Before a joint hearing of the

Otago Regional Council
Waitaki District Council

RM 20.024

Under	the Resource Management Act 1991
In the matter of	applications by Oceana Gold (New Zealand) Limited for resource consents for the Deepdell North Stage III Project

Statement of evidence of Eric Torvelainen for Oceana Gold (New Zealand) Limited

4 August 2020

Counsel:
Stephen Christensen
Project Barrister
PO Box 1251, Dunedin Metro 9054
P 027 448 2325
stephen@projectbarrister.nz

1. INTRODUCTION

1.1 My name is Eric Torvelainen. I am a civil engineer at Engineering Geology Ltd (EGL), a consulting engineering company that provides specialist services in geotechnical and earthquake engineering.

1.2 I hold a Bachelor of Engineering (Civil) with Honours from the University of Canterbury. I am a Member of Engineer New Zealand, New Zealand Geotechnical Society, New Zealand Society of Earthquake Engineering and New Zealand Society on Large Dams.

1.3 I have been engaged in the fields of geotechnical and earthquake engineering in a professional capacity for the past 11 years. I have 3 years experience with Oceana Gold (New Zealand) Limited's (OGNZL) Waihi and Macraes Gold Operations.

1.4 I have undertaken the work presented in the Deepdell East Waste Rock Stack Design Report, Deepdell North Stage III Erosion and Sediment Control Report, Deepdell North Stage III Horse Flat Road Realignment Technical Report for Resource Consent.

1.5 My firm EGL has been involved in the Macraes Gold Operation providing engineering ground investigation, design and construction services for the tailings storage facilities, waste rock stacks and silt ponds for since 1989. My work was internally reviewed by Jeremy Yeats past Director of EGL with 12 years designing WRS and Tailings Storage Facilities at Macraes and Reefton Gold Operation.

1.6 I have read the Environment Court's code of conduct for expert witnesses and agree to comply with it. I have prepared my statement of evidence accordingly. I confirm that my evidence is within my area of expertise and that I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

2. BACKGROUND

2.1 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 (See EGL report reference 8528). Gold extraction from the current mining operation involves mining of open pits and underground (Frasers Underground). Associated with the MGP are waste rock stacks for disposal of pit overburden material and tailings storage facilities for disposal of tailings.

2.2 Oceana Gold (New Zealand) Limited (OGNZL) proposes to develop a new pit and waste rock stack at the Macraes Gold Operation north of Deepdell Creek on Horse Flat. The pit is called Deepdell North Stage III Pit and re-mines and extends the Deepdell North Pit (Stage II). The waste rock stack is called Deepdell East Waste Rock Stack (WRS) and is positioned on Horse Flat and fills in the existing Deepdell South Pit as shown on Figure 3 (See EGL report reference 8528).

3. SCOPE OF EVIDENCE

3.1 My evidence will cover:

(a) Deepdell East WRS;

(b) Horse Flat Road Realignment; and

(c) Erosion and Sediment Control.

4. DEEPDELL EAST WASTE ROCK STACK

4.1 Deepdell East WRS comprises backfilling of the existing Deepdell South Pit and will approximately re-establish the original ground contours, before raising the ground profile to the north over Horse Flat.

4.2 The source of waste rock for Deepdell East WRS is Deepdell North Stage III Pit. The 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) and the waste rock will be placed permanently in Deepdell East WRS. The footprint of the pit will be 38ha of which 18.7ha was previously disturbed by mining. Pells Sullivan Meynink (PSM) have carried out the design work for Deepdell North Stage III Pit.

4.3 Overall the Deepdell East WRS has a footprint of 70.8ha and a storage capacity of 27 million m^3, up to the design crest elevation of RL580. At a density of 2.1t/m^3 this is a total waste rock storage capacity of 56.7Mt.

4.4 There is an existing haul road between the Coronation North Project to the north and the Macraes Gold Project 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 in EGL Report Reference 8529) 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.

4.5 The scheduled waste rock mass coming out of the pit is estimated to fill Deepdell East WRS to a crest elevation of approximately RL556, not the full design height. The exact crest height reached depends on the final quantities of material and the density of the placed material.

4.6 Specific geotechnical investigations for Deepdell East WRS comprised field mapping of surface exposures, logging of test pits, and geological inspection of pitwall within Deepdell South Pit by a senior engineering geologist from EGL. The field investigation is described in the Deepdell East WRS Design Report. Information on the structural features in the geology i.e. faults/shear zones in the Deepdell North Pit adjacent to Deepdell WRS was documented by PSM.

4.7 The site is underlain by a profile of topsoil, over a thin mantle of loess soils, over schist rock. The prevalent rock outcrops and head scarps of shallow slips observed on the sides of gullies and farm tracks show that there is generally only a thin layer of soil overlying the bedrock on Horse Flat. Soil depths over the extent of the WRS are typically 0.3 to 0.5m with one investigation location (TP4) with 4m of soil and another location (TP3) with 1.3m of soil. The soil comprises loess or residual soil (of the underlying schist) and comprises layers of silt with varying amounts of clay, sand and gravel. The schist rock observed on site comprises well foliated, highly to moderately jointed schist. The field walk over survey and test pits showed the foliation generally dipping between 10 degrees and 30 degrees to mine south east on Horse Flat.

4.8 No areas of significant historical or incipient instability feature were observed in the foundation on site.

4.9 The batter slopes of the WRS have been designed to blend as naturally as possible with the natural landscape. The outer shoulders have an overall slope of about 1(v):3(h). The maximum height of the WRS is approximately 200m, when taken from the toe in Deepdell South Pit to the design crest of RL580. On Horse Flat the RL580 crest is up to 110m high when taken from the toe in the infilled gullies.

4.10 The estimated duration of the operation and rehabilitation of the Deepdell East WRS is about 5 years (2020 – 2025) and it will remain in place in perpetuity.

