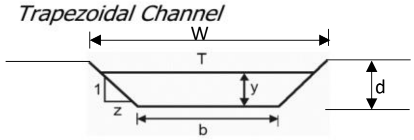
Fr > 1, supercritical flow (fast rapid flow),

Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check:	Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	1.0	m
d	0.560	m
Side Slopes z	2.5	H
Top width, W	3.8	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Permanent Swale Drain 4

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Permanent

Catchment area	=	27000	m^2
Max Intensity from a 1:100 AEP storm	=	1.365	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	0.369	m^3/s

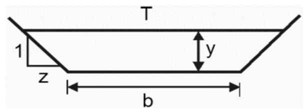
Bottom Width
b(L)= 0.50 m

Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined
And Full Flow Capacity

Bottom Slope H V
S_0= 0.066666 15.00015 to 1

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth
y(L)= 0.2 m

Wetted Area
P= 1.577 m

Top Width
T= 1.5 m

Area
A= 0.2 m2

Hydraulic Radius
R_h= 0.127 m A/P

Hydraulic Depth
Dh= 0.133 m A/T

Flow Velocity
V= 2.17 m/s $V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$

Flow Capacity (Flux)
Q= 0.43 m3/s $Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$

Channel Conveyance (Metric Units) $K = (\phi/n)\ A\ R_h^{2/3}$ phi=1
K= 1.681651

Froude Number
Fr 1.898254

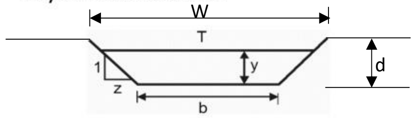
$$Fr = \frac{V}{\sqrt{gD}}$$

Where:
V = Water velocity
D = Hydraulic depth (cross sectional area of flow / top width)
g = Gravity
When:
Fr = 1, critical flow,
Fr > 1, supercritical flow (fast rapid flow),
Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	0.50	m
d	0.450	m
Side Slopes z	2.5	H
Top width, W	2.75	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Temporary Swale Drain 5

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.

Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.

Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Temporary - Small Drain Freeboard Relaxed to 150mm

Catchment area	=	9000	m^2
Max Intensity from a 1:20 AEP storm	=	0.866667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	0.078	m^3/s

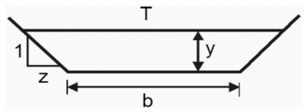
Bottom Width
b(L)= 0.4 m

Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined And Full Flow Capacity

Bottom Slope
S_0= 0.066667 H 15.00002 V to 1

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth
y(L)= 0.1 m

Wetted Area
P= 0.939 m

Top Width
T= 0.9 m

Area
A= 0.065 m2

Hydraulic Radius
R_h= 0.069 m A/P

Hydraulic Depth
Dh= 0.072 m A/T

Flow Velocity
V= 1.45 m/s

$$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$$

Flow Capacity (Flux)
Q= 0.09 m3/s

$$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$$

Channel Conveyance (Metric Units)
K= 0.365079

$$K = (\phi/n)\, A\, R_h^{2/3} \quad \text{phi=1}$$

Froude Number
Fr 1.72289

$$Fr = \frac{V}{\sqrt{gD}}$$

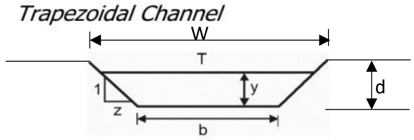
Where:
- V = Water velocity
- D = Hydraulic depth (cross sectional area of flow / top width)
- g = Gravity

When:
- Fr = 1, critical flow,
- Fr > 1, supercritical flow (fast rapid flow),
- Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	0.40	m
d	0.350	m
Side Slopes z	2.5	H
Top width, W	2.15	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Temporary Swale Drain 6

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Temporary - Small Drain Freeboard Relaxed to 150mm

Catchment area	=	20000	m^2
Max Intensity from a 1:20 AEP storm	=	0.866667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	0.173	m^3/s

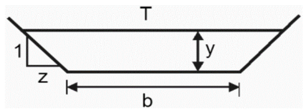
Bottom Width
b(L)= 0.5 m

Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined And Full Flow Capacity

Bottom Slope H V
S_0= 0.066667 15.00002 to 1

Trapezoidal Channel



$$A = (b + z\,y)\,y \quad ; \quad P = b + 2y\sqrt{1 + z^2} \quad ; \quad T = b + 2z\,y$$

Depth
y(L)= 0.13 m

Wetted Area
P= 1.200 m

Top Width
T= 1.15 m

Area
A= 0.10725 m2

Hydraulic Radius
R_h= 0.089 m A/P

Hydraulic Depth
Dh= 0.093 m A/T

Flow Velocity
V= 1.72 m/s

$$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$$

Flow Capacity (Flux)
Q= 0.18 m3/s

$$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$$

Channel Conveyance (Metric Units)
K= 0.714036

$K = (\phi/n)\ A\ R_h^{2/3}$ phi=1

Froude Number
Fr 1.797184

$$Fr = \frac{V}{\sqrt{gD}}$$

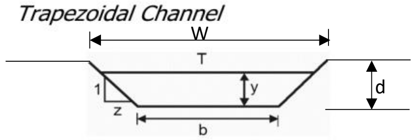
Where:
- V = Water velocity
- D = Hydraulic depth (cross sectional area of flow / top width)
- g = Gravity

When:
- Fr = 1, critical flow,
- Fr > 1, supercritical flow (fast rapid flow),
- Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	0.50	m
d	0.380	m
Side Slopes z	2.5	H
Top width, W	2.4	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Temporary Flume Drain 7

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Temporary - Small Drain Freeboard Relaxed to 150mm

Catchment area	=	21000	m^2
Max Intensity from a 1:20 AEP storm	=	0.866667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	0.182	m^3/s

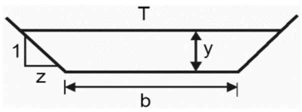
Bottom Width
b(L)= 0.2 m

Side Slope
z:1= 1

Manning's n
n= 0.025 Geofabric lined or armco flume

Bottom Slope H V
S_0= 0.16 6.25 to 1

Trapezoidal Channel



$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$

Depth
y(L)= 0.16 m

Wetted Area
P= 0.653 m

Top Width
T= 0.52 m

Area
A= 0.0576 m2

Hydraulic Radius
R_h= 0.088 m A/P

Hydraulic Depth
Dh= 0.111 m A/T

Flow Velocity
V= 3.17 m/s $V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$

Flow Capacity (Flux)
Q= 0.18 m3/s $Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$

Channel Conveyance (Metric Units) $K = (\phi/n)\, A\, R_h^{2/3}$ phi=1
K= 0.456392

Froude Number
Fr 3.040402

$$Fr = \frac{V}{\sqrt{gD}}$$

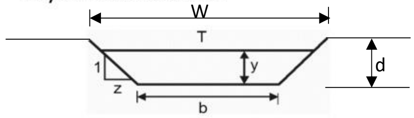
Where:
- V = Water velocity
- D = Hydraulic depth (cross sectional area of flow / top width)
- g = Gravity

When:
- Fr = 1, critical flow,
- Fr > 1, supercritical flow (fast rapid flow),
- Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	0.20	m
d	0.410	m
Side Slopes z	1	H
Top width, W	1.02	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell Stage III Uphill Clean Water Diversion - Temporary Flume Drain 8

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell Stage III Uphill Clean Water Diversion - Temporary - Small Drain Freeboard Relaxed to 150mm

Catchment area	=	90000 m^2
Max Intensity from a 1:20 AEP storm	=	0.866667 mm/min
Runoff coefficient	=	0.32
Design Flux	=	0.416 m^3/s

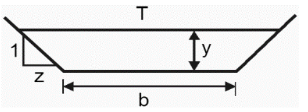
Bottom Width
b(L)= 0.25 m

Side Slope
z:1= 1

Manning's n
n= 0.025 Geofabric lined or armco flume

Bottom Slope H V
S_0= 0.08 12.5 to 1

Trapezoidal Channel



$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$

Depth
y(L)= 0.27 m

Wetted Area
P= 1.014 m

Top Width
T= 0.79 m

Area
A= 0.1404 m2

Hydraulic Radius
R_h= 0.139 m A/P

Hydraulic Depth
Dh= 0.178 m A/T

Flow Velocity
V= 3.03 m/s $V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$

Flow Capacity (Flux)
Q= 0.42 m3/s $Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$

Channel Conveyance (Metric Units) $K = (\phi/n)\, A\, R_h^{2/3}$ phi=1
K= 1.502403

Froude Number
Fr 2.292238

$Fr = \frac{V}{\sqrt{gD}}$

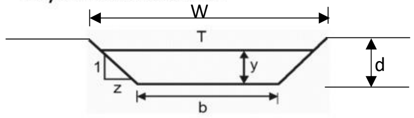
Where:
- V = Water velocity
- D = Hydraulic depth (cross sectional area of flow / top width)
- g = Gravity

When:
- Fr = 1, critical flow,
- Fr > 1, supercritical flow (fast rapid flow),
- Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions	
Freeboard allowance	150 mm
b	0.25 m
d	0.420 m
Side Slopes z	1 H
Top width, W	1.09 m

Trapezoidal Channel



Trapezoidal Channel - Deepdell East WRS to Deepdell North Silt Pond

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Drain from East WRS to North Silt Pond - Temporary Drain

Catchment area	=	180000	m^2
Max Intensity from a 1:20 AEP storm	=	0.866667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	1.560	m^3/s

18ha is the catchment area to pass the pit

Bottom Width
b(L)= 1.0 m

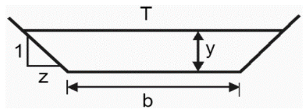
Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined And Full Flow Capacity

Bottom Slope

		H	V	
S_0=	0.02	50	to 1	Ratio i.e. 1V to 100H

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth
y(L)= 0.4 m

Wetted Area
P= 3.154 m

Top Width
T= 3 m

Area
A= 0.8 m2

Hydraulic Radius
R_h= 0.254 m A/P

Hydraulic Depth
Dh= 0.267 m A/T

Flow Velocity
V= 1.89 m/s

$$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$$

Flow Capacity (Flux)
Q= 1.51 m3/s

$$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$$

Channel Conveyance (Metric Units)
K= 10.68029

$$K = (\phi/n)\, A\, R_h^{2/3}$$ phi=1

Froude Number
Fr 1.167318

$$Fr = \frac{V}{\sqrt{gD}}$$

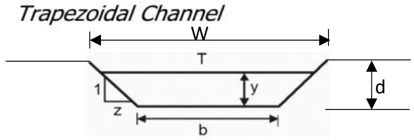
Where:
V = Water velocity
D = Hydraulic depth (cross sectional area of flow / top width)
g = Gravity

When:
Fr = 1, critical flow,
Fr > 1, supercritical flow (fast rapid flow),
Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Not Okay - Channel Capacity < Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	1.0	m
d	0.650	m
Side Slopes z	2.5	H
Top width, W	4.25	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell East WRS Perimeter Drains as Temporary Drains (C=0.6)

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

g 9.81 m/s2

Deepdell East WRS Perimeter Drains - Temporary

Catchment area	=	150000	m^2
Max Intensity from a 1:20 AEP storm	=	0.866667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	1.300	m^3/s

15ha used as practical area feeding a perimeter drain on stripping, which conveys water to natural channels and silt ponds.

Bottom Width
b(L)= 1.0 m

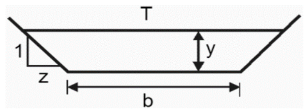
Side Slope
z:1= 2.5

Manning's n
n= 0.03 Assumes Unmowed Grass Lined And Full Flow Capacity

Bottom Slope

		H	V	
S_0=	0.02	50	to 1	Ratio i.e. 1V to 100H

Trapezoidal Channel



$$A = (b + zy)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Depth
y(L)= 0.4 m

Wetted Area
P= 3.154 m

Top Width
T= 3 m

Area
A= 0.8 m2

Hydraulic Radius
R_h= 0.254 m A/P

Hydraulic Depth
Dh= 0.267 m A/T

Flow Velocity
V= 1.89 m/s

$$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$$

Flow Capacity (Flux)
Q= 1.51 m3/s

$$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$$

Channel Conveyance (Metric Units)
K= 10.68029

$$K = (\phi/n)\ A\ R_h^{2/3}$$ phi=1

Froude Number
Fr 1.167318

$$Fr = \frac{V}{\sqrt{gD}}$$

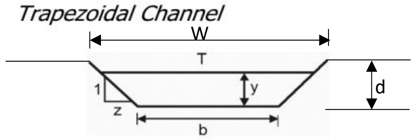
Where:
V = Water velocity
D = Hydraulic depth (cross sectional area of flow / top width)
g = Gravity

When:
Fr = 1, critical flow,
Fr > 1, supercritical flow (fast rapid flow),
Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	1.0	m
d	0.650	m
Side Slopes z to 1	2.5	H
Top width, W	4.25	m

Trapezoidal Channel



Trapezoidal Channel - Deepdell East WRS Perimeter Drains as Permanent Drains (C=0.32)

General design basis

Surface water drains will be located around the perimeter of the WRS and pit (in the early stages) where appropriate, to ensure runoff from disturbed areas is conveyed to silt ponds.
Temporary drains will be designed for a 1 in 20 AEP storm with 0.25m freeboard. Permanent drains will be designed for a 1 in 100 AEP storm with 0.25m freeboard.
Such drains will be lined where necessary and energy dissipation will be provided at high energy locations (i.e. at the bottom of steeper sections of the drains where velocities are high).

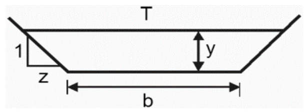
g 9.81 m/s2

Deepdell East WRS Perimeter Drains - Permanent

Catchment area	=	200000	m^2
Max Intensity from a 1:100 AEP storm	=	1.365	mm/min
Runoff coefficient	=	0.32	
Design Flux	=	1.456	m^3/s

20ha used as practical area feeding a perimeter drain once rehabilitated, which conveys water to natural channels and silt ponds.

Trapezoidal Channel



$$A = (b + z\,y)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$$

Bottom Width				
b(L)=	1.0 m			
Side Slope				
z:1=	2.5			
Manning's n				
n=	0.03	Assumes Unmowed Grass Lined And Full Flow Capacity		
Bottom Slope		H	V	
S_0=	0.02	50	to 1	Ratio i.e. 1V to 100H

Depth	
y(L)=	0.4 m

Wetted Area		
P=	3.154 m	
Top Width		
T=	3 m	
Area		
A=	0.8 m2	
Hydraulic Radius		
R_h=	0.254 m	A/P
Hydraulic Depth		
Dh=	0.267 m	A/T

Flow Velocity		
V=	1.89 m/s	$V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$
Flow Capacity (Flux)		
Q=	**1.51 m3/s**	$Q = \frac{1}{n} A R_h^{2/3} S_f^{1/2}$
Channel Conveyance (Metric Units)		$K = (\phi/n)\ A\ R_h^{2/3}$ phi=1
K=	10.68029	
Froude Number		
Fr	1.167318	

$$Fr = \frac{V}{\sqrt{gD}}$$

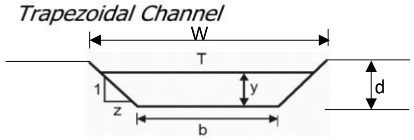
Where:
- V = Water velocity
- D = Hydraulic depth (cross sectional area of flow / top width)
- g = Gravity

When:
- Fr = 1, critical flow,
- Fr > 1, supercritical flow (fast rapid flow),
- Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions		
Freeboard allowance	250	mm
b	1.0	m
d = y + freeboard	0.650	m
Side Slopes z to 1	2.5	H
Top width, W	4.25	m

Trapezoidal Channel



Appendix S:

Proposed Otago Regional Council and Waitaki District Council consent conditions for Deepdell North Stage III

These suggested conditions are intended to assist with managing specific matters raised in the AEE. OceanaGold expects that a complete set of additional standard consent conditions will be applied to the decision.

1 Otago Regional Council Conditions

1.1 Otago Regional Council Conditions – General

The Otago Regional Council will require a suite of different consent certificates for the various activities being applied for and in some cases, these will require the application of the same conditions across the suite of consents. To avoid repetition, these conditions are listed here:

1[1]	The 'activity' shall occur in the area(s) labelled 'x' shown on Appendix I attached.
2	The consent holder shall submit a Project Overview and Annual Work and Rehabilitation Plan to the Otago Regional Council by 31 March each year that will cover the forthcoming year (1 July to 30 June). The consent holder may, at any time, submit to the Otago Regional Council an amended Project Overview and Annual Work and Rehabilitation Plan. The Project Overview and Annual Work and Rehabilitation Plan shall include, but not be limited to: (a) A description and timeline of intended mining activities for the duration of mining operations including a plan showing the location and contours of all existing and proposed structures at completion of mining; (b) A description (including sequence, method and form) of mining operations, monitoring and reporting carried out in the last 12 months; (c) A detailed description (including sequence, method and form) of all mining operations, monitoring and reporting, not covered by a separate management plan intended to be carried out in the next 12 months; (d) An explanation of any departure in the last 12 months from the previous Project Overview and Annual Work and Rehabilitation Plan; (e) Plans showing the contours (at 5 metre intervals) and footprints of all works and structures and any proposed changes at the end of the next 12 months;

[1] This condition is expected on all consents.

	(f)	A description and analysis of any unexpected adverse effects on the environment that have arisen as a result of the exercise of the consent in the last 12 months and the steps taken to deal with it and the results of those steps;
	(g)	A description and analysis of any non-compliance with any conditions of consent that have occurred in the last 12 months and the steps that were taken to deal with it and the results of those steps;
	(h)	A full report describing and evaluating the mitigation measures used in the last 12 months and any that are proposed to be implemented in the next 12 months. This should detail where further mitigation is proposed or has been undertaken as a result of a non-compliance event and/or any adverse effects on the environment;
	(i)	A summary description of all Management Plans and Manuals required under this land use consent and any resource consents issued by Otago Regional Council and details of any review or amendment of any of the Management Plans or Manuals;
	(j)	An overview of the monitoring and reporting programme for the previous 12 months and any changes proposed for the next 12 months;
	(k)	A detailed section on rehabilitation including, but not limited to the following: (i) The total area of disturbed land during the mining of Deepdell North Stage III, including the haul road, yet to receive rehabilitation and indicative rehabilitation dates for various areas of the mine site; (ii) The area of additional disturbed land in the coming year that will require future rehabilitation; (iii) The area of disturbed land rehabilitated in the previous year; (iv) The area of disturbed land proposed to be rehabilitated in coming year; (v) A description of rehabilitation planned for the life of mine at Deepdell North Stage III; (vi) A description of proposed rehabilitation methods for any area, including proposed topsoil to be stripped and stockpiled, surface pre-treatment and re-use of topsoil on finished areas in the next 12 months.; (vii) The details of the location, design (including shape form and contour) and construction of all permanent structures; (viii) Drainage details for any disturbed land and recently rehabilitated areas; (ix) Details of any vegetation to be used as part of rehabilitation for the next 12-month period; (x) Detailed results of any revegetation trials.
3	(a)	The consent holder shall submit to the Consent Authority a Site Decommissioning Plan, not less than 12 months before completion of mine operations. The Decommissioning Plan may be part of any other Decommissioning Plan required for the Macraes Gold Project.

