Visual simulation 01A of Photograph 02. Vegetation is shown at approximately 1 year of age and with one tank.

Figure 5A: Visual Simulation of Viewpoint A

Viewpoint Details

MP2000 Easting	: 427641.3 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 814381.9 mN	Focal length of lens: 50mm
Eye level	: 382.582m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 2 March 2020, 1.54 p.m.	

Visual simulation 01B of Photograph 02. Vegetation is shown at approximately 5 years of age and with one tank.

Figure 5B: Visual Simulation of Viewpoint A

Viewpoint Details

MP2000 Easting	: 427641.3 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 814381.9 mN	Focal length of lens: 50mm
Eye level	: 382.582m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 2 March 2020, 1.54 p.m.	

Visual simulation 01D of Photograph 02. Vegetation is shown at approximately 10 years of age and with three tanks.

Figure 5C: Visual Simulation of Viewpoint A

Viewpoint Details

MP2000 Easting	: 427641.3 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 814381.9 mN	Focal length of lens: 50mm
Eye level	: 382.582m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 2 March 2020, 1.54 p.m.	

Photograph 03: View looking West from corner of Ferry Hill Drive and current access towards the existing reservoir. Distance between viewpoint and proposed reservoir approx 405m. Focal length: 50mm.

Figure 6: Viewpoint A Updated 2022

Photograph 04: View looking West from lower section of Ferry Hill Drive. Distance between viewpoint and proposed reservoir approx 420m. Focal length: 50mm.

Figure 7: Viewpoint B

Photograph 05: View looking West from Ferry Hill Dr turning head area. Distance between viewpoint and existing reservoir approx 445m. Focal length: 50mm.

Figure 8: Viewpoint C

SOURCE - Photographs taken by Yvonne Pfluger, Boffa Miskell Limited. 2nd of March 2020.

Photograph 06: View looking North from State Highway 6. Distance between viewpoint and existing reservoir approx 335m. Focal length: 50mm.

Figure 9: Viewpoint D

SOURCE - Boffa Miskell Limited. 11th of July 2022.

Photograph 07: View looking North from South of roundabout on Hawthorne Drive near State Highway 6. Distance between viewpoint and proposed reservoir approx 475m. Focal length: 50mm.

Figure 10: Viewpoint E

Photograph 08: View looking North from roundabout on Hawthorne Drive, Glenda Dr and Central St. Distance between viewpoint and proposed reservoir approx 620m. Focal length: 50mm.

Figure 11: Viewpoint F

SOURCE - Photographs taken by Yvonne Pfluger, Boffa Miskell Limited. 2nd of March 2020.

Visual simulation 02A of Photograph 08. Vegetation is shown at approximately 1 year of age and with one tank.

Figure 12A: Visual Simulation of Viewpoint F

Viewpoint Details

MP2000 Easting	: 427468.25 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 813531.5 mN	Focal length of lens: 50mm
Eye level	: 361.802m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 11 July 2022, 3.20p.m.	

Visual simulation 02B of Photograph 08. Vegetation is shown at approximately 5 years of age and with one tank.

Figure 12B: Visual Simulation of Viewpoint F

Viewpoint Details

MP2000 Easting	: 427468.25 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 813531.5 mN	Focal length of lens: 50mm
Eye level	: 361.802m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 11 July 2022, 3.20p.m.	

Visual simulation 02D of Photograph 08. Vegetation is shown at approximately 10 years of age with three tanks.

Figure 12C: Visual Simulation of Viewpoint F

Viewpoint Details

MP2000 Easting	: 427468.25 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 813531.5 mN	Focal length of lens: 50mm
Eye level	: 361.802m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 11 July 2022, 3.20p.m.	

Photograph 10: View looking North Central St. Distance between viewpoint and proposed reservoir approx 660m. Focal length: 24mm.

Figure 14: Viewpoint G

Photograph 11: View looking West from State Highway 6 across the the Shotover River. Distance between viewpoint and proposed reservoir approx 1,900m. Focal length: 50mm.

Figure 15: Viewpoint H

SOURCE - Photographs taken by Yvonne Pfluger, Boffa Miskell Limited, 7th of August 2019.

Photograph 12: View looking North-West from Hawthorne Drive. Distance between viewpoint and proposed reservoir approx 1,305m. Focal length: 50mm.

Figure 16: Viewpoint I

SOURCE - Boffa Miskell Limited. 11th of July 2022.

Photograph 13: View looking North West from Universal Land towards the existing reservoir. Focal length: 50mm.

Figure 17: Viewpoint J

SOURCE - Photographs taken by Yvonne Pfluger, Boffa Miskell Limited. 2nd of March 2020.

Visual simulation 03A of Photograph 13. Vegetation is shown at approximately 1 year of age and with one tank.

Figure 18A: Visual Simulation of Viewpoint J

Viewpoint Details

MP2000 Easting	: 427602.1 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 814083.4 mN	Focal length of lens: 50mm
Eye level	: 364.7m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 2 March 2020, 2.09p.m.	

Visual simulation 03B of Photograph 13. Vegetation is shown at approximately 5 years of age and with one tank.

Figure 18B: Visual Simulation of Viewpoint J

Viewpoint Details

MP2000 Easting	: 427602.1 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 814083.4 mN	Focal length of lens: 50mm
Eye level	: 364.7m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 2 March 2020, 2.09p.m.	

Visual simulation 03D of Photograph 13. Vegetation is shown at approximately 10 years of age and with three tanks.

Figure 18C: Visual Simulation of Viewpoint J

Viewpoint Details

MP2000 Easting	: 427602.1 mE	Horizontal Field of View :39.6°
MP2000 Northing	: 814083.4 mN	Focal length of lens: 50mm
Eye level	: 364.7m (1.5m AGL)	Viewing distance: 480mm
Date of Photography	: 2 March 2020, 2.09p.m.	

Photograph 14: View looking North West from Universal Land towards the existing reservoir. Focal length: 50mm.

Figure 19: Viewpoint J Updated 2022

SOURCE - Boffa Miskell Limited. 11th of July 2022.

SCHEME PLAN
SCALE 1:2000

LEGEND - EXISTING

- PROPERTY BOUNDARY
- EASEMENT
- TOP OF BANK
- BOTTOM OF BANK
- BUILDING
- FENCE'
- TOP OF WALL
- BOTTOM OF WALL
- DRIPLINE
- BOUNDARY MARK
- SURVEY MARK
- WATER LATERAL
- MANHOLE
- WATER TANK
- TREE

LEGEND - EXISTING SERVICES

- HV — HIGH VOLTAGE POWER
- LV — LOW VOLTAGE POWER
- T — CHORUS
- C — VODAFONE
- FO — FIBRE OPTIC CABLE
- G — GAS
- S — SEWER
- SEWER ABANDONED
- SW — STORMWATER
- W — WATER
- WATER ABANDONED

LEGEND - PROPOSED

- EXTENT OF SCHEME
- EDGE OF ROAD
- TOP OF BATTER
- BOTTOM OF BATTER
- EARTHWORKS INTERFACE

Rev	Description	Checked	Approved	Date
F	DETAILED DESIGN - FINAL ISSUE	IP*	AWh*	22.07.22
E	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	05.05.22
D	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	14.04.22
C	PRELIMINARY DESIGN UPDATES FROM CLIENT REVIEW	IP*	AWh*	03.11.21
B	PRELIMINARY DESIGN	IP*	AWh*	08.10.21
A	PRELIMINARY - FOR PRICING	IP*	AWh*	04.10.21

Author R. GERONIMO | Drafting Check G. DOUGHERTY*
Designer K. ATKINS | Design Check I. PARTINGTON*

0 20 40 60 80 100m
SCALE 1:2000 AT ORIGINAL SIZE

QUEENSTOWN LAKES DISTRICT COUNCIL

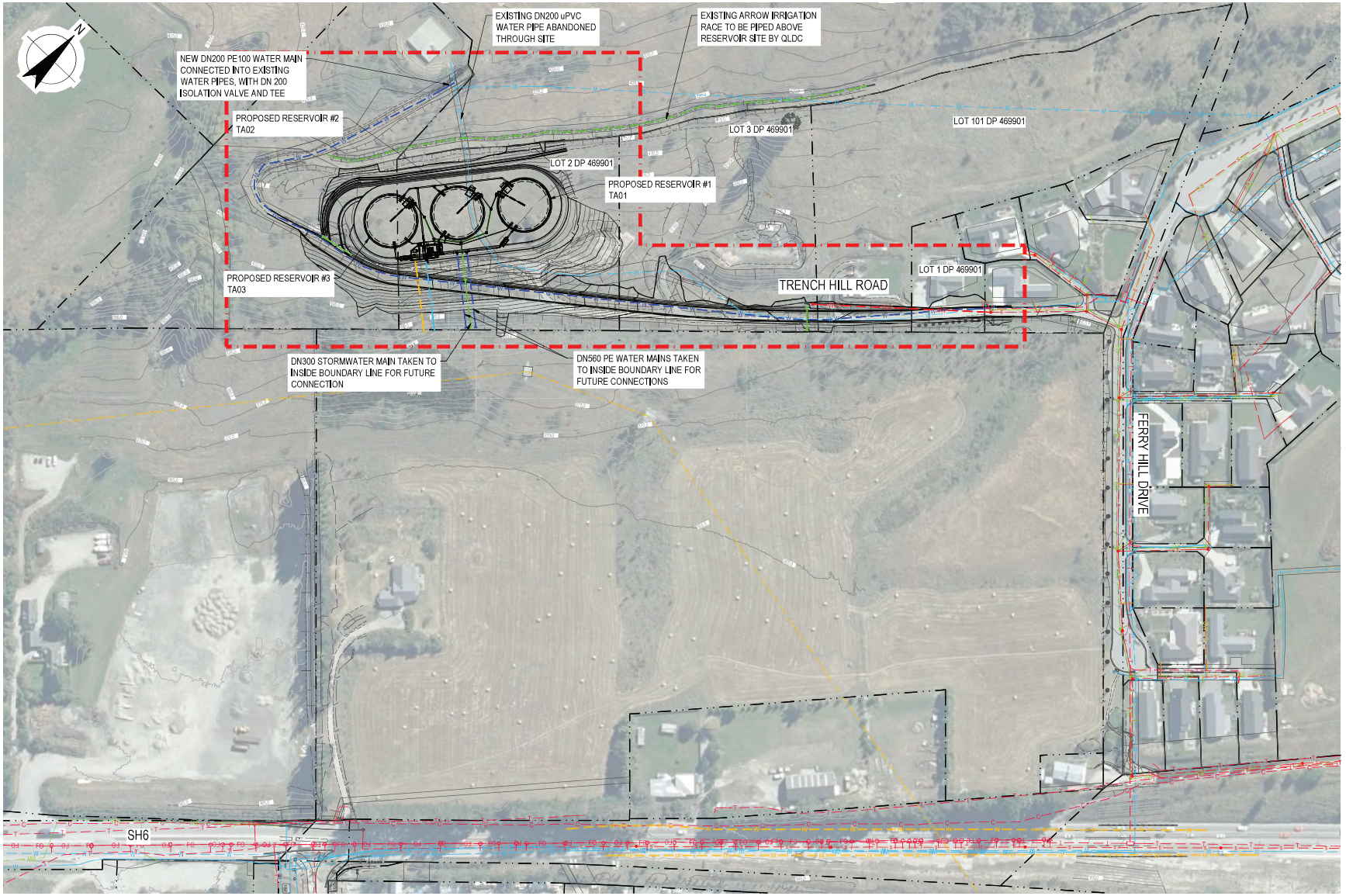
GHD
Level 3, 138 Victoria Street
Christchurch 8013, New Zealand
T 64 3 378 0900 F 64 3 370 8001
E chcmail@ghd.com W www.ghd.com
www.ghd.com