4.11 The proposed construction methods and rehabilitation strategies are similar to those employed on the existing tailing storage facilities and waste rock stacks, and these have been successful during the approximately 30 years of operation at the Macraes Gold Project.

4.12 The waste rock to be placed in the WRS and Pit Backfill will be end-tipped, so it is assumed to be non-structural fill. The waste rock segregates when end-tipped, such that each lift (approximately 10-20m high) varies from coarse rock at the bottom to silty sandy rockfill at the top. Consequently, the WRS consists of layers of rockfill of varying permeability. Generally, the rockfill could be expected to be free draining, except at the top of each lift where a thin low permeability layer is created by the trafficking of the dump trucks. Photos of the end tipping face are included in the EGL report reference 8529.

4.13 The waste rock is anticipated to consist of a mixture of psammitic and pelitic schist. It is to be excavated from the new Deepdell North Stage III Pit. The schist rock varies from completely to slightly weathered, depending on the relative depth of excavation.

4.14 The stability analyses for the WRS assume that the natural ground is fully saturated and the waste rock is fully drained. The WRS will be comprised of rockfill and the gullies beneath the WRS are to be infilled with coarse rockfill to ensure good drainage.

4.15 The shear strengths adopted for waste rock and foundation schist rock is consistent with that previously used for the WRS at MGP and Coronation WRS. The schist rock is foliated (bedding defects), with weaker strengths on the foliations than in the intact rock mass. The range of likely dip directions, based on site observation, was considered in the stability assessment.

4.16 The slope stability analyses find the performance of the WRS under static loading is satisfactory, as all the calculated slope stability Factors of Safety are above 1.5. The value of 1.5 is a typical minimum value applied for long-term static stability in geotechnical engineering and considered suitable for the WRS.

4.17 The Institute of Geological and Nuclear Science (GNS) carried out a site-specific seismic hazard study for the Macraes Gold Project (GNS report reference 2005/135). The study carried out an extensive review of the faults in the region which included the nearby Billy’s Ridge, Taieri Ridge, and Hyde faults.

4.18 The 150 year return period horizontal peak ground acceleration is 0.13g (13% of gravity) and the 2500 year return period is 0.65g (65% of gravity). The dominant contributing earthquakes have a mean magnitude of approximately 7 for both the 150 and 2500 year return period peak ground acceleration values.

4.19 The overlying loess soils found over the schist rock on Horse Flat are potentially liquefiable if saturated under a 2500 year earthquake. Placement of waste rock in the Deepdell East WRS over the loess soil could cause this condition. Removal of the loess soil around the toe of Deepdell East WRS on Horse Flat is proposed over a 30m width to provide a shear key to mitigate any potential for notable displacement in an earthquake. The loess soils removed from the shear key will be placed in the centre of the WRS where they will not affect stability. The loess soil that remains is assumed to liquefy under the 2500 year return period earthquake.

4.20 Earthquake displacement estimates indicate that 0 to 46cm of slope displacement could occur for the proposed profile in a 2500 year return period earthquake. Some shake down settlement of the rockfill can also be expected. This is unlikely to be evident to observers and there are no structures on the WRS that would be affected.

4.21 Overall the proposed design profile for the Deepdell East WRS is assessed to be stable under static conditions, as is observed with other WRS at the Macraes Gold Project and only minor displacements, relative to the size of the WRS, are expected in a 2500 year return period earthquake.

4.22 The final contoured surface of the WRS is to be rehabilitated by spreading weathered rock plus topsoil (excavated from the foundations) and then grassed. Rehabilitation is generally done progressively as the WRS is raised. Once the grass is established, any runoff from the WRS is generally of good quality.

5. HORSE FLAT ROAD REALIGNMENT

5.1 Horse Flat Road is to be partially realigned to make space for the Deepdell East WRS. The existing road is a two-way single lane unsealed road, which provides access to two dwellings and a forestry block. The average daily traffic (ADT) volume is expected to be less than 20 vehicles. The realigned section will replace the existing access. The proposed alignment is shown on Figures 2 and 3 in the EGL report reference 8946.

5.2 The realignment moves Horse Flat Road to the north as shown on Figure 2 in EGL report 8946. The length of the existing road that is to be realigned is approximately 1220m and the new length of road will be 1050m.

5.3 The following preliminary design criteria were proposed for the road realignment:

(a) 15m to 40m wide road reserve

(b) The road shall also be delineated and marked to a public road standard

(c) Geometric design will be in terms of Rural Road Design manual published by AUSTROADS – Sydney 1989 edition [Ref. 3] and any subsequent revisions [Ref. 4]

(d) Permanent culvert sizing for 1/100 Annual Exceedance Probability (AEP) rainfall event

(e) Minimum 150 mm sub-base, a basecourse of 100mm AP40 with a wearing course of AP20

A preliminary design has been proposed as detailed in the EGL report reference 8946. All detailed design and construction details shall be lodged with Waitaki District Council for approval.

5.4 Over the road alignment ground conditions will consist of topsoil, over loess soil (0 to 4m thick), over schist rock. In some locations there is no loess soils and schist rock is at the surface. In some location the schist rock is weathered to a residual soil over a shallow depth.

5.5 The alignment was chosen to avoid the waste rock stack during operation, which presents a rock fall hazard during operation, and to minimise the steepness of the longitudinal grade of the carriage way to less than 8% to minimise the frequency of maintenance.

5.6 The Horse Flat Road realignment will require a fill embankment to cross the gully which drains the surface water runoff from the proposed area for the Deepdell East WRS. This gully then conveys water to the east via a series of gullies and ephemeral tributaries of Highlay Creek, a tributary of Deepdell Creek. The preliminary design of the embankment has an embankment up to 11m high (10m at its centre) requiring 5m cuts through schist rock on the eastern approach.