	(b) The Site Decommissioning Plan shall be prepared in consultation with Takata Whenua (Aukaha), Macraes Community Development Trust, Macraes Community Incorporated and any successive groups. (c) The Site Decommissioning Plan shall include but not be limited to: (i) A plan(s) showing the final design and intended contours (at 5 metre intervals) of all permanent structures and works, including but not limited to, waste rock stacks, permanent earthworks, tailings impoundments, dam embankments, water storage reservoirs, pit lakes, water bodies, roads or other works which under this consent or any related consent are authorised or required to remain after the relevant consents expire; (ii) A summary of rehabilitation completed to date, and a summary of rehabilitation required to fulfil the conditions of this consent and any related consents; (iii) Details on infrastructure to be decommissioned, such infrastructure may include buildings, plant, and equipment; (iv) Details of specific infrastructure to remain on-site post-closure. Such infrastructure may include buildings, plant, equipment and any monitoring structures required by this consent and any related consent to remain after the expiry of the consents; (v) Details on the decommissioning of infrastructure associated with existing art works, heritage sites, tracks and interpretation signage; and (vi) Details of management, any ongoing maintenance, monitoring and reporting proposed by the consent holder to ensure post-closure compliance with numerical standards and mitigation plans.
4	The consent holder shall maintain a register of complaints received regarding their operation. The register shall include, but not be limited to: (a) Name and location of site where the problem is experienced; (b) Nature of the problem; (c) Date and time problem occurred, and when reported: (d) Action taken by consent holder to remedy the situation and any policies or methods put in place to avoid or mitigate the problem occurring again. The register of complaints shall be incorporated into the Project Overview and Annual Work and Rehabilitation Plan required by Condition 'x' of this consent.
5	In the event of any non-compliance with the conditions of this consent, the consent holder shall notify the Consent Authority within 24 hours of the non-compliance being detected. Within five working days the consent holder shall provide written notification to the Otago Regional Council providing details of the non-compliance. This notification will at a minimum include an explanation of the cause of the non-compliance, the steps taken to remedy the situation and steps taken to mitigate any future occurrence of the non-compliance.

6	(a) The consent holder shall provide and maintain in favour of the Consent Authority one or more bonds to secure: (i) The performance and completion of rehabilitation in accordance with the conditions of this consent; and (ii) The carrying out of the monitoring required by the conditions of this consent; and (iii) The remediation of any adverse effect on the environment that may arise from the exercise of this consent. (iv) Compliance with Conditions 6(m) to 6(q) of this consent. (b) Before the first exercise of this consent, the consent holder shall provide to the Consent Authority one or more bonds required by Condition 6(a). (c) Subject to the other provisions of this consent, any bond shall be in the form and on the terms and conditions approved by the Consent Authority. (d) Any bond shall be given or guaranteed by a surety acceptable to the Consent Authority. (e) The surety shall bind itself to pay for the carrying out and completion of the conditions of consent which are the subject of the bond on default by the consent holder or the occurrence of any adverse environment effect requiring remedy; during or after the expiry of this consent. (f) The amount of each bond shall be fixed annually by the Consent Authority which will take into account any calculations and other matters submitted by the consent holder relevant to the determination of the amount to be bonded in the Project Overview and Annual Work and Rehabilitation Plan. (g) The amount of the bond(s) shall include: (i) The estimated costs of complete rehabilitation in accordance with the conditions of consent on the completion of the mining operations proposed for the next year and described in the Project Overview and Annual Work and Rehabilitation Plan. (ii) The estimated costs of: - Monitoring in accordance with the monitoring conditions of the consent; - Monitoring for and of any adverse effect of the activity authorised by this consent which may become apparent during or after expiry of this consent; - Monitoring any rehabilitation required by this consent. (iii) Any further sum which the Consent Authority considers necessary for monitoring and dealing with any adverse effect on the environment that may arise from the exercise of the consent whether during or after the expiry of this consent. (h) The amount shall be calculated for the duration of this consent and for a period of 20 years after its expiry.

	(i) If, on review, the total amount of bond to be provided by the consent holder is greater or less than the sum secured by the current bond(s), the consent holder, surety and the Consent Authority may, in writing, vary the amount of the bond(s). (j) While the liability of the surety is limited to the amount of the bond(s), the liability of the consent holder is unlimited. (k) Any bond may be varied, cancelled, or renewed at any time by written agreement between the consent holder, surety and Consent Authority. (l) The costs (including the costs of the Consent Authority) of providing, maintaining, varying and reviewing any bond shall be paid by the consent holder. (m) For a period of 20 years from the expiry or surrender of this consent the consent holder shall provide in favour of the Consent Authority one or more bonds. (n) The amount of the bond to be provided under Condition 6(m) shall include the amount (if any) considered by the Consent Authority necessary for: (i) Completing rehabilitation in accordance with the conditions of this consent. (ii) Monitoring for and of any adverse effect on the environment that may arise from the exercise of the consent. (iii) Monitoring any measures taken to prevent, remedy or mitigate any adverse effect on the environment that may arise from the exercise of this consent. (iv) Dealing with any adverse effect on the environment which may become apparent after the surrender or expiry of this consent. (v) Contingencies. (o) Without limitation, the amount secured by the bond given under Condition 6(m) may include provision to deal with structural instability or failure, land and water contamination, and the failure of rehabilitation in terms of the rehabilitation objectives and conditions of this consent. Costs shall include costs of investigating, preventing, remedying or mitigating any adverse effect. (p) The bond(s) required by Condition 6(m) must be provided on the earlier of: (i) 12 months before the expiry of this consent. (ii) Three months before the surrender of this consent. (q) Conditions 6(c), (d), (e), (h), (i), (j) and (k) apply to the bond(s) required by Condition 6(m).
7	The Otago Regional Council may, in accordance with Sections 128 and 129 of the Resource Management Act 1991, serve notice on the consent holder of its intention to review the conditions of this consent within three months of each anniversary of the commencement of this consent, for the purpose of: (a) Determining whether the conditions of this consent are adequate to deal with any adverse effect on the environment which may arise from the exercise of the consent and which it is appropriate to deal with at a later stage, or which become evident after the date of commencement of the consent; or

	(b) Ensuring the conditions of this consent are consistent with any National Environmental Standards; or (c) Requiring the consent holder to adopt the best practicable option, in order to remove or reduce any adverse effect on the environment arising as a result of the exercise of this consent.

1.2 Conditions for resource consent to disturb, deposit and reclaim the bed of unnamed tributaries of Highlay Creek, Camp Creek and Deepdell Creek for the purpose of the following activities:

- **Constructing the Deepdell East Waste Rock Stack, Deepdell South backfill and associated silt ponds;**
- **Constructing the earth - embankment culvert crossing of the realignment of Horse Flat Road.**

1	The disturbance, deposition and reclamation shall not occur outside of the areas marked Deepdell East Waste Rock Stack and culvert embankment as shown on Appendix I attached and the areas marked as silt ponds as shown on Appendix III attached.
2	The consent holder shall notify the Otago Regional Council in writing at least ten working days prior to the commencement of work authorised by this consent.
3	Prior to the first exercise of this consent in part of Camp Creek, the consent holder shall develop and submit a Mitigation Plan to the Otago Regional Council that achieves the creation of freshwater crayfish (Koura/*Paranephrops planifons*) habitat in the clear water drainage channel upstream of where it will meet the unnamed tributary of Camp Creek. The Mitigation Plan shall identify methods and measures to be carried out to ensure that enough habitat is created to offset the loss of habitat in Camp Creek and: • Suitable bed habitat is created • Maximum practicable water depth is achieved • Shading from bank vegetation is provided as far as practicable
4	The consent holder shall implement the programme of activities specified in the Mitigation Plan developed under condition 3.
5	All machinery and equipment that has been in watercourses shall be water blasted and treated with suitable chemicals or agents prior to being brought on site and following completion of the works, to reduce the potential for pest species being introduced to or taken from the watercourses, such as didymo. At no time during the exercise of this consent shall machinery be washed within the bed of a watercourse.
6	(a) Works shall, as far as practicable, be undertaken when flows in the watercourses are low. (b) Work shall be undertaken with the minimum time required in the wet bed of the watercourses and with the minimum necessary bed disturbance. (c) All reasonable steps shall be taken to minimise the release of sediment to water. (d) At the completion of the works authorised by this consent, the consent holder shall ensure that all plant, equipment, chemicals, fencing, signage, debris, rubbish and any other material brought on site

	is removed from the site. The site shall be tidied to a degree at least equivalent to that prior to the works commencing
7	The consent holder shall ensure that once completed the works authorised by this consent do not cause any flooding, erosion, scouring, land instability or property damage. Should such effects occur due to the exercise of this consent, the consent holder shall, if so required by the Otago Regional Council and at no cost to the Otago Regional Council , take all such practicable action as the Otago Regional Council may require to remedy any such damage.
8	The Consent Authority may, within 6 months of receipt of the Deepdell North Stage III Project Cultural Impact Assessment prepared by Kai Tahu Ki Otago on behalf of Te Runanga o Moeraki, Te Runanga o Otakou and Kati Hurapa Runanga ki Puketeraki, to be commissioned prior to carrying out any works authorised by this consent; serve notice of its intention to review the conditions of this consent for the purpose of amending or adding conditions to address mitigation of the effect(s) of the exercise of this consent on cultural values and associations. All actual and reasonable costs associated with any such review shall be borne by the consent holder.
9	During the exercise of this consent, the consent holder should ensure that fuel storage tanks and machinery working and stored in the construction area shall be maintained at all times to prevent leakage of oil and other contaminants into the watercourse name. No refuelling of machinery shall occur within any watercourse. In the event of contamination, the consent holder shall undertake remedial action and notify the Consent Authority within 24 hours.
10	If the consent holder: (a) Discovers koiwi tangata (human skeletal remains), or Maori artefact material, the consent holder shall without delay: (i) Notify the Consent Authority, Tangata whenua, Heritage New Zealand, and in the case of skeletal remains, the New Zealand Police; (ii) Stop work within the immediate vicinity of the discovery and within 20 metres around the site to allow a site inspection by the Heritage New Zealand Regional Archaeologist and the appropriate iwi groups or kaitiaki representative who shall determine whether the discovery is likely to be extensive; if a thorough site investigation is required and whether an Archaeological Authority is required; (iii) Site access shall be facilitated to enable appropriate cultural procedures and tikanga to be undertaken, as long as all statutory requirements under legislation are met (Heritage New Zealand Pouhere Taonga Act 2014, Protected Objects Act 1975); (iv) Remains are not to be moved until such time as Heritage New Zealand and iwi have responded. Any koiwi takata discovered shall be handled and removed by tribal elders responsible for the tikanga (custom) appropriate to its removal or preservation; and (v) Site work shall recommence following consultation with the Consent Authority, Heritage New Zealand, Takata whenua, and in the case of skeletal remains, the NZ Police, have provided that any relevant statutory permissions have been obtained.

	(b) Discovers any feature or archaeological material that predates 1900, or heritage Material, or disturbs a previously unidentified archaeological or heritage site, the consent holder shall without delay: (i) Cease work immediately at that place and within 20m around the site; (ii) The contractor must shut down all machinery, secure the area, and advise the Site Manager; (iii) The Site Manager shall secure the site and notify the Heritage New Zealand Regional Archaeologist and the Consent Authority. Further assessment by an archaeologist may be required; (iv) If the site is of Maori origin (or is thought to possibly be of Maori origin), the Site Manager shall notify the Heritage New Zealand Regional Archaeologist, the Otago Regional Council and the appropriate iwi groups or kaitiaki representative of the discovery and ensure site access to enable appropriate cultural procedures and tikanga to be undertaken, as land as all statutory requirements under legislation are met (Heritage New Zealand Pouhere Taonga Act 2014, Protected Objects Act 1975). Heritage New Zealand will determine if an archaeological authority under the Heritage New Zealand Pouhere Taonga Act 2014 is required for works to continue; and (v) Site work shall recommence following consultation with the Otago Regional Council, Heritage New Zealand and iwi, provided that any relevant statutory permissions have been obtained.

1.3 **Compliance and monitoring schedule to apply to discharge consents** RM20.XXX.(1.4), RM20.XXX.(1.5), RM20.XXX.(1.6) and RM20.XXX.(1.7).

1.	**General Provisions**
1.1	This schedule describes monitoring and sampling required pursuant to consent numbers RM20.XXX.(1.4), RM20.XXX.(1.5), RM20.XXX.(1.6) and RM20.XXX.(1.7) in addition to any monitoring specified in those consents.
1.2	The design of all monitoring and sampling programs shall be to the satisfaction of the Otago Regional Council. Where the consent to which the monitoring programme relates, directs that an Operations and Management Plan shall be prepared then the monitoring programme shall be incorporated into that plan.
1.3	The parameters analysed, site locations and frequency of sampling shall be reviewed as part of the annual review of the management plan for the consent(s) to which this monitoring relates. New parameters, sites and frequencies may be approved by the Otago Regional Council under an application by the consent holder for a change of conditions for monitoring made pursuant to Section 127 of the Act.
1.4	All sampling procedures, including collection, transportation of samples and laboratory analyses undertaken in accordance with this consent must be performed to IANZ registered standards, or otherwise as specifically approved by the Otago Regional Council.
1.5	Reporting shall be quarterly unless specified otherwise. A quarterly consolidated report containing all sampling and monitoring results shall be submitted to the Otago Regional Council within one month of the

	end of the quarter being reported. This report shall highlight any particular features arising from monitoring and sampling and shall provide appropriate commentary on such features.
1.6	Where a monitoring location is destroyed, made redundant or unusable for any other reason, the consent holder shall, in consultation with the Otago Regional Council: a) Discuss and determine whether an alternative monitoring location is required and if so where it should be located; and b) Assign a timeframe for establishment of the new monitoring location.
2	**Reporting of non-compliance**
2.1	Any non-compliance with any compliance criteria shall be reported to the Otago Regional Council within 24 hours of the non-compliance first being detected.
3	**Compliance criteria**
3.1	The following describes the compliance criteria pursuant to consent numbers RM20.XXX.04 (1.4) and RM20.XXX.05 (1.5). **(a) Narrative Standard for Receiving Waters** The waters of the Deepdell Creek and Highlay Creek shall at all times be free of contaminants attributable to mineral processing and associated activities in concentrations which adversely affect directly or indirectly water uses or which adversely affect humans, animals, plants and/or aquatic life. **(b) Numerical Compliance Criteria** **(i) Highlay Creek Deepdell Creek and Shag River** Surface water within the Deepdell Creek at the Deepdell Creek Compliance Point (DC08), and in the waters of Shag River at Loop Road shall not exceed the following water quality compliance criteria (where the metals standards are all soluble determinations), unless infallible evidence can be provided that the level of a parameter is either naturally occurring or unrelated to mining activities:

Constituent	DC08 Standard[b]	Shag River at Loop Road Standard[b]
Arsenic	0.15	0.01
$Cyanide_{WAD}$	0.1	0.1
Copper [a]	0.009	0.009
Iron	1.0	0.2
Lead [a]	0.0025	0.0025
Zinc [a]	0.12	0.12
Sulphate	1,000	250
pH (range)	6.0 - 9.5 pH units	7 - 8.5 pH units

	a *Note: Copper, lead and zinc standards are hardness related limits in accordance with an assumed hardness value of 100g/m^3 $CaCO_3$ and will vary depending on actual hardness according to established calculation methodologies.* b *(g/m^3) unless stated otherwise* **(ii) Waste Rock – ANC/MPA Ratio** The acid neutralising capacity to maximum potential acidity (ANC:MPA) ratio, as referred to in California Administrative Code Article 7, 1992, shall be greater than 3:1 in rock discharged into the Waste Rock Stack.
	MONITORING **(a) Surface Waters** The consent holder shall collect monthly representative water samples from the following surface water sites (as shown on Appendix XX attached): (i) Deepdell Creek at DC08 (ii) Deepdell Creek at DC01 (Upstream of mine activities); (iii) Shag river compliance point 1 (Shag River- Loop Road) (iv) Highlay Creek at HC02 (Immediately upstream of the confluence with Deepdell Creek) All surface water sampling shall occur on the same day. Samples taken for the monitoring points listed above shall also be analysed for the following parameters monthly: • Calcium • Magnesium • Potassium • Sodium • Bicarbonate • Carbonate • Chloride • Sulphate • pH • Electrical conductivity • Arsenic • Copper • Iron • Lead • Zinc • Cyanide (WAD) • Total inorganic nitrogen • Nitrate • Nitrite • Ammonia • Phosphorous

With the prior written approval of Otago Regional Council, the consent holder may reduce the frequency of monitoring or the number of contaminants being monitored in accordance with the list above where it is demonstrated that maintenance of the original monitoring programme is not required. The Otago Regional Council may, by notice in writing at any time, require the consent holder to resume the full monitoring program as set out above.

(b) Waste Rock Stack Seepage

The consent holder will obtain representative samples of groundwater seepage from the toe of the Deepdell East Waste Rock Stack. These samples will be collected at the following points:

(i) Highlay Silt Pond 1;
(ii) Highlay Silt Pond 2;
(iii) Deepdell South Silt Pond; and
(iv) Deepdell North Silt pond.

Commencement of monitoring of groundwater seepage will be dependent on a) waste rock being deposited in the catchment of each seepage collection point and there being sufficient seepage water discharged to allow a sample to be collected.

Samples taken will be analysed for the following parameters monthly:

- Calcium
- Magnesium
- Potassium
- Sodium
- Bicarbonate
- Carbonate
- Chloride
- Sulphate
- pH
- Conductivity

Samples will be analysed for the following parameters quarterly:

- Copper
- Iron
- Lead
- Total Inorganic Nitrogen
- Arsenic

(c) Aquatic Biological Monitoring

The consent holder shall engage a suitably qualified and experienced freshwater biologist to design and undertake an aquatic biological monitoring programme and the requirements of this program will commence in the first year of this consent being exercised.

Biological monitoring shall be undertaken at the following sites as shown on Appendix XX attached:

- DC01 Deepdell Creek
- DC08 Deepdell Creek
- HC02 Highlay Creek immediately above the confluence with Deepdell Creek

Monitoring of macro-invertebrates and periphyton shall be carried out at each of the sites on one occasion during each of the following periods each year:

- December to February inclusive;
- March to May inclusive;
- June to August inclusive; and
- September to November inclusive

(unless there are insufficient flows to support any significant aquatic community). A flow reading shall be completed on each monitoring occasion.

