DAMWATCH
ENGINEERING BEYOND THE SURFACE

Ohau A Reservoir – Dam-Break Inundation Maps for Emergency Management

18 June 2018

Prepared for Meridian Energy Limited

Issue 2

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1	29/06/2016	Issue 1	BV	DS	SM
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Current Document Approval

Prepared By Bill Veale

-

Reviewed By Grant Webby

Approved For Issue Ian Davison Signature:

Executive Summary

Dam-break flood inundation maps for the Ohau A Reservoir have been compiled from existing dam-break studies. The maps are provided in Appendix A and are intended to be integrated into Emergency Action Plans which form part of the Dam Safety Management System for the Ohau A Reservoir.

This report summarises the studies from which the inundation maps have been sourced and outlines the methodology to develop the maps. The report also includes an assessment of the dam-break hazard for Pukaki Canal between chainage 10,900 to 12,100 m which was found to be negligible.

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1.0 Introduction

This report outlines the methodology to develop of dam-break inundation maps for the Ohau A Reservoir.

The dam-break inundation maps for the Ohau A Reservoir are intended for use by agencies involved with emergency planning and response should a dam safety emergency event arise or in the event that a dam failure cannot be prevented.

The potential dam break inundation maps provided in this report do not in any way reflect adversely on the condition or integrity of the dams which retain the Ohau A Reservoir. Modern water retaining structures such as dams have an extremely low likelihood of failure. This high level of safety is achieved by close attention and management by the dam owner, throughout the operational life of the dam through a comprehensive Dam Safety Assurance Programme (DSAP).

2.0 Background

The Pukaki, Ohau and Ohau A Canal systems are part of Ohau A Reservoir of the Upper Waitaki Power Scheme. The Pukaki Canal begins immediately downstream of the Pukaki Lake Control Dam and is approximately 12 km long to the junction with the Ohau Canal and Ohau A Canal. The Ohau Canal begins at Lake Ohau and is approximately 9 km long to the junction with the Pukaki Canal and Ohau A Canal. Ohau A Canal is approximately 1 km long and conveys combined flow from Pukaki and Ohau Canals to Ohau A Power Station. The canals are earthfill embankments constructed in cut and fill sections along their length.

Section 3.0 outlines the development of the dam-break inundation maps for the Ohau A Reservoir.

3.0 Development of Dam-Break Inundation Maps

3.1 Existing Ohau A Dam-Break Inundation Studies

Table 3.1 lists the existing dam-break studies completed for the Ohau A Reservoir. The New Zealand Society on Large Dams (NZSOLD) Dam Safety Guidelines (NZSOLD, 2015) discuss three different levels of assessment to undertake dam-break flood hazard and consequence assessments which are summarised as follows:

- An *initial* assessment is based on readily available data and existing knowledge or from a qualitative estimation of the magnitude of a potential dam-break flood. It is likely to be conservative and may raise uncertainties that need to be resolved by an intermediate or comprehensive level of assessment.
- An *intermediate* assessment requires a more quantitative assessment in terms of the dam-break flood hazard and resulting downstream impact to people, property and the environment.
- A *comprehensive* assessment is typically required for dams that would have considerable downstream impact in a hypothetical dam failure event, or if there are unresolved uncertainties from an initial or intermediate assessment. This level of assessment requires detailed computational hydraulic modelling of the dam-break flood and detailed data gathering to determine the downstream impact to people, property and environment.

Table 3.1 also includes the level of detail of the existing dam-break studies.

The existing dam-break studies listed in Table 3.1 provide the maximum flood extents resulting from a hypothetical breach that develops over the full height of the dam or canal and drains the entire contents of the reservoir at maximum operation level.

The Pukaki, Ohau and Ohau A canals consist of sections constructed in cut and fill below natural ground level. Only the fill embankment sections have been subject to dam-break inundation studies as the cut sections are unlikely to have significant breach potential.

Table 3.1 – Summary of sources used to compile dam-break flood hazard areas

CANAL	DAM-BREAK FLOOD MAPPING REFERENCE	DAM-BREAK FLOOD MAPPING LEVEL OF DETAIL
Pukaki Canal	True left bank – Damwatch (2013a) True right bank – Damwatch (2018)	True left bank – Comprehensive True right bank – Comprehensive
Ohau Canal	True left bank – Damwatch (2013b) True right bank – Damwatch (2013b)	True left bank – Comprehensive True right bank – Comprehensive
Ohau A Canal	Damwatch (2005) & Opus (2005)	True left bank – Intermediate True right bank – Intermediate

3.2 Compilation of Dam-Break Inundation Maps

Appendix A provides dam-break inundation maps for the Pukaki, Ohau and Ohau A Canals.

Map Sheet No.1 (E1643\OHA\ERP\01) provides a register of the maps.

Map Sheet No.2, 3 and 4 (E1643\OHA\ERP\02, 03 and 04) provide background information and user notes for the dam-break flood maps.

Map Sheets No. 5 to 12 provide the dam-break flood inundation information.

Canal breach could occur at any location on embankments which hold back water above natural ground level. However, a discrete number of potential breach locations have been simulated in the existing dam-break studies. These locations are shown on the map legend as “Modelled breach location”. It is not feasible to model every possible breach location on the canals, and so secondary areas potentially subject to inundation are shown with cross-hatching on the maps and labelled “Potential Flood Inundation”.

Flood information shown on the maps represents the maximum flood depth from a composite of all breach locations simulated. This does not imply that any of the hypothetical breaches considered would occur, or that they could occur at all locations simultaneously.

3.3 Dam-Break Hazard for Pukaki Canal Chainage 10,900 to 12,100 m

3.3.1 Background

Pukaki Canal from chainage 10,900 to 12,100 m is largely constructed in cut below natural ground level with limited potential for breach and release of canal water. However, there are low fill embankment sections that may have potential to breach and release canal water.

Existing dam-break studies listed in Section 3.1 have not addressed this potential dam-break hazard. As a result the dam-break flood hazard for Pukaki Canal between chainage 10,900 to 12,100 m has been assessed at an “initial” level of detail as described in Section 3.2. The following section summarises the findings.