Project No. 12506856

Client: QUEENSTOWN LAKES DISTRICT COUNCIL
Project: QLDC WATER RESERVOIRS
Status: PRELIMINARY | Status Code: S2

Drawing Title: QUAIL RISE RESERVOIR SCHEME PLAN
Size: A1
Drawing No.: 12506856-300-G100
Rev: F

Plot Date: 26 July 2022 - 9:29 PM | Plotted by: Rey Emmanuel Geronimo
File Name: C:\12dSW\data\P-00-12D-00151-12506856 - QLDC Reservoir Tender_269\CADD\Drawings\Quail Rise\12506856-300-G100.dwg



GENERAL ARRANGEMENT PLAN

SCALE 1:1000

LEGEND - EXISTING

- PROPERTY BOUNDARY
- EASEMENT
- TOP OF BANK
- BOTTOM OF BANK
- BUILDING
- FENCE'
- TOP OF WALL
- BOTTOM OF WALL
- DRIPLINE
- BOUNDARY MARK
- SURVEY MARK
- WATER LATERAL
- MANHOLE
- WATER TANK
- TREE

LEGEND - EXISTING SERVICES

- HV — HIGH VOLTAGE POWER
- LV — LOW VOLTAGE POWER
- T — CHORUS
- C — VODAFONE
- FO — FIBRE OPTIC CABLE
- G — GAS
- S — SEWER
- SEWER ABANDONED
- SW — STORMWATER
- W — WATER
- WATER ABANDONED

LEGEND - PROPOSED

- EXTENT OF SCHEME BONDARY
- CENTRE LINE & CHAINAGE
- EDGE OF ROAD
- TOP OF BATTER
- BOTTOM OF BATTER
- EARTHWORKS INTERFACE
- MANHOLE
- CATCHPIT
- SW — STORMWATER
- W — WATER MAIN
- W — WATER RISING
- WW — WASTE WATER
- E — ELECTRICITY

NOTES:

1. FOR GENERAL NOTES AND LEGEND REFER TO DRGS 12506856-300-G005 TO G007
2. FOR EARTHWORKS, ACCESS ROAD AND STORMWATER DETAILS REFER TO CIVIL DRGS 12506856-300-C200 TO C521
3. FOR RESERVOIR AND PIPEWORK DETAILS REFER TO MECHANICAL DRGS 12506856-300-M100 TO M213
4. SERVICE LOCATIONS AS PER SUPPLIED DETAILS FROM QLDC GIS DATABASE

Rev	Description		Checked	Approved	Date
F	DETAILED DESIGN - FINAL ISSUE	IP*	AWh*		22.07.22
E	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*		05.05.22
D	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*		14.04.22
C	PRELIMINARY DESIGN UPDATES FROM CLIENT REVIEW	IP*	AWh*		03.11.21
B	PRELIMINARY DESIGN	IP*	AWh*		08.10.21
A	PRELIMINARY - FOR PRICING	IP*	AWh*		04.10.21

Author R. GERONIMO Drafting Check G. DOUGHERTY*

Designer K. ATKINS Design Check I. PARTINGTON*

0 10 20 30 40 50m

SCALE 1:1000 AT ORIGINAL SIZE

GHD Limited
Level 3, 138 Victoria Street
Christchurch 8013, New Zealand
T 64 3 378 0900 F 64 3 370 8001
E chcmail@ghd.com W www.ghd.com
www.ghd.com

Project No. 12506856

Client QUEENSTOWN LAKES DISTRICT COUNCIL

Project QLDC WATER RESERVOIRS

Status PRELIMINARY Status Code S2

Drawing Title QUAIL RISE RESERVOIR GENERAL ARRANGEMENT PLAN ULTIMATE STAGE

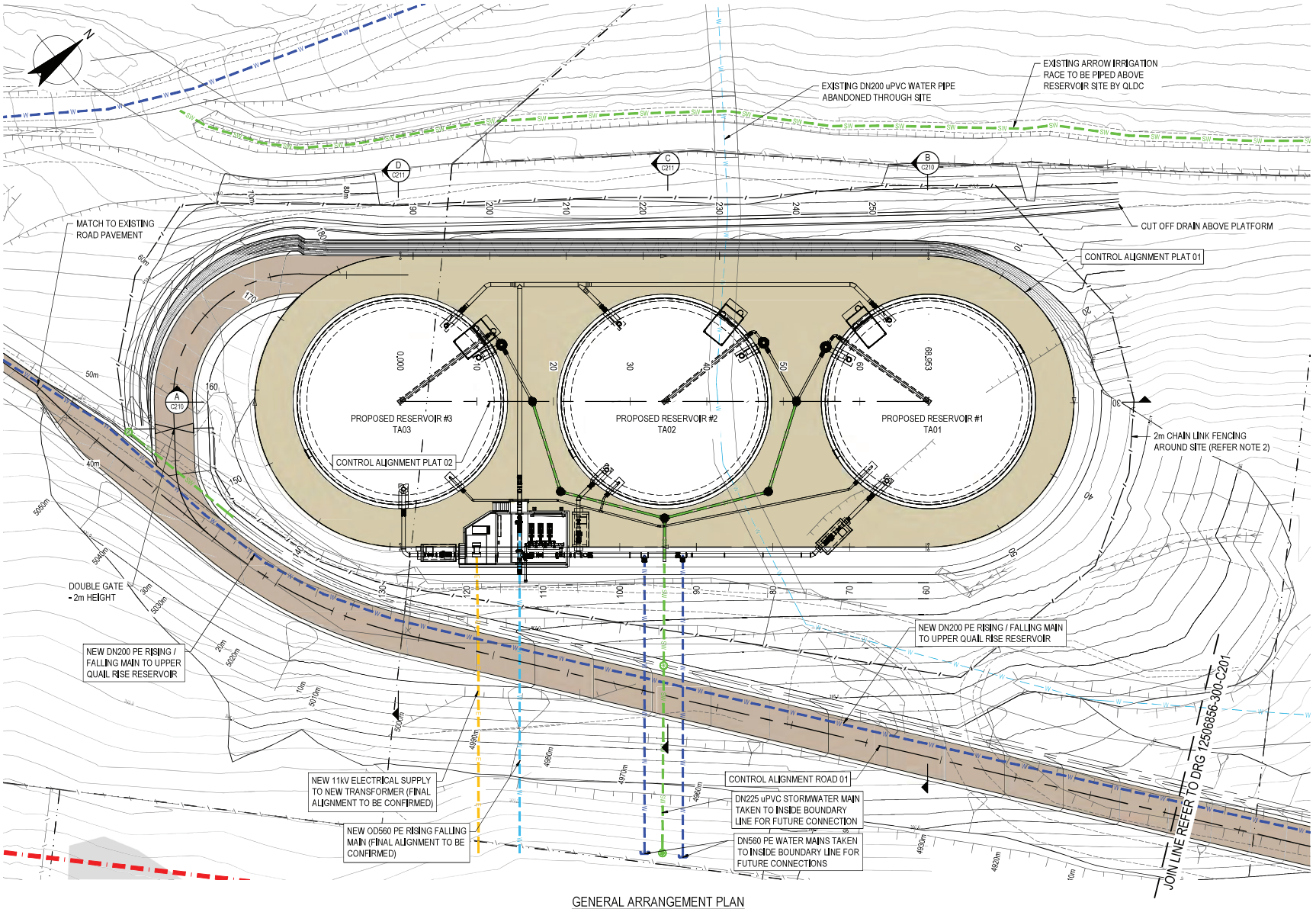
Size A1

Drawing No. 12506856-300-G200

Rev F

Plot Date: 26 July 2022 - 9:31 PM Plotted by: Rey Emmanuel Geronimo

File Name: C:\12dSW\data\P-00-12D-00101-12506856 - QLDC Reservoir Tender_269\CADD\Drawings\Quail Rise\12506856-300-G200.dwg



GENERAL ARRANGEMENT PLAN

SCALE 1:250

LEGEND - EXISTING

- PROPERTY BOUNDARY
- EASEMENT
- TOP OF BANK
- BOTTOM OF BANK
- BUILDING
- FENCE
- REMOVE FENCE
- TOP OF WALL
- BOTTOM OF WALL
- DRIPLINE
- BOUNDARY MARK
- SURVEY MARK
- WATER LATERAL
- MANHOLE
- WATER TANK
- TREE
- REMOVE TREE
- TREE PROTECTION

LEGEND - EXISTING SERVICES

- HIGH VOLTAGE POWER
- LOW VOLTAGE POWER
- CHORUS
- VODAFONE
- FIBRE OPTIC CABLE
- GAS
- SEWER
- SEWER ABANDONED
- STORMWATER
- WATER
- WATER ABANDONED

LEGEND - PROPOSED

- EXTENT OF SCHEME BONDARY
- CENTRE LINE & CHAINAGE
- EDGE OF ROAD
- TOP OF BATTER
- BOTTOM OF BATTER
- SEALED ROAD PAVEMENT
- UNSEALED ROAD PAVEMENT
- PLATFORM PAVEMENT
- MANHOLE
- CATCHPIT
- STORMWATER
- WATER MAIN
- WATER RISING
- WASTE WATER
- ELECTRICITY

NOTES:

1. FOR GENERAL NOTES AND LEGEND REFER TO DRGS 12506856-300-G005 TO G007.
2. FENCE AND GATE TO BE FABRICATED WITH RECESSIVE COLOUR TUBES AND MESH. FINAL ALIGNMENT TO BE AGREED ON SITE.

Rev	Description	Checked	Approved	Date
F	DETAILED DESIGN - FINAL ISSUE	IP*	AWh*	22.07.22
E	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	05.05.22
D	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	14.04.22
C	PRELIMINARY DESIGN UPDATES FROM CLIENT REVIEW	IP*	AWh*	03.11.21
B	PRELIMINARY DESIGN	IP*	AWh*	08.10.21
A	PRELIMINARY - FOR PRICING	IP*	AWh*	04.10.21

Author R. GERONIMO | Drafting Check G. DOUGHERTY* | Designer K. ATKINS | Design Check I. PARTINGTON*

0 2.5 5 7.5 10 12.5m

SCALE 1:250 AT ORIGINAL SIZE

QUEENSTOWN LAKES DISTRICT COUNCIL

GHD
Level 3, 138 Victoria Street
Christchurch 8013, New Zealand
T 64 3 378 0900 F 64 3 370 8001
E chcmail@ghd.com W www.ghd.com
www.ghd.com
GHD Limited