Macroinvertebrate sampling shall include calculation and consideration of Macroinvertebrate Community Index (MCI) and its semi-quantitative variant (SQMCI).

An annual electric fishing survey shall be carried out at each of the sites (unless there are insufficient flows) during the period 1 February to 31 March inclusive. A flow reading shall be completed at each site.

Electric fish surveying shall be consistent with the method developed and documented under Compliance and Monitoring Schedules for the Consent Holders existing resource consents. This method shall be followed for all fish surveys undertaken in accordance with this schedule.

All aquatic biology monitoring shall be undertaken during low or stable flows.

All aquatic biology monitoring shall be undertaken during low or stable flows.

Components to be Monitored:

1. Benthic macro-invertebrates - the taxonomic composition and abundances shall be monitored at all sites.
2. Fish - the taxonomic composition and abundances of fish shall be monitored by an electric-fishing survey at each of the sites.
3. Benthic Algae – a qualitative assessment of the height and percentage cover of dominant species of benthic algae shall be made at all sites.
4. A visual estimation from the stream bank of the habitat length (m) and the percentage of stream bed within the wetted with covered by sediment <2mm in size, for each riffle, run and pool present and take a representative photograph.

(d) Groundwater monitoring

(i) Water levels will be measured and recorded monthly at groundwater monitoring bores DDB01 – DDB06.

	(ii) The consent holder will measure and record groundwater quality at bores DDB01 – DDB06. Samples taken will be analysed for the following parameters monthly: • Calcium • Magnesium • Potassium • Sodium • Bicarbonate • Carbonate • Chloride • Sulphate • pH • Conductivity Samples will be analysed for the following parameters quarterly: • Copper • Iron • Lead • Total Inorganic Nitrogen • Arsenic With the prior written approval of Otago Regional Council, the consent holder may reduce the frequency of monitoring or the number of contaminants being monitored in accordance with the list above where it is demonstrated that maintenance of the original monitoring programme is not required. The Otago Regional Council may, by notice in writing at any time, require the consent holder to resume the full monitoring program as set out above.

Discharges

1.4 Conditions for resource consent to discharge silt and sediment to water for the purpose of constructing the Deepdell East Waste Rock Stack, backfilling the Deepdell South Pit and associated silt ponds.

1	The discharges shall occur within and immediately downstream of the area marked Deepdell East Waste Rock Stack shown on Appendix I attached and the areas marked as silt ponds as shown on Appendix III attached.
2	No contaminants other than sediment shall be discharged to water.
3	The consent holder shall take all practicable steps to minimise the release of sediment into water.
4	This consent shall be exercised in accordance with and be subject to the monitoring and compliance schedule appended to this consent certificate.

5	(a)	Prior to exercise of this consent, the consent holder shall submit to the Otago Regional Council a final Erosion and Sediment Control Plan for the Deepdell North Stage III Project. The Erosion and Sediment Control Plan and plan requirements shall not be of a standard less than that required by the latest revision of the Environment Canterbury document "Erosion and Sediment Control Guideline", except that the sediment retention ponds shall be designed in accordance with Engineering Geology Limited "Deepdell North Stage III Project Erosion and Sediment Control" report dated 11 November 2019 and attached to the consent application. The Erosion and Sediment Control Plan shall be in general accordance with details contained in that document and shall include, but not be limited to: (i) Details of the design and location of all erosion and sediment control devices including final details of all catchments and sub-catchments of all works related to erosion and sediment control within the Deepdell North Stage III Project area; (ii) Key responsibilities relating to implementation of the plan; (iii) Construction details and specifications of all proposed erosion and sediment control measures e.g. including but not limited to details of all drains and ponds associated with erosion and sediment control and surface water management; (iv) A construction timetable and details of necessary staging; (v) Maintenance, monitoring and reporting procedures (e.g. including but not limited to details of parameters to be measured, frequency of monitoring, monitoring locations and corrective actions to be implemented in the event that test results are inconsistent with monitoring requirements and/or cross reference to the Water Quality Management Plan and Compliance and Monitoring Schedule that otherwise provide for all such requirements); (vi) Emergency response procedures, including response procedures for flood events and silt pond dam failure scenarios; and (vii) Certification from a suitably qualified engineer, that is approved by the Consent Authority, that the proposed erosion and sediment control measures comply with the conditions of the consent.
	(b)	The Erosion and Sediment Control Plan for this consent may be combined with any Erosion and Sediment Control Plan required by any other consent held by the consent holder for mining operations at Macraes Flat.
	(c)	The consent holder shall exercise this consent in accordance with the Erosion and Sediment Control Plan.
	(d)	If required due to adverse effects on site, the consent holder shall amend the Erosion and Sediment Control Plan. The consent holder shall exercise this consent in accordance with the Erosion and Sediment Control Plan.
	(e)	The consent holder shall review the Erosion and Sediment Control Plan annually and if necessary, update it. Details of the review shall be included in the Project Overview and Annual Work and

	Rehabilitation Plan. The Otago Regional Council shall be provided with any updates of the plan within 1 month.

1.5 To discharge waste rock to land within the Deepdell South Pit and to land at Horse Flat for the purpose of disposing of waste rock and constructing the Deepdell East Waste Rock Stack.

1	The discharge shall occur in the area marked as Deepdell East Waste Rock Stack as shown on Appendix I attached.
2	This consent shall be exercised in accordance with and be subject to the monitoring and compliance schedule appended to this consent certificate.
3	The waste rock stack shall be constructed to ensure slope stability has a minimum factor of safety of 1.5.
4	The ratio of acid neutralising capacity to maximum potential acidity ratio, as referred to in California Administrative Code Article 7, 1992, shall be not less than 3:1 in rock discharged under this resource consent.
5	A review of waste rock discharge completed, including a plan with updated waste rock levels shall be included in the Project Overview and Work and Rehabilitation Plan submitted annually to the Consent Authority.

1.6 To discharge treated sediment laden water from silt ponds to unnamed tributaries of Highlay Creek, Camp Creek and Deepdell Creek for the purpose of operating the Deepdell East Waste Rock Stack

1	The discharge shall occur from the areas marked as silt ponds as shown on Appendix III attached.
2	This consent shall be exercised in accordance with and be subject to the monitoring and compliance schedule appended to this consent certificate.
3	(a) Prior to the exercise of this consent, the consent holder shall submit to the Otago Regional Council, a Water Quality Management Plan for the Deepdell North Stage III project. The Water Quality Management Plan shall include but not be limited to: (i) Details of surface water and groundwater quality monitoring within the Deepdell catchment, including locations, frequencies and parameters being measured; (ii) Identification of monitoring results that would trigger the requirement for a comprehensive review of water quality to determine whether additional measures should be adopted to ensure appropriate surface water and groundwater quality; (iii) A description of mitigation measures implemented or available to ensure compliance with the conditions of this consent during the operational period of the Deepdell North Stage III Project; (iv) A description of mitigation measures implemented or available to ensure compliance with the conditions of this consent after mining and rehabilitation as part of the Deepdell North Stage III

		Project has been completed (post closure); (v) A timeline detailing when it is anticipated that any mitigation measures may be required in order to meet (iii) and (iv);
	(b)	The Water Quality Management Plan for this consent may be combined with any other consent held by the consent holder for mining operations at Macraes Flat so long as all conditions of this consent are met.
	(c)	The consent holder shall review the Water Quality Management Plan annually for the first ten years of this consent, and every three years thereafter, and, if necessary, update it. Details of this review shall be included in the Project Overview and Rehabilitation Plan required by conditions X of RMXXXXX. The consent authority shall be provided with any updated versions of the plan within one month of the completion of the review.
4	(a)	Prior to exercise of this consent, the consent holder shall submit to the Otago Regional Council a final Erosion and Sediment Control Plan for the Deepdell North Stage III Project. The Erosion and Sediment Control Plan and plan requirements shall not be of a standard less than that required by the latest revision of the Environment Canterbury document "Erosion and Sediment Control Guideline", except that the sediment retention ponds shall be designed in accordance with Engineering Geology Limited "Deepdell North Stage III Project Erosion and Sediment Control" report dated 11 November 2019 and attached to the consent application. The Erosion and Sediment Control Plan shall be in general accordance with details contained in that document and shall include, but not be limited to: (i) Details of the design and location of all erosion and sediment control devices including final details of all catchments and sub-catchments of all works related to erosion and sediment control within the Deepdell North Stage III Project area; (ii) Key responsibilities relating to implementation of the plan; (iii) Construction details and specifications of all proposed erosion and sediment control measures e.g. including but not limited to details of all drains and ponds associated with erosion and sediment control and surface water management; (iv) A construction timetable and details of necessary staging; (v) Maintenance, monitoring and reporting procedures (e.g. including but not limited to details of parameters to be measured, frequency of monitoring, monitoring locations and corrective actions to be implemented in the event that test results are inconsistent with monitoring requirements and/or cross reference to the Water Quality Management Plan and Compliance and Monitoring Schedule that otherwise provide for all such requirements); (vi) Emergency response procedures, including response procedures for flood events and silt pond dam failure scenarios; and (vii) Certification from a suitably qualified engineer, that is approved by the Consent Authority, that the proposed erosion and sediment control measures comply with the conditions of the consent.

	(b) The Erosion and Sediment Control Plan for this consent may be combined with any Erosion and Sediment Control Plan required by any other consent held by the consent holder for mining operations at Macraes Flat. (c) The consent holder shall exercise this consent in accordance with the Erosion and Sediment Control Plan. (d) Not less than three weeks prior to the commencement of soil disturbance, the consent holder shall submit to the Consent Authority the Erosion and Sediment Control Plan. If required by the Consent Authority, the consent holder shall amend the Erosion and Sediment Control Plan. The consent holder shall exercise this consent in accordance with the Erosion and Sediment Control Plan. (e) The consent holder shall review the Erosion and Sediment Control Plan annually and if necessary, update it. Details of the review shall be included in the Project Overview and Annual Work and Rehabilitation Plan. The Otago Regional Council shall be provided with any updates of the plan within 1 month.
5	The discharge shall not give rise to any significant adverse effect on aquatic life.
6	The exercise of this consent shall not give rise to the following effects in any receiving waters after reasonable mixing: (a) The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials: (b) Any conspicuous change in the colour or visual clarity: (c) Any emission of objectionable odour: (d) The rendering of fresh water unsuitable for consumption by farm animals: (e) Any significant adverse effects on aquatic life.
7	No chemical additives shall be used in the silt pond or shall be discharged from the silt pond without the prior written approval of the consent authority. *Note: This condition is intended to cover the addition of flocculants to the silt pond and the discharge of soil binding agents used in the silt pond catchment for erosion control purposes. It is not intended to cover the discharge of fertiliser used in any silt pond catchment for rehabilitation purposes.*

1.7 To discharge contaminants from the base and toe of the Deepdell East Waste Rock Stack to land where they may enter water for the purpose of operating the Deepdell East Waste Rock Stack

1	The discharge shall occur in the area marked as Deepdell East Waste Rock Stack as shown on Appendix I attached.
2	(a) No less than one month prior to the first exercise of this consent, the consent holder shall submit to the consent authority, an Operations and Management Plan for the Deepdell North Stage III Waste Rock Stack. The Operations and Management Plan shall be in accordance with the conditions of this

	consent, and shall include (but not be limited to): (i) A general description of the site, including topography, natural water sources and geotechnical investigations: (ii) A description of all stages of construction, operation and rehabilitation of the waste rock stack; (iii) A plan showing the proposed final footprint and contours for the Deepdell North Stage III Waste Rock Stack; (iv) An assessment of all potential environmental effects and the measures that will be put in place to avoid, remedy or mitigate these environmental effects; (v) A description of water management at the site, including procedures for controlling adverse effects of runoff and seepage on groundwater and surface water bodies in accordance with the Water Quality Management Plan required by RMXXXX (1.4), RMXXXXX (1.5) and the Erosion and Sediment Control Plan required by discharge permit RMXXXXX(1.4); (vi) A plan showing all monitoring locations relevant to this consent, a description of monitoring frequencies, parameters analysis and relevant compliance limits and details of all measuring, recording, sampling and testing methods including any relevant standards and accreditations; (vii) A monitoring program for the discharge of waste rock, including regular topographic and aerial surveys for the determination of the volumes of waste rock discharged, resultant changes to the ground surface levels and areas affected by the discharge; and; (viii) A monitoring program to assess waste rock stack cover integrity, vegetation health, any movement, erosion or other geotechnical instability, including a contingency plan should instability result in any health and safety issues at the site and a procedure for recording the outcome of the monitoring and any maintenance, remedial or corrective measures undertaken. (b) The consent holder shall exercise this consent in accordance with the Operations and Management Plan. (c) The consent holder shall review the Operations and Management Plan annually and if necessary, update it. Details of the review shall be included in the Project Overview and Annual Work and Rehabilitation Plan. The Consent Authority shall be provided with any updates of the plan within 1 month.
3	This consent shall be exercised in accordance with and be subject to the monitoring and compliance schedule appended to this consent certificate.
4	(a) Prior to the exercise of this consent, the consent holder shall submit to the Otago Regional Council, a Water Quality Management Plan for the Deepdell North Stage III project. The Water Quality Management Plan shall include but not be limited to: (i) Details of surface water and groundwater quality monitoring within the Deepdell catchment, including locations, frequencies and parameters being measured; (ii) Identification of monitoring results that would trigger the requirement for a comprehensive

	review of water quality to determine whether additional measures should be adopted to ensure appropriate surface water and groundwater quality; (iii) A description of mitigation measures implemented or available to ensure compliance with the conditions of this consent during the operational period of the Deepdell North Stage III Project; (iv) A description of mitigation measures implemented or available to ensure compliance with the conditions of this consent after mining and rehabilitation as part of the Deepdell North Stage III Project has been completed (post closure); (v) A timeline detailing when it is anticipated that any mitigation measures may be required in order to meet (iii) and (iv); (b) The Water Quality Management Plan for this consent may be combined with any other consent held by the consent holder for mining operations at Macraes Flat so long as all conditions of this consent are met. (c) The consent holder shall review the Water Quality Management Plan annually for the first ten years of this consent, and every three years thereafter, and, if necessary, update it. Details of this review shall be included in the project Overview and Rehabilitation Plan. The Otago Regional Council shall be provided with any updated versions of the plan within one month of the completion of the review.
5	**Site decommissioning and closure**
5.1	(a) The consent holder shall submit to the Otago Regional Council a Site Decommissioning Plan, not less than 12 months before completion of the operations. (b) The Site Decommissioning Plan shall be prepared in consultation with Takata Whenua, Macraes Community Development Trust, Macraes Community Incorporated and any successive groups.
5.2	The Site Decommissioning Plan shall include but not be limited to: (a) A plan(s) showing the final design and intended contours (at 5 metre intervals) of all permanent structures and works, including but not limited to, waste rock stacks, permanent earthworks, pit lakes, roads, water storage reservoirs or other works which under this consent or any related consent are authorised or required to remain after the relevant consents expire; (b) A summary of rehabilitation completed to date, and details of rehabilitation required to fulfil the conditions of this consent and any related consents; (c) Details on infrastructure to be decommissioned, such infrastructure may include buildings, plant, and equipment; (d) Details of specific infrastructure to remain on-site post-closure. Such infrastructure may include buildings, plant, equipment and any monitoring structures required by this consent and any related consent to remain after the expiry of the consents; (e) Details of management, any ongoing maintenance, monitoring and reporting proposed by the consent holder to ensure post-closure activities are carried out in accordance with the conditions of this consent;

	(f) Details of measures to protect public safety, including any fencing yet to be completed; (g) The costs of complying with (a)-(f) above.

1.8 Conditions for discharge of contaminants to air for the purposes of mining and rehabilitation

1	This consent shall be carried out in conjunction with Discharge Permit 96785, Discharge Permit 2006.689, Discharge Permit RM10.351, Discharge Permit RM12.378.15, Discharge Permit RM16.138.19 and any subsequent variations to those permits
2	This consent authorises the discharge of contaminants to air from the Deepdell North Stage III Pit, Deepdell East Waste Rock Stack and all associated working areas of supporting infrastructure and rehabilitation of the proposal.
3	There shall be no visible dust beyond the boundary of the Macraes Gold Project that, in the opinion of an RMA enforcement officer, is offensive or objectionable to such an extent that it has an adverse effect on the environment.
	Performance monitoring
4	Insoluble dust deposition rates will be measured by the consent holder on a monthly basis at existing dust monitoring sites DG07 and DG17 as shown on Appendix II attached.
5	Insoluble dust deposition rates at sites DG17 and DG07 as shown on Appendix II attached, must not exceed 3 grams per square metre per 30 days (g/m^2/30 days) of insoluble dust above background more than twice in any calendar year. Compliance with this condition shall be demonstrated by the monitoring required in Condition 4 of this consent.
6	Background concentrations will be calculated by measuring the insoluble dust deposition rate at DG24 as shown on Appendix II attached.
7	Twenty-four-hour average total suspended particulate at site DG15, as shown on Appendix II attached, must not exceed 120µg/m^3. Compliance with this condition will be demonstrated by the monitoring required in Condition 9 of this consent.
8	In the event of any exceedance of those limits specified in Conditions 5, 7 of this consent, the Consent Holder must undertake an immediate review of the cause of the exceedance. A report detailing the findings of this review shall be provided to the Otago Regional Council within 1 month of the non-compliant result(s) being received. If it is shown that activities within the Macraes Gold Project site were the cause of the exceedance, then dust mitigation measures within the Macraes Gold Project shall be reviewed by an independent consultant engaged in consultation with the Otago Regional Council. The independent consultant shall provide a report summarising the cause of the exceedance and recommending measures to improve dust mitigation at the Macraes Gold Project site so that the exceedance does not occur again. This report shall be provided to the Consent Authority within 2 months of the non-compliant result(s) being received.