3.3.2 Dam-Break Hazard

The breach mechanism for Pukaki Canal between 10,900 to 12,100 m is assumed to be triggered by extreme seismic ground motions resulting in localised deformation and failure of the embankment (i.e. a Sunny Day failure).

Overtopping failure (i.e. a Rainy Day scenario) is not considered a possible breach mechanism, as inflow into the canals is controlled by the Pukaki and Ohau inlet structures and the Pukaki toppling block spillway provides an emergency overtopping flow path. Any overland flow that could enter sections of the canal in cut below natural ground level would be absorbed by the canal freeboard or flow through the Pukaki toppling block spillway in an extreme rainfall runoff event.

Figure 1 shows a plan of the Pukaki Canal from chainage 10,900 to 12,000 m overlain with a digital elevation model developed from 0.5 m contours derived from LiDAR aerial survey data

flown in 2012. Cross-sections, at locations shown on Figure 1, have been extracted from the digital elevation model and shown in Figure 2. Note that LiDAR aerial survey does not penetrate water surfaces and the submerged profile is shown with a dashed line in Figure 2.

Figure 2 illustrates that natural ground level on the true right bank of the canal is above the maximum canal operation level of 517.5 m RL[2] with no potential for release of canal water. An exception is at cross-section 11,300 m where the ground level drops below 517.5 m RL approximately 1.5 km from the true right bank. However due to the significant distance from the canal bank this section does not have the potential to breach.

The true left bank of the canal between approximately chainage 11,000 to 11,900 m has embankments up to 2.5 m above natural ground level. However, the maximum canal operation level is only around 0.2 m above natural ground level.

The maximum peak breach outflow from the true left bank of the canal between chainage 11,100 to 11,900 m is estimated with the Froehlich (1995) equation to be less than 5 m^3/s. Such a discharge will produce a shallow overland flow with depths less than 0.3 m and would cause negligible flood hazard to downstream people or property.

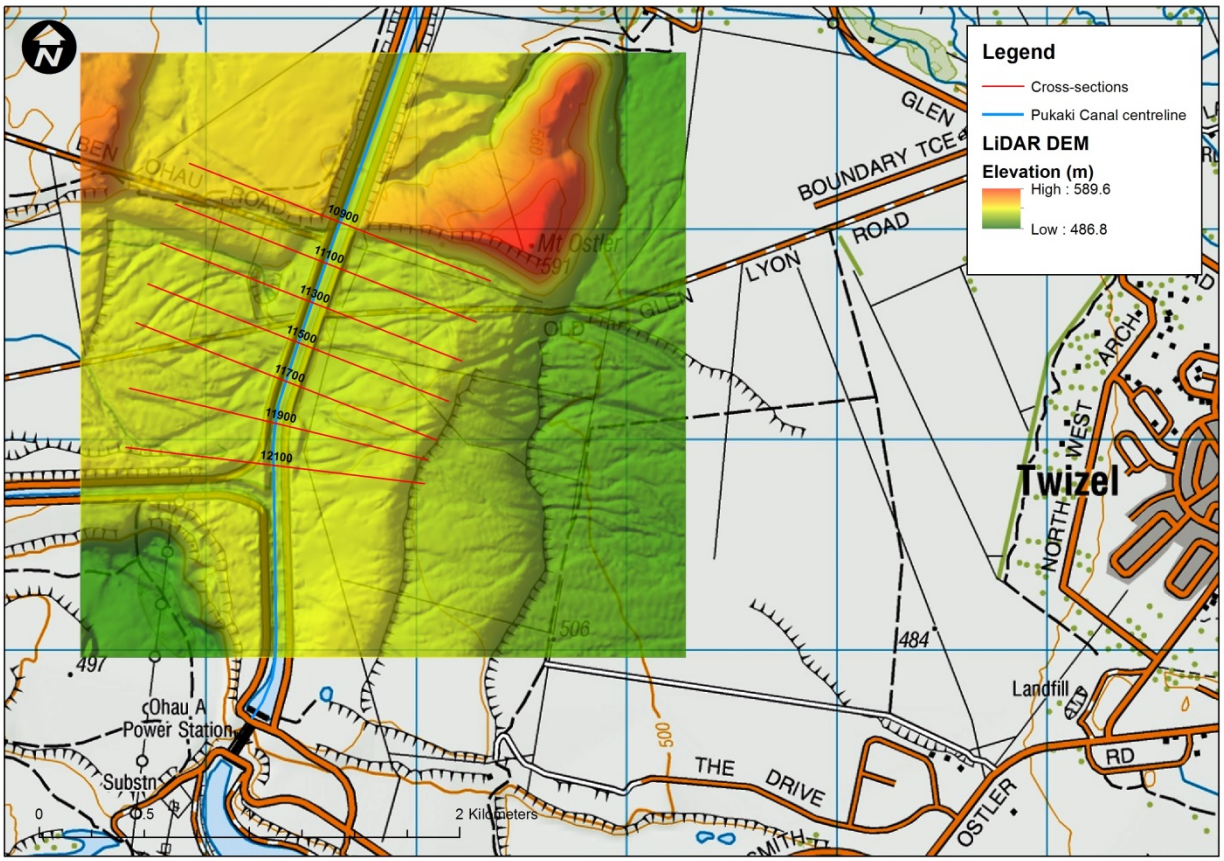


Figure 1 – Location of cross-sections and LiDAR Digital Elevation Model (DEM). Pukaki Canal flow is from north to south.

[2] Pukaki Canal normal maximum operating level extracted from: *Opus (2014). Hydraulic Structures Hydrological Data, Issue 9. A report prepared by Opus International Consultants Limited for Meridian Energy Limited*.