5.7 A culvert will be required to convey surface water runoff past the fill embankment. This has been preliminarily sized as a 900mm internal diameter culvert to pass a surface water runoff for a 100 year Average Recurrence Interval (ARI) Rainfall from an area of 20ha. The culvert pipe is approximately 50 m long at a grade of 40h to

1v. At the eastern approach to the embankment an approximate 5m cut in schist rock is required. Tonkin & Taylor Limited noted in their review for Otago Regional Council (ORC) that the climate RCP6.0 scenario for the years 2081 to 2100 be considered. We have assessed that upsizing the pipe to 1050mm internal diameter would be able to accommodate this climate scenario at a 100 year ARI. Updated calculations are included with the EGL letter reference 8946 dated 04 August 2020 attached to this evidence.

5.8 A culvert is also required to pass surface runoff, from the paddocks to the north, beneath the realigned road at its western end. This has been preliminarily sized as a 685mm internal diameter culvert to pass surface water runoff for a 100 year ARI historic rainfall from a 6.3ha area. Tonkin & Taylor Limited noted in their review for ORC that the climate RCP6.0 scenario for the years 2081 to 2100 be considered. Further detailed assessment of the culvert size will undertaken as part of detailed design work for the road realignment. Upsizing the pipe to 760mm internal diameter would be able to accommodate this climate scenario at a 100 year ARI, or alternatively a double pipe culvert could be installed. Updated calculations are included with the EGL letter reference 8946 dated 04 August 2020 attached to this evidence.

5.9 For the section of the realigned road, the estimated earthworks volumes were a cut of 3,200m3 and fill of 8,000m3. The estimated total disturbed area for the full length of the realignment is 12,500m^2 or 1.25 ha.

5.10 Tonkin & Taylor Limited noted in their review for ORC that if the culvert passing the road embankment blocks, the embankment would impound water and could form a dam and that the consequences of this should be assessed. The volume would be up to 30,000m^3. We have considered the consequences of a breach and find the area of potential impact is not populated (i.e. there are no houses), no infrastructure apart from the Horse Flat Road and any environmental damage would be minor with short term effects. Under the New Zealand Society of Large Dams New Zealand Dam Safety Guidelines we find that if a dam formed, through blockage of the culvert then it would be in the Low Potential Impact Category. We consider the risk of a dam forming, breaching and causing any notable loss is very low. The basis of this assessment is included with the EGL letter reference 8946 dated 04 August 2020 attached to this evidence.

6. EROSION AND SEDIMENT CONTROL

6.1 In this part of my evidence I discuss erosion and sediment control concepts associated with Deepdell North Stage III Pit, Deepdell East WRS and the proposed realignment of Horse Flat Road.

6.2 EGL has prepared an erosion and sediment control report (Reference 8529) outlining the proposed concepts for managing erosion and sedimentation to support the Assessment of Environmental Effects (AEE) for consents for Deepdell North Stage III. It identifies the practices and procedures to minimise erosion and sedimentation associated with the project and the treatment of runoff prior to discharge. Preliminary sizings of the diversion drains and silt ponds are detailed in the report.

6.3 An Operation Management Plan (OMP) will be prepared prior to construction commencing for each individual element of Deepdell North Stage III. The OMP will generally follow the erosion and sediment control principles embodied in the Environment Canterbury's Erosion and Sediment Control Toolbox and Guidelines, applied to suit the site-specific conditions and experience gained from over 25 years of operation. 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.

6.4 Extensive site-specific experience managing erosion and sediment exists with the operations team at Macraes Gold Project. The existing erosion and sediment control practice at the MGP includes:

(a) Cleanwater drains to divert run-on and clean water away from disturbed areas;

(b) Silt ponds to allow time for settlement of suspended solids associated with runoff from disturbed areas. Silt ponds are design to the NZSOLD New Zealand Dam Safety Guidelines;

(c) Diversion drains to divert runoff from disturbed areas to silt ponds;

(d) Staged stripping of WRS footprints to minimise disturbed areas, particular of loess soils, before rockfill is placed which provides detention and minimises runoff;

(e) 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;

(f) Stripping of topsoil and loess soils is undertaken in dry weather conditions, generally over summer months:

(g) 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);

(h) Placement of coarser rock in gullies which act as underdrains for natural water courses;

(i) Progressive rehabilitation of WRS and TSF embankments consisting typically of oxidised waste rock, topsoil and grassing to minimise bare areas;

(j) Shoulders of the WRS will form slopes up to about 1V:3H to minimise erosion of the rehabilitation layer;

(k) Monitoring of discharges as required by consent conditions;

(l) Regular inspections of silt ponds and diversion drains to check condition and undertake maintenance if required.

6.5 Silt ponds are constructed at the Macraes Gold Project in advance of placement of waste rock in WRSs or construction of Tailing Storage Facilities. 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.

6.6 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.

6.7 The silt ponds are design to have storage sufficient to contain at least the initial 24 hour rainfall from a 2 year rainfall event. For past assessments the 24 hour rainfall from a 2 year event has been estimated to be 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 of rainfall is continued as the design value for sizing ponds so the ponds are as effective as previously specified. For comparison the 2007 Environment Canterbury Erosion and Sediment Control Guidance indicates sediment retention ponds (silt ponds) are sized for a 10 hour rainfall from a 5 year rainfall event. For Macraes Gold Project area this is 41mm of rainfall, a value lower than previously used onsite.

6.8 The Environment Canterbury Toolbox recommends forebays, flow spreader bars, baffles, and floating decants. Floating decants have been included on some ponds at Macraes Gold Project, however, many ponds have perforated manholes. 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. Similarly, forebays, flow spreader bars and baffles can be installed as required.

6.9 Onsite practices for the stripping and management of rockfill placement have resulted in little sediment laden water, with little cleaning of the silt ponds required, primarily because the waste rock acts as a natural filter for sediment.

6.10 The existing erosion and sediment control practices have worked well throughout the life of the mine. There has also been no need to remove silt from the existing silt ponds, confirming that the inflowing water typically has a low silt content.

