

Workshop on Consequence Assessment and Potential Impact Classification

Online Webinar

2nd to 3rd November 2020

Consequence Assessment - Damage Levels (Ohau A Reservoir)

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Dam Consequence Assessment - Assessing Damage Level

- One of the two parts to the Determination of Potential Impact Classification, along with Population at Risk.
- The focus of this presentation is the Assessment of Damage Level, using an example case (Ohau A Reservoir, the canal system that links Lakes Ohau, Pukaki and Ruataniwha).

Table 3.1: Determination of Potential Impact Classification (PIC)

Assessed damage level	Population at risk (PAR)			
	0	1 to 10	11 to 100	More than 100
Catastrophic	High potential impact	High	High	High
Major	Medium potential impact	Medium/High (see note 4)	High	High
Moderate	Low potential impact	Low/Medium/High (see notes 3, and 4)	Medium/High (see note 4)	Medium/High (see notes 2 and 4)
Minimal	Low potential impact	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)	Low/Medium/High (see notes 1, 3, and 4)

Overview of Damage Levels and Categories

Table 2.2: Determination of Assessed Damage Level

From the NZSOLD Guidelines, Module 2, Section 2.9 and Table 2.2, outlines the “Damage to Property, Infrastructure and the Environment”.

Damage Level	Specified categories				
	Residential houses ¹	Critical or major infrastructure ²	Time to restore to operation ³	Natural environment	Community recovery time
Catastrophic	More than 50 houses destroyed	Extensive and widespread destruction of and damage to several major infrastructure components	More than 1 year	Extensive and widespread damage	Many years
Major	4 to 49 houses destroyed and a number of houses damaged	Extensive destruction of and damage to more than 1 major infrastructure component	Up to 12 months	Heavy damage and costly restoration	Years
Moderate	1 to 3 houses destroyed and some damaged	Significant damage to at least 1 major infrastructure component	Up to 3 months	Significant but recoverable damage	Months
Minimal	Minor damage	Minor damage to major infrastructure components	Up to 1 week	Short-term damage	Days to weeks

Overview of the Ohau A Reservoir Damage Assessment

Why the assessment was completed?

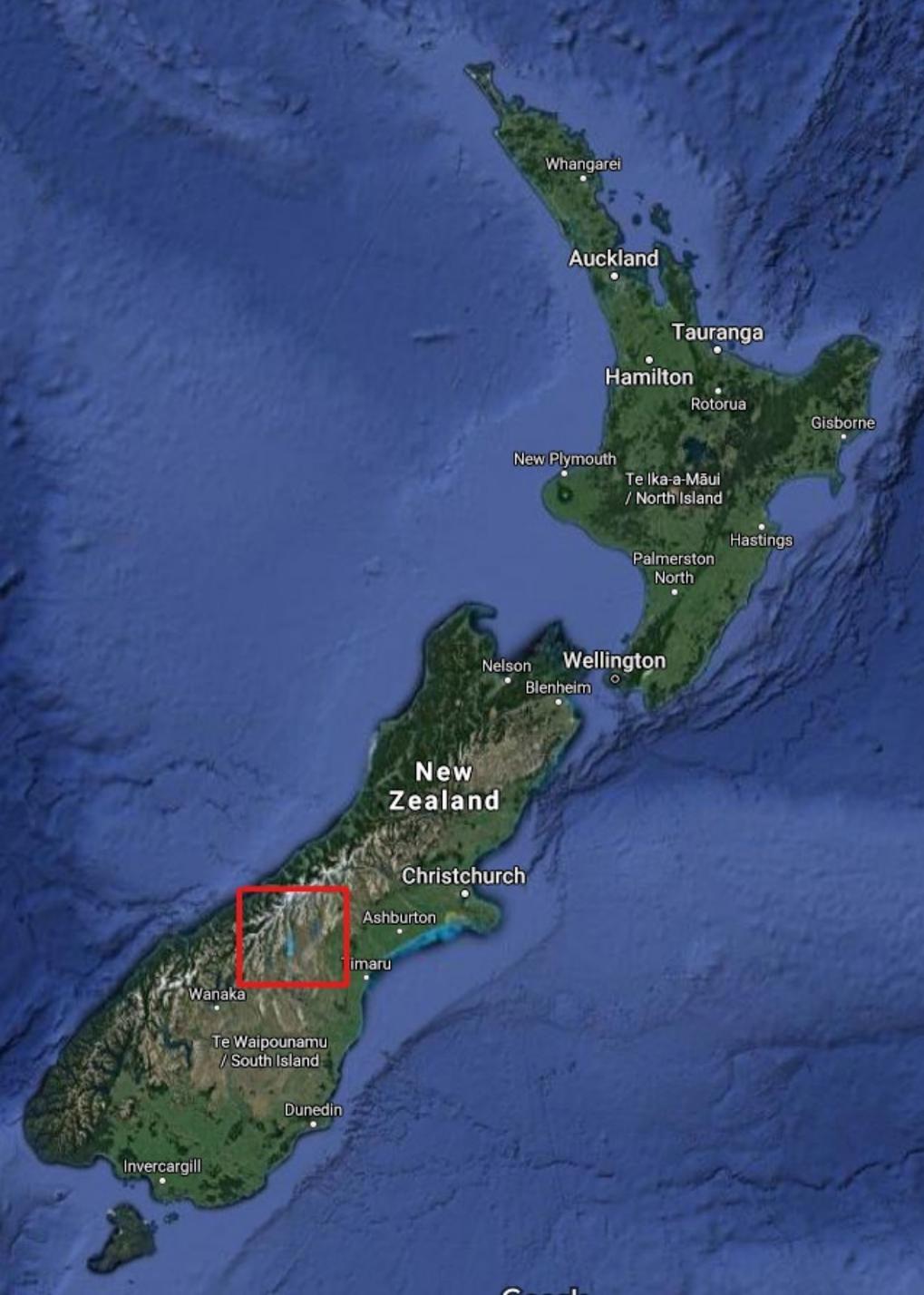
- PIC reviews for all Meridian Dams, outlined that the Ohau A Reservoir, which has a lot of different locations for potential breach (from different embankment reach sections), and has some variable and in places unquantified consequences.
- Previous dam break modelling had been completed in 2018 (14 breach locations).
- The results of the comprehensive assessment was for various reasons which became clearer following the initial PIC assessment (PIC reviews/updates for Meridian assets in 2019).