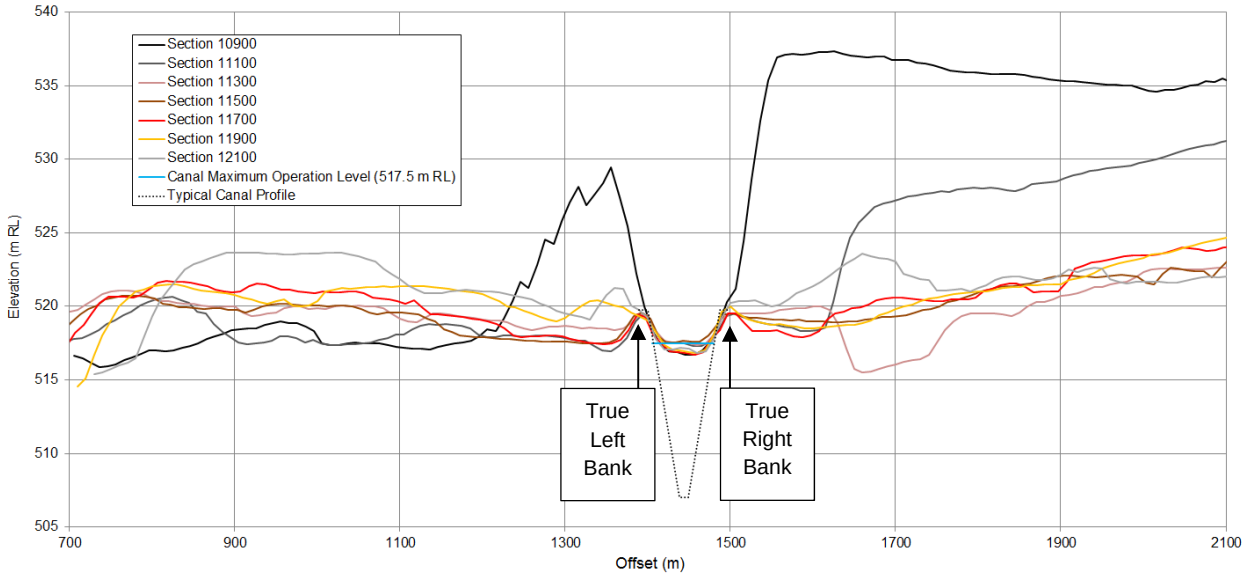


Figure 2 – Cross-sections

4.0 Conclusions

Dam-break flood inundation maps for the Ohau A Reservoir have been compiled from existing dam-break studies. The maps are provided in Appendix A and are intended to be integrated into Emergency Action Plans for the Ohau A Reservoir.

Dam-break flood hazard for Pukaki Canal between chainage 10,900 to 12,100 m has been assessed at an “initial” level of detail described in the NZSOLD Guidelines. The potential dam-break flood hazard for this section has not been assessed in existing dam-break studies for the Ohau A Reservoir. This section of the canal has potential to breach at the true left bank between chainage 11,100 to 11,900 m where the embankments are up to 2.5 m above natural ground level. However, the peak dam-break discharge from breach of this section is estimated to be less than 5 m^3/s and a discharge of this magnitude would cause negligible flood hazard to downstream people or property.

5.0 References

Damwatch. (2005). *Assessment of the Potential Impact Category for Upper Waitaki Power Scheme Structures and Lake Te Anau and Lake Manapouri Control Structures.* A report prepared by Damwatch Services Ltd for Meridian Energy Ltd. Ref: DW 397-2; Issue 1.

Damwatch. (2013a). *Pukaki Canal Embankments: Dam Break Flood Hazard Assessment.* A report prepared by Damwatch Services Ltd for Merdian Energy Ltd. Ref: E1227; Issue 3, March 2013.

Damwatch. (2013b). *Ohau Canal: Dam Break Flood Hazard Assessment.* A report prepared by Damwatch Services Ltd for Meridian Energy Ltd. Ref: E1270; Issue 2, June 2013.

Damwatch. (2018). *Dam-Break Flood Inundation Mapping for Ohau A Reservoir - Pukaki Canal Right Bank.* A report prepared by Damwatch Engineering Ltd for Meridian Energy Ltd. Ref: E1643, Issue 2.

NSWSG. (2005). *Floodplain Development Manual.* New South Wales State Government, Department of Environment, Climate Change and Water.

NZSOLD. (2015). *New Zealand Dam Safety Guidelines.* New Zealand Society on Large Dams.

Opus. (2005). *Upper Waitaki Power Scheme - Canal and Dam Breach Flood Hazard Assessment. Appendix 1 of Companion Report "Assessment of Potential Impact Category for Upper Waitaki Power Scheme Structures and Lake Te Anau and Lake Manapouri Control Structures.* A report prepared by Opus International Consultants Ltd for Meridian Energy Ltd. Ref: 350377.00; Issue 1.

Opus. (2007). *A letter report from Opus International Consultants Ltd to Meridian Energy Ltd entitled “Upper Ohau River Flood Risk Assessment.* Dated 18 December 2007.

Appendix A

Dam-break inundation maps

MAP REGISTER

Map Sheet No.	Map Reference No.	Subject Dam	Map Information	Revision Number & Issue Date				
				1	2	3	4	5
01	E1643\OHA\ERP\01	OHAU A RESERVOIR	MAP REGISTER	18/06/18				
02	E1643\OHA\ERP\02	OHAU A RESERVOIR	NOTES (PAGE 1 OF 3)	18/06/18				
03	E1643\OHA\ERP\03	OHAU A RESERVOIR	NOTES (PAGE 2 OF 3)	18/06/18				
04	E1643\OHA\ERP\04	OHAU A RESERVOIR	NOTES (PAGE 3 OF 3)	18/06/18				
05	E1643\OHA\ERP\05	OHAU A RESERVOIR	OVERVIEW MAP	18/06/18				
06	E1643\OHA\ERP\06	OHAU CANAL - TRUE RIGHT BANK	MAXIMUM FLOOD DEPTH AND TRAVEL TIME	18/06/18				
07	E1643\OHA\ERP\07	OHAU CANAL - TRUE LEFT BANK	MAXIMUM FLOOD DEPTH AND TRAVEL TIME	18/06/18				
08	E1643\OHA\ERP\08	OHAU A CANAL	MAXIMUM FLOOD EXTENT	18/06/18				
09	E1643\OHA\ERP\09	PUKAKI CANAL - TRUE RIGHT BANK	MAXIMUM FLOOD DEPTH AND TRAVEL TIME	18/06/18				
10	E1643\OHA\ERP\10	PUKAKI CANAL - TRUE LEFT BANK	MAXIMUM FLOOD DEPTH AND TRAVEL TIME (PAGE 1 OF 3)	18/06/18				
11	E1643\OHA\ERP\11	PUKAKI CANAL - TRUE LEFT BANK	MAXIMUM FLOOD DEPTH AND TRAVEL TIME (PAGE 2 OF 3)	18/06/18				
12	E1643\OHA\ERP\12	PUKAKI CANAL - TRUE LEFT BANK	MAXIMUM FLOOD DEPTH AND TRAVEL TIME (PAGE 3 OF 3)	18/06/18				