6.11 An important part of the works is the stripping of the loess soils to key the rock stack slopes on to the rock foundation. Limiting exposure of the loess to rainfall and runoff during this time is an important aspect of the OMPs to be prepared. This can be effectively done by staging the works, removing loess soils and immediately placing rockfill during times of dry weather.

6.12 Rockfill will naturally be placed in the low point of gullies first. The slope face of this fill can be rehabilitated early. This will minimise sediment laden runoff from subsequent lifts.

6.13 The catchment divide for stormwater runoff is along the top of the northern hills/mountain range (refer Figure 2 EGL report reference 8529). All stormwater runoff from the Deepdell North Stage III project will therefore drain via a series of creeks to Deepdell Creek to the south, that forms part of the Shag Catchment.

6.14 Uphill clean water diversion drains will be formed to divert clean water away from areas of exposed earthworks.

6.15 Where the clean water drains are diverting clean water away from the WRS they are sized to be permanent. This is the case along the uphill side of the realigned section of Horse Flat Road. Permanent clean water diversion drains will be sized for a 100 year ARI rainfall intensity. The locations and preliminary sizing of the drains is included in the EGL report reference 8529.

6.16 Other clean water drains are temporary and will be sized for a 20 year ARI rainfall intensity. The location and preliminary sizing of the drains is included in the EGL report reference 8529.

6.17 Two existing silt ponds will be reutilised for the Deepdell North Stage III works. This is the Deepdell North Silt Pond and the Deepdell South Silt Pond. These ponds have sufficient capacity to hold, in live storage, the surface runoff from a 70mm rainfall event, which is the past rainfall prediction for a 2 year ARI 24 hour event.

6.18 The Deepdell North Silt Pond will receive dirty water from the west side of Deepdell East WRS and any initial works for the North Pit Stage III works before the pit is formed and is a self-contained system.

6.19 The runoff from the initial fill placed in the gully down to Deepdell South Silt Pond will flow into Deepdell South Silt Pond.

6.20 Deepdell South Pit is self-contained until fill rises above the lowest lip on the south west side. The fill will be left below the level of this lip so that it forms a silt pond where water initially soaks back into the waste rock in the pit. After rehabilitation and the waste rock voids within the pit fills up with water, water will decant slowly over the lip and down the slope to Deepdell Creek, as would natural runoff. As slopes are likely to be rehabilitated by this time surface water runoff will most likely be clean.

6.21 Two new silt ponds are required in gullies to the east, at the toe of the Deepdell East WRS. The locations of the new silt ponds are shown on Figures 5 and 6 in the EGL report reference 8529.

6.22 Dirty water diversion drains will be formed to collect potential sediment laden water and divert it to the silt ponds, to settle out sediment before discharge to the receiving water course. Proposed drains are shown on Figure 5 and 6 in the EGL report reference 8529.

6.23 On Horse Flat, a local high point lies beneath the centre of the WRS with ground sloping to the east, west and south. This allows the initial foundation works to be easily staged to manage the catchment areas reporting to each silt pond as shown on Figure 6 in the EGL report reference 8529.

6.24 Separate silt ponds will be required for the construction of the Horse Flat Road realignment. These will be located immediately downstream of the Horse Flat embankment construction and at the western end of the realignment. These are more temporary compared to the Deepdell East WRS silt pond and will be sized as per the Environment Canterbury's Erosion and Sediment Control Toolbox and Guidelines.

6.25 Construction of table drains for the realigned road, along with silt fences will minimise sediment laden runoff and direct it to the silt ponds.

6.26 For the construction of the Horse Flat Road embankment a coffer dam with diversion pipes can be used to divert clean surface water through the exposed earthworks to limit the amount of dirty water the silt ponds need to manage. These pipes will be temporary and removed after construction.

6.27 The Deepdell North Stage III site benefits from the existing silt ponds and the existing Deepdell South Pit in managing erosion and sediment. Controls exist to manage erosion and sediment which have been proven to be effective for other parts of the Macraes Gold Project which have resulted in no more than minor effects to water ways.

6.28 An effective Operation Management Plan is to be developed utilising existing site experience incorporating the principles embodied in the Environment Canterbury's Erosion and Sediment Control Toolbox and Guidelines. This Operation Management Plan should be reviewed regularly and adapted based on monitoring the silt ponds and water quality testing under the existing resource consent conditions.

6.29 Details of our assessments are included in our reports (EGL Reference 8528, 8529 and 8946). I include with this evidence a brief letter with comment on aspects raised in review of the application that are updates to our reports. I am happy to answer any questions you may have.

E. Torvelainen

Eric Torvelainen
04 August 2020

REFERENCES

EGL Report Reference 8528. Oceana Gold (New Zealand) Limited. Macraes Gold Project Deepdell Waste Rock Stack Design Report. Revision 1. Date 10 March 2020

EGL Report Reference 8529. Oceana Gold (New Zealand) Limited. Macraes Gold Project Deepdell North Stage III Erosion and Sediment Control Report. Date 11 November 2019

EGL Report Reference 8946. Oceana Gold (New Zealand) Limited. Macraes Gold Project Deepdell North Stage III Horse Flat Road Realignment Technical Report for Resource Consent. Date 26 November 2019

GNS 2005 'Seismic Hazard Study for Tailings Embankments at Macraes Gold Project' GNS Client Report 2005/135.

Engineering Geology Ltd
+64 9 486 2546
info@egl.co.nz
Unit 7C, 331 Rosedale Road, Albany, Auckland
PO Box 301054, Albany, Auckland 0752
www.egl.co.nz

EGL
Geotechnical, Earthquake and Dam Engineers

Ref: 8946

Oceana Gold (New Zealand) Limited
P O Box 5442
DUNEDIN 9058

4 August 2020

Attention: Gavin Lee

Dear Gavin,

Deepdell North Stage III
Horse Flat Road Embankment and Culverts
Resource Consent – Effects Related to Technical Review Comments

As part of the resource consent application process for Deepdell North Stage III project Tonkin & Taylor Limited, in their technical review of the hydrology and hydraulic components of the project for Otago Regional Council, made comment relating to the Horse Flat Road realignment culverts and road embankment. This letter provides information, in addition to our technical reports (EGL Ref. 8528, 8529, 8946), to clarify for Oceana Gold (New Zealand) Limited any effects of Tonkin & Taylor's comments.