Project No. 12506856

Client: QUEENSTOWN LAKES DISTRICT COUNCIL

Project: QLDC WATER RESERVOIRS

Status: PRELIMINARY | Status Code: S2

Drawing Title: QUAIL RISE RESERVOIR CIVIL GENERAL ARRANGEMENT PLAN ULTIMATE STAGE - SHEET 1

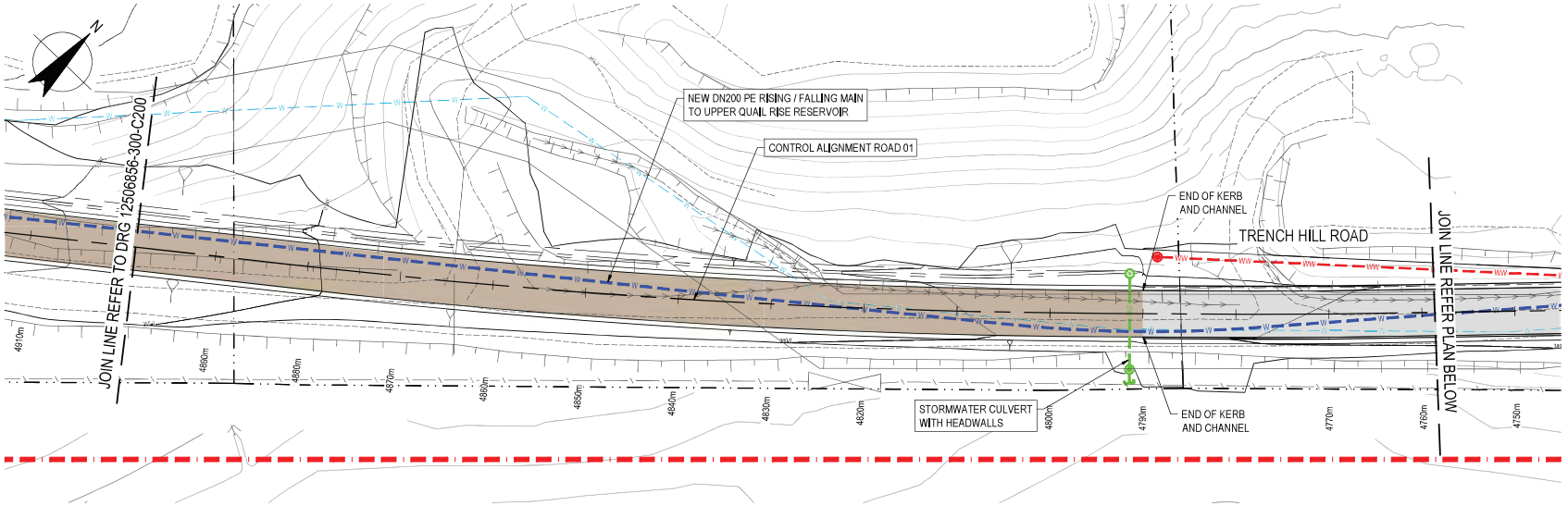
Size: A1

Drawing No.: 12506856-300-C200

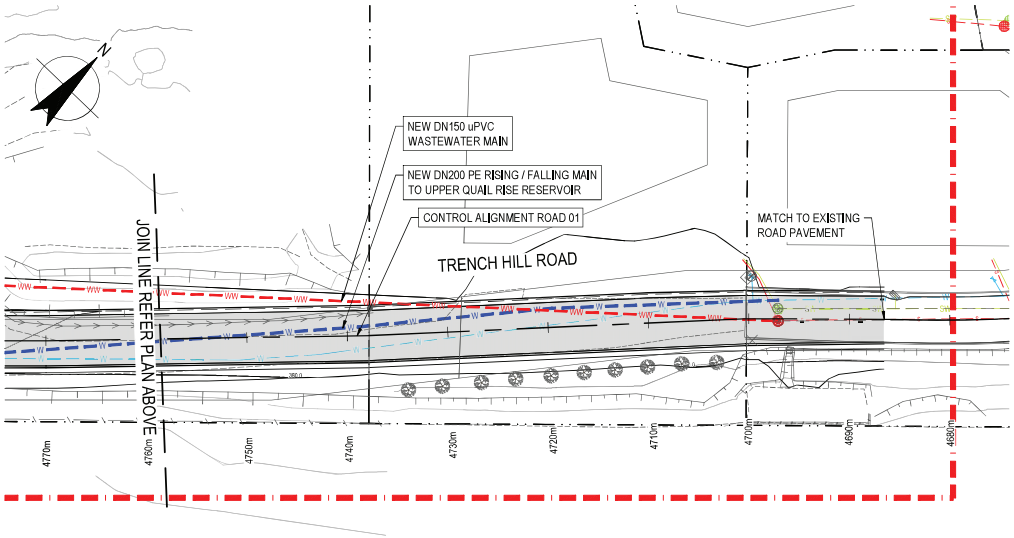
Rev: F

Plot Date: 26 July 2022 - 9:22 AM | Plotted by: Rey Emmanuel Geronimo

File Name: C:\12d\BW\data\P-00-12D-001\51-12506856 - QLDC Reservoir Tender_269\CADD\Drawings\Quail Rise\12506856-300-C200_C201.dwg



GENERAL ARRANGEMENT PLAN
SCALE 1:250



GENERAL ARRANGEMENT PLAN
SCALE 1:250

LEGEND - EXISTING

- PROPERTY BOUNDARY
- EASEMENT
- TOP OF BANK
- BOTTOM OF BANK
- BUILDING
- FENCE
- REMOVE FENCE
- TOP OF WALL
- BOTTOM OF WALL
- DRIPLINE
- BOUNDARY MARK
- SURVEY MARK
- WATER LATERAL
- MANHOLE
- WATER TANK
- TREE
- REMOVE TREE
- TREE PROTECTION

LEGEND - EXISTING SERVICES

- HIGH VOLTAGE POWER
- LOW VOLTAGE POWER
- CHORUS
- VODAFONE
- FIBRE OPTIC CABLE
- GAS
- SEWER
- SEWER ABANDONED
- STORMWATER
- WATER
- WATER ABANDONED

LEGEND - PROPOSED

- EXTENT OF SCHEME BONDARY
- CENTRE LINE & CHAINAGE
- EDGE OF ROAD
- TOP OF BATTER
- BOTTOM OF BATTER
- SEALED ROAD PAVEMENT
- UNSEALED ROAD PAVEMENT
- PLATFORM PAVEMENT
- MANHOLE
- CATCHPIT
- STORMWATER
- WATER MAIN
- WATER RISING
- WASTE WATER
- ELECTRICITY

NOTE:

1. FOR GENERAL NOTES AND LEGEND REFER TO DRGS 12506856-300-G005 TO G007

Rev	Description	Checked	Approved	Date
F	DETAILED DESIGN - FINAL ISSUE	IP*	AWh*	22.07.22
E	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	05.05.22
D	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	14.04.22
C	PRELIMINARY DESIGN UPDATES FROM CLIENT REVIEW	IP*	AWh*	03.11.21
B	PRELIMINARY DESIGN	IP*	AWh*	08.10.21
A	PRELIMINARY - FOR PRICING	IP*	AWh*	04.10.21

Author R. GERONIMO | Drafting Check G. DOUGHERTY*
Designer K. ATKINS | Design Check I. PARTINGTON*

0 2.5 5 7.5 10 12.5m
SCALE 1:250 AT ORIGINAL SIZE

QUEENSTOWN LAKES DISTRICT COUNCIL

GHD
Level 3, 138 Victoria Street
Christchurch 8013, New Zealand
T 64 3 378 0900 F 64 3 370 8001
E chcmail@ghd.com W www.ghd.com
www.ghd.com

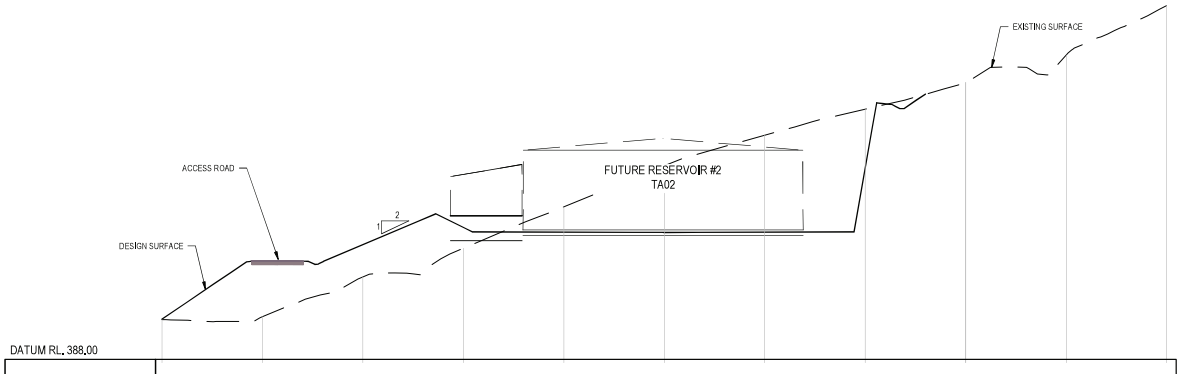
Project No. 12506856

Client: QUEENSTOWN LAKES DISTRICT COUNCIL
Project: QLDC WATER RESERVOIRS
Status: PRELIMINARY | Status Code: S2

Drawing Title: QUAIL RISE RESERVOIR
CIVIL GENERAL
ARRANGEMENT PLAN
ULTIMATE STAGE - SHEET 2

Size: A1
Drawing No.: 12506856-300-C201
Rev: F

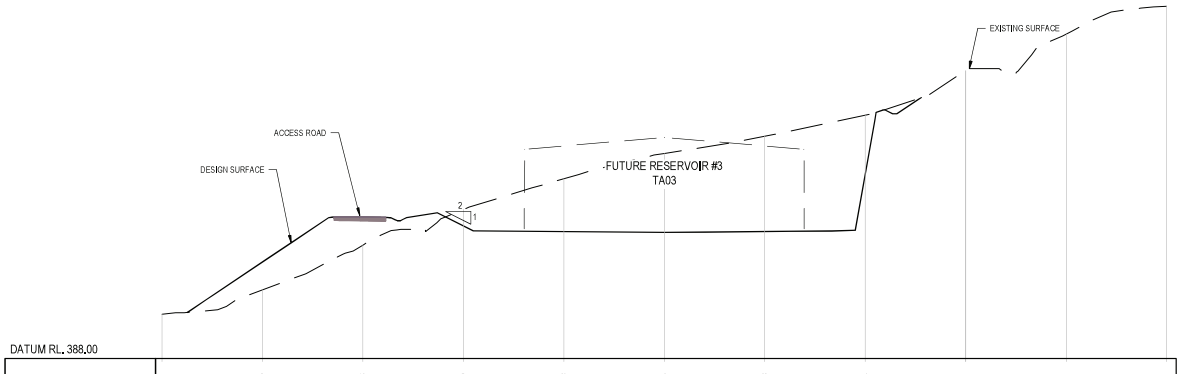
Plot Date: 26 July 2022 - 8:40 AM | Plotted by: Rey Emmanuel Geronimo
File Name: C:\12d\8W\data\P-00-12D-001\51-12506856 - QLDC Reservoir Tender_269\CADD\Drawings\Quail Rise\12506856-300-C200_C201.dwg



DATUM RL. 388,00

DESIGN SURFACE LEVEL	392.00	397.79	398.43	401.14	400.67	400.65	400.88	407.04		
EXISTING SURFACE LEVEL	391.98	392.26	398.22	399.08	403.19	407.27	410.31	412.90	415.58	418.29	423.21
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00

C SECTION
C200 SCALE 1 : 250



DATUM RL. 388,00

DESIGN SURFACE LEVEL		397.59	402.06	401.20	400.63	400.55	400.63	406.34		
EXISTING SURFACE LEVEL	392.42	394.83	399.25	402.82	405.89	408.40	410.12	412.20	416.64	420.28	423.07
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00

D SECTION
C200 SCALE 1 : 250

Rev	Description	Checked	Approved	Date
F	DETAILED DESIGN - FINAL ISSUE	IP*	AWh*	22.07.22
E	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	05.05.22
D	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	14.04.22
C	PRELIMINARY DESIGN UPDATES FROM CLIENT REVIEW	IP*	AWh*	03.11.21
B	PRELIMINARY DESIGN	IP*	AWh*	08.10.21
A	PRELIMINARY - FOR PRICING	IP*	AWh*	04.10.21