9	The consent holder shall monitor dust deposition rates at monthly intervals in accordance with draft ISO Standard ISO/SIS 4222.2 (“Air Quality Measurement of Atmospheric Dustfall – Horizontal Deposit Gauge Method” 1980), or another method approved in writing by the Consent Authority. The monitoring shall be undertaken at the sites shown on Appendix II attached.
10	(a) The consent holder shall monitor real time total suspended particulate concentrations at site DG15 as shown on Appendix II attached. The monitoring shall be undertaken using a nephelometer, or other instrument as agreed in writing by the Otago Regional Council. The instrument shall be sited in accordance with AS/NZS 3580.1.1:2007. (b) The consent holder shall monitor total suspended particulate at monitoring site DG15 as shown on Appendix II in accordance with Australian Standard AS/NZS3580.9.3:2003 (Determination of suspended particulate matter - Total Suspended Particulates [TSP] - High Volume Sampler Gravimetric Method), or another method approved by the Otago Regional Council. Twenty-four-hour measurements must be taken every six days March to October inclusive, and every three days November to February inclusive, for a minimum period of twelve months or for however long is required to ensure that adequate data is collected to achieve the objectives of Condition 10(d). (c) Parameters to be recorded shall include, but not be limited to: (i) Hourly average TSP concentrations as measured by the instrument installed in accordance with Condition 10(a) of this consent; (ii) 24-hour average TSP concentrations as measured by the instruments installed in accordance with Conditions 10(a) and 10(b). (d) The instruments installed in accordance with Conditions 10(a) and 10(b) shall be operated concurrently for a period of no less then twelve months to ensure that twelve months of coincident data is collected. A correlation between the data shall be established by an independent consultant engaged in consultation with the Otago Regional Council. A report detailing this investigation shall be provided to the Otago Regional Council within two months of the data being collected.
11	Prior to the exercise of this consent, the consent holder shall update the Dust Management Plan for the Macraes Gold Project as required by Discharge Permit 96785, Discharge Permit 2006.689, Discharge Permit RM10.351, Discharge Permit RM12.378.15, Discharge Permit RM16.138.19 and include the Deepdell North Stage III Project within this document. A copy of the Dust Management Plan shall be provided to Otago Regional Council prior to the exercise of this consent.
12	The exercise of this consent shall be carried out in accordance with the updated Dust Management Plan required by condition 11 of this consent.

1.9 Conditions for take of groundwater and surface water from the Deepdell North Stage III pit and silt ponds for the purposes of pit dewatering, water management and dust suppression

1	The taking of surface and groundwater shall occur from the Deepdell North stage III Pit, as shown on Appendix 1 attached and associated pit sumps. The taking of groundwater and surface water from the silt ponds shall occur in the areas shown in Appendix II attached and labelled as silt ponds.
2	The total maximum rate of take of water authorised by this consent shall not exceed 200 litres per second.
	Performance monitoring
3	(a) The consent holder shall install a water meter to record the water take, within an error accuracy range of +/- 5% over the meter's nominal flow range, and telemetry compatible datalogger with at least 24 months data storage to record the rate and volume of take, and the date and time this water was taken. (b) The datalogger shall record the date, time and flow in litres per second. (c) The water meter shall be installed in a straight length of pipe, before any diversion of water occurs. The straight length of pipe shall be part of the pump outlet plumbing, easily accessible, have no fittings and obstructions in it. There shall be a straight length of pipe on either side of the water meter: on the upstream side there shall be a distance that is 10 times the diameter of the pipe and on the downstream side there shall be a distance of 5 times the diameter of the pipe. (d) The consent holder shall ensure the full operation of the water meter and datalogger at all times during the exercise of this consent. All malfunctions of the water meter and/or datalogger during the exercise of this consent shall be reported to the Otago Regional Council within 5 working days of observation and appropriate repairs shall be performed as soon as reasonably practicable. Once the malfunction has been remedied, a Water Measuring Device Verification Form completed with photographic evidence must be submitted to the Otago Regional Council within 5 working days of the completion of repairs (e) The installation of the water meter shall be completed to full and accurate operation prior to the exercise of the consent. The consent holder shall forward a copy of the installation certificate to the Otago Regional Council within one month of installing the water meter and datalogger. (f) (i) If a mechanical insert water meter is installed it shall be verified for accuracy each and every year from the first exercise of this consent. (ii) Any electromagnetic or ultrasonic flow meter shall be verified for accuracy every five years from the first exercise of this consent. (iii) Each verification shall be undertaken by an Otago Regional Council approved operator and a Water Measuring Device Verification Form shall be completed and supplied to the Otago Regional Council with receipts of service. These shall be supplied within 5 working days of the verification, and at any time upon request. (g) The consent holder shall provide records from the datalogger to the Otago Regional Council by 31 July each year and at any other time on request. Data shall be available electronically giving date,

	time and flow rates in no more than 15-minute increments, via a datalogger approved by the Otago Regional Council.
4	The consent holder shall take all practicable steps to ensure that: (a) There is no leakage from pipes and structures; (b) The use of water is confined to targeted areas; (c) There is no runoff of dust suppression water to where it may enter a surface water body.
5	The consent holder will carry out groundwater monitoring monthly at DDB01 – 06 in accordance with the compliance and monitoring schedule for this consent.

1.10 Conditions for land use consent to place a road earth embankment and culvert structure in the bed of an unnamed tributary of Highlay Creek

1	All works must be undertaken and located in accordance with the application for resource consent lodged with the Otago Regional Council on XX January 2020. If there are any inconsistencies between the application and the consent, the conditions of the consent will prevail.
2	The base of the culvert structure must be embedded into the bed of Highlay Creek at least 200 millimetres
3	Work must not be undertaken during high rainfall events, or when high rainfall is forecast
4	If, at the time of works, there is flow in the watercourse affected, measures will be taken to separate the flow from the area of active works.
	Performance Monitoring
5	At least two working days prior to the commencement of this activity, notification of the intention to start works shall be provided to the environmental services unit of the Otago Regional Council (compliance@orc.govt.nz).
6	The consent holder must take photographs of all proposed and actual bed disturbance and the dates the photographs were taken as follows: (a) Prior to the start of bed disturbance works (b) At the completion of bed disturbance works The photographs taken under (a) and (b) above shall be forwarded to compliance@orc.govt.nz and Aukaha within ten working days of the completion of the works.
	General
7	All machinery and vehicles must be, as far as is practicable and appropriate, clean and well maintained before entering any water course on the work site. All machinery and equipment that has made contact with water courses within the last ten working days must be water blasted and treated with suitable chemicals or agents prior to being brought on site and following completion of the works, to reduce the

	potential for pest species, such as didymo being introduced to or taken from the watercourses. At no time during the exercise of this consent will any machinery or vehicles be washed within the bed of a water course.
8	All practical measures must be taken to minimise the risk of contamination entering the water course, ie fuel from machinery or vehicles.
9	All excess excavated material must either be reused if suitable or disposed of appropriately.
10	(a) Work in the wet bed of the water course must be undertaken within the minimum practicable time required and with the minimum practicable bed disturbance required to carry out the activity. (b) Damage to riparian vegetation on the banks of the water course must be minimised when exercising this consent. (c) All reasonable steps must be taken to minimise the loss of sediment to water. (d) At completion of the works authorised by this consent, the consent holder must ensure that all machinery, vehicles, equipment chemicals, fencing, debris, litter and any other materials brought to site are removed and that the site is tidied to a degree that is at least equivalent to that prior to the works commencing.
11	The consent holder must ensure that once completed, the works authorised by this consent do not cause any flooding, erosion, scouring land instability or property damage.
12	If the consent holder discovers koiwi takata (human skeletal remains}, or Maori artefact material, the consent holder shall without delay: (a) Notify the Consent Authority, Takata whenua and New Zealand Historic Places Trust and in the case of skeletal remains, the New Zealand Police. (b) Stop work within the immediate vicinity of the discovery to allow a site inspection by the New Zealand Historic Places Trust and the appropriate runaka and their advisors, who shall determine whether the discovery is likely to be extensive; if a thorough site investigation is required and whether an Archaeological Authority is required. (c) Any koiwi takata discovered shall be handled and removed by tribal elders responsible for the tikanga (custom) appropriate to its removal or preservation. **Advice note**: An archaeological authority from the Heritage New Zealand Pouhere Taonga may be required before work can proceed. (d) Site work shall recommence following consultation with the Consent Authority, Heritage New Zealand Pouhere Taonga, Takata whenua, and in the case of skeletal remains, the NZ Police, provided that any relevant statutory permissions have been obtained.

1.11 Conditions for damming of water in the Deepdell North Stage III Pit for the purposes of creating a Pit Lake

1	This consent shall be exercised in conjunction with discharge permit RMXXXX (1.9) and any subsequent variations to that consent.
2	For the purposes of Section 125 of the Resource Management Act 1991, this consent shall be deemed to have been given effect to upon beginning excavation of the Deepdell North Stage III Pit.
3	The damming will occur in the area marked Deepdell North Pit on Appendix I attached.
	Management Plans
4	The consent shall be exercised in accordance with and be subject to a Pit Lake Compliance and Monitoring Schedule to be developed in consultation with the Otago Regional Council prior to the exercise of this consent
5	(a) No less than twelve months prior to allowing the pit lake to start to form through ending pit dewatering activities authorised by water permit RM XXXXXX (1.9), the consent holder shall provide the Otago Regional Council with a closure manual for the Deepdell North Stage III Pit Lake. The manual shall include but not be limited to: (i) Details of the pit lake design requirements (ii) Details of the lake filling requirements, including but not limited to; • The location, method and quality of the discharge into the pit, and; • Details of the long-term pit wall stability (b) The consent holder shall exercise the consent in accordance with the Closure Manual. (c) The consent holder shall review the Closure Manual annually and if necessary, update it. Details of the review shall be included in the Project overview and Annual Work and Rehabilitation Plan. The Consent Authority shall be provided with any updates of the plan within one month of any update occurring.

1.12 Conditions for discharge of water containing contaminants from the Deepdell North Stage III Pit to land where it may enter water.

1	This consent shall be exercised in conjunction with discharge permits RMXXXX (1.4 – 1.7), water permit RMXXXX (1.9), water permit RMXXXX (1.11) and any subsequent variations to those consents
2	For the purposes of Section 125 of the Resource Management Act 1991, this consent shall be deemed to have been given effect to upon beginning excavation of the Deepdell North Stage III Pit.
3	The discharge will occur from the area marked Deepdell North Pit on Appendix I attached.

	Performance monitoring
4	The consent shall be exercised in accordance with and be subject to a Pit Lake Compliance and Monitoring Schedule to be developed in consultation with the Otago Regional Council prior to the exercise of this consent
5	The quality of water to be discharged shall be compliant with the parameters stipulated in the Pit Lake Compliance and Monitoring Schedule that is to be developed prior to the exercise of this consent.
6	The consent holder shall develop and implement any practicable and reasonable water treatment or other measure required to comply with conditions 4 and 5 of this consent prior to discharging any water from the pit lake and maintain those measures as long as they are required.
7	(a) No less than twelve months prior to allowing the pit lake to form through ending pit dewatering activities authorised by water permit RM XXXXXX (1.9), the consent holder shall provide the Otago Regional Council with a closure manual for the Deepdell North Stage III Pit Lake. The manual shall include but not be limited to: (i) Details of the pit lake design requirements (ii) Details of the lake filling requirements, including but not limited to; • The location, method and quality of the discharge into the pit, and; • Details of the long-term pit wall stability (b) The consent holder shall exercise the consent in accordance with the Closure Manual. The consent holder shall review the Closure Manual annually and if necessary, update it. Details of the review shall be included in the Project overview and Annual Work and Rehabilitation Plan. The Otago Regional Council shall be provided with any updates of the plan within one month of any update occurring.

2. Waitaki District Council Conditions

These suggested conditions are intended to assist with managing specific land use consent matters and offer approaches to managing specific effects associated with the proposal.

1	**General**
1.1	This consent shall be exercised in accordance with the Deepdell North Stage III application for resource consent lodged with, and receipted by, the Waitaki District Council on XX December 2019, including the Assessment of Environmental Effects and all Supporting Documents (which are deemed to be incorporated in, and form part of this consent), except to the extent that any condition in this consent is inconsistent with such material. If there is an inconsistency the conditions and terms of this consent shall prevail.
1.2	Pursuant to Section 125(1) of the Resource Management Act 1991 this consent shall lapse on the expiry of five years after the date of issue of the consent unless the consent is given effect to before the end of that period or upon application in terms of Section 125 (1) (b) of the Act, the Waitaki District Council may grant a longer period of time.
1.3	The consent holder shall notify the Waitaki District Council in writing of the first exercise of this consent.
1.4	In the event of any non-compliance with the conditions of this consent, the consent holder shall notify the Waitaki District Council within one working day of the non-compliance being detected. Within five working days the consent holder shall provide written notification to the Waitaki District Council providing details of the non-compliance. This notification will at a minimum include an explanation of the cause of the non-compliance, the steps taken to remedy the situation and steps taken to avoid any future occurrence of the non-compliance.
1.5	The Waitaki District Council may, in accordance with sections 128 and 129 of the Act, serve notice on the consent holder of its intention to review the conditions in the last week of March in any year for the purposes of: (a) Dealing with any adverse effect on the environment (including cultural values) which may arise from the exercise of this consent and which is appropriate to deal with at a later stage, or which become evident after the date of commencement of the consent, (b) Ensuring the conditions of this consent are appropriate, (c) Ensuring rehabilitation is completed in accordance with the rehabilitation conditions of this consent; (d) Requiring the consent holder to adopt the best practicable option to remove or reduce any adverse effect on the environment arising as a result of the exercise of this consent.
1.6	The Council may, within 6 months of receipt of the Deepdell North Stage III Project Cultural Impact Assessment prepared by Kai Tahu Ki Otago on behalf of Te Rūnanga o Moeraki, Te Runanga o Otakou and Kāti Huirapa Rūnaka ki Puketeraki, commissioned in 2019, serve notice of its intention under Sections 128 and 129 of the Act to review the conditions of this consent for the purpose of amending or adding conditions to address mitigation of the effect(s) from activities authorised under this consent on cultural values and associations.

1.7	The consent holder shall remedy or adequately mitigate any adverse effect on the environment from the exercise of this consent which becomes apparent after the expiry of this consent.
1.8	Prior to the expiry of this consent, the consent holder shall ensure that all rehabilitation and everything necessary to comply with the conditions of this consent has been completed.
2.	**Location of various mining activities**
2.1	The pit, waste rock stack, and haul road shall not materially exceed those footprints shown on "Map 1 - Deepdell North Stage III proposal areas" annexed as appendix I.
3	**Project Overview and Annual Work and Rehabilitation Plan**
3.1	The consent holder shall submit a Project Overview and Annual Work and Rehabilitation Plan to the Waitaki District Council by 31 March each year that will cover the forthcoming year (1 July to 30 June). The consent holder may, at any time, submit to the Waitaki District Council an amended Project Overview and Annual Work and Rehabilitation Plan. The Project Overview and Annual Work and Rehabilitation Plan shall include, but not be limited to: (a) A description and timeline of intended mining activities for the duration of mining operations including a plan showing the location and contours of all existing and proposed structures at completion of mining; (b) A description (including sequence, method and form) of mining operations, monitoring and reporting carried out in the last 12 months; (c) A detailed description (including sequence, method and form) of all mining operations, monitoring and reporting, not covered by a separate management plan intended to be carried out in the next 12 months; (d) An explanation of any departure in the last 12 months from the previous Project Overview and Annual Work and Rehabilitation Plan; (e) Plans showing the contours (at 5 metre intervals) and footprints of all works and structures and any proposed changes at the end of the next 12 months; (f) A description and analysis of any unexpected adverse effects on the environment that have arisen as a result of the exercise of the consent in the last 12 months and the steps taken to deal with it and the results of those steps; (g) A description and analysis of any non-compliance with any conditions of consent that have occurred in the last 12 months and the steps that were taken to deal with it and the results of those steps; (h) A full report describing and evaluating the mitigation measures used in the last 12 months and any that are proposed to be implemented in the next 12 months. This should detail where further mitigation is proposed or has been undertaken as a result of a non-compliance event and/or any adverse effects on the environment;

	(i) A summary description of all Management Plans and Manuals required under this land use consent and any resource consents issued by ORC and details of any review or amendment of any of the Management Plans or Manuals; (j) An overview of the monitoring and reporting programme for the previous 12 months and any changes proposed for the next 12 months; (k) A detailed section on rehabilitation including, but not limited to the following: (i) The total area of disturbed land during the mining of Deepdell North Stage III, including the haul road, yet to receive rehabilitation and indicative rehabilitation dates for various areas of the mine site; (ii) The area of additional disturbed land in the coming year that will require future rehabilitation; (iii) The area of disturbed land rehabilitated in the previous year; (iv) The area of disturbed land proposed to be rehabilitated in coming year; (v) A description of rehabilitation planned for the life of mine at Deepdell North Stage III; (vi) A description of proposed rehabilitation methods for any area, including proposed topsoil to be stripped and stockpiled, surface pre-treatment and re-use of topsoil on finished areas in the next 12 months.; (vi) The details of the location, design (including shape form and contour) and construction of all permanent structures; (vii) Drainage details for any disturbed land and recently rehabilitated areas; (ix) Details of any vegetation to be used as part of rehabilitation for the next 12-month period; (x) Detailed results of any revegetation trials.
3.2	Each year the consent holder shall provide the Chair of Macraes Community Incorporated, Kāti Huirapa ki Puketeraki, Te Runanga o Otakou and Te Rūnanga o Moeraki with a copy of the Project Overview and Annual Work and Rehabilitation Plan.
3.3	The Project Overview and Annual Work and Rehabilitation Plan for this consent may be combined with any Project Overview and Annual Work and Rehabilitation Plan required by any other consent held by the consent holder for mining operations at Macraes Flat.
3.4	The consent holder shall provide the Waitaki District Council with any further information, or report, which the Waitaki District Council may request after considering any Project Overview and Annual Work and Rehabilitation Plan. This information or report shall be provided in the time and manner required by the Waitaki District Council.
3.5	The consent holder shall exercise this consent in accordance with all defined conditions and the current Project Overview and Annual Work and Rehabilitation Plan.
3.6	The consent holder shall design and construct all permanent earthworks to the form shown in the Project Overview and Annual Work and Rehabilitation Plan.

4.	**Rehabilitation**
4.1	The rehabilitation objectives to be achieved by the consent holder are: (a) To ensure short-term and long-term stability of all structures and works and their surrounds; (b) To avoid the need for maintenance after completion of rehabilitation requirements; (c) To protect soil from erosion and to protect water from contaminants affected by mining operations; (d) To stabilise and rehabilitate the banks and surrounds of any waterbodies; (e) To return land to grazing pasture; (f) To visually integrate finished structures, landforms and vegetation into the surrounding landscape so they appear to be naturally occurring features; and, (g) To control invasive environmental weeds, including wilding conifers, in the Disturbed Land for the Life of the Macraes Gold Project.
4.2	The consent holder shall locate, form and shape all earthworks so that their profiles, contours, skylines and transitions closely resemble and blend with the surrounding natural landforms. If earthworks cannot be fully naturalised, the consent holder shall minimise the extent of their visibility and maximise their integration into the surroundings.
4.3	The consent holder shall use a Landscape Architect in the planning and design of all permanent earthworks and structures.
4.4	The consent holder shall design and construct the waste rock stack in accordance with the following principles: (a) Slopes shall be suitably shaped in cross-profile to match nearby natural slopes; (b) Slope gradients shall be no steeper than nearby natural surfaces; (c) Transitions between natural and formed surfaces shall be rounded and naturalised; (d) Contours should be curvilinear in plan form, in keeping with original natural contours in that area; (e) The skyline shall be variable and curved, simulating natural skylines; (f) New landforms shall be aligned and located so they seem to continue, not cut across, existing landscape patterns; and (g) Silt ponds shall be removed, and the site rehabilitated or be converted to stock water drinking ponds following completion of mining operations and rehabilitation.
4.5	The consent holder shall stage the construction of Deepdell East Waste Rock Stack (WRS) so that waste rock deposition will commence in the area occupied by Deepdell South Pit prior to other areas.
4.6	The consent holder shall, as far as practicable, stockpile soil from any disturbed land, unless the soil is required to be left in place to protect water and soil values.
4.7	All salvaged soil shall be used on disturbed land for rehabilitation purposes.