Tonkin & Taylor raised that permanent works be sized using the climate RCP6.0 scenario for the years 2081 to 2100. We had used historic rainfall estimates from the high intensity rainfall database version 4 (HIRDS V4). Rainfall intensity at the site for the 100 year ARI (average recurrence interval) event based on historical data is 81.9mm/hour for a 10 minute duration. The RCP6.0 scenario increases the intensity to 100mm/hr for a 10min duration.

There are two culverts that will be permanent. One through the road embankment at the eastern end of the road realignment and one to pass water beneath the road at the western end of the alignment.

The culvert through the road embankment at the eastern end of the realignment was previously sized to be 900mm internal diameter. Making the same assumptions and only increasing the rainfall intensity, the culvert pipe would need to be increased to 1050mm internal diameter to accommodate the climate RCP6.0 scenario. Updated calculations are attached. Alternatively, a double pipe culvert could be installed.

The culvert beneath the road at the western end of the realignment was previously sized to be 685mm internal diameter. Making the same assumptions and only increasing the rainfall intensity, the culvert pipe would need to be increased to 760mm internal diameter to accommodate RCP6.0 scenario. Updated calculations are attached. Alternatively, a double pipe culvert could be installed.

Tonkin & Taylor made comment that permanent drains be sized for the RCP6.0 climate scenario. We have reassessed the size of the permanent drains along the northern side of the Horse Flat Road realignment (referred to in the calculations as Drain No.3 and 4) and find that the increase in depth of the drain is less than 30mm over that specific in the Deepdell Erosion and Sediment Control Report (EGL8529).

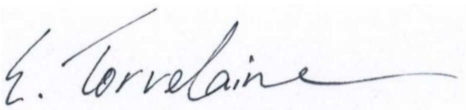
Tonkin & Taylor made comment that if the culvert passing the road embankment blocks, the embankment would impound water and could form a dam and that the consequences of this should be assessed. The volume of water that could impound is up to 30,000m^3. We have considered the consequences of a breach and find the area of potential impact is Highlay Creek, Deepdell Creek and Shag River. Highlay Creek immediately downstream is incised and is not populated (i.e. there are no houses), there is no infrastructure apart from the Horse Flat Road crossing where there is a small culvert, and any environmental damage would be minor with short term effects. Highlay Creek flows into Deepdell Creek and then the Shag River. We have previously undertaken dam breach assessments for the Tailings Storage Facilities at the Macraes Gold Operation which flow down the same stretch of Deepdell Creek and into Shag River. Based on our knowledge of these dam breach scenarios we can say that there would be no houses or infrastructure that would be impacted along Deepdell Creek and Shag River from a breach of the Horse Flat Road embankment. Under the New Zealand Society of Large Dams New Zealand Dam Safety Guidelines we find that if a dam formed, through blockage of the culvert then it would be in the Low Potential Impact Category. We consider the risk of a dam forming, breaching and causing any notable loss is very low. We include Figure 1 and 2 which show the breach flow path down Highlay Creek and Deepdell Creek to Shag River.

We trust this clarifies any effects related to Tonkin & Taylor's comments on the hydrology and hydraulic components of the Deepdell North Stage III project.

Yours sincerely

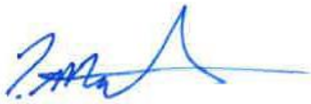
ENGINEERING GEOLOGY LTD

Letter prepared by:



E Torvelainen
Senior Geotechnical Engineer
BE (Hons), MEngNZ

Letter review by:



T. Matuschka
Director
CPEng, FEngNZ

Attachments

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	$C_{Catchment} := RF \cdot C_{ROCK} + OG \cdot C_{GROUND} = 0.376$

$C := 0.38$

$i := 100\ \frac{mm}{hr}$

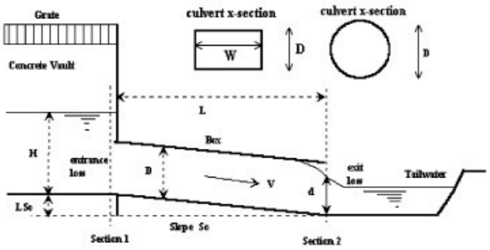
$Q := i \cdot C \cdot Area = 2.111\ \frac{m^3}{s}$

Use 1.7m3/s as design inflow

$2.1\ \frac{m^3}{s} = 74.161\ \frac{ft^3}{s}$

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

Project: **Deepdell Stage 3**
Basin ID: **Horse Flat Road - 1050mm ID Culvert**
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = 41 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 =	1.04
Sum of All Loss Coefficients	K_s =	2.54
Orifice Inlet Condition Coefficient	C_d =	0.86
Minimum Energy Condition Coefficient	KE_{low} =	-0.0427