Author R. GERONIMO Drafting Check G. DOUGHERTY*
Designer K. ATKINS Design Check I. PARTINGTON*

0 2.5 5 7.5 10 12.5m
SCALE 1:250 AT ORIGINAL SIZE

QUEENSTOWN LAKES DISTRICT COUNCIL

GHD
Level 3, 136 Victoria Street
Christchurch 8013, New Zealand
T 64 3 378 0900 F 64 3 370 8001
E chcmail@ghd.com W www.ghd.com
www.ghd.com
GHD Limited

Project No. 12506856

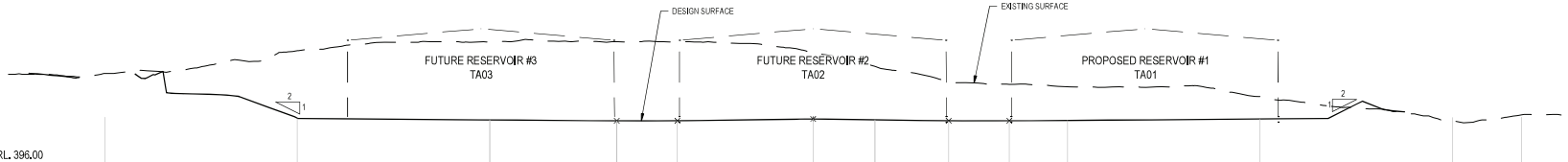
Client QUEENSTOWN LAKES DISTRICT COUNCIL
Project QLDC WATER RESERVOIRS
Status PRELIMINARY Status Code S2

Drawing Title QUAIL RISE RESERVOIR SITE WIDE SECTIONS SHEET 2

Size A1
Drawing No. 12506856-300-C211
Rev F

Plot Date: 26 July 2022 - 9:10 PM Plotted by: Rey Emmanuel Geronimo

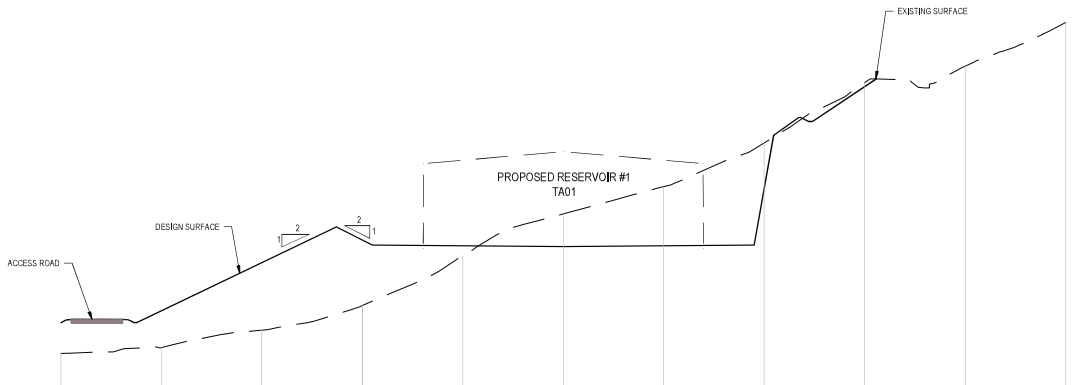
File Name: C:\12d\SWdata\P-00-12D-001\51-12506856 - QLDC Reservoir Tender_269\CADD\Drawings\Quail Rise\12506856-300-C210_C211.dwg



DATUM RL. 396.00

LEVEL DIFFERENCE CUT - / FILL +	-6.54	-7.05	-8.10	-8.21	-8.18	-6.95	-5.54	-4.06	-3.79	-3.51	-2.32	0.31	-0.23
DESIGN SURFACE LEVEL		400.74	400.54	400.45	400.45	400.65	400.56	400.45	400.45	400.49	400.64		
EXISTING SURFACE LEVEL	405.37	407.73	408.64	408.66	408.63	407.60	406.10	404.51	404.24	404.00	402.96	400.46	401.06
CHAINAGE	0.00	20.00	40.00	53.18	59.48	73.57	80.00	87.66	93.95	100.00	120.00	140.00	147.13

A C200 SECTION
SCALE 1 : 250



DATUM RL. 386.00

DESIGN SURFACE LEVEL	392.97	394.17	398.96	401.20	400.63	400.55	400.63	406.37	416.46	
EXISTING SURFACE LEVEL	388.92	390.52	392.23	394.66	398.61	403.81	406.52	410.88	416.87	418.51	422.86
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00

B C200 SECTION
SCALE 1 : 250

Rev	Description	Checked	Approved	Date
F	DETAILED DESIGN - FINAL ISSUE	IP*	AWh*	22.07.22
E	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	05.05.22
D	DETAILED DESIGN - FOR CLIENT REVIEW	IP*	AWh*	14.04.22
C	PRELIMINARY DESIGN UPDATES FROM CLIENT REVIEW	IP*	AWh*	03.11.21
B	PRELIMINARY DESIGN	IP*	AWh*	08.10.21
A	PRELIMINARY - FOR PRICING	IP*	AWh*	04.10.21

Author R. GERONIMO Drafting Check G. DOUGHERTY*
Designer K. ATKINS Design Check I. PARTINGTON*

0 2.5 5 7.5 10 12.5m
SCALE 1:250 AT ORIGINAL SIZE

QUEENSTOWN LAKES DISTRICT COUNCIL

GHD
Level 3, 138 Victoria Street
Christchurch 8013, New Zealand
T 64 3 378 0900 F 64 3 370 8001
E chcmail@ghd.com W www.ghd.com
www.ghd.com
GHD Limited

Project No. 12506856

Client QUEENSTOWN LAKES DISTRICT COUNCIL
Project QLDC WATER RESERVOIRS
Status PRELIMINARY Status Code S2

Drawing Title QUAIL RISE RESERVOIR SITE WIDE SECTIONS SHEET 1
Size A1
Drawing No. 12506856-300-C210
Rev F

Plot Date: 26 July 2022 - 9:10 PM Plotted by: Rey Emmanuel Geronimo
File Name: C:\12d\SWdata\P-00-12D-00151-12506856 - QLDC Reservoir Tender_269\CADD\Drawings\Quail Rise\12506856-300-C210_C211.dwg

Summary of submissions – RM200455 – Notice of Requirement for Water Reservoirs at Quail Rise

Submitter	Relief Sought
Arrow Irrigation Company Support subject to conditions	Pipe the open water race from the end of the existing Quail Rise pipe to the pipe at the Hansen boundary.
	Include a suitable connection to enable the continued supply to the Frankton Flats.
Hansen Family Partnership Oppose	Provide for public access through the site connecting to the trail constructed under RM151046.
	Better screen the reservoirs from public places and the Hansen Family Partnership land and protect the Ferry Hill ONL.
	Suggestion to increase the cut into the bank so to provide space to plant directly in front of the reservoirs.
Queenstown Trails Trust Neutral	Seeks a trail link through the NOR area from the existing trail constructed on the Hansen land to the Ferry Hill Drive ROW
Ferry Hill Trust (Ross Copland) Support subject to conditions	Seeks a trail link through the designation area along the access road. However to allow this, the submitter wants the road widened.
	Seeks timber guardrails on the outside edge of the access road / trail.
	Piping of the irrigation race.
	Changes to conditions: Condition 7 - Fence posts are to be finished in a recessive colour and fencing material is limited to mesh with no barbed wire Condition 12 – Require peer review of the geotech reports and specific consideration of any potential overland flow paths.
Universal Developments Limited	Important that the process of the reservoirs and pipes are interrelated.
	Careful consideration of screening from the submitter's land should be provided. Look at suitable species that can achieve higher growth rates and stature.
	Extension of the trail through the site – suggestion of widening of the access road.
	Pipe the water race.

Support subject to conditions	Changes to conditions: Condition 7 - Fence posts are to be finished in a recessive colour and fencing material is limited to mesh with no barbed wire Condition 12 – Require peer review of the geotech reports, specific consideration of any potential overland flow paths and peer review to confirm the structural integrity of the reservoir and associated works so not to have any adverse impact or risk to the future housing on the submitters land.
FII Holdings Limited Conditional support	Adverse visual and landscape effects
	Risk from land stability and natural hazards
	Adverse effects from the installation of the rising-falling main and other underground infrastructure
	Construction effects
	Effects from ongoing operation
	Inconsistent with the relevant provisions of the Operative and Proposed District Plan and Operative and Partially Operative Regional Policy Statement.
	Does not give effect to Part 2.
	Has not given adequate consideration to alternative sites and methods.
Terri Anderson Oppose	Submitter seeks clarity on timelines for work being carried out. Clarity on duration and scale of construction and hours of transport and construction.
	Design showing one reservoir is not comprehensive given that there could be two or three added.
	Concerns that the visual impact will be greater than shown.
	Concerns on the volume of traffic and the risks to safety, security and amenity. Consideration should be given to a gate being added to the easement on the border of 6 Trench Hill Road (where the seal ends) to improve safety and security.
	ROW not to be damaged and planting to be undamaged. Minimisation of dust, noise caused by heavy vehicles. Possible screening.
	Seeking confirmation that the ROW will not be widened, will not be utilised as a public through road or trail.
	Confirmation that the open water race will be managed to pose no greater flooding risk to the submitter's property. Land slump and damaged fencing from the recently flooding should be repaired. Planting to eliminate flooding or slip risk.
Woodlot Properties Ltd	Provide for public access through the site connecting to the trail constructed under RM151046.
	Better screen the reservoirs from public places and protect the Ferry Hill ONL.

Oppose	Suggestion to increase the cut into the bank so to provide space to plant directly in front of the reservoirs.

Technical Memorandum

24 February 2022

To	QLDC
Copy to	
From	GHD
Subject	Quail Rise Preliminary Design – Geotechnical Analysis Reporting

1. Introduction

This memo has been prepared to accompany, and provide technical support to, the Notice of Requirement (NOR) Application. The content has been directly extracted from the wider project Preliminary Design Report, prepared for the Quail Rise Reservoir Scheme, and issued to Queenstown Lakes District Council in November 2021.

Whilst the content of this memo can be read in isolation for the purpose of supporting the NOR Application, any wider technical reliance on the specific content should be taken in conjunction with the information contained in the full Preliminary Design Report.

2. Overview

The proposed earthworks for the scheme includes cutting of the in situ foliated schist and the placing of granular fill in order to create the required platform for the new reservoirs.

In order to assess the geotechnical stability issues associated with the works, GHD carried out the following tasks. This was completed in 2021 as part of the design process for the reconfigured scheme that was initiated by QLDC following the earlier NOR application.

- A derivation of a ground model for the site based on the 2019 ground investigation, including derivation of geotechnical parameters
- Derivation of the SLS and DCLS seismic disturbing loads for the site (peak ground accelerations)
- Determination of the key cross sections for analysis
- Stability analyses using slope stability software of both “downslope” filled areas and “upslope” cuts in the foliated schist rock

This memorandum summarises the results and findings from the above work.

3. Key risks and objectives

One key objective of the re-design work carried out for the Quail Rise site has been to remove the need for the use of mechanically stabilised fill in the earthworks. This has been achieved by limiting the gradients of all filled slopes to a maximum of 1 vertical to 2 horizontal, and by assuming they will be constructed from well graded, properly engineered, site won or imported granular fill.

Weathered colluvium exists across the Quail Rise site. If left in place, there is a risk that this material will form a “preferential slip plane” and lead to instability. It has therefore been assumed that all this material will be removed as part of the works. A suitable allowance should be made for this in any Bill of Quantities or tendering process. The material may be able to be reused for general landscaping, in which case this will reduce the need to dispose off site leading to a saving.