4.8	The consent holder shall take practical measures to ensure that the areas of vegetation requiring disturbance to give effect to this consent are minimised where possible. This shall include the following protocols: (a) Clearly marking out areas to be cleared (b) Only clearing authorised areas as they are required Avoiding driving vehicles and machinery outside of established tracks or areas that are authorised by this consent to be cleared.
4.9	The consent holder shall in accordance with the rehabilitation objectives undertake progressive rehabilitation of disturbed land as completion of operational activities allow. It shall be revegetated with exotic pastoral species.
4.10	After rehabilitation, the consent holder shall maintain vegetation cover within rehabilitated areas until the expiry of this consent and ensure that the vegetation, including any vegetation established on disturbed land, as far as practicable, shall be designed and implemented to be self-sustaining after expiry of the consent.
4.11	At three yearly intervals, the consent holder shall complete a review of all soil and pasture on land that has been rehabilitated. The first review shall be not later than the third anniversary of the commencement of this consent. The review shall include, but not be limited to, the following: (a) Monitoring for ground cover, species components, plant nutrition status, soil organic matter and concentrations of exchangeable nutrients in the soil; (b) Analysis and interpretation of the monitoring results by a suitably qualified soil or agricultural scientist; (c) Evaluation of the vegetation and its potential to be self-sustaining for pastoral farming after mining ceases; and (d) Any necessary recommendations for future rehabilitation, including plant species or varieties to be used, cultivation and seeding methods to be introduced, or fertilisers to be used; and, (e) A copy of the review will be forwarded to the Waitaki District Council within three months of the review being completed.
5	**Site decommissioning and closure**
5.1	The consent holder shall submit a Site Decommissioning Plan to the Waitaki District Council, not less than 12 months before completion of the operations.
5.2	The Site Decommissioning Plan shall include but not be limited to: (a) A plan(s) showing the final design and intended contours (at 5 metre intervals) of all permanent structures and works, including but not limited to, waste rock stacks, permanent earthworks, pit lakes, roads, water storage reservoirs or other works which under this consent or any related consent are authorised or required to remain after the relevant consents expire;

	(b) A summary of rehabilitation completed to date, and details of rehabilitation required to fulfil the conditions of this consent and any related consents; (c) Details on infrastructure to be decommissioned, such infrastructure may include buildings, plant, and equipment; (d) Details of specific infrastructure to remain on-site post-closure. Such infrastructure may include buildings, plant, equipment and any monitoring structures required by this consent and any related consent to remain after the expiry of the consents; (e) Details of management, any ongoing maintenance, monitoring and reporting proposed by the consent holder to ensure post-closure activities are carried out in accordance with the conditions of this consent; (f) Details of measures to protect public safety, including any fencing yet to be completed; (g) The costs of complying with (a)-(f) above.
5.3	The consent holder shall remove all buildings, plant and equipment (whether attached to the land or not) associated with site decommissioning. This condition does not apply to: (a) Any waste rock stacks, permanent earthworks, silt pond, waterbody, road or other works and any associated plant and equipment which under this or any other resource consent is permitted or required to remain after decommissioning or after this consent expires; (b) Any monitoring structure required by this or any other resource consent to remain after the expiry of this consent.
6.	**Complaints**
6.1	The consent holder shall maintain a record of any complaints received regarding their operation. The register shall include, but not be limited to: (a) Name and location of site where the problem is experienced; (b) Nature of the problem; (c) Date and time problem occurred, and when reported; (d) Action taken by consent holder to remedy the situation and any policies or methods put in place to avoid or mitigate the problem occurring again.
6.2	The register of complaints shall be incorporated into the Project Overview and Annual Work and Rehabilitation Plan required by Condition 3 of this consent and provided to the Waitaki District Council on request.
7.	**Blasting and vibration**
7.1	The consent holder shall ensure that blasting practices minimise air and ground borne vibration. Fly-rock shall be minimised, and all blasting procedures shall be carried out so as to ensure the safety of employees and the public.

7.2	Blasting authorised by this consent shall be restricted to within the following hours: Monday-Friday 9am to 530pm, Saturday, Sunday and public holidays 10am to 430pm.
7.3	Details of blasting method, strength of the blast and time of blast shall be entered into a record kept for that purpose and shall be available to the Waitaki District Council on request. This information shall also be included in the monitoring report, required under Condition 9.
7.4	Vibration due to blasting or any other activity associated with the mining operation, when measured at any point within the notional boundary of any dwelling not owned by the consent holder, shall not exceed a peak particle velocity measured in the frequency range 3-12 Hz of 5 mm/sec provided this level may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 10 mm/sec at any time.
7.5	Airblast overpressure from blasting associated with the mining operation, when measured at any point within the notional boundary of any dwelling not owned by the consent holder shall not exceed a peak non-frequency-weighted (Linear or flat) level of 115 decibels (dB), provided this level may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 120 dB (Linear peak) at any time. For the purpose of this consent, C-frequency-weighting may be considered equivalent to the Linear or Flat-frequency-weighting. *Note: The notional boundary is defined as a line 20 metres from the exterior wall of any rural dwelling or the legal boundary where this is closer to the dwelling*.
7.6	The consent holder shall send an email notification to surrounding residents on days that blasting is to occur with times of blasting and will notify residents at least 3 days prior with any changes to the blasting program.
8.	**Noise**
8.1	The consent holder shall ensure that all construction and operation activities associated with the mining operations are designed and conducted so that the following noise limits are not exceeded unless condition 8.2 applies at the locations specified in Condition 8.3: (a) On any day between 7 am to 9 pm (daytime): 55 dBA LAeq; and (b) On any day between 9.00 pm to 7.00am the following day (night-time): 40dBA LAeq; and/or 70 dBA LAmax.
8.2	No Heavy Vehicles other than a service truck shall use the haul road between the Deepdell North Stage III, Coronation, Coronation North or Coronation North Extension mine sites and the gold processing plant as shown on Figure Map 1 between the hours of 9.00 pm to 7.00am each day. Condition 8.2 ceases to have effect if the consent holder obtains an agreement with the residents of 406 Horse Flat Road that the condition is no longer necessary. If this agreement is obtained and verified by the Waitaki District Council, the Consent Holder shall be authorised to utilise this haul road for heavy vehicle purposes during the hours of 9.00pm to 7.00am, provided the noise levels at the notional boundary of 406 Horse Flat Road do not exceed 51dBA LAeq.

8.3	Noise measurements shall be taken at the notional boundary of any dwelling not owned by the consent holder. *Note: The notional boundary is defined as a line 20 metres from the exterior wall of any rural dwelling or the legal boundary where this is closer to the dwelling.*
8.4	All noise measurements referred to in Conditions 8.1 - 8.3 above shall be measured in accordance with the provisions of NZS 6801:2008 Acoustics: Measurement of Environmental Sound, and shall be assessed in accordance with the provisions of NZS 6802:2008 Acoustics: Environmental Noise.
9.	**Monitoring of noise, airblast and vibration**
9.1	Prior to exercise of this consent, the consent holder shall prepare a Noise, Airblast and Vibration Monitoring Plan, which shall be provided to Waitaki District Council. The plan shall include but not be limited to: (a) Details of the monitoring locations, the frequency of monitoring and the method of measurement and assessment in accordance with Conditions 7.4, 7.5 8.1, 8.2, 8.3; (b) Procedures for recording blasting method, strength of the blast and time of blast; and (c) Procedures for addressing non-compliant results and notification of the Waitaki District Council.
9.2	The Noise, Airblast and Vibration Monitoring Plan for this consent may be combined with any other Noise, Airblast and Vibration Monitoring Plan required by any other consent held by the consent holder for mining operations at Macraes Flat.
9.3	The consent holder shall exercise this consent in accordance with the Noise, Airblast and Vibration Monitoring Plan. The consent holder shall review the plan annually and if necessary, update it. Confirmation of the review shall be included in the Project Overview and Annual Work and Rehabilitation Plan. The Waitaki District Council shall be provided with any updates of the plan within one month of any update occurring.
9.4	The consent holder shall produce a report each year summarising the results of the Noise, Airblast and Vibration Monitoring. The report shall be included in the Project Overview and Annual Work and Rehabilitation Programme required by condition 3.1 of this consent.
9.5	All measurements from the monitoring program required by conditions 7.3 and 8.3 shall be recorded and shall be made available to the Waitaki District Council on request.
10	**Dust**
10.1	The consent holder shall carry out dust suppression measures on site in accordance with a Dust Management Plan.
11	**Fire**
11.1	The consent holder shall maintain an emergency response capability at the Macraes Gold Operation site and will take every reasonable precaution in the operation of the Deepdell North Stage III site to prevent fires from establishing.

12.	**Lighting**
12.1	All flood lighting luminaires utilised at site between sunset and sunrise that could potentially cause a glare nuisance, or a traffic hazard shall be, as far as is practicable, orientated so that the principal output is directed away from residences and traffic.
13.	**Waste Rock Stacks**
13.1	The Deepdell East Waste Rock Stack shall be constructed in general accordance with the design outlined in the consent application, in particular, the Waste Rock Stack design document attached to the resource consent application as Appendix J.
13.2	The Deepdell East Waste Rock Stack shown on Appendix I to this consent "Appendix I – Map 1 - Deepdell North Stage III proposal areas" shall not exceed a height of 680mRL.
14.	**Final Pit Lake**
14.1	(a) No less than twelve months prior to allowing the pit lake to fill through ending pit dewatering, the consent holder shall provide the Waitaki District Council with a closure manual for the Deepdell North Stage III Pit Lake. The manual shall include but not be limited to: (i) Details of the pit lake design requirements (ii) Details of the lake filling requirements, including but not limited to; • The location and method of the discharge into the pit, and; • Details of the long-term pit wall stability (b) The consent holder shall exercise the consent in accordance with the Closure Manual.
14.2	The consent holder shall exercise this consent in accordance with the Closure Manual in condition 14.1. The consent holder shall review the manual required by 14.1 annually and if necessary, update it. Confirmation of the review shall be included in the Project Overview and Annual Work and Rehabilitation Plan required by condition 3.1 of this consent. The consent holder shall provide the Waitaki District Council with any updates of the plan within one month of any update occurring.
15.	**Roading**
15.1	Within 6 months of all of Coronation, Coronation North, Coronation North Extension and Deepdell North Stage III pit excavations and rehabilitation ceasing, the consent holder shall reinstate for public use that part of Golden Point Road south of Horse Flat Road shown on "Appendix I – Map 1 – Deepdell North Stage III proposal areas" annexed.
15.2	Prior to any construction of the Deepdell East Waste rock stack that prevents the safe and practical public use of the existing alignment of Horse Flat Road, the realignment of Horse Flat Road and associated earth embankment and culvert must be constructed on the route shown on "Appendix I – Map 1 - Deepdell North Stage III proposal areas" and approved as open to the public by Waitaki District Council.
15.3	On Horse Flat Road, the sequence of vesting of new roads, road construction and road closures shall ensure that public vehicle and pedestrian access along this road is maintained within a legal road reserve

	on a carriageway conforming to the relevant standards set out in the conditions of this consent at all times, except that the roads may be temporarily closed from time to time for the purpose of blasting. All works on public roads shall be signed and managed in accordance with the NZTA Code of Practice for Temporary Traffic Management.
15.4	The realignment of Horse Flat Road required by condition 15.2 and the reinstatement of Golden Point Road south of Horse Flat Road required by condition 15.1 shall be constructed to the following details: (a) 15m minimum road reserve (b) 5m minimum carriageway width (c) Road shall be formed to a minimum 150 mm sub-base and a basecourse of 100mm AP40 with a wearing course of AP20 (d) The road shall also be delineated and marked to a public road standard (e) Geometric design will be in terms of Rural Road Design manual published by AUSTROADS – Sydney 1989 edition and any subsequent revisions.
15.5	No new tree planting by the consent holder shall be positioned such that when the trees grow, they would shade the new Horse Flat Road alignment between the hours of 1000 and 1400 on the shortest day of the year.
16	**Land for new public roads**
16.1	All land to be vested as road reserve for new roads shall be transferred to Waitaki District Council by the consent holder at no cost to Waitaki District Council. If any actual and reasonable costs are incurred by Waitaki District Council in facilitating the vesting of the road, such as survey, legal and consulting costs, these costs shall be paid in full by the consent holder.
17	**Road Closures**
17.1	The consent holder shall request the Waitaki District Council to initiate road stopping procedures in relation to all public roads to be stopped. All actual and reasonable costs including survey, legal and other consulting fees, and all of Waitaki District Council's direct costs associated with the closure procedures shall be paid in full to the Waitaki District Council by the consent holder.
18	**Disposal of Land under Closed Roads**
18.1	All road reserve land comprised as closed road shall be transferred from the Waitaki District Council to the consent holder as the owner of adjacent land. All land created by road closure shall immediately be amalgamated with the adjoining land.
18.2	The consent holder shall ensure that all existing parcels of land have frontage to a legal road at the completion of the amalgamations.
18.3	All actual and reasonable costs, including survey, legal, consulting fees and costs and disbursements incurred by the Waitaki District Council in disposing of the land under the closed roads shall be paid in full to the Waitaki District Council by the consent holder.

19	**Bonds**
19.1	(a) The consent holder shall provide and maintain in favour of the Consent Authority one or more bonds to secure: (i) The performance and completion of rehabilitation in accordance with the conditions of this consent; and (ii) The carrying out of the monitoring required by the conditions of this consent; and (iii) The remediation of any adverse effect on the environment that may arise from the exercise of this consent. (iv) Compliance with conditions 19.1(m) to 19.1(q) of this consent. (b) Before the first exercise of this consent, the consent holder shall provide to the Consent Authority one or more bonds required by condition 19.1(a). (c) Subject to the other provisions of this consent, any bond shall be in the form and on the terms and conditions approved by the Consent Authority. (d) Any bond shall be given or guaranteed by a surety acceptable to the Consent Authority. (e) The surety shall bind itself to pay for the carrying out and completion of the conditions of consent which are the subject of the bond on default by the consent holder or the occurrence of any adverse environment effect requiring remedy; during or after the expiry of this consent. (f) The amount of each bond shall be fixed annually by the Consent Authority which will take into account any calculations and other matters submitted by the consent holder relevant to the determination of the amount to be bonded in the Project Overview and Annual Work and Rehabilitation Plan. (g) The amount of the bond(s) shall include: (i) The estimated costs of complete rehabilitation in accordance with the conditions of consent on the completion of the mining operations proposed for the next year and described in the Project Overview and Annual Work and Rehabilitation Plan. (ii) The estimated costs of: - Monitoring in accordance with the monitoring conditions of the consent; - Monitoring for and of any adverse effect of the activity authorised by this consent which may become apparent during or after expiry of this consent; - Monitoring any rehabilitation required by this consent. (iii) Any further sum which the Consent Authority considers necessary for monitoring and dealing with any adverse effect on the environment that may arise from the exercise of the consent whether during or after the expiry of this consent. (h) The amount shall be calculated for the duration of this consent and for a period of 20 years after its expiry.

	(i) If, on review, the total amount of bond to be provided by the consent holder is greater or less than the sum secured by the current bond(s), the consent holder, surety and the Consent Authority may, in writing, vary the amount of the bond(s). (j) While the liability of the surety is limited to the amount of the bond(s), the liability of the consent holder is unlimited. (k) Any bond may be varied, cancelled, or renewed at any time by written agreement between the consent holder, surety and Consent Authority (l) The actual and reasonable costs (including the costs of the Consent Authority) of providing, maintaining, varying and reviewing any bond shall be paid by the consent holder. (m) For a period of 20 years from the expiry or surrender of this consent the consent holder shall provide in favour of the Consent Authority one or more bonds. (n) The amount of the bond to be provided under Condition 6(m) shall include the amount (if any) considered by the Consent Authority necessary for: (i) Completing rehabilitation in accordance with the conditions of this consent. (ii) Monitoring for and of any adverse effect on the environment that may arise from the exercise of the consent. (iii) Monitoring any measures taken to prevent, remedy or mitigate any adverse effect on the environment that may arise from the exercise of this consent. (iv) Dealing with any adverse effect on the environment which may become apparent after the surrender or expiry of this consent. (v) Contingencies. (o) Without limitation, the amount secured by the bond given under condition 19.1(m) may include provision to deal with structural instability or failure, land and water contamination, and the failure of rehabilitation in terms of the rehabilitation objectives and conditions of this consent. Costs shall include costs of investigating, preventing, remedying or mitigating any adverse effect. (p) The bond(s) required by condition 19.1(m) must be provided on the earlier of: (i) 12 months before the expiry of this consent. (ii) Three months before the surrender of this consent. (q) Conditions 19.1(c), (d), (e), (h), (i), (j) and (k) apply to the bond(s) required by Condition 19.1(m).
20.	**Nature conservation and landscape values**
	Ecological Management Plan (EMP)
20.1	Prior to exercising this consent, the consent holder shall engage a suitably qualified and experienced ecologist to prepare and submit to the Council a Deepdell North Stage III Project Ecological Management Plan ("EMP"). The EMP may be combined with any EMP required by any other consent held by the consent

	holder for mining operations at Macraes Flat. The purpose of the EMP is to minimise the actual and potential adverse effects on the Threatened, At Risk and Locally Uncommon species and general ecological values. The EMP shall be in accordance with the resource consent application and particularly the recommendations within the Terrestrial Effects Assessment and Impact Management Plan attached to the application as Appendix D and within the Aquatic Ecology Effects Assessment Report attached to the application as Appendix O. The consent holder shall provide a copy to the Department of Conservation, Nga Runaka, Otago Regional Council and Waitaki District Council.
20.2	The EMP shall: (a) Include sections covering vegetation and threatened plant management, lizard management and aquatic management; (b) Have the following objectives: (i) To minimise the adverse effects from the implementation of the Deepdell North Stage III Project on amenity/landscape; indigenous vegetation; threatened plants; resident lizard populations; and aquatic biota; (ii) To protect indigenous flora, threatened, at risk and locally uncommon plants and vegetation types; resident lizard populations, and aquatic fauna where practicable. (c) Detail the methods by which the objectives set out in Condition 20.2(b) shall be achieved, including: (i) Legal protection, fencing and management of offset area(s) as described in conditions 20.4-20.6; (ii) Salvage, propagation and transplanting of the threatened plants identified in condition 20.8; (iii) Minimisation of construction effects of Deepdell East Waste Rock Stack by keeping the area of disturbed land to a minimum; and (iv) Monitoring. (d) The consent holder shall implement the programme of activities specified in the EMP and in any subsequent EMP actions created pursuant to condition 20.2(c).
	Ecological Monitoring Report (EMR)
20.3	The consent holder shall engage a suitably experienced and qualified ecologist, to prepare an annual Deepdell North Stage III EMR: (a) Describing the works and other actions completed by the consent holder in the previous twelve months in order meet the purpose and objectives of the EMP; and (b) Evaluating the progress of the planting on rehabilitated land, transplanting of threatened plant species and the propagation and subsequent planting of the two Locally Uncommon and Naturally Uncommon plant species listed in condition 20.8. (c) Describing what methods are to be implemented in the following 12 months in order to meet the purpose and objectives of the EMP.