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	6.20	67.49	**6.20**	Min. Energy. Eqn.	INLET
2.00	-2.30	21.60	74.96	**21.60**	Regression Eqn.	INLET
3.00	-2.30	41.20	81.96	**41.20**	Regression Eqn.	INLET
4.00	-2.30	61.30	91.80	**61.30**	Regression Eqn.	INLET
5.00	-2.30	77.50	103.09	**77.50**	Regression Eqn.	INLET
6.00	-2.30	90.70	113.26	**90.70**	Regression Eqn.	INLET
7.00	-2.30	102.10	122.57	**102.10**	Regression Eqn.	INLET
8.00	-2.30	112.20	131.22	**112.20**	Regression Eqn.	INLET
9.00	-2.30	121.40	139.34	**121.40**	Regression Eqn.	INLET
10.00	-2.30	130.00	147.01	**130.00**	Regression Eqn.	INLET
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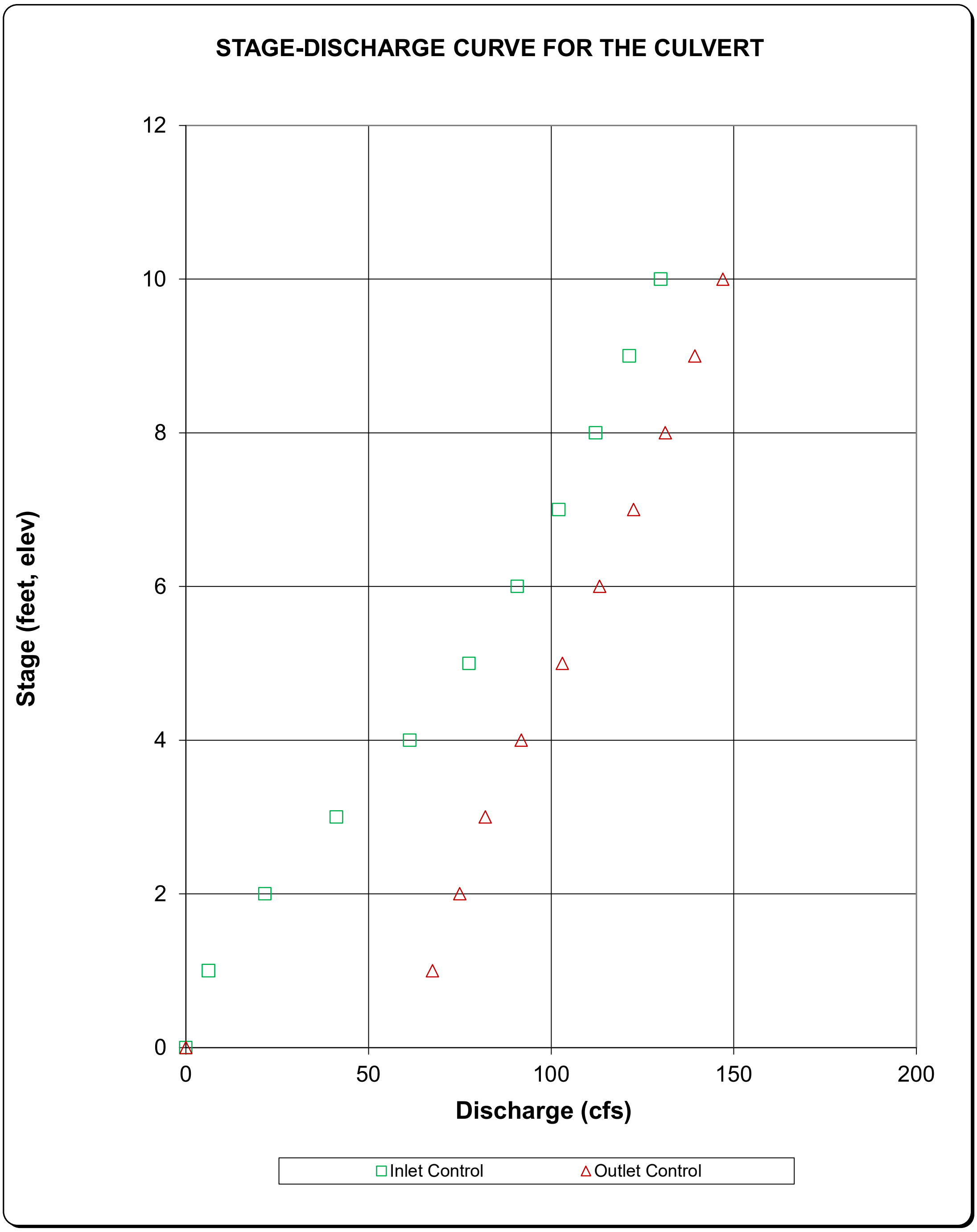
Processing Time: 01.54 Seconds

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

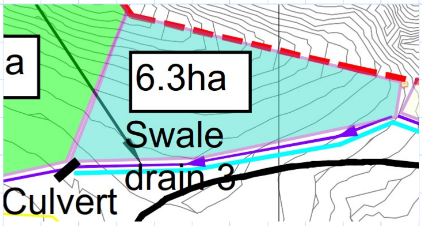
Project: Deepdell Stage 3
Basin ID: Horse Flat Road - 1050mm ID Culvert



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

$C := 0.6$

$i := 100\ \frac{mm}{hr}$

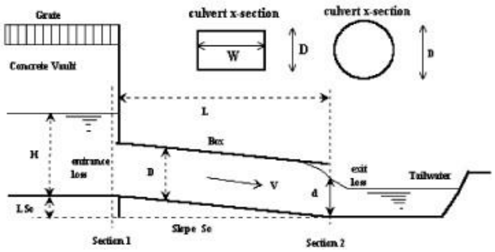
$Q := i \cdot C \cdot Area = 1.05\ \frac{m^3}{s}$

Use 0.86m3/s as design inflow

$1.05\ \frac{m^3}{s} = 37.08\ \frac{ft^3}{s}$

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

Project: Deepdell North Stage 3
Basin ID: Horse Flat Road - 760mm ID Culvert
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = 30 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 =	26	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 =	0.32
Sum of All Loss Coefficients	K_s =	1.82
Orifice Inlet Condition Coefficient	C_d =	0.86
Minimum Energy Condition Coefficient	KE_{low} =	-0.0279