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

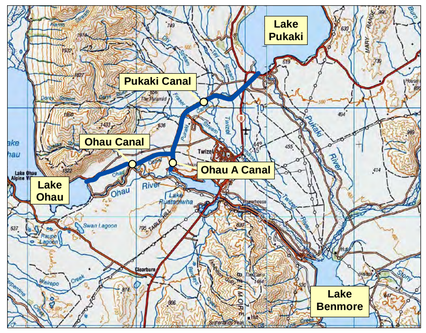
Subject Dam
OHAU A RESERVOIR

Map Sheet No.
01

Map Information
MAP REGISTER

Key Plan

Ohau A Reservoir



Legend
N/A

Notes

1. For background and information on the use of this set of maps refer to Map Sheets No. 02 to 04.

2. This Potential Flood Inundation Map remains the property of Meridian Energy Limited (Meridian). It may not be copied, scanned or reproduced in any format without written permission from Meridian. Background mapping is sourced from Land Information New Zealand (LINZ) and licensed by LINZ for re-use under the Creative Commons Attribution 3.0 New Zealand licence.

Map Details

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CHECKED BY	GW	
APPROVED BY	ID	
MAP REFERENCE No.	E1643\OHA\ERP\01	
REVISION NUMBER	1	
DATE	18/06/18	

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NOTES (PAGE 1 OF 3)

Background

1. Meridian Energy Limited (Meridian) manages Ohau A Reservoir pursuant to a best practice Dam Safety Assurance Programme (DSAP) and the *New Zealand Dam Safety Guidelines* (May 2015).

2. In line with best practice, Meridian's DSAP includes Emergency Response Planning, to manage any small residual risk of dam failure. An element of this, is the development and issue of Potential Flood Inundation Maps based on Hypothetical Dam-Break Scenarios (the Information). These are provided primarily for use by Central, Regional and Local Government authorities in Civil Defence emergency response and evacuation planning of potentially affected communities.

3. The Potential Flood Inundation Maps indicate the combined hazard from the various hypothetical dam-break scenarios assessed for the Ohau A Reservoir.

4. The hypothetical dam-break scenarios used to develop the Information DO NOT, IN ANY WAY imply any failing in the structural capability or integrity of a dam or canal, or a likelihood of a dam or canal experiencing a dam safety incident.

5. The structures retaining Ohau A Reservoir are designed, constructed, managed and maintained to withstand normal, unusual and extreme load scenarios, without uncontrolled release of the reservoir. These load scenarios include operational, seismic and flood conditions.

6. The purpose of Meridian's DSAP Emergency Response Planning is to identify potential dam failure threats, that could reasonably be foreseen, and to implement a response that allows any incident to be averted or reasonable steps to prevent or stop it developing, or if it cannot be averted, its consequences mitigated and/or effects on the safety of people, property and the environment minimised. This information relates to the last element, consequence mitigation.

Information Warning for Users

7. By utilising the Information you acknowledge you have read and accepted these terms and conditions.

8. The Information provided has been prepared following the methodologies recommended in the *New Zealand Dam Safety Guidelines* (May 2015), and provides an indication of the effects of flooding (extent, depth, severity and timing) from a hypothetical "worst case" dam or canal failure scenario. Please note actual dam or canal failure may give rise to conditions that vary from those indicated.

9. The Information is principally provided for use by agencies responsible for Civil Defence and Emergency Management planning and being data that will be relevant and continue to form part of any Land Information Memorandum request for land affected and made pursuant to s44A of the Local Government Official Information and Meetings Act 1987.

10. While every endeavour has been made to supply accurate information, errors and omissions may occur.

(a) The Information is indicative only, and provided for emergency management planning purposes. It does not identify, warrant or guarantee the safety of any area in the unlikely event of a dam, or canal breach.

(b) The Information identifies areas that may potentially be affected by inundation in the unlikely event of a dam or canal breach only and do not reflect any natural hazards, for example flooding from rivers.

(c) Notwithstanding that best industry practice methods as would reasonably and ordinarily be expected from a skilled and experienced operator have been used to identify all potentially affected areas, actual areas affected may differ for example, if flow paths vary due to land form change.

11. Meridian does not accept any liability, and you (and any person claiming through you) shall not be entitled to make any claim for any loss or damage which may directly or indirectly result from any reliance, representation or omission from the Information, whether in contract, tort (including, negligence), equity, nuisance, public nuisance, under any statute or otherwise.

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13. Amendments, alterations and /or changes to the Information may be made by Meridian from time to time. Meridian will make available to Central, Regional and Local Government authorities as required, any such revisions to the Information as soon as practicable after they have been approved for release. You are responsible for ensuring that you hold the latest revisions of the Information and that you review any emergency response plans which make use of this Information.