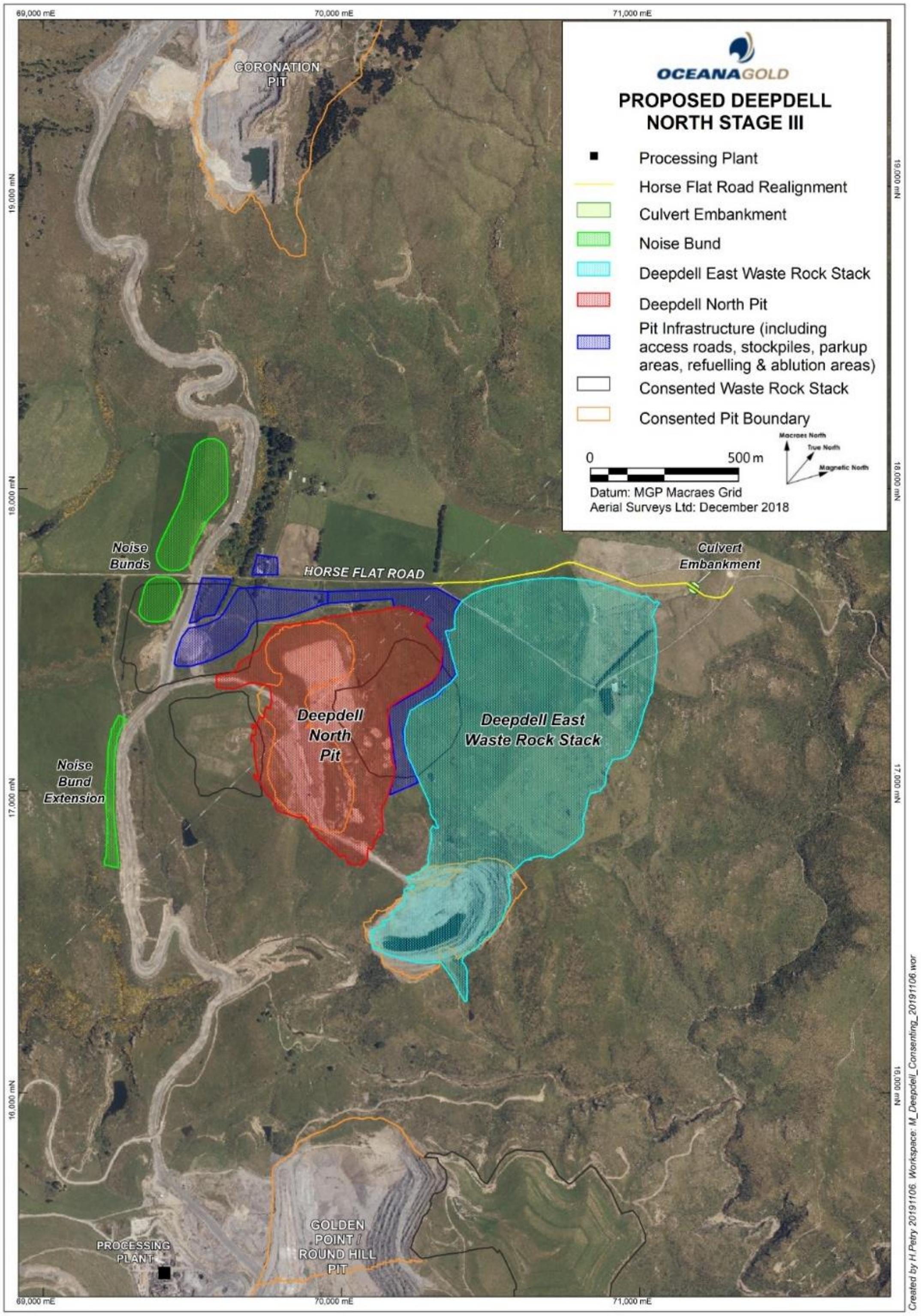
	The consent holder shall provide the Waitaki District Council, Aukaha and the Department of Conservation with a copy of the report by no later than 31 July each year. The report may be combined with any EMP report required by any other consent held by the consent holder for mining operations at Macraes Flat.
	Ecological Enhancement Area Programme (EEAP)
20.4	Not less than 20 working days prior to the commencement of any works associated with the Deepdell North Stage III, the consent holder shall prepare as a subset of the EMP in conditions 20.1 and 20.2 of this consent, an EEAP. The purpose of this programme shall be to offset any residual adverse effects of the Deepdell North Stage III on terrestrial ecology and indigenous biodiversity values within the Macraes Ecological District. The overriding objective of the programme shall be to achieve a no-net-loss and preferably a net gain in indigenous biological diversity in the Macraes Ecological District. The EEAP shall achieve this by ensuring that any offset that is undertaken aligns with the following objectives: (a) There is no loss of individuals of rare or vulnerable species as defined in reports published prior to 14 January 2019 under the New Zealand Threat Classification System ("NZTCS"); (b) The offset is undertaken where it will result in the best ecological outcome, preferably: (i) Close to the location of development; or (ii) Within the same Ecological District; (c) The offset is applied so that the ecological values being achieved are the same or similar to those being lost; (d) The positive ecological outcomes of the offset last at least as long as the impact of the activity, preferably in perpetuity; (e) The offset will achieve biological diversity outcomes beyond results that would have occurred if the offset was not proposed; and (f) The delay between the loss of biological diversity through the proposal and the gain or maturation of the offset's biological diversity outcomes is minimised.
20.5	The EEAP shall be implemented in at least two locations. The location and extent of these areas shall be confirmed in the EEAP submitted to the Waitaki District Council in condition 20.4. The consent holder shall ensure that the selected sites contain biodiversity that is of similar or better character to that being affected by the mining activities.
20.6	As part of the Ecological Enhancement Area Programme the consent holder shall prepare a plan for each site specified in condition 20.5 which shall include: (a) a description of the offset, the calculation basis, locations and management activities by which enhancements will be generated. These activities shall include but not be limited to: (b) Planting of a total of 5 ha of new shrubland comprising at least 18 different indigenous shrub species in the offset and reaching 2 m in height and 75% canopy cover within 10 to 20 years, respectively and keeping these 5ha free of exotic shrub species for 10 years (c) Using weed control to achieve a 20% improvement in indigenous species dominance within a

	minimum of 0.82 ha seepage wetland at the offset sites within 10 years (d) In addition to (ii), planting at least 50 individuals of Juncus distegus within seepage wetlands within the offset sites. (e) Including existing area(s) of low producing grassland of at least 24.55 ha within the offset sites and establishing safeguards against invasion of woody weed species and land disturbance within this habitat. (f) Using weed control to produce a 25% improvement in indigenous vegetation cover at ephemeral wetlands at 5-7 locations within the offset sites and totalling at least 2 ha and an improvement in indigenous plant diversity at each of the 5-7 locations to at least 11 indigenous plant species characteristic of Macraes ephemeral wetlands within 10 years. (g) Confirmation of the ability to undertake enhancement works within management sites by way of landowner agreements (e.g. covenants) or acquisitions; (h) The technical detail of the offset works; (i) The financial costs of site management into bond calculations or other similar instruments as required by Council that secure financial delivery of biodiversity enhancements; (j) A monitoring programme to assess the degree to which enhancement targets are being achieved and the ability to adjust biodiversity management to ensure that gains are achieved and maintained for the long term; (k) The roles and responsibilities of those carrying out the work, and the governance and management structures relating to the operation of the enhancement site(s); and (l) Reporting the results of monitoring results and a process for undertaking actions if enhancement targets are not being achieved as anticipated.
20.7	The consent holder shall be required to implement the components of the plan(s) set out in conditions 20.1 – 20.6.
20.8	The consent holder shall, using a suitably qualified person or persons, fund measures for the translocation and/or cultivation of seeds, cuttings or other cultivation material from the following plant species taken from plants located within the impacted footprint of the Deepdell North Stage III project ("salvage species") for planting out in the Highlay Creek shrubland covenant: (a) The Locally Uncommon shrub *Melicope simplex* from the eleven trees in the WRS to twenty individuals at one site in the nearby OceanaGold Highlay Creek Shrubland Covenant to create a new population there. (b) The Naturally Uncommon shrub *Myrsine divaricata* from the two individuals in the WRS to 10 individuals at one site in the nearby OceanaGold Highlay Creek Shrubland Covenant to create a new population adjacent to an existing population.
20.9	The consent holder shall monitor the success of all plantings carried out under the requirements of condition 20.8 annually for five years following planting and shall detail the plantings carried out and the

	"success" of the plantings in its annual Deepdell North Stage III Ecological Monitoring Report (EMR). In this context, success means the successful survival and growth of the plant species so that they may form potentially viable populations and shall be monitored by recording the survival and growth of individual plants and noting any flowering and recruitment of new individuals. Success shall be demonstrated by at least 75% of established plants surviving, or at least 50% of transplants increasing in size compared with their establishment.
20.10	The waste rock stack shall be progressively rehabilitated as areas are completed.
20.11	Upon mine closure the Consent Holder shall Remove and rehabilitate the haul roads and the areas used for mining infrastructure and parking, unless they are required within a reasonable timeframe for other ongoing or future mining projects.
21	**Fencing and marking**
21.1	Stock-proof fencing shall be used to keep livestock away from all working areas.
21.2	The consent holder shall Identify sensitive values on mine plans and limit disturbance to within the planned footprint by placing survey markers in the field prior to disturbance commencing.
21.3	On the completion of mining operations, the consent holder shall ensure that all fences, required to restrict people and/or stock for safety purposes, are installed and maintained. This shall include fences to be installed and maintained around the pit lake.
22	**Management of hazardous substances**
22.1	The Consent Holder shall ensure that all fuels and oils used at the site are contained in appropriately bunded facilities and that all fuel/oil dispensers are fitted with non-return valves.
22.2	Refuelling, lubrication and any mechanical repairs shall be undertaken in a manner that provides sufficient mitigation measures to ensure that no spillages onto the land surface or into water occur.
23	**Accidental discovery protocols**
23.1	If the consent holder discovers koiwi takata (human skeletal remains}, or Maori artefact material, the consent holder shall without delay: (a) Notify the Consent Authority, Takata whenua and New Zealand Historic Places Trust and in the case of skeletal remains, the New Zealand Police. (b) Stop work within the immediate vicinity of the discovery to allow a site inspection by the New Zealand Historic Places Trust and the appropriate runaka and their advisors, who shall determine whether the discovery is likely to be extensive; if a thorough site investigation is required and whether an Archaeological Authority is required. (c) Any koiwi takata discovered shall be handled and removed by tribal elders responsible for the tikanga (custom) appropriate tolsremoval or preservation. **Advice note:** An archaeological authority from the Heritage New Zealand Pouhere Taonga may be required before work can proceed.

	(d) Site work shall recommence following consultation with the Consent Authority, Heritage New Zealand Pouhere Taonga, Takata whenua, and in the case of skeletal remains, the NZ Police, provided that any relevant statutory permissions have been obtained.
24.	**Closure of Operations**
24.1	The consent holder shall annually supply to the Waitaki District Council a contingency plan for the early closure of the mine, as part of the Project Overview Annual Work and Rehabilitation Program. This contingency plan shall be updated annually. The plan shall address the objectives listed in condition 4.1 and include: (a) An evaluation of the residual risk of the operation with regard to the surrounding environment (b) A plan for the long term management of the site, in particular the pit, waste rock stack and the pit lake and include details of ongoing maintenance and monitoring requirements and restrictions on future use. (c) Describe in adequate detail what deeds to be carried out to: (i) Decommission the mine in accordance with this consent (ii) Rehabilitate the mine site in accordance with this consent to achieve the rehabilitation objectives (iii) Comply with other conditions with regard to cessation of mining; and (iv) The costs of complying with (i) – (iii)

Appendix I – Map 1 - Deepdell North Stage III proposal areas



Appendix II – To supply appropriate map illustrating monitoring locations

Appendix III – To supply appropriate map illustrating silt pond locations

T

APPENDIX T

Groundwater Effects Assessment

Oceana Gold (New Zealand) Limited (OGNZL)

Deepdell North Stage III Project Groundwater Assessment

January 2020

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Appendices

1. Introduction

1.1 Introduction

Oceana Gold (New Zealand) Limited (OGNZL) are planning to expand the Deepdell North pit and construct a new waste rock stack (WRS) within the Deepdell catchment at the Macraes mine site. Extension of the pit and development of the new WRS is termed the Deepdell North Stage III project.

The Macraes mine site has been operating since 1990 and comprises a number of open pits, the Frasers underground mine, tailings storage facilities (TSF's), ore processing facilities and several WRS's.

GHD Limited (GHD) has been engaged to complete an assessment of effects on groundwater from the proposed Deepdell North Stage III project. GHD has previously completed an assessment of effects on surface water for the project (GHD, 2019) which includes an assessment of waste rock seepage on receiving water quality.

1.2 Purpose of this report

The purpose of this report is to provide an assessment of groundwater effects to support OGNZL's consent application for the Deepdell North Stage III project (Mitchell Daysh, 2019). This report includes:

- A description of the groundwater setting
- An assessment of effects on groundwater levels from the proposed activities
- An assessment of effects on groundwater quality

1.3 Limitations

This report has been prepared by GHD for Oceana Gold (New Zealand) Limited (OGNZL) and may only be used and relied on by Oceana Gold (New Zealand) Limited (OGNZL) for the purpose agreed between GHD and Oceana Gold (New Zealand) Limited (OGNZL) as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Oceana Gold (New Zealand) Limited (OGNZL) arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Oceana Gold (New Zealand) Limited (OGNZL) and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.4 Assumptions

In preparing this groundwater assessment GHD has relied on information presented in a number of reports that describe the groundwater setting at the Macraes site. In particular, the following reports have been referenced and relied upon:

- Golder Associates, 2011. Macraes Phase III Project: Groundwater Contaminant Transport Assessment - Deepdell Creek, North Branch Wakouaiti River and Murphys Creek Catchments.
- Golder Associates, 2016. Coronation North Project: Groundwater Assessment.

In addition, GHD has assumed that the groundwater level and water quality data provided by OGNZL is representative of the groundwater and surface water environment at the Site.

2. Project Description

A full description of the proposed Deepdell North Stage III project is provided in Mitchell Daysh, 2019. In summary, OGNZL propose to:

- Extend the existing Deepdell North Pit further to the east. An additional 19.6 ha is proposed to be disturbed from the existing mining footprint. The existing pit floor is proposed to be deepened, from 438 m RL to 372 m RL.
- Develop a new WRS, Deepdell East WRS. The Deepdell East WRS is proposed to include back filling of the existing Deepdell South Pit, and is planned to extend north beyond Horse Flat Road. The WRS stack is expected to cover an area of 70.8 ha of which 57.6 ha will be new disturbance and the remainder will be backfilling in the pit.

Operational water management

- Water, comprising stormwater run-off and groundwater, is proposed to be collected in a sump at the base of the pit and pumped to an existing drain and directed to the Deepdell North Silt Pond (DNSP).
- Run-off from the WRS will be directed to sediment retention (silt) ponds as outlined in the erosion and sediment control report (Appendix R of the overall AEE). Some of the water in the silt ponds is proposed to be utilised for dust control on site during drier periods.
- Seepage through the WRS is planned to be collected at toe drains and directed to silt ponds.

Closure

- OGNZL do not intend to backfill the Deepdell North pit. At closure, surface water including WRS run-off, is proposed to be directed to the pit void to contribute to creating a lake, along with groundwater inflow to the pit. Due to the groundwater gradient and high evaporation rates, it is unlikely that the pit lake will overflow.

2.1 Resource Consents

The project requires a number of consents to be granted from both territorial and regional authorities. The following consents are applicable to the groundwater assessment:

- To take and use groundwater for the purpose of dewatering and dust suppression.
- To discharge contaminants to land in a manner that may enter (ground) water from the Deepdell North Stage III pit while constructing the open pit.
- To create a pit lake in the completed Deepdell North Stage III pit.
- To discharge contaminants to land in a manner that may enter (ground) water from the waste rock stack.

3. Description of the Environment

3.1 Climate

The average annual rainfall recorded at OGNZL's Golden Point climate station was 550 mm for the period 2012-2018 (Mitchell Daysh, 2019). Pan evaporation is approximately 1000 mm a year (Golder, 2016), exceeding 100 mm a month from October to March. Further detail on the site climate is presented in GHD (2019).

3.2 Hydrology

The project area is located within the Deepdell catchment. The Deepdell East WRS will be located on the catchment boundary of Highlay Creek (a tributary of Deepdell Creek) and an unnamed tributary of Deepdell Creek.

Deepdell Creek flows northeast through the site ultimately joining the Shag/Waihemo River. Deepdell Creek is characterised by extended periods of low flow, with occasional periods or sections of no surface flow, particularly through the summer months. Highlay Creek is also intermittent with periods of no visible flow in summer. A detailed description of the surface water system is provided in GHD (2019).

3.3 Geology

The geology of the Macraes area is described in Golder, 2011 and 2016. The geology of the project area comprises schist bedrock with thin cover of alluvium and colluvium. The area surrounding the project area is also mainly schist bedrock but also includes Eocene and Miocene age alluvial and lacustrine sediments (deposited on top of the bedrock), and Miocene basalts and shallow intrusive deposits.

Exploratory drilling indicates that a thin layer of loess covers much of the Macraes area. The loess soils comprise a very stiff, light grey silt, sandy silt or silty fine sand. Colluvium is present along the lower slopes of hillsides around the Macraes area and in the floor of local gullies. The colluvium comprises angular schist within a sandy/silty matrix (derived from loess).

The Hyde-Macraes Shear Zone (HMSZ) trends northwest to southeast (approximately north-south on the mine grid). The HMSZ comprises three components:

- The hanging wall shear
- The intrashear schist
- The footwall fault.