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	0.00	0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
1.00	0.00	5.10	13.95	**5.10**	Min. Energy. Eqn.	INLET
2.00	0.00	16.10	18.06	**16.10**	Regression Eqn.	INLET
3.00	0.00	28.40	29.62	**28.40**	Regression Eqn.	INLET
4.00	0.00	37.70	41.33	**37.70**	Regression Eqn.	INLET
5.00	0.00	45.00	50.50	**45.00**	Regression Eqn.	INLET
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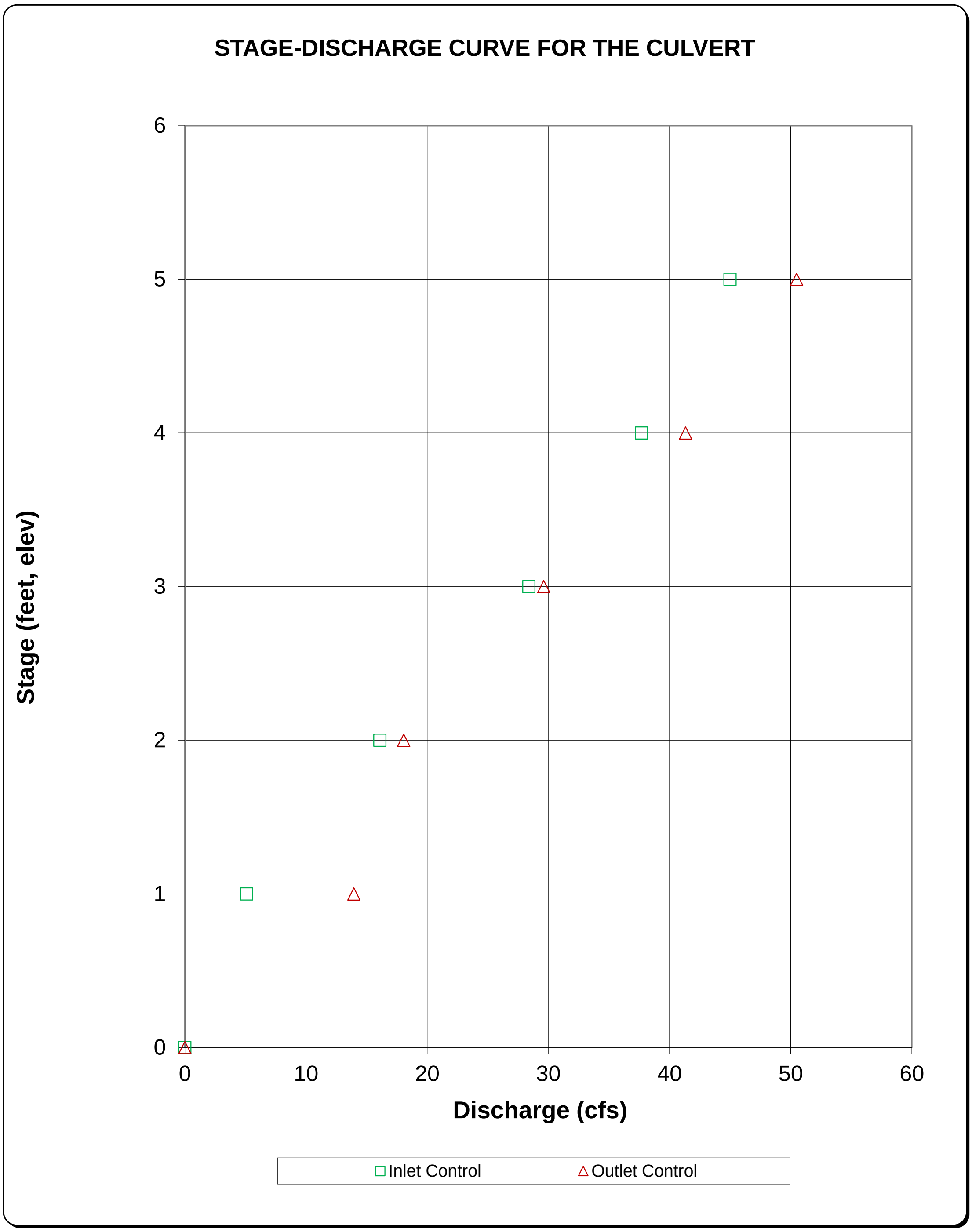
Processing Time: 01.86 Seconds

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

Project: Deepdell North Stage 3
Basin ID: Horse Flat Road - 760mm ID Culvert



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	=	1.666667 mm/min
Runoff coefficient	=	0.6
Design Flux	=	1.050 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

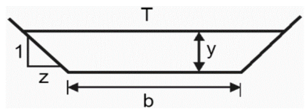
Bottom Slope

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

Depth

y(L)= 0.34 m Historic 0.31m

Trapezoidal Channel



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

Wetted Area

P= 2.831 m

Top Width

T= 2.7 m

Area

A= 0.629 m2

Hydraulic Radius

R_h= 0.222 m A/P

Hydraulic Depth

Dh= 0.233 m A/T

Flow Velocity

V= 1.73 m/s $V = \frac{1}{n} R_h^{2/3} S_f^{1/2}$

Flow Capacity (Flux)

Q= 1.09 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= 7.687586

Froude Number

Fr 1.143343

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

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),

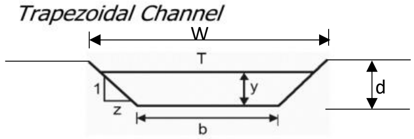
Fr < 1, subcritical flow (slow / tranquil flow)

Capacity Check: Okay - Channel Capacity > Design Flow

Actual Channel Dimensions

Freeboard allowance	250	mm
b	1.0	m
d	0.590	m
Side Slopes z	2.5	H
Top width, W	3.95	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	=	1.666667	mm/min
Runoff coefficient	=	0.6	
Design Flux	=	0.450	m^3/s