A key risk associated with the earthworks proposed at the Quail Rise site is the stability of the cut slopes to be created in the foliated schist. Steep cut slopes are proposed in this material to the rear of the reservoir platform. It is not possible to be definitive, prior to commencement of the site works, exactly what direction the foliations will be in all the proposed cut areas. For this reason, we propose an observational approach to the creation of these cut slopes. Remedial measures that may be required include localised anchors, soil nails and/or shotcrete. Further details on this are provided later in this memorandum.

4. References and software tools used

The following key references have been used during the geotechnical design process:

- BS8002. Code of Practice for Earth Retaining Structures.
- AS/NZS 1170.0:2002. Structural Design Actions. Part 0 : General Principles.
- AS/NZS 1170.5:2004. Structural Design Actions. Part 5 : Earthquake actions – New Zealand
- NZTA Bridge Manual, Third edition, Amendment 3, effective October 2018.
- CIRIA Report 143 (1995) : The Standard Penetration Test (SPT) : Methods and Use
- Turnbull, I.M. (compiler) 2000. Geology of the Wakatipu Area. Institute of Geological and Nuclear Sciences 1:250,000 geological map 18. 1 sheet + 72 p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences.

The following software has been used during the design process:

- SLOPEW by Geostudio 2018
- Settle 3D Version:4.022. April 2019. Rocscience Inc.

5. Site investigation data

As part of the earlier project work (2019), a Geotechnical Assessment Report (GAR) for the Quail Rise site was prepared. This site investigation consisted of four machine boreholes. Two of the holes were drilled to a target depth of 15 m bgl and the other two to target depths of 5 m bgl and 8 m bgl. A plan showing the location of these four boreholes is shown in Figure 1.

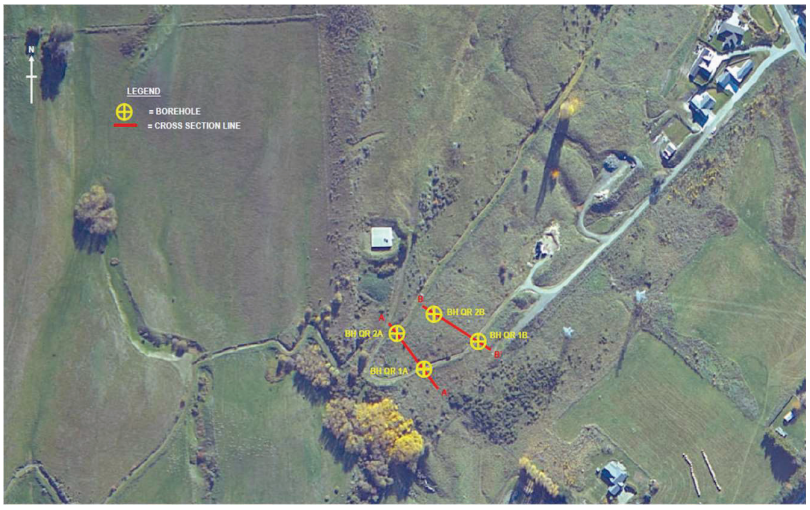


Figure 1 *Plan showing the location of boreholes drilled at the Quail Rise Site (2019)*

6. Foliated schist - geotechnical parameters employed

Foliated schist exists at the Quail Rise site. This material presents a particular challenge for slope stability modelling as the mobilised strength varies depending on the orientation of any assumed slip surface.

To derive credible strength parameters for the foliated schist, we carried out a back analysis. The details of this back analysis are as follows:

- We derived a cross sectional geometry based on the gradient of the existing ground close to the site of the proposed reservoir. The cross section was chosen to be perpendicular to the dip direction of the schist, thus resulting in the maximum foliation dip and the “least favourable” conditions, stability-wise.
- We assumed a historical acceleration of at least 0.35g had acted in the past directly parallel to the derived cross section. This is considered a conservative assumption.
- Groundwater was modelled with an Ru value assumed to be 0.15 to model partial saturation.
- The angle of friction of the foliated schist was assumed to be 18 degrees. The justification of this friction angle has been covered in previous GHD reporting.
- The cohesion value of the schist was varied within the model by means of a “foliation function” and the value required to produce stability (signified by a factor safety greater than one) was derived.
- The cohesion value required was found to be approximately 200 kPa.

Based on the above, the foliated schist at the site was modelled using the following parameters:

Angle of friction (Φ’) = 18º , Cohesion (c’) = 200 kPa

7. Groundwater

Groundwater was not encountered in any of the four boreholes carried out on the site. Therefore, to model groundwater in the slope stability analyses, “Ru” values have been used. “Ru” is defined as the ratio of pore water pressure to total overburden pressure. As there is no evidence of a standing water table that might lead to total saturation, Ru values between 0.1 and 0.2 have typically been employed in the analyses.

8. Stability cases analysed – rear cut slope and access road filled zones

Three key cross sections have either been analysed or considered as part of the slope stability assessment work. The locations of these cross sections are shown in Figure 2:

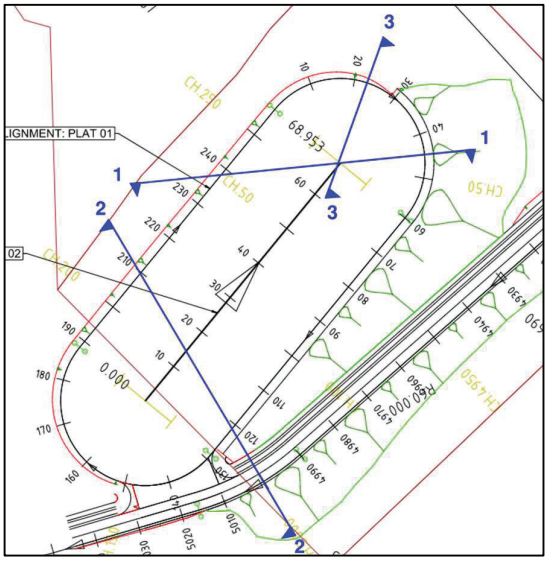


Figure 2 Plan showing the location of cross sections at the Quail Rise Site

Figure 3 below shows the cross sections analysed. The red boxes drawn onto the section diagrams show the zone which was analysed for slope stability. The following should be noted:

- Section 1-1 was selected to examine the stability of the filled zone downslope from the reservoir platform but upslope of the access road.
- Section 2-2 was selected to examine the stability of the rear cut slope in the foliated schist material.
- Section 3-3 was selected to examine a “worst case” cut in the foliated schist material.

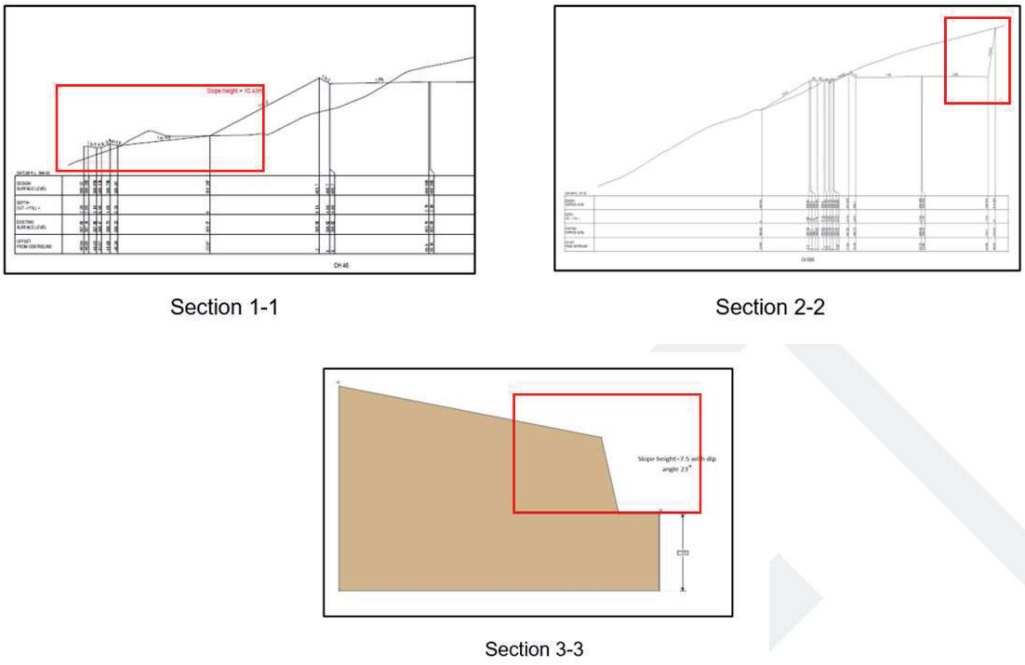


Figure 3 Cross sections analysed at the Quail Rise site

9. Seismic disturbing loads

The Importance Level ("IL") for the site has been assumed to be 4, as agreed earlier in the project.

Table 1 below shows the inputs to the design seismic acceleration.

Table 1 Design seismic acceleration inputs

Item	Site Design Value	Reference
Site Subsoil Class	B	NZS1170, Pt.5, Cl.3.1.3.
C0,1000 (1,000 yr return period PGA co-efficient)	0.4	NZTA Bridge Manual, Commentary Table C6.1
Design Life	50 years	Client defined information
f,Site subsoil class factor	1.0	NZTA Bridge Manual, Sec 6.2.2.
Design Return Period DCLS	1 in 2,500	NZS1170, Pt.0, 2002 Table 3.3.
Design Return Period SLS1	1 in 25	
Design Return Period SLS2	1 in 500	
Return Period Factor for DCLS, "Ru"	1.8	NZTA Bridge Manual, Table 5.1 for definition of CALS case &
Return Period Factor for SLS1, "Rs"	0.25	

Item	Site Design Value	Reference
Return Period Factor for SLS2, "Rs"	1.0	NZS1170, Pt.5, 2004 Table 3.5.
DCLS Design PGA	**0.55g**	
SLS1 Design PGA	**0.08g**	Equation shown above. (For IL4 areas of the site only)
SLS2 Design PGA	**0.31g**	

10. Stability Analysis - results

The results from the stability analyses are summarised in Table 2 below.