Intellectual Property

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

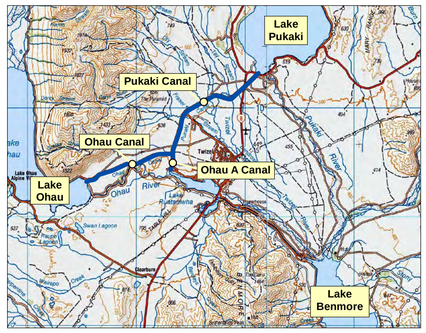
Subject Dam	Map Sheet No.
OHAU A RESERVOIR	02

Map Information

NOTES (PAGE 1 OF 3)

Key Plan

Ohau A Reservoir



Legend

N/A

Notes

1. For Potential Flood Inundation Maps refer Map Sheets No. 05 to 12.

Map Details

PREPARED BY	BV	SCALE: REFER TO SCALE BAR
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NOTES (PAGE 2 OF 3)

Map Information

MAXIMUM FLOOD EXTENT & DEPTH

The maps show the maximum likely depth of flooding arising from failure of the **Ohau A Reservoir**. The maximum flood depth (above natural ground level) is shown in five bands as illustrated in Figure 1 and 2. Maximum flood depth is derived from computational hydraulic modelling results (refer to data sources below).

Only maximum flood extent (not depth) information is available downstream of Ohau A Power Station headpond (refer Map Sheet No. 8). The maximum flood extent is shaded in dark blue on this map.

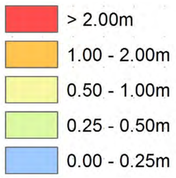


Figure 1 - Maximum Flood Depth Bands

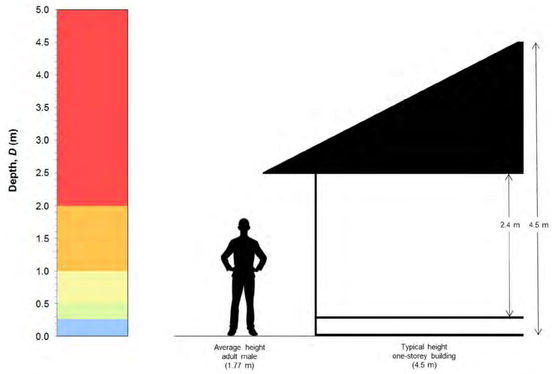


Figure 2 - Illustration of Maximum Flood Depth Bands

FLOOD WAVE TRAVEL TIME

At key locations down the valley, information on initial and peak flood arrival times are provided, where:

Initial flood arrival time is the time at which the location experiences a water level rise greater than approximately 0.1 m.

Peak flood arrival time is the time at which the location experiences the peak flood water level.

All flood wave travel times are measured from the onset of rapid failure of the dam.

Figure 3 illustrates how travel time information is provided on the maps. Travel times should not be interpreted as precise, but as an indication of the possible flood travel time for emergency planning.

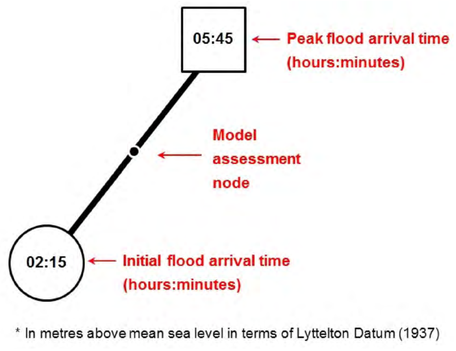


Figure 3 - Travel time information.

CANAL BREACH LOCATION

A canal breach is an extremely unlikely event. However, it could potentially occur at any location on embankments which hold back water above natural ground level. A discrete number of potential breach locations have been simulated with computational hydraulic models. These breach locations are shown on the maps and labelled "Modelled breach locations".

Potential flood inundation areas that have not been subject to computational hydraulic modelling but would be inundated were canal breach to occur upslope are shown on the maps with blue cross-hatching.

Flood information shown on the maps represents the maximum flood depth from a composite of all breach locations simulated. This does not imply that any of the hypothetical breaches considered would occur, or that they could occur at all locations simultaneously.

Data Sources

The Information shown on the maps is sourced from the following reports:

• Damwatch (2005). Assessment of the Potential Impact Category for Upper Waitaki Power Scheme Structures and Lake Te Anau and Lake Manapouri Control Structures. A report prepared by Damwatch Services Ltd for Meridian Energy Ltd. Ref: DW 397-2; Issue 1.

• Damwatch. (2013a). Pukaki Canal Embankments: Dam Break Flood Hazard Assessment. A report prepared by Damwatch Services Ltd for Merdian Energy Ltd. Ref: E1227; Issue 3, March 2013.

• Damwatch. (2013b). Ohau Canal: Dam Break Flood Hazard Assessment. A report prepared by Damwatch Services Ltd for Meridian Energy Ltd. Ref: E1270; Issue 2, June 2013.

• Damwatch. (2018). Dam-Break Flood Inundation Mapping for Ohau A Reservoir - Pukaki Canal Right Bank. A report prepared by Damwatch Engineering Ltd for Meridian Energy Ltd. Ref: E1643, Issue 2.

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

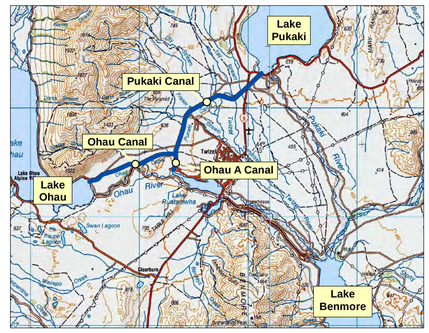
Subject Dam	Map Sheet No.
OHAU A RESERVOIR	03

Map Information

NOTES (PAGE 2 OF 3)