The mineralisation is focussed on the hanging wall shear and immediately underlying intrashear schist. There appears to be no significant difference between the hydraulic properties of the schist mass on either side of the footwall fault, with weathering and secondary fractures/faults being the significant influence on hydraulic conductivity

3.4 Water Quality

A description of the water quality at compliance locations in Deepdell Creek and the Shag River is provided in GHD (2018). Concentrations of key water quality parameters used in the water balance model are summarised in Table 3-1. This provides indicative water quality for different parts of the mine operation. In general, surface and groundwater waters have a neutral to slightly alkaline pH.

Table 3-1 Projected surface water quality from mine activity –mean values (g/m^3)

Parameter	Natural	Impacted	[1]Rehab Impact	Pit	Ponds	TSF
Ammonia	0.011	0.012	0.012	0.8	0.011	0.012
Arsenic	0.0018	0.04	0.02	0.2	0.0018	0.04
Copper	0.001	0.0012	0.001	0.02	0.001	0.0012
Hardness	65	1200	630	880	65	1200
Iron	0.05	0.032	0.14	0.9	0.24	0.032
Lead	0.00015	0.0002	0.00019	0.001	0.00015	0.00022
Nitrate	0.05	0.094	0.4	2.0	10.5	0.1
Sulphate	24	930	470	1400	1500	930
Zinc	0.001	0.001	0.001	0.0056	0.001	0.001

Notes

1. Rehab impact – areas other than WRS that have been rehabilitated

4. Groundwater Assessment

4.1 Introduction

A conceptual model of the groundwater system was developed based on site information provided by OGNZL and previous reports which are referenced throughout this report. Key hydrogeological parameters are discussed in the following sections, including groundwater levels (hydraulic head), groundwater flow direction, and hydraulic conductivity of the rock mass.

The proposed Deepdell North Stage III project is an extension of a previously mined area. Therefore, an understanding of the mining history is required when reviewing the groundwater information. The history of mining operations in the Deepdell area is summarised below:

- 2001 – 2002: Mining in Deepdell North Pit.
- 2002 – 2003: Back filling of Deepdell North Pit
- 2002 – 2003 : Mining of Deepdell South Pit, pit void left to fill as a lake

4.2 Groundwater Levels

Groundwater levels in six monitoring wells (DDB01-06) located in the Deepdell Pit vicinity are monitored on a monthly basis. The groundwater monitoring record extends from 2001 to present, however there is a large gap in the record from April 2008 to March 2010. In addition, from December 2010 to January 2014 groundwater levels were only measured on a quarterly basis. Groundwater level plots are included in Appendix A. The groundwater level plots indicate:

- A delay/lag in the groundwater response to dewatering activities in the Deepdell area. Minimum recorded groundwater levels generally occurred in early 2004, after mining and backfilling in Deepdell North Pit had finished.
- The magnitude of groundwater drawdown and level fluctuations varies between monitoring wells. The greatest drawdown was recorded in DDB02, with approximately 17 m of groundwater drawdown. However, it is noted that the groundwater level between November 2002 and June 2004 was consistent, with levels at or about 24.35 m below ground level (463.65 mRL). This is similar to the total depth of the well (25 m). It is likely that these measurements represent a dry well, with the small amount of water at the base of the well below the well screen within the blank and capped end section of the piezo being measured. If this is the case, it is likely that the groundwater level in the surrounding rock continued to decrease further in response to dewatering activities. Groundwater levels in DDB02 had fully recovered by October 2010 to levels observed pre-dewatering.
- Groundwater levels in DDB04 decreased by approximately 10 m, with the lowest groundwater level recorded in April 2004. Groundwater levels started to increase in August 2004, but have not recovered to levels observed prior to dewatering activities at the Site. Since 2010 groundwater levels have fluctuated between 468 mRL and 472 mRL, down from 476.5 m recorded in 2001. DDB04 is the closest well to Deepdell South Pit.
- Smaller groundwater drawdowns (5 m or less) were measured in the other monitoring wells. Groundwater levels in DDB05 remain approximately 2.5 m below 2001 measurements. While no dewatering impact is evident in the DDB06 groundwater level record, there has been a steady increase in water levels since 2001. This may be related to the presence of a silt pond at the base of the existing Deepdell North WRS.

Groundwater contour plots showing groundwater levels measured in 2019 and 2004 are included in Appendix A. These plots show the groundwater elevation at present and the lowest recorded water levels (~June 2004). It is assumed that Deepdell Creek acts as a groundwater divide, capturing groundwater flow from both sides of the waterbody. Therefore, surface water elevations in Deepdell Creek (approximate from contours) were used to constrain the groundwater elevation to the south of the project area. Following mining the Deepdell South Pit was left to fill as a lake. After an initial increase, the Deepdell South Pit Lake has been relatively stable since 2008, stabilising at a level of around 376 mRL. The water level of the pit lake has also been included in 2019 the groundwater contour map.

The groundwater contours maps show:

- Groundwater flow to the south east (towards Deepdell Creek)
- The shape of the groundwater contours and groundwater gradients are similar for the two monitoring events, with the following exceptions:
  - The 2004 contours show a lower groundwater level in the north of the project area, particularly around DDB02 due to the dewatering activities.
  - The impact of the Deepdell South Pit Lake intercepting groundwater from the north and west and inferred to discharge to the south and east (towards Deepdell Creek)
- The elevation of the groundwater surface is below the elevation of valley inverts. This suggests that the small surface watercourses on the north side of Deepdell Creek are unlikely to receive significant groundwater base flow. It is possible that localised fractures in the schist may intercept perched groundwater and discharge to surface water.

4.3 Hydraulic Conductivity

The hydraulic conductivity of the schist rock mass has been defined through a combination of hydraulic and packer testing, and through the calibration of the site wide groundwater model (Golder 2011). While there are localised variations in permeability depending on the degree and connectedness of fractures, Golder (2011) considered that the permeability of the schist mass as a whole does not vary substantially across the site. However, the following variations in hydraulic conductivity are noted:

- Degree of weathering: the upper weathered schist is considered to have a higher hydraulic conductivity due to an increase in fractures and fracture aperture
- Anisotrophy due to structural features

Drillhole data indicates numerous northwest striking high angle faults. Calibration of the site groundwater model has indicated a higher permeability in the northwest-southeast (Macraes north-south) direction compared to the southwest-northeast (Macraes east-west) orientation.

The hydraulic conductivities used by Golder (2011) in the site groundwater model have been adopted for this assessment and are shown in Table 4-1 below:

Table 4-1 Adopted hydraulic conductivity (from Golder, 2011)

Geological feature	K_x (m/s)	K_y (m/s)	K_z (m/s)
Weathered schist	3.5×10^{-7}	1.0×10^{-6}	2.5×10^{-7}
Moderately weathered schist	1×10^{-7}	2.5×10^{-7}	6.0×10^{-8}

Geological feature	K_x (m/s)	K_y (m/s)	K_z (m/s)
Slightly weathered schist	9.0×10^{-9}	9.0×10^{-9}	1.0×10^{-9}
Unweathered schist	1.0×10^{-9}	5.0×10^{-9}	5.0×10^{-10}
Waste rock	1.0×10^{-6}	1.0×10^{-6}	1.0×10^{-6}

The Hyde-Macraes Shear Zone (HMSZ) trends northwest to southeast (approximately north-south on the mine grid). The HMSZ comprises three components:

- The hanging wall shear
- The intrashear schist
- The footwall fault.

The mineralisation is focussed on the hanging wall shear and immediately underlying intrashear schist. There appears to no significant difference between the hydraulic properties of the schist mass on either side of the footwall fault, with weathering and secondary fractures/faults being the significant influence on hydraulic conductivity.

4.4 Groundwater conceptual model

The conceptual model for the groundwater system is shown in Figure 4-1. The conceptual model has been divided into three stages, representing:

- Current groundwater conditions (A)
- Groundwater drawdown at maximum pit depth (B)
- Formation of a pit lake (C)

The conceptual model shows;

- Groundwater flow from the northwest to the southeast towards Deepdell Creek
- Greater drawdown impact on the northwest side of the pit compared to the southeast
- The base of the pit is higher than the elevation of Deepdell Creek, therefore drawdown impacts are not expected to extend to the Creek.
- Formation of a lake in the pit void.

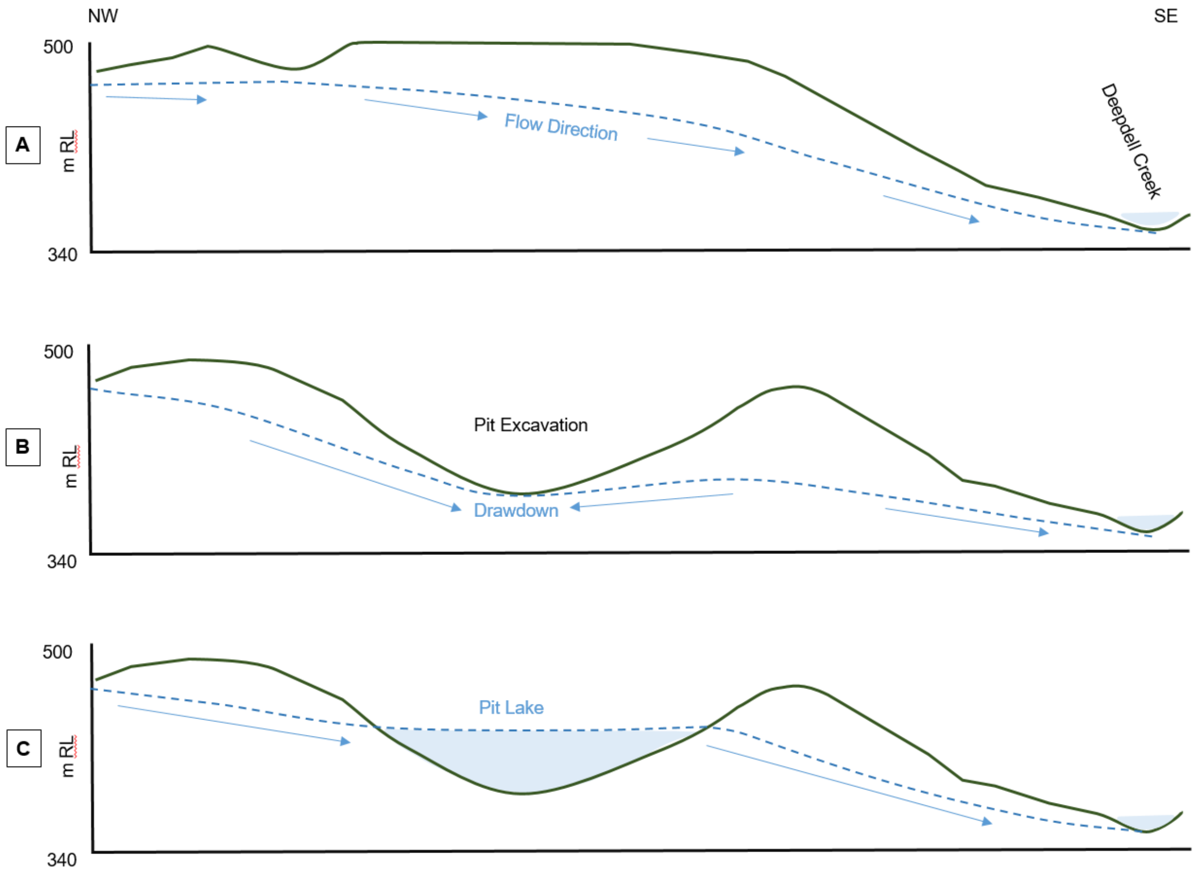


Figure 4-1 Conceptual Model of the groundwater system

4.5 Groundwater flow into pit

Groundwater flow into the proposed Deepdell North pit has been calculated using analytical equations (Marinelli & Niccoli, 2000) to define a groundwater drawdown cone around the pit. The pit inflow calculations are provided in Appendix B and the results are included in Table 4-2. The analytical method is considered to be conservative (i.e. it is likely to over-estimate inflows to the pit). A key assumption of the analytical method is that the pit inflows are axially symmetric, (i.e. inflows are the same in all directions), whereas the groundwater model calibration indicates that groundwater flow is anisotrophic due to faulting and other structural features in the schist. The pit inflow calculation has used the hydraulic conductivity K_x of the more permeable northwest-southeast (Macraes north-south) orientation.

In addition, the assessment has been based on the maximum drawdown using the groundwater level at the northern end of the proposed pit. Due to the steep groundwater hydraulic gradient the drawdown effects are expected to be much less on the southern side (nearer to Deepdell Creek). The historical water level observations in the Deepdell monitoring wells confirm that the groundwater drawdown effects are less towards the south-southeast, compared to the northern side (eg. DDB02).

Table 4-2 Predicted groundwater inflows

	At closure (pit floor 372 m RL)	Pit lake (lake level 430 m RL)
Drawdown cone radius (m)	580	370
Inflow seepage rate (zone 1 -m^3/day)	98	4.5
Inflow seepage rate (zone 2 - m^3/day)	29	0.1
Inflow seepage rate (total - m^3/day)	127	4.6
Inflow seepage rate (total - L/s)	1.5	0.05

4.6 Pit lake level

The water balance model (WBM) (GHD, 2018) predicts that the pit lake will reach a level of 430 mRL by 2060. This value has been used in the groundwater inflow assessment (Appendix B). The water balance modelling is primarily based on surface water flows and did not incorporate ground water inflow rates for the proposed Deepdell North Pit. Based on this assumption, the WBM predicts that the lake will not reach the potential overflow level of 465 mRL for at least 100 years. With the additional consideration of the projected ground water elevation of 430 mRL at the southern extent of the pit (Figure A-2), it is likely that the lake level will equilibrate with groundwater system on the southern side as shown in the conceptual model (Figure 4-1). At this lake level the groundwater analytical assessment predicts a groundwater inflow of approximately 0.05 L/s. Given the precipitation balance of rainfall and evaporation in the Macraes area, it is likely that the pit lake will equilibrate at approximately 430 mRL and not reach the overflow level of 465 mRL.

4.7 Seepage through WRS

An assessment of seepage water quality is provided in the WBM report (GHD, 2019). It is assumed that the vast majority of seepage water will be intercepted by toe drains at the base of the WRS. A small proportion may be intercepted by fractures at the ground surface and into groundwater. The WBM assumes that all seepage will be intercepted by toe drains, directed to sediment ponds and ultimately discharge to Deepdell Creek or other streams. While the groundwater component has not been directly assessed, the flows and water quality effects of the WRS seepage on the receiving water bodies has already been taken into account in the surface water modelling.

4.8 Lake and groundwater quality

Following mine closure, surface water and groundwater will be directed to the proposed Deepdell North Pit Lake. Initially, groundwater will flow into the pit void from all directions. However, as the lake fills, groundwater will predominantly flow into the pit from the north-northwest. In later stages, when equilibrium conditions are met, lake water will migrate into groundwater and flow down gradient towards Deepdell Creek. Therefore, to understand the impact of the project on groundwater quality, water quality data from the Deepdell South Pit Lake was reviewed (Golder, 2014). The Deepdell South Pit Lake water samples shows the changes in water quality as the pit lake evolves. Initially the concentration of arsenic was elevated (~0.5 g/m^3). The concentration of arsenic decreased over a 4-5 year period to 0.2 g/m^3. This is interpreted to reflect the transition from groundwater dominated to a surface water dominated lake and the rapid weathering of relict arsenic minerals in the pit wall. It is likely that a similar process will occur in the proposed Deepdell North Pit Lake prior to any discharge to groundwater.

5. Assessment of Effects

The following section discusses the actual and potential effects on the groundwater system from the proposed Deepdell North Stage III project. The potential effects considered are:

- Effects on groundwater levels from the proposed activities
- Effects of dewatering on surface water flows
- Effects on groundwater quality

5.1 Assessment of effects on groundwater levels

The base elevation of the Deepdell North Pit is proposed to be 372 mRL. As this level is below the groundwater surface, dewatering via a sump at the base of the pit is likely to be required. The analytical solution (Appendix B) provides an estimate of likely dewatering volumes and the anticipated groundwater drawdown at mine closure. The drawdown impact is expected to extend approximately 580 m from the centre of the pit, with greater drawdown impacts on the north-northwest side of the pit. Groundwater drawdown effects to the south-southeast of the pit are expected to be less, as shown by the groundwater response to the dewatering of the Deepdell North Stage I pit. The groundwater drawdown effects are expected to be constrained within the boundaries of land owned by OGNZL. The ORC bore consent database only shows OGNZL monitoring wells located in the surrounding area, therefore no other groundwater users are expected to be impacted by dewatering activities.

5.2 Assessment of effects on surface water flows

The impact of the proposed dewatering on groundwater levels and flows into Deepdell Creek is expected to be less than minor, for the following reasons:

- Deepdell Creek is outside of the estimated zone of groundwater drawdown impacts.
- Deepdell Creek is at a lower elevation than the base the proposed pit, therefore the groundwater level will not be drawn below the stream bed elevation.

While the proposed dewatering is not expected to directly impact groundwater levels near Deepdell Creek, it may reduce groundwater discharge to the stream. However, as groundwater is only a very small proportion of flows in Deepdell Creek[1], the effect of the project on surface water flows are likely to be less than minor.

5.3 Assessment of effects on groundwater quality

The project has the potential to impact groundwater quality through the following ways:

- Infiltration of WRS seepage into groundwater
- Inflow of pit lake water into groundwater (at equilibrium)

The impact of the WRS seepage has been assessed in the WBM (GHD, 2019) while this assessment considered the surface water quality effects, the receiving environment of any groundwater seepage is surface water bodies (i.e. Deepdell Creek). The WBM showed a low potential for future non-compliance with applicable water quality resource consent conditions.

The impact of lake water inflow on groundwater quality is expected to be less than minor. The review of the Deepdell South Pit Lake water quality showed the water quality stabilising

[1] Mean flow to Deepdell catchment DC04 is ~150 L/s, but stream flows regularly drops below 10 L/s, based on this groundwater inflows are assumed to be <10 L/s (GHD WBM)

following initial high arsenic concentrations. Given the slow rate of lake filling (GHD, 2019) it is expected that the pit lake water quality will stabilise several years before any discharge to groundwater.

5.4 Summary

This assessment has shown that the effects of the proposed Deepdell North Stage III project on groundwater is expected to be less than minor. To assess the impact of the proposed dewatering on groundwater levels, it is recommended that monthly monitoring of groundwater levels in DDB01-06 is continued.

6. References

GHD, 2019. Deepdell North Stage III Project: Receiving Water Quality Analysis. Report prepared for Ocean Gold New Zealand Limited, November 2019.

Golder Associates, 2011. Macraes Phase III Project: Groundwater Contaminant Transport Assesssment – Deepdell Creek, North Branch, Waikouiti River and Murphys Creek Catchment. Report prepared for Oceana Gold (New Zealand) Ltd, April 2011.