The following assumptions applied to the analyses:

- A target factor of safety for the long-term static case of 1.5
- A target factor of safety for the high groundwater level case of 1.2
- For the construction cases, a target factor of safety of 1.2
- For the two SLS seismic cases, a target factor of safety of 1.0
- For the DCLS seismic cases, displacement-based acceptance criteria have been adopted
- Where a surcharge has been adopted to model the reservoir, this was assumed to be 60 kPa
- Construction traffic surcharge, where applied, was modelled with a 24 kPa surcharge

Table 2 Stability analyses results

Cross Section No	Static Long Term	Static High Groundwater	Construction Case	SLS1 Seismic Case	SLS2 Seismic Case	DCLS Seismic Case
1-1a Fill stability only	Reservoir surcharge Ru=0.1 **FoS achieved = 1.5** Acceptable ✓	Reservoir surcharge Piezometric level of 1.0mBGL assumed **FoS achieved = 1.2** Acceptable ✓	Construction surcharge assumed to be 24kPa, with reservoir surcharge Ru=0.1 **FoS achieved = 1.5** Acceptable ✓	Reservoir surcharge Ru=0 applied PGA = 0.08g **FoS achieved = 1.4** Acceptable ✓	Reservoir surcharge Ru=0 applied PGA = 0.31g **Displacement derived < 10mm** Acceptable ✓	Reservoir surcharge Ru=0 applied PGA = 0.55g **Displacement derived ≈ 50mm** ** See note*
1-1b Fill stability beneath reservoir slab	Reservoir surcharge Ru=0.1 **FoS achieved = 1.5** Acceptable ✓	Reservoir surcharge Piezometric level of 1.0mBGL assumed **FoS achieved = 1.2** Acceptable ✓	Construction surcharge assumed to be 24kPa, with reservoir surcharge Ru=0.1 **FoS achieved = 1.5** Acceptable ✓	Reservoir surcharge Ru=0 applied PGA = 0.08g **FoS achieved = 1.6** Acceptable ✓	Reservoir surcharge Ru=0 applied PGA = 0.31g **FoS achieved = 1.6** Acceptable ✓	Reservoir surcharge Ru=0 applied PGA = 0.55g **Displacement derived ≈ 10-15mm** *# See note*
2-2	Cut slope in foliated schist – refer to qualitative discussion later in memorandum for recommendations on management of stability issues					
3-3	Cut slope in foliated schist – refer to qualitative discussion later in memorandum for recommendations on management of stability issues					

****** - This displacement derived is solely within the filled slope. It is considered this level of displacement is acceptable, given that the predicted movement will not affect the reservoir structure.*

***#** - This is a displacement which may occur beneath the reservoir slab or ring beam. Consultation with structural designers will occur to assess effects and any mitigation required in the structural design.*

10.1 Discussion on stability analysis results

10.1.1 Section 1-1a

Analysis 1-1a was designed to examine the stability of the filled section of the slope below the reservoir platform only. The result below shows the yield acceleration to be approximately 0.23g. This corresponds to a slope movement of less than approximately 50 mm. It is considered this will be acceptable in the filled slope as this is likely to lead to “aesthetic” and/or easily remediated effects only.

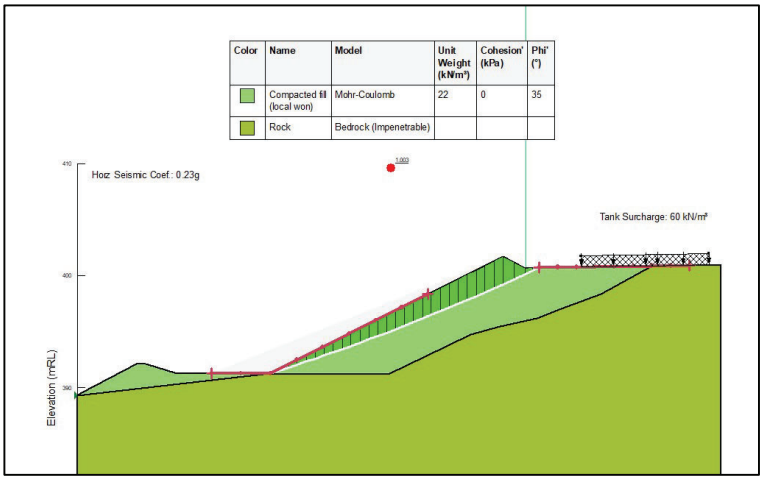


Figure 4 *Result of seismic yield stability analysis for section 1-1a*

10.1.2 Section 1-1b

Analysis 1-1b was designed to examine the potential movement of the fill placed beneath the reservoir slab. For this configuration, the result below shows the yield acceleration to be approximately 0.32g. This corresponds to an estimated movement of approximately 10 mm to 15 mm. The potential effects of this movement on the proposed reservoir foundation system has been discussed with the structural designers. It has been decided that the reservoir slab will not be able to tolerate the movements predicted which may lead to a loss of support, and effectively a “cantilevering” of the footing. The preferred method for dealing with this risk is to construct a zone of MSE beneath the reservoir footing to support the section of slab which extends beyond the rock/fill interface. For further details of the structure proposed, please refer to section 11.3.

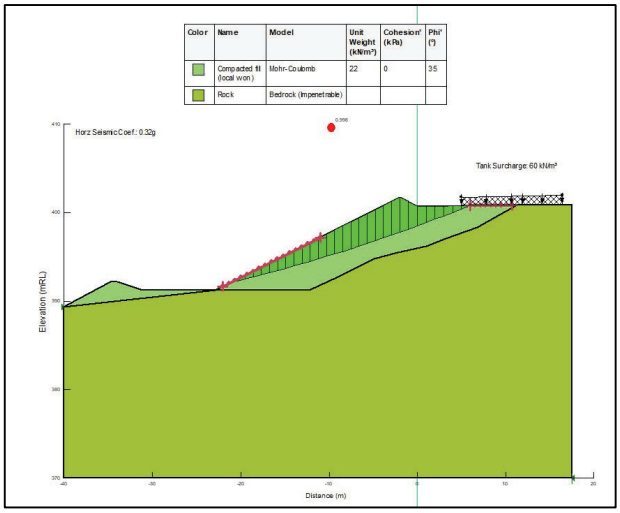


Figure 5 *Result of seismic yield stability analysis for section 1-1b*

10.2 Discussion on stability condition in the case of reservoir tank rupture

We have examined the stability condition for the case when the reservoir tank has ruptured and the water is being retained by the bund at the top of the engineered slope. Two analyses showing this case being modelled are shown and discussed below.

Case 1 – This case models the scenario shortly after the tank has ruptured. As can be seen, the tank has emptied (zero tank surcharge) and the water is being retained by the bund to a depth of approximately 1 m. As can be seen the stability condition is acceptable with a Factor of Safety returned of approximately 1.2.

Case 2 – This case models the scenario in the medium term (can be considered to mean a few days) after the tank has ruptured. The tank has emptied (zero tank surcharge) and the water has now saturated the material below the bund. As can be seen the stability condition is now not acceptable with a Factor of Safety returned of less than one.

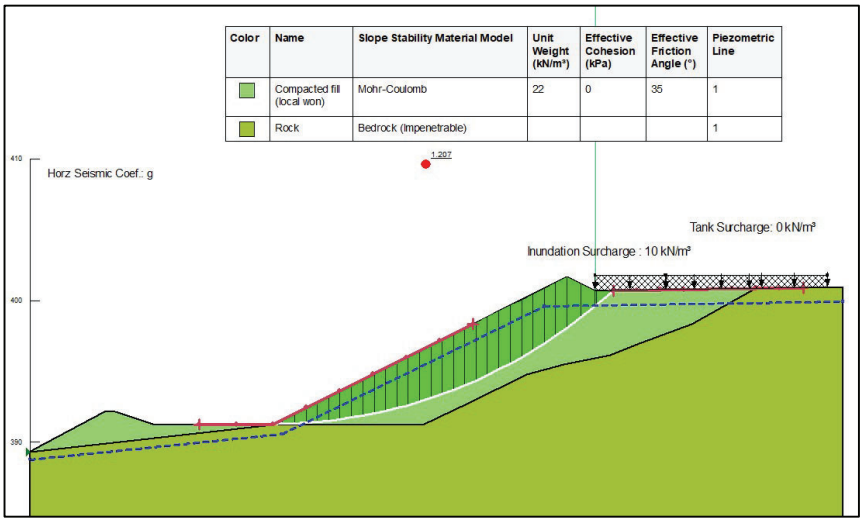


Figure 6 *Case 1 – Reservoir Tank Ruptured – "Short" Term*

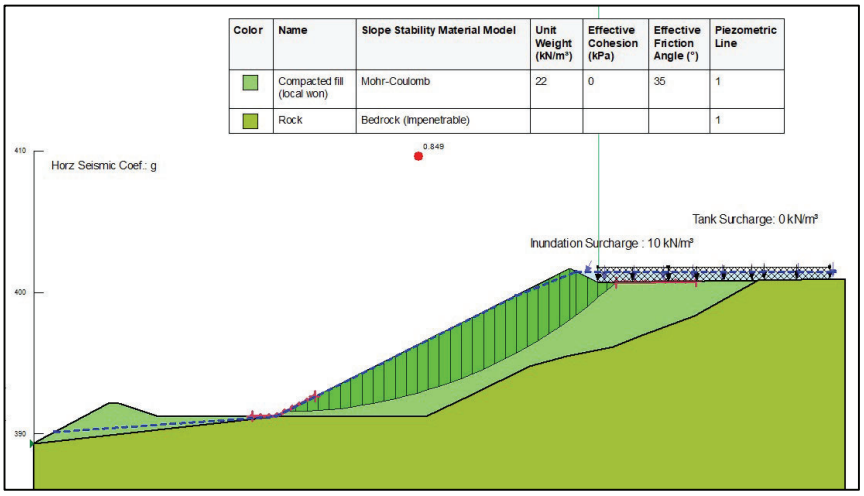


Figure 7 *Case 2 – Reservoir Tank Ruptured – "Medium" Term*

Cases 1 and 2 above show that if the tank ruptures, it would be advisable to ensure that the water is able to drain away within a period of time that would preferably be less than 24 hours.

10.3 Discussion on qualitative slope assessment of rock cutting

10.3.1 Section 2-2

The published regional foliation is mapped as dipping to the southwest. This regional dip was confirmed on site during mapping at the early stage of this project, albeit limited to a small number of rock outcrops. The orientation of the back face of the reservoir platform runs approximately northeast to southwest; this means that the cut face will be perpendicular to foliation. Faces cut perpendicular to foliation are assessed as favourable in terms of foliated driven planar failure. However, whilst foliation is favourable, there could be the presence of other discontinuities that create small block failures.

Due to the lack of certainty regarding foliation orientation and other discontinuities, whilst the cut slope orientation is deemed favourable, allowance should be made an observational approach with for top-down excavation and stabilisation. This is discussed further in Section 11.

10.3.2 Section 3-3

At the top northwest corner of the reservoir platform, the back rock cutting swings round from perpendicular to foliation to parallel to foliation. As the slope orientation becomes closer to parallel to foliation, the risk of slope instability from planar failure along foliation increases. However, in this case, the slope height decreases from the full height to no height. Section 3-3 represents a cross-section mid-way along this change where there is still slope height and foliation orientation is less favourable. As for Section 2-2, uncertainty with foliation and the possible presence of other discontinuities it is probable that small scale slope instability could exist along this section of the rock cutting.

Due to this uncertainty, allowance should be made an observational approach with for top-down excavation and stabilisation. This is discussed further in Section 12

11. Earthworks and cut slopes – recommendations and risks

The following recommendations and risks are noted.

11.1 Colluvium – actions required

It is likely that colluvial material will be encountered above the foliated rock within the excavations on site. This material may form a preferential slip plane which will lead to instability of the filled slopes. For this reason, we recommend that all colluvial material, where it is encountered in the location of proposed filled slopes, is removed. It may be possible to place this for landscaping purposes, subject to review on site.