Key Plan

Ohau A Reservoir



Legend

N/A

Notes

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MAP REFERENCE No.	E1643\OHA\ERP\03	
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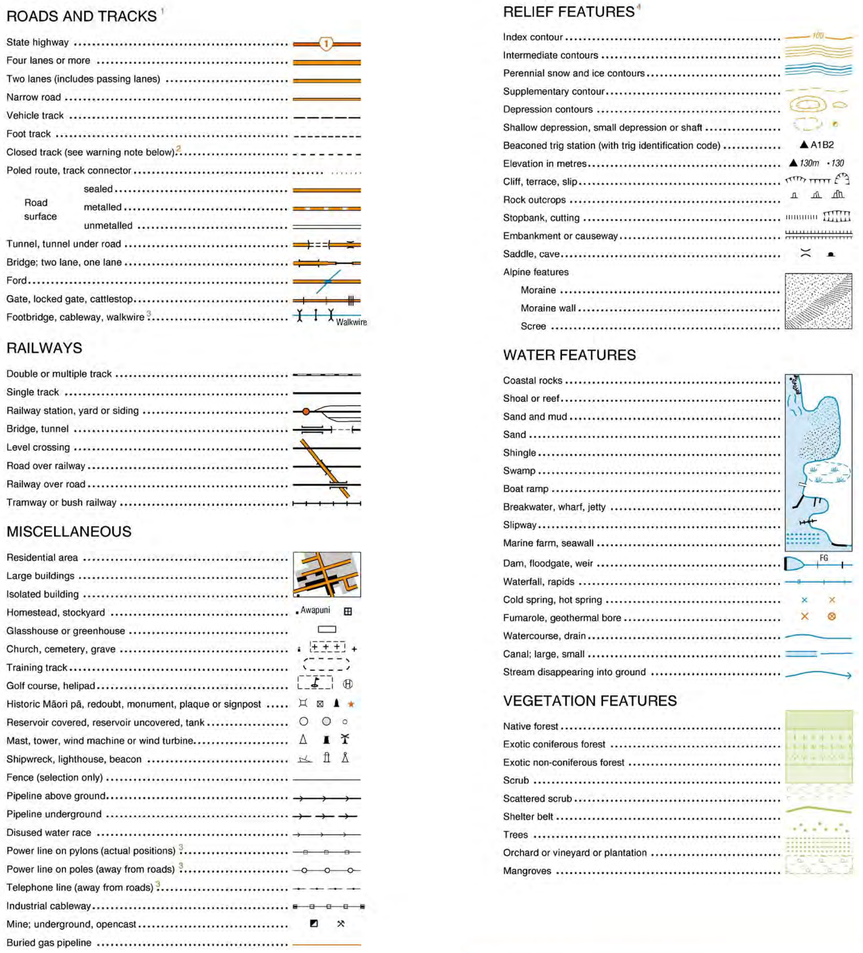
NOTES (PAGE 3 OF 3)

LINZ Topo50 Map Legend

Land Information New Zealand (LINZ) Topo50 series topographic maps are used as a background mapping layer. The legend for these maps is shown in Figure 1.



IMPORTANT INFORMATION:

1. Representation on this map of a road or track does not necessarily indicate public right of access.
2. Closed tracks or routes on this map are defined as being no longer maintained or passable and should not be used by recreationalists. The Department of Conservation or other authorities should be contacted for the latest information on tracks and huts.
3. Not all aerial wires, cableways and obstructions that could be hazardous to aircraft are shown on this map.
4. Contours and spot elevations in forest and snow areas may be less accurate.

Figure 1 - LINZ Topo50 series topographic map legend

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

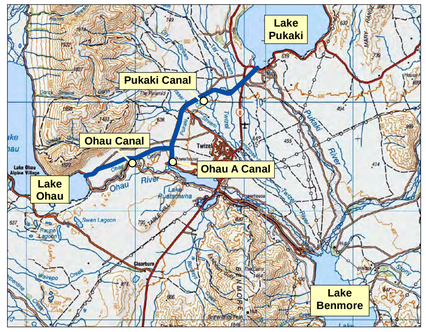
Subject Dam	Map Sheet No.
OHAU A RESERVOIR	04

Map Information

NOTES (PAGE 3 OF 3)

Key Plan

Ohau A Reservoir



Legend

N/A

Notes

1. For Potential Flood Inundation Maps refer Map Sheets No. 05 to 12.

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Map Details

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OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
OHAU A RESERVOIR	05

Map Information

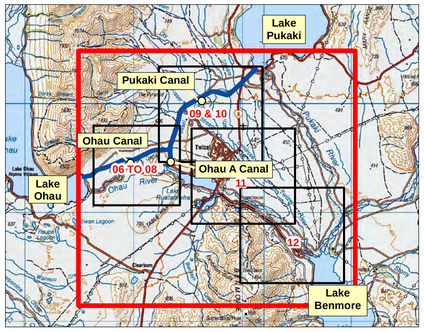
OVERVIEW MAP

Key Plan

Ohau A Reservoir

Current Map Frame

12 Map Sheet No.



Legend

MAXIMUM FLOOD DEPTH & EXTENT

Potential Flood Inundation

Notes

1. For background and information on the use of this map refer to Map Sheets No. 02 to 04.

2. This Potential Flood Inundation Map remains the property of Meridian Energy Limited (Meridian). It may not be copied, scanned or reproduced in any format without written permission from Meridian. Background mapping is sourced from Land Information New Zealand (LINZ) and licensed by LINZ for re-use under the Creative Commons Attribution 3.0 New Zealand licence.

Map Details

PREPARED BY	BV	SCALE 1:40,000 @ A1
CHECKED BY	GW	
APPROVED BY	ID	
MAP REFERENCE No.	E1643\OHA\ERP\05	
REVISION NUMBER	1	
DATE	18/06/18	

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DAMWATCH ENGINEERING BEYOND THE SURFACE

0 1 2 3 4 Kilometers

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
OHAU CANAL - TRUE RIGHT BANK	06

Map Information

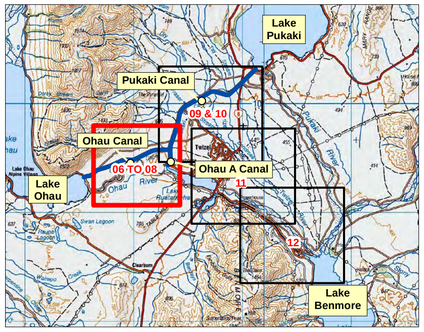
MAXIMUM FLOOD DEPTH AND TRAVEL TIME

Key Plan

Ohau A Reservoir

Current Map Frame

12 Map Sheet No.

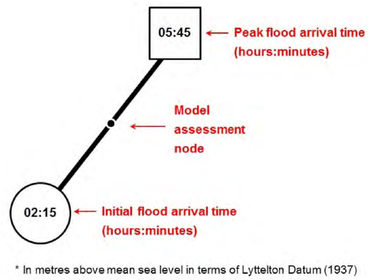


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

IMPORTANT NOTE:

Potential flood depth and extent shown on this map represents a composite of all individual breach locations simulated for the true right bank of the Ohau Canal. This does not imply that any of the hypothetical breaches considered would occur, or that they could occur at all locations simultaneously.