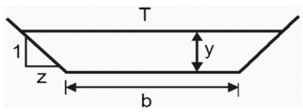
Bottom Width
b(L)= 0.50 m

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)= 0.22 m Historic 0.2m

Wetted Area
P= 1.685 m

Top Width
T= 1.6 m

Area
A= 0.231 m2

Hydraulic Radius
R_h= 0.137 m A/P

Hydraulic Depth
Dh= 0.144 m A/T

Flow Velocity
V= 2.29 m/s $V=\frac{1}{n}R_h^{2/3}S_f^{1/2}$

Flow Capacity (Flux)
Q= 0.53 m3/s $Q=\frac{1}{n}AR_h^{2/3}S_f^{1/2}$

Channel Conveyance (Metric Units) $K = (\phi/n)\ A\ R_h^{2/3}$ phi=1
K= 2.046082

Froude Number
Fr 1.921688

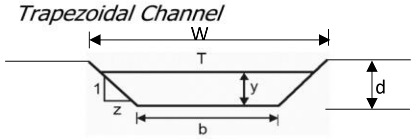
$$Fr = \frac{V}{\sqrt{gD}}$$

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

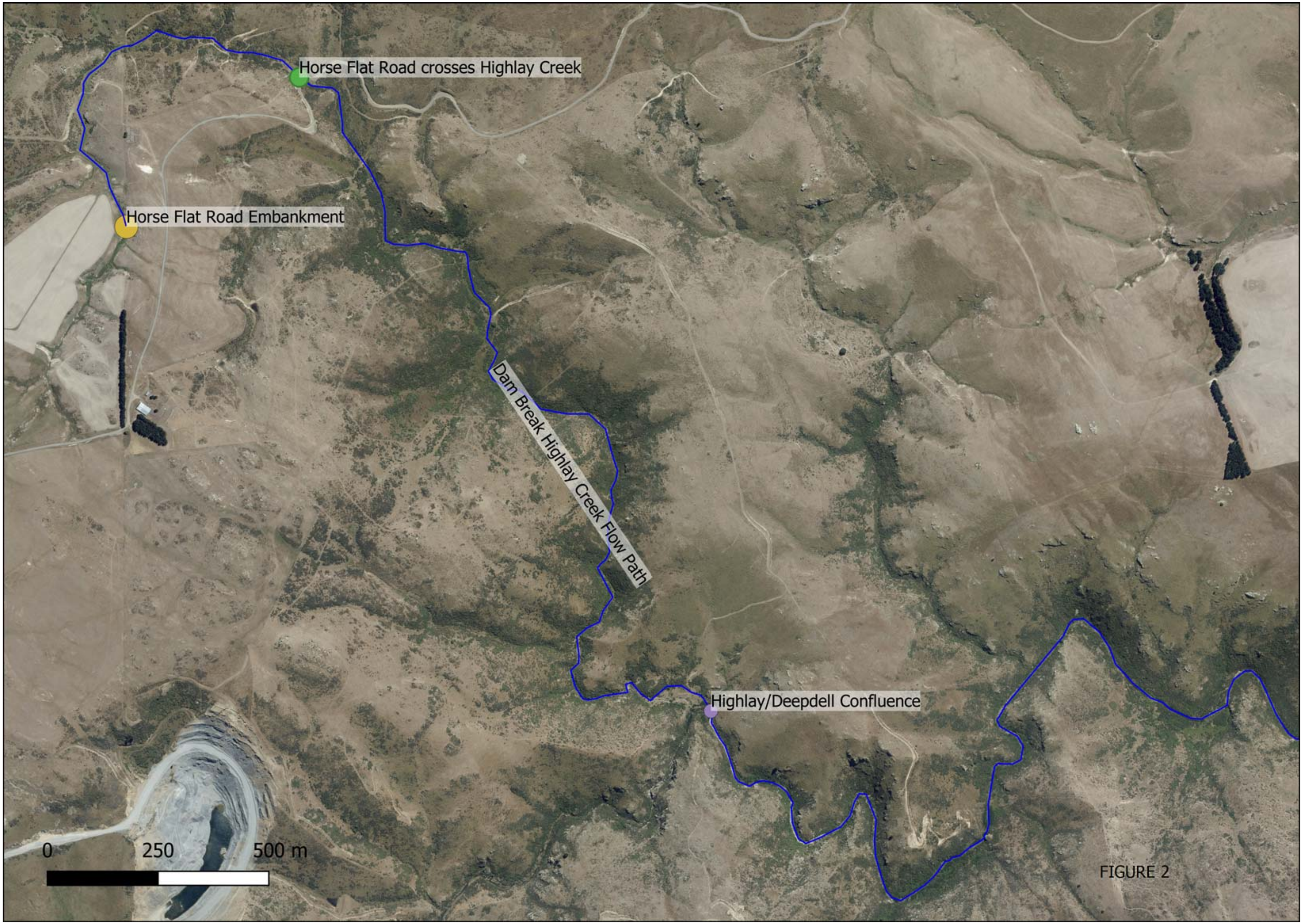
Actual Channel Dimensions		
Freeboard allowance	250	mm
b	0.50	m
d	0.470	m
Side Slopes z	2.5	H
Top width, W	2.85	m

Trapezoidal Channel



Horse Flat Road crosses Highlay Creek
Horse Flat Road Embankment
Dam Break Highlay Creek Flow Path
Highlay/Deepdell Confluence
Deepdell/Shag Confluence
Highlay Hill
820
Gully
Highlay
Deepdell
Creek
Jims
Cranky
Creek
COOKHOUSE RD
Bellfield
Braeburn
ROAD
FLAT
Historic battery
MACRAES
ROAD
HOCKING
ROAD
SHAG
VALLEY
Airstrip
Glendale
Mt Helle
170°25'
170°30'
0
750
1500 m
739
571
469
363
303
294
345
231
563
452
470
307
542

FIGURE 1


Horse Flat Road crosses Highlay Creek
Horse Flat Road Embankment
Dam Break Highlay Creek Flow Path
Highlay/Deepdell Confluence
0
250
500 m
FIGURE 2