11.2 Rock cutting remediation (provisional item recommended)

As described above, a key risk associated with the earthworks proposed at the Quail Rise site is the stability of the cut slopes in the foliated schist. An observational approach is proposed in order to manage the stability of the cuts. Remedial works required may include soil nails, shotcrete and/or anchors. At this stage, for preliminary design and risk budgeting purposes we propose it is assumed that approximately 30% of the total face area to be exposed. This implies an area of approximately 300 m^2 should be treated and that the following quantities of treatment should be included in the stabilisation budget:

- Rockfall Netting :100 m^2
- Rock anchors, ea 3 m long :45 (Assume 32 mm diameter bars)
- Soil nails – 5 m long, 1.5 m sq grid, shotcrete face :100 m^2

11.3 MSE support to tank edge

As discussed above, it is proposed to install a zone of buried but “freestanding” MSE beneath the section of the tank slab which extends out over the fill/schist boundary. A diagram showing this concept is shown in

Figure 8. It should be noted that only imported, quarried, well-graded, granular materials, with at least one broken face should be used to form the MSE zone. Approximate quantities that may be assumed for budgeting purposes are as follows:

Height of MSE structure	=	2 m to 4 m approx.
Length over which MSE extends	=	25 m approx.
Length of geogrids assumed	=	4 m approx.
Volume of imported granular fill required	=	400 m^3 approx
Type of geogrid	=	Cirtex SG500 (or similar approved)
Vertical spacing assumed for geogrids	=	400 mm
Approx area of geogrid required	=	800 m^2

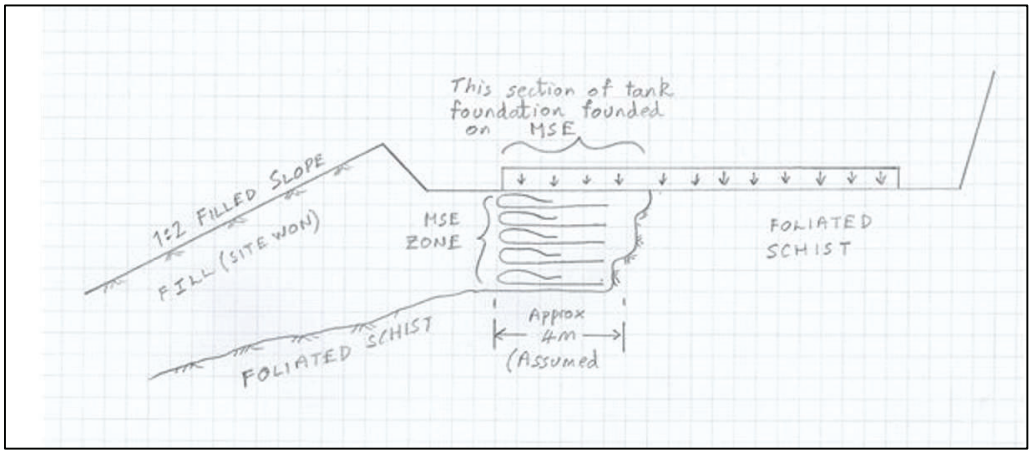


Figure 8 *Proposed MSE Zone beneath reservoir slab to mitigate effects of differential movement*

12. Producer Statement No.4 - Geotechnical

To prepare the Producer Statement No.4 that is required for the geotechnical design work, GHD will need to carry out construction observations to gather the necessary monitoring records. The construction observations will include the tasks described in the table below.

In addition to the tasks set out in the table below, to facilitate the production of a PS4, the contractor will need to supply information relating to the imported fill as follows:

- The address of the source quarry (for imported materials)
- The description of the parent rock
- The results of Maximum Dry Density test results for fills as set out in the overall project Specification

Table 3 *Quail Rise – Site Observations Required for Geotechnical PS4*

Inspection No	Inspection required	Inspection By	Records to be supplied or taken
1	Rear cut slope – observations from "top down" as excavation proceeds. Decision to be made on a "local, case-by-case" basis on the need or otherwise for anchors, nails, meshing, or shotcrete as required.	Designer's staff : Geologist or Engineering Geologist	Inspection of whole area to be cut measuring approximately 1,000 m^2. Photographic and written records of geology exposed and decisions made as to whether to adopt stabilisation measures or not – area covered / remedial method adopted / finished product photographic record required.

Inspection No	Inspection required	Inspection By	Records to be supplied or taken
2	Reservoir footing formation testing Testing of formation material exposed – Scala testing or other tests as required.	Designer's staff : Geologist or Engineering Geologist Contractor's staff may carry out Scala testing with agreement of Designer	Photographic records of material exposed for each site visit Scala testing results Written record on SVR of suitability of material exposed or otherwise
3	Reservoir structure formation Excavation and replacement of soft or unsuitable materials with well graded granular fill	Designer's staff : Geologist or Engineering Geologist	Written and photographic record on SVR of material exposed and excavated at each location where softer spots were encountered and excavated/replaced – approx. area, depth, volume treated to be noted.
4	Placement and compaction of well graded granular filled zones Density testing via NDM to be carried out for each 30 m^3 of fill placed in the 1 in 2 filled slope zones.	Designer's staff : Geologist or Engineering Geologist	Written and photographic record on SVR for each site visit. Inspections required at approximately 10 m lateral intervals. All density testing results to be supplied.
5 **(MSE)**	**For MSE Zones:** Inspection and testing of formation at 5 m intervals – scala values to be returned of 3 blows or greater per 100 mm over the upper 500 mm of formation	Can be Designers staff or contractor's staff with consent of the Designer	Plan diagram of platform area tested showing scala locations and results. Results to be recorded on Site Visit Report prepared by Designer's staff.
6 **(MSE)**	**For MSE Zones:** Inspection of placement of first level of geogrid – confirm geogrid is pulled taught and specified overlaps and "wrap arounds" are being observed	Designer's staff : Geologist or Engineering Geologist	Single site visit – recorded on SVR. It is not necessary to observe the placement of the whole of the lowest layer of geogrid. Inspection needs to confirm required construction techniques as specified to left are being observed.
7 **(MSE)**	**For MSE Zones:** Placement and compaction of well graded granular filled in MSE zone Density testing via NDM to be carried out for each 30 m^3 of fill placed in the 1 in 2 filled slope zones.	Designer's staff : Geologist or Engineering Geologist	Written and photographic record on SVR for each site visit. Density tests required for each 30 m^3 of fill placed in the MSE zone All density testing results to be supplied.

Technical Memorandum

09 December 2022

To	QLDC
Copy to	
From	GHD
Subject	Quail Rise Preliminary design – Stormwater Analysis and Design

1. Introduction

This memo has been prepared to accompany, and provide technical support to, the Notice of Requirement (NOR) Application. The content has been extracted (and updated) from the wider project Preliminary Design Report, prepared for the Quail Rise Reservoir Scheme, and issued to Queenstown Lakes District Council in November 2021.

Whilst the content of this memo can be read in isolation for the purpose of supporting the NOR Application, any wider technical reliance on the specific content should be taken in conjunction with the information contained in the full Preliminary Design Report.

2. Background

The construction of the Quail Rise reservoir platform will disrupt the current stormwater flow paths down the slopes within the QLDC-owned land at Lot 300 DP 457085, Lot 2 DP 469901, and Lot 3 DP 469901. The requirement for land development is that any water collected on the platform can be channelled into the existing stormwater system for discharge with only minimal or no effect on the pre-development hydrology.

The original Quail Rise concept design (2019) included a facility for the platform stormwater to be piped alongside the proposed rising falling main alignment through the Universal Developments land east of the site, discharging to the existing stormwater pipe located on the State Highway. The updated scheme configuration has removed this infrastructure connection through private property, therefore requiring a revision of the earlier planned stormwater disposal system.

The solution considered in the updated Preliminary Design Report (2021) was to extend the existing stormwater pipes servicing the southern part of the Quail Rise development through to the reservoir platform. This would add the reservoir platform catchment to the existing and future catchments within the Quail Rise subdivision (i.e. developed, and planned development areas) with the combined area discharging to the Shotover River via SH6. This initial proposal is illustrated in Figure 1.

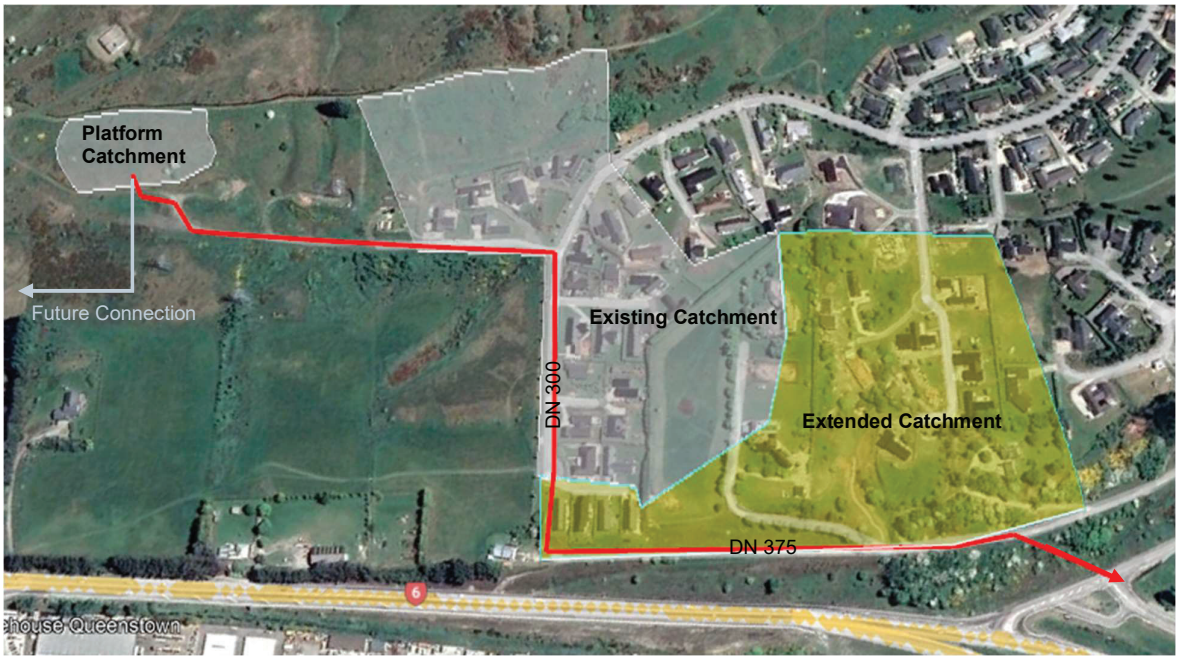


Figure 1 Stormwater Scheme (Preliminary Design Report)

This solution was to be considered a temporary scheme only, until the land below the reservoirs is developed and the link road through that development is constructed below the platform. At that time the stormwater from the platform area would be connected into the stormwater system in the link road and ultimately discharged to the DN1400 stormwater pipe at the Hawthorne Drive roundabout.

Analysis of the existing downstream catchment identified that only minimal free capacity remained to deal with expected storm flows from the platform if connected, meaning the proposed connection was potentially unviable, and required further consideration. Design development since the issue of the Preliminary Design Report has concluded that the best short term solution is to not connect into the Quail Rise system, but utilise the existing natural drainage paths from the slopes and access road, as described below, until there is available facility to connect into the new development east of the site.

3. Final Proposed Scheme

3.1 Expected Normal Stormwater Flows

To assess and design the revised stormwater system it is important to consider the downstream effects and additional load on the existing systems. GHD used the Rational Method, which is considered conservative, to determine suitable design parameters, which is typical for this type of system hydraulic design. Further, the impacts of climate change were considered by using RCP8.5 Hirds data. RCP8.5 2031-2050 was used because any initial system design is only a temporary system which is intended to be decommissioned by 2050 and RCP8.5 offers the most conservative estimation of climate change effects over that period.

As per the QLDC Code of Practice the new platform catchment development is being assessed based on a 5% AEP (1 in 20-year event); this assessment is used for sizing any new infrastructure including pipework. Conversely, according to the CoP, any connecting downstream catchments are to be assessed for a 60 min 20% AEP event (1 in 5-year event). Due to the small size of the catchment the 10 minute event is being used as a more conservative approach compared with the 60 minute flood. This combination of parameters has been determined as the most appropriate for this application, and is summarised in Table 1.