The Ohau River is braided so flow path in the river channel may vary depending on actual river conditions/alignment at the time.

0 0.5 1 1.5 2 Kilometers

Notes

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Map Details

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MAP REFERENCE No.	E1643\OHA\ERP\06	
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DAMWATCH ENGINEERING BEYOND THE SURFACE

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
OHAU CANAL - TRUE LEFT BANK	07

Map Information

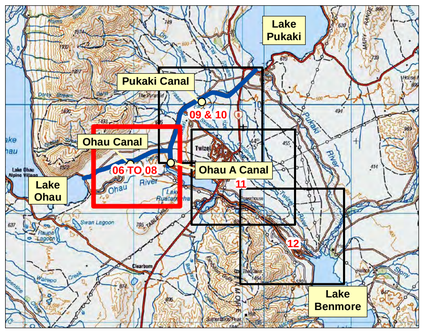
MAXIMUM FLOOD DEPTH AND TRAVEL TIME

Key Plan

Ohau A Reservoir

Current Map Frame

12 Map Sheet No.

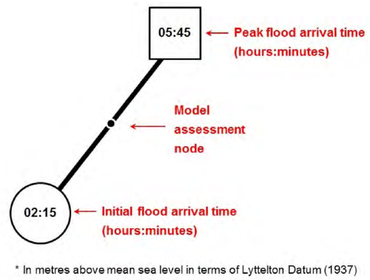


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



* In metres above mean sea level in terms of Lyttelton Datum (1937)

All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

Notes

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IMPORTANT NOTE:

Potential flood depth and extent shown on this map represents a composite of all individual breach locations simulated for the true left bank of the Ohau Canal. This does not imply that any of the hypothetical breaches considered would occur, or that they could occur at all locations simultaneously.

0 0.5 1 1.5 2

Kilometers

Map Details

PREPARED BY	BV	SCALE 1:12,500 @ A1
CHECKED BY	GW	
APPROVED BY	ID	
MAP REFERENCE No.	E1643\OHA\ERP\07	
REVISION NUMBER	1	
DATE	18/06/18	

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DAMWATCH ENGINEERING BEYOND THE SURFACE

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
OHAU A CANAL	08

Map Information

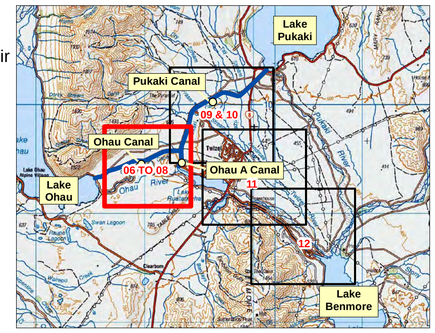
MAXIMUM FLOOD EXTENT

Key Plan

Ohau A Reservoir

Current Map Frame

12 Map Sheet No.

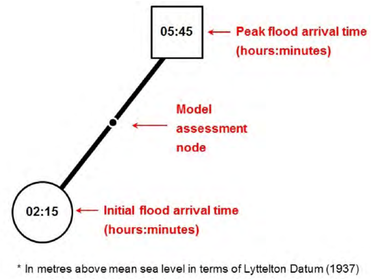


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



* In metres above mean sea level in terms of Lyttelton Datum (1937)

All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

Notes

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Map Details

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MAP REFERENCE No.	E1643\OHA\ERP\08	
REVISION NUMBER	1	
DATE	18/06/18	

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DAMWATCH ENGINEERING BEYOND THE SURFACE

0 0.5 1 1.5 2 Kilometers

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

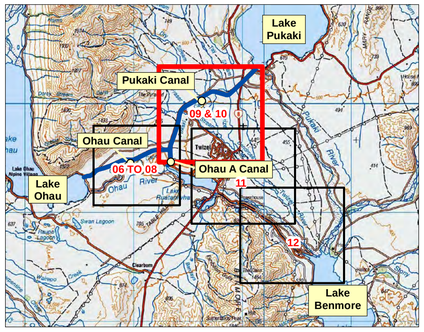
Subject Dam	Map Sheet No.
PUKAKI CANAL - TRUE RIGHT BANK	09

Map Information

MAXIMUM FLOOD DEPTH AND TRAVEL TIME

Key Plan

- Ohau A Reservoir
- Current Map Frame
- 12 Map Sheet No.

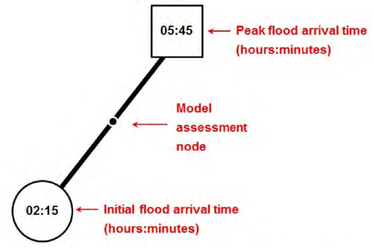


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

Notes

1. For background and information on the use of this map refer to Map Sheets No. 02 to 04.

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Map Details

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CHECKED BY	GW		
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MAP REFERENCE No.	E1643\OHA\ERP\09		
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DAMWATCH ENGINEERING BEYOND THE SURFACE

FLOW FROM DRY STREAM CULVERT
Peak discharge = 95 cumecs (approx.)

FLOW FROM TWIZEL RIVER CULVERT
Peak discharge = 415 cumecs (approx.)

FLOW FROM FRASER STREAM CULVERT
Peak discharge = 215 cumecs (approx.)