Golder Associates, 2014. Macraes Gold Project: Review of Deepdell South Pit Lake Monitoring Data (Draft). Report prepared for Oceana Gold (New Zealand) Ltd, October 2014.

Golder Associates, 2016. Coronation North Project: Groundwater Assessment. Prepared for Oceana Gold (New Zealand) Ltd, 13 May 2016.

Marinelli, R. & Niccoli, W., 2000. Simple Analytical Equations for Estimating Ground Water Inflow to a Mine Pit. Ground Water 38 (2) 311-314

Mitchell Daysh Limited, 2019. Deepdell North Stage III Project: Assessment of Environmental Effects. Prepared for Oceana Gold (NZ) Ltd, 6 December 2019.

Appendices

Appendix A – Groundwater Levels

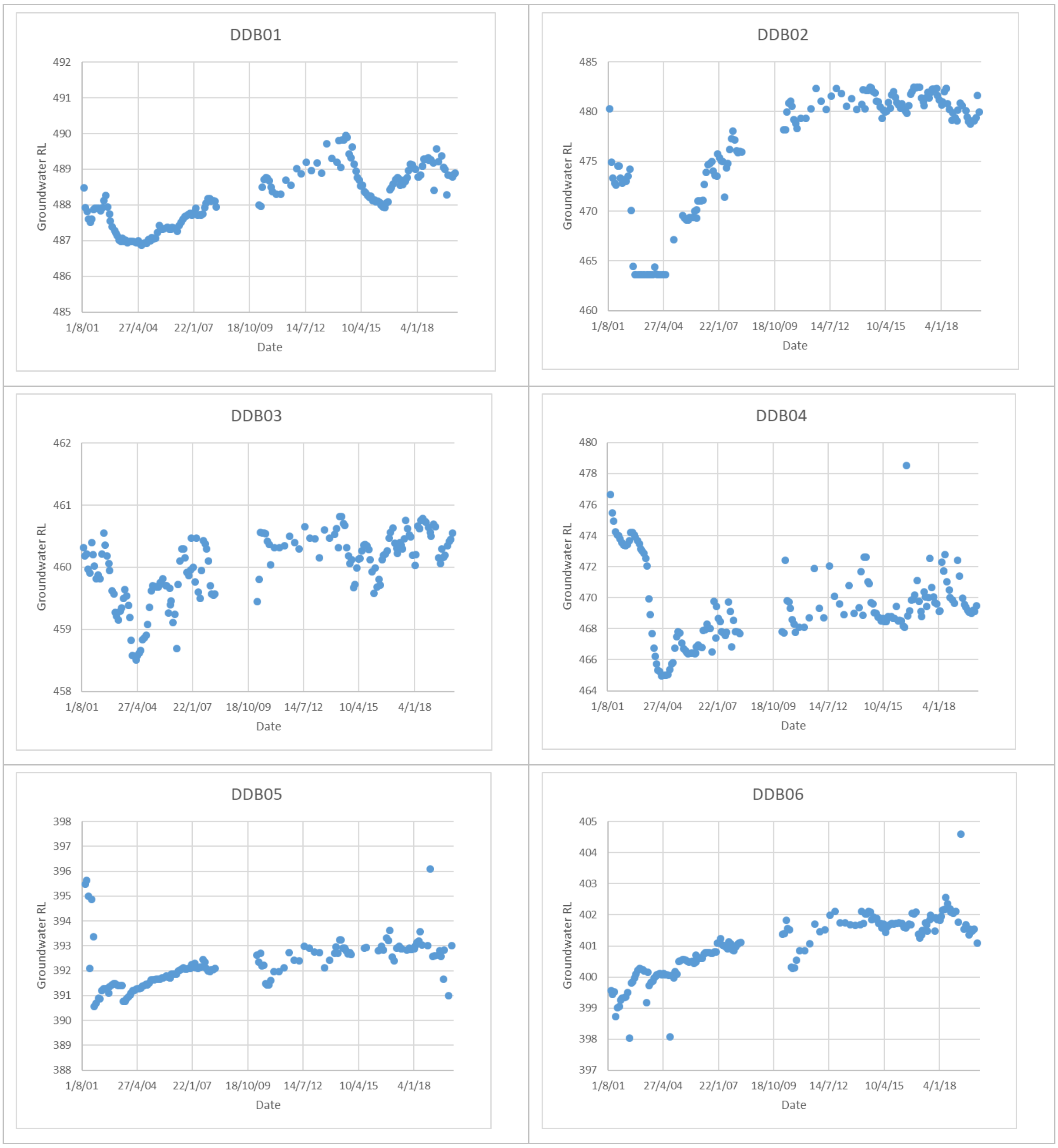
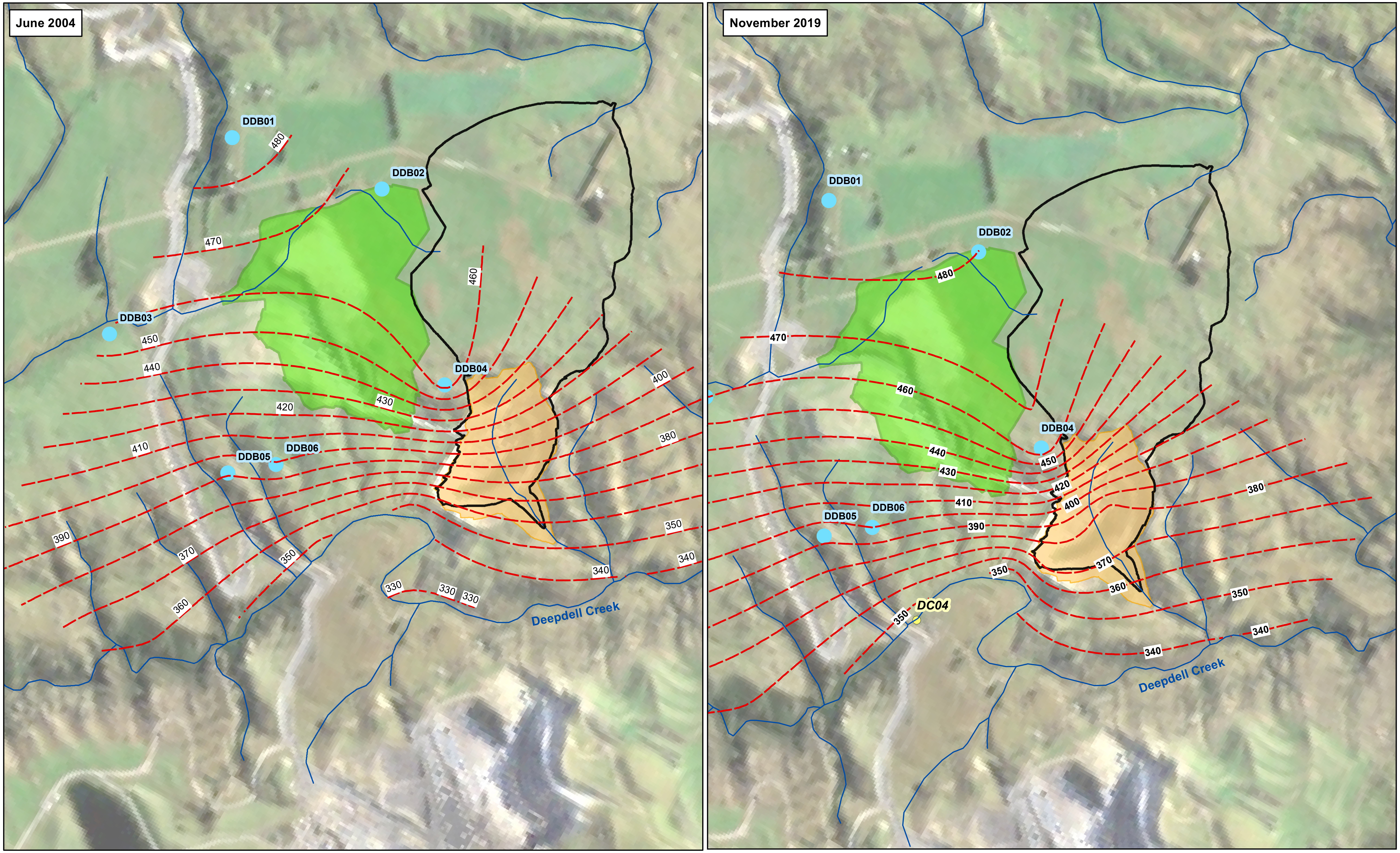


Figure A1: Groundwater levels in Deepdell monitoring wells



Paper Size A3

0 55 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

LEGEND

- Groundwater Contours
- Watercourses
- Monitoring Wells
- Deepdell North III Pit Boundary
- Deepdell South Pit Backfill
- Deepdell East Waste Rock Stack

GHD

OCEANAGOLD

Oceana Gold Limited
Deepdell North Stage III Project

Groundwater Contours

Job Number	12502848
Revision	A
Date	22 Jan 2020

Figure A-2

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Appendix B – Analytical assessment of pit inflows

Introduction

Groundwater inflows were estimated using the steady state analytical solutions of Marinelli & Niccoli (2000). Groundwater inflows were assessed for the following scenarios:

- Groundwater inflows at pit closure (maximum pit depth) - representing the maximum dewatering volumes
- Groundwater inflows at 430 m RL lake level (Year 2060)

The analytical solutions represent the steady state groundwater conditions and provide an estimate of the average long term inflow rate. As the pit is excavated in stages, the dewatering sump at the base of the pit is lowered and the groundwater level will reach a new equilibrium. Transient (short term) groundwater inflows may occur at higher rates, this is dependent on where significant fracture sets are intercepted and is difficult to predict.

The analytical solution assumptions are listed on the attached worksheets. A key assumption of the analytical method is that the pit inflows are axially symmetric, ie inflows are the same in all directions. Whereas, the groundwater model calibration indicates that groundwater flow is anisotrophic due to faulting and other structural features in the schist (Golder, 2011). The pit inflow calculation has used the hydraulic conductivity K_x of the more permeable northwest-southeast (Macraes north-south) orientation.

In addition, the assessment has been based on the maximum drawdown using the groundwater level at the northern end of the proposed pit. Due to the steep groundwater gradient, the drawdown effects are expected to be much less on the southern side (nearer to Deepdell Creek). The historical water level observations in the Deepdell monitoring wells confirm that the groundwater drawdown effects are less towards the south-southeast, compared to the northern side (eg. DDB02).

Table B1: Input parameters for analytical assessment at pit closure

Parameter	Units	Value	Comments
W	m/day	0.0015	Based on recharge of 32 mm/yr
K_{h1}	m/s	9.0×10^{-9}	K_h for slightly weathered schist
K_{h2}	m/s	1.0×10^{-9}	K_h for unweathered schist
K_v	m/s	5.0×10^{-9}	K_v for unweathered schist
h_o	m	108	Height from pre mining water table (at northern end) to base of proposed pit
h_p	m	2	Estimated based on observations of other pits
r_p	m	356	Approximate from pit layout design
d	m	2	Assumed depth of water in pit sump

Table B2: Input parameters for analytical assessment at lake level 430 m RL

Parameter	Units	Value	Comments
W	m/day	0.0015	Based on recharge of 32 mm/yr
K_{h1}	m/s	9.0×10^{-9}	K_h for slightly weathered schist
K_{h2}	m/s	1.0×10^{-9}	K_h for unweathered schist
K_v	m/s	5.0×10^{-9}	K_v for unweathered schist
h_o	m	108	Height from pre mining water table (at northern end) to base of proposed pit
h_p	m	58	Estimated based on observations of other pits
r_p	m	356	Approximate from pit layout design
d	m	58	Assumed depth of water in pit sump

Table B3: Results of analytical assessment

	At closure (pit floor 372 m RL)	Pit lake (lake level 430 m RL)
Drawdown cone radius (m)	580	370
Inflow seepage rate (zone 1 -m^3/day)	98	4.5
Inflow seepage rate (zone 2 - m^3/day)	29	0.1
Inflow seepage rate (total - m^3/day)	127	4.6
Inflow seepage rate (total - L/s)	1.5	0.05

Estimating Groundwater Inflow into a Mine Pit

For conceptualisation purposes:
Zone 1 exists above the base of the pit and represents flow to the pit walls
Zone 2 extends from the bottom of the pit downward and considers flow into the pit bottom.
Analytical models assume that there is no groundwater flow between Zones 1 and 2

Reference
Marinelli, F., and W.L. Niccoli, 2000: Simple Analytical Equations for Estimating Ground Water Inflow to a Mine Pit. Groundwater Vol 38, No.2

$$h_o = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left(r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \left(\frac{r_o^2 - r_p^2}{2}\right)\right)}$$

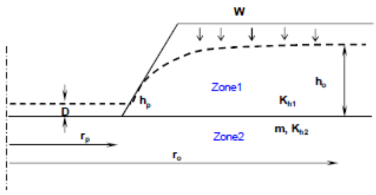
$$Q_1 = W\pi\left(r_o^2 - r_p^2\right)$$

$$Q_2 = 4r_p\left(\frac{K_{h2}}{m_2}\right)(h_o - d)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

Assumptions
Zone 1
Pit walls are approximated as a right circular cylinder
Groundwater flow is horizontal (Dupuit - Forchheimer approximation is valid)
The static (premining) water table is horizontal
Groundwater flow toward the pit is axially symmetric
Uniform distributed recharge occurs across the site as a result of surface infiltration.
All recharge in the radius of influence is captured by the pit.

Zone 2
Hydraulic head is initially uniform throughout the zone. Initial head is equal to the elevation of the initial water table in zone 1
The disk sink has constant hydraulic head equal to the elevation of the pit lake water surface. If the pit is dewatered the disk sink head is equal to the elevation of the pit bottom.
Flow to the disk sink is three dimensional and axially symmetric



If a rectangular pit		
Length	800	m
Width	500	m
R_{pit}	356.82	m
Distributed recharge flux (W):	0.00015	m/day
Horizontal hydraulic conductivity (K_{h1}):	7.70E-04	m/day
Horizontal hydraulic conductivity (K_{h2}):	8.60E-05	m/day
Effective pit radius (r_p):	356.82	m
Saturated thickness at pit wall (h_p):	2	m
Radius of influence (r_o):	580	m
Depth of the pit lake (D):	2	m
Initial (pre-mining) saturated thickness above base (h):	108	m

Recharge check: 32 mm/yr

(set this to zero to maximise pit inflow)

Ground level	500	mAHD
Observed WL	20	mBG
	480	mAHD
Base of Pit	372	mAHD
Depth below WL	108	m

Deepdell North Stage III Project
Estimate of groundwater inflows into Deepdell North Stage III Pit

Groundwater inflow at maximum pit depth (372 mRL)

Step 1 Calculate h_o using an assumed radius of influence
h_o = 107.119 m

Step 2 Iterate to determine the radius of influence until it calibrates the standing water level (h)

Step 3 Calculate pit inflow rate from Zone 1

Effective pit radius (r_p):	356.82	
Radius of influence (r_o):	580	
Q_1 =	98.53	m^3/day

Step 4 Calculate pit inflow rate from Zone 2

Horizontal hydraulic conductivity (K_{h2}):	8.60E-05	m/day
Vertical k (kv) factor	0.2	
Vertical hydraulic conductivity (K_{v2}):	4.30E-04	m/day
Q_2 =	28.85	m^3/day

Step 5 Calculate total pit inflow

Q_t =	127.38	m^3/day		
	127378	L/day	1.47	L/s

Estimating Groundwater Inflow into a Mine Pit

For conceptualisation purposes:
Zone 1 exists above the base of the pit and represents flow to the pit walls
Zone 2 extends from the bottom of the pit downward and considers flow into the pit bottom.
Analytical models assume that there is no groundwater flow between Zones 1 and 2

Reference

Marinelli, F., and W.L. Niccoli, 2000: Simple Analytical Equations for Estimating Ground Water Inflow to a Mine Pit. Groundwater Vol 38, No.2

Assumptions

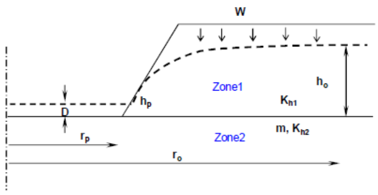
Zone 1
Pit walls are approximated as a right circular cylinder
Groundwater flow is horizontal (Dupuit - Forchheimer approximation is valid)
The static (premining) water table is horizontal
Groundwater flow toward the pit is axially symmetric
Uniform distributed recharge occurs across the site as a result of surface infiltration.
All recharge in the radius of influence is captured by the pit.

$$h_o = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left(r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \left(\frac{r_o^2 - r_p^2}{2}\right)\right)}$$

$$Q_1 = W\pi\left(r_o^2 - r_p^2\right)$$

$$Q_2 = 4r_p\left(\frac{K_{h2}}{m_2}\right)(h_o - d)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$



Zone 2
Hydraulic head is initially uniform throughout the zone. Initial head is equal to the elevation of the initial water table in zone 1
The disk sink has constant hydraulic head equal to the elevation of the pit lake water surface. If the pit is dewatered the disk sink head is equal to the elevation of the pit bottom.
Flow to the disk sink is three dimensional and axially symmetric

If a rectangular pit

Length	800	m
Width	500	m
R_{pit}	356.82	m

Ground level	500	mAHD
Observed WL	20	mBG
	480	mAHD
Base of Pit	372	mAHD
Depth below WL	108	m

Recharge check: 32 mm/yr

Distributed recharge flux (W):	0.00015	m/day	
Horizontal hydraulic conductivity (K_{h1}):	7.70E-04	m/day	
Horizontal hydraulic conductivity (K_{h2}):	8.60E-05	m/day	
Effective pit radius (r_p):	356.82	m	
Saturated thickness at pit wall (h_p):	58	m	(set this to zero to maximise pit inflow)
Radius of influence (r_o):	370	m	
Depth of the pit lake (D):	58	m	
tial (pre-mining) saturated thickness above base (h_0):	108	m	

Deepdell North Stage III Project
Estimate of groundwater inflows into Deepdell North Stage III Pit

Groundwater inflow at pit lake level 430 m RL (year 2060)

Step 1 Calculate h_o using an assumed radius of influence

h_o = 58.295 m

Step 2 Iterate to determine the radius of influence until it calibrates the standing water level (h_o)

Step 3 Calculate pit inflow rate from Zone 1

Effective pit radius (r_p):	356.82	
Radius of influence (r_o):	370	
Q_1 =	4.51	m^3/day

Step 4 Calculate pit inflow rate from Zone 2

Horizontal hydraulic conductivity (K_{h2}):	8.60E-05	m/day
Vertical k (kv) factor	0.2	
Vertical hydraulic conductivity (K_{v2}):	4.30E-04	m/day
Q_2 =	0.08	m^3/day

Step 5 Calculate total pit inflow

Q_t =	4.60	m^3/day		
	4595	L/day	0.05	L/s

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
	D Mains	S Douglas	[signature]	N Eldred	[signature]	22/02/20

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