Table 1 Results of the Rational Method calculations

	Platform Catchment	Unit
RCP:	RCP8.5 for 2031-2050	
AEP	5%	
Duration	10	min
Catchment Area	6,100	m^2
Runoff coefficient	0.71	
Depth	4.95	mm
Intensity	29.7	mm/hr
Flow	35.8	L/s

The calculations demonstrate that it is expected the platform will capture peak flows of 36 L/s under the assessed conditions. As noted in Section 4, this is almost negligible compared with the existing and potential runoff generated from the existing catchment on the slopes, and no negative impact is expected from this concentrated outflow from the platform.

3.2 System Configuration

The system configuration which is to be adopted is to discharge the stormwater to the surface drain in the access road which leads to an existing overland flow path through Lot 3 DP 469901. This flow path crosses at a low point in the access road at the boundary between Lot 3 and Lot 101 DP 469901, and continues downslope in a natural flow path into the private property.

Currently, stormwater falling on the undeveloped land area passes as sheet flow onto the existing access road, or follows the overland path described above. Although the road is not sealed, it is equipped with some purpose-built drainage, and it is likely that some proportion of the runoff would be captured and channelled to the overland flow path. The existing configuration is illustrated in Figure 2.

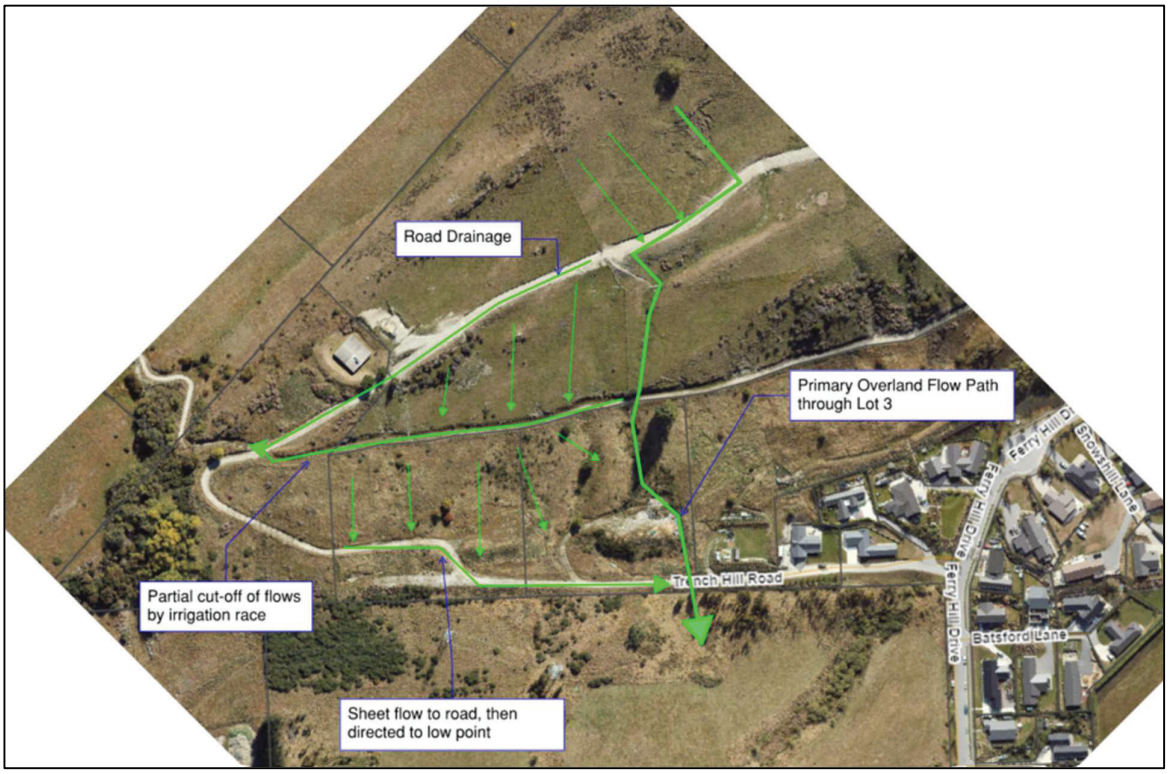


Figure 2 Existing Stormwater Flows

The reservoir scheme proposes to upgrade and realign the access road up to the reservoir to suit the revised earthworks. As part of this, the road formation and road-side drainage will be improved, and will remain directed to the natural flow path crossing point. This point will incorporate a piped culvert under the elevated road to maintain hydraulic connectivity across the road. A wing-wall and stone rip-rap discharge point will direct water back into the natural overland flow path downslope of the road. This feature mirrors a similar discharge utilised to continue upslope flows outside #6 Trench Hill Road.

The upgraded configuration is illustrated in Figure 3.

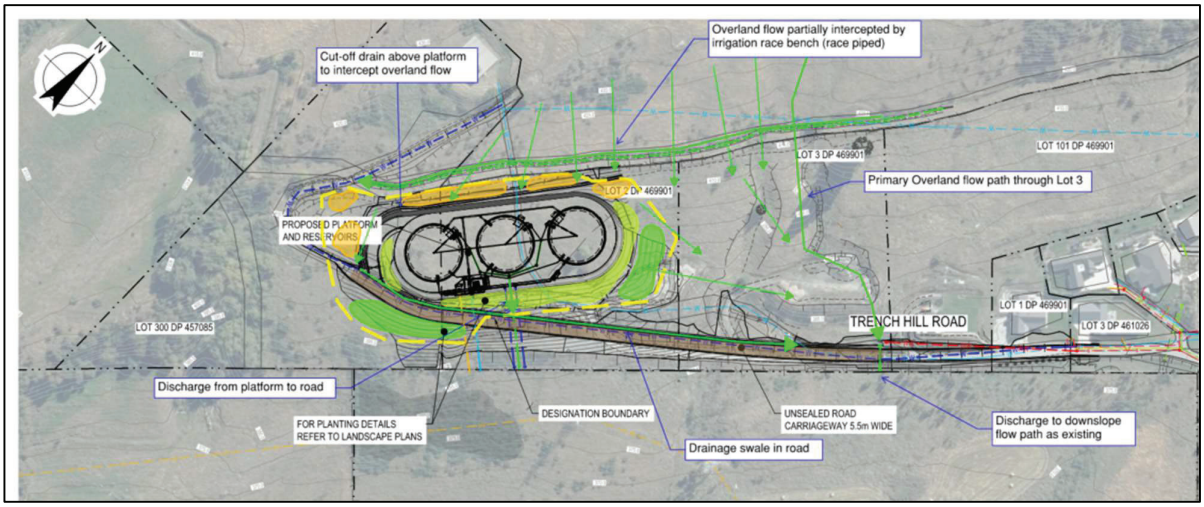


Figure 3 Amended Stormwater Flows

In summary, despite the development of the scheme, the overall stormwater management at the site and adjacent areas remains as existing.

It is intended that excess material generated from the bulk earthworks will be placed onto Lot 3, owned by QLDC. Placement of material will be in a manner to ensure long term stability, through management of height and grade, and by encouragement of rapid vegetation to bind the surface. So as not to adversely affect the current overland flow discharges, the material will be placed to encourage the flows to follow a similar route to existing, collecting at the discharge point described above.

3.3 Platform Drainage

A slight grade will be constructed across the tank platform from the outside towards two sumps located between Tank 1 & 2, and Tank 2 & 3. These sumps will catch the flows and pipe to a common sump at the front bund, from where a DN300 pipe will discharge flows to a new bubble-up manhole in the access road swale. The manhole also includes a DN300 capped pipe which will extend to just inside the eastern boundary of Lot 2 DP 469901, to be used for the future connection to the link road stormwater system.

Any stormwater which falls on the existing and remodelled slopes to the side and below the platform will be allowed to sheet flow to the access road, where it will be collected by the shoulder swales and directed to the lower discharge point with the other collected flows. This is consistent with the current, pre-development, condition.

3.4 Swale Design

As described above, the swale below the platform is used to channel flows off the platform to the existing overland flow path, where the water will pass under the road through a culvert. The swale follows the elevation of the road down to the culvert with a grade nominally at 13% but fluctuating between 3% and 20%.

According to QLDC standard construction drawings a check dam is required for a swale when the grade is steeper than 5% to prevent scouring within the swale. This means that a check dam would be required every 2 m in the steeper sections. To mitigate any scouring while reducing the need for check dams the swale will be rock lined. This will absorb some of the kinetic energy and slow the average velocity in the

swale. The top and bottom ends will be lined with railway ballast and the middle section will be lined with D50 of 100 mm blinded by AP40. The middle section of the swale is where the gradient is steepest, exceeding 20% requiring additional 200 mm vertical drops to be added every 5 m for a 20 m section, to further slow the average velocity in the swale.

This design will prevent scouring during normal PWWF conditions which are based on the 5% ARP as shown above. During an overflow or burst event when the flows increase to up to 260 L/s it is likely that damage to the swale will incur and require remedial works. This risk was deemed acceptable, due to the unlikelihood of such an event. At the end of the swale the water will be channelled under the road through a DN375 culvert. To avoid scouring of the road bund flows will daylight at the bottom of the bund, requiring a nominal grade of 25%. To avoid extreme flow velocities this was split into a 24.4% section and 2% section separated by an energy dissipating manhole.

3.5 Overflow and Burst Control

An overflow event is an uncontrolled and un-planned event that is activated when the maximum operating level within the reservoir is exceeded. A burst is a catastrophic failure of the tank that results in an uncontrolled discharge of the full volume of a tank.

The earthworks design has included a 1.8m high bund around the front of the platform, which intentionally creates a basin housing the reservoirs. The intent of this is to provide a buffer volume at the facility to attenuate excessive flows that will be generated under an overflow or burst scenario.

Each tank has an overflow pipe that is capable of handling the peak design flow that could be directed to the reservoir scheme, which is 260 L/s. The stormwater pipe connecting the platform to the access road (and in the future to the downslope development) has a hydraulic capacity capable of passing this peak flow. However, the stormwater pipework within the platform itself is smaller, which will help to attenuate any overflow within the platform and mitigate the peak instantaneous discharge to the environment.

Similarly, should a burst occur, the basin will attenuate flows off the platform down to levels which are less than naturally generated over the area in high intensity storm events.

Peak discharge rates onto the road are less than possible upper catchment peak storm flows, as outlined in Section 4, meaning the impact is expected to be negligible. For a one-time event, even if an overflow or burst were to occur during a peak event storm, the added flows are unlikely to be significant enough to cause any additional damage to property or risk to life.

As noted in the Quail Rise Preliminary Geotechnical Design, there is a risk that prolonged saturation of the front bund may reduce stability to resist seismic loads. The pipe configuration and sizing noted above is designed to enable the full volume of a tank to be discharged from the platform over 4 to 6 hours, depending on rate of release and attenuation on the platform. This is less than 25% of the maximum duration recommended by the Geotechnical Design.

4. Arrow Irrigation Race and Uphill Catchments

Through ongoing discussions between QLDC and Arrow Irrigation Ltd, it is proposed that the existing irrigation race above the site will be piped, extending from the current piped section above the Quail Rise development, through to the culvert under the existing access road above the site. This is primarily to:

- Remove the risk of the race blocking and causing overtopping of race flows directly onto the new reservoir site;
- Reduce the volumes of water which may be seeping from the race into rock, and that may daylight into the new reservoir site.

The open race is presumed to act as a cutoff drain to catch some of the overland rainfall runoff flow from the slopes above. The capacity of the race is not considerable, and is likely to be much less than the overland flow generated in a major event. There is clear evidence of flow crossing the race into Lot 3 adjacent to the new reservoir site, as well as seepage daylighting from the lower slopes of the lot.