For flow paths and travel times of outflows from the Twizel River, Dry Stream and Fraser Stream culverts, refer to Map Sheets 09 to 12 produced for hypothetical left bank canal breaches at these culvert locations.

IMPORTANT NOTE:

Potential flood depth and extent shown on this map represents a composite of all individual breach locations simulated for the true right bank of the Pukaki Canal. This does not imply that any of the hypothetical breaches considered would occur, or that they could occur at all locations simultaneously.

Potential maximum flood depths and extents downstream of the Twizel River, Dry Stream and Fraser Stream culverts are not shown. Refer to Map Sheets No. 10 to 12 for potential flood inundation areas downstream of these culverts. These maps will be conservative as the culvert flows from the right bank breach scenarios will be much smaller than the left bank canal breach outflows.

0 0.5 1 1.5 2 Kilometers

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
PUKAKI CANAL - TRUE LEFT BANK	10

Map Information

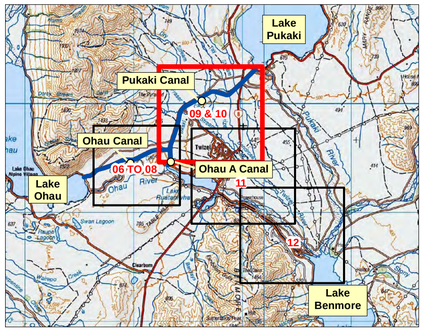
MAXIMUM FLOOD DEPTH AND TRAVEL TIME

Key Plan

Ohau A Reservoir

Current Map Frame

12 Map Sheet No.

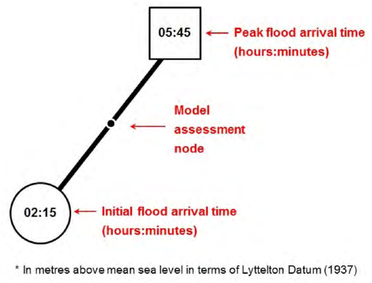


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

Notes

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The Twizel River is braided so flow path in the river channel may vary depending on actual river conditions/alignment at the time.

0 0.5 1 1.5 2 Kilometers

Map Details

PREPARED BY	BV	SCALE	1:15,000 @ A1
CHECKED BY	GW		
APPROVED BY	ID		
MAP REFERENCE No.	E1643\OHA\ERP\10		
REVISION NUMBER	1		
DATE	18/06/18		

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DAMWATCH ENGINEERING BEYOND THE SURFACE

OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
PUKAKI CANAL - TRUE LEFT BANK	11

Map Information

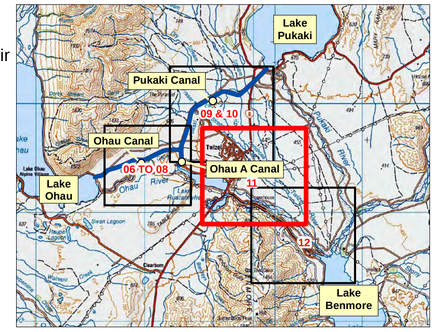
MAXIMUM FLOOD DEPTH AND TRAVEL TIME

Key Plan

Ohau A Reservoir

Current Map Frame

12 Map Sheet No.

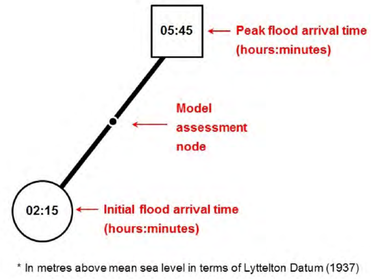


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

Notes

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0 0.5 1 1.5 2 Kilometers

Map Details

PREPARED BY	BV	SCALE	1:15,000 @ A1
CHECKED BY	GW		
APPROVED BY	ID		
MAP REFERENCE No.	E1643\OHA\ERP\11		
REVISION NUMBER	1		
DATE	18/06/18		

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DAMWATCH ENGINEERING BEYOND THE SURFACE

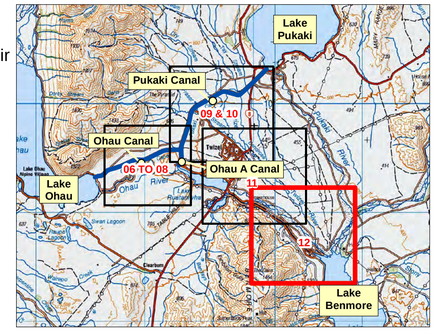
OHAU A RESERVOIR
POTENTIAL FLOOD INUNDATION MAP BASED ON HYPOTHETICAL DAM-BREAK SCENARIOS

Subject Dam	Map Sheet No.
PUKAKI CANAL - TRUE LEFT BANK	12

Map Information

MAXIMUM FLOOD DEPTH AND TRAVEL TIME

Key Plan

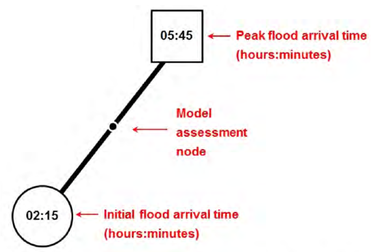


Legend

MAXIMUM FLOOD DEPTH & EXTENT

- Modelled breach location
- 0 - 0.25m
- 0.25 - 0.50m
- 0.50 - 1.00m
- 1.00 - 2.00m
- > 2.00m
- Potential flood inundation

FLOOD TRAVEL TIME



* In metres above mean sea level in terms of Lyttelton Datum (1937)

All flood wave travel times measured from the onset of rapid failure of the dam at 00:00 hours:minutes. Refer to Map Sheet No.03 for further information on flood wave travel times.

IMPORTANT NOTE:

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The Twizel River is braided so flow path in the river channel may vary depending on actual river conditions/alignment at the time.

0 0.5 1 1.5 2 Kilometers

Notes

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Map Details

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MAP REFERENCE No.	E1643\OHA\ERP\12	
REVISION NUMBER	1	
DATE	18/06/18	

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DAMWATCH ENGINEERING BEYOND THE SURFACE