Overview of the Ohau A Reservoir Damage Assessment

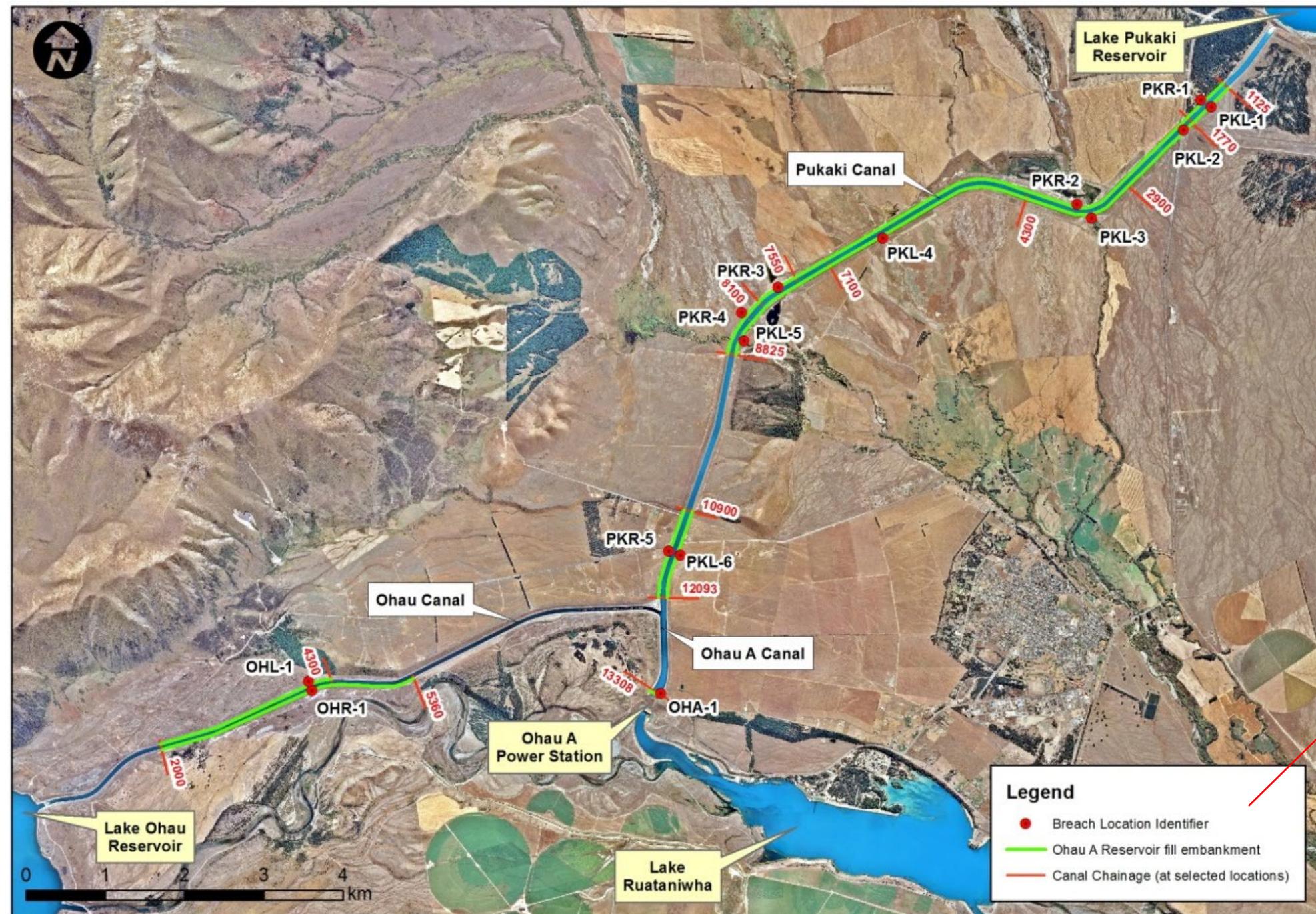
The comprehensive consequence assessment was used for:

- Update and confirmation of the PIC for the various canal embankment reaches. This would supersede the estimated (qualitative to semi-quantitative) assessments to date.
- Assist with future updates/revisions to Meridian Emergency Response Plans (maps and data).
- Better information for other Meridian uses (such as community consultation, future consenting, insurance valuations, input to district land plan changes).

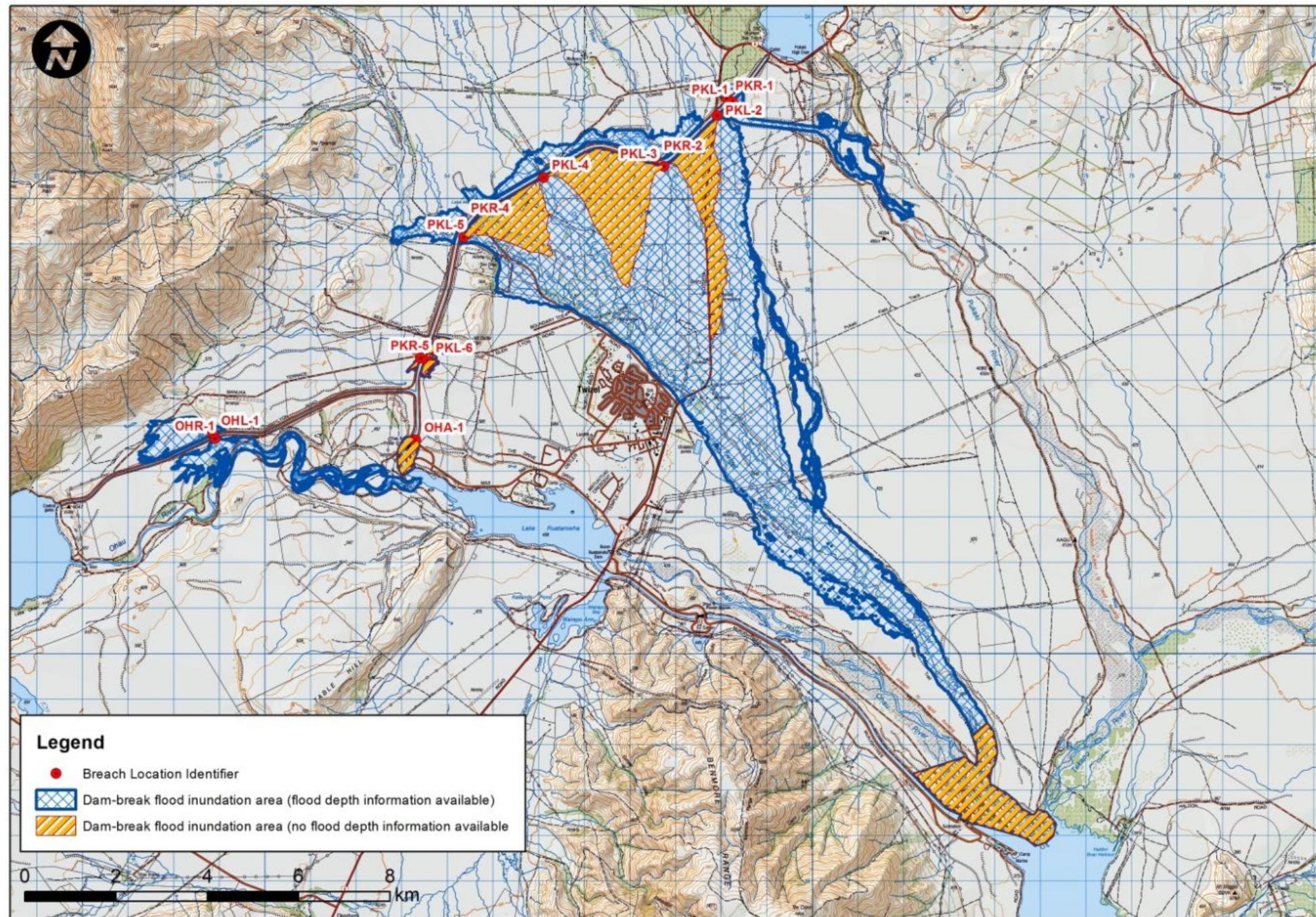
Ohau A Reservoir - Overview



Ohau A Reservoir - Overview

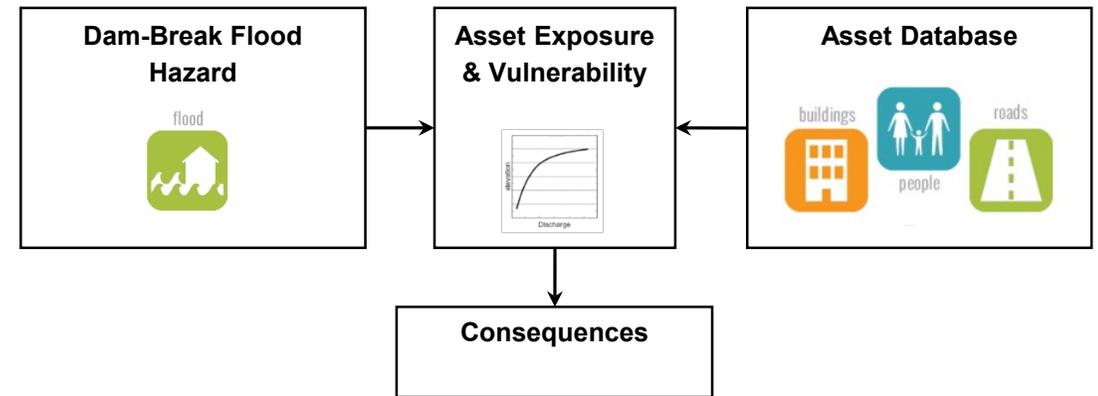


Ohau A Reservoir - Dam Break Modelling



Consequence Assessment - Methodology

- The direct consequences were evaluated by aggregating Ohau A Reservoir dam-break flood hazard information with an asset database developed using a Geographic Information System (GIS). The consequence of the dam-break flood on each asset was analysed using Microsoft-Excel spreadsheets which took the vulnerability of each asset to dam-break flood inundation into consideration.
- Data used included:
 - Aerial photography flown in 2017 from Land Information New Zealand (LINZ)
 - 1:50,000 scale topographic maps from LINZ
 - Property boundaries from LINZ
 - Building outlines from LINZ
 - Land cover database from Landcare Research
 - Local information from MacKenzie District Council and other sources



Consequence Assessment - Asset Database

Assets in the hypothetical dam-break flood inundation area were identified using GIS and categorised according to the asset classes. The three main asset classes were:

Building Assets (e.g. residential dwellings, office buildings, farm buildings, etc).

Non-Building Assets (e.g. roads, bridges, canals, irrigation pivots, etc).

Open Spaces (e.g. private property, farmland, camp grounds, etc).

As well as an assessment of Population at Risk (not covered in detail in this presentation), the damage assessment included:

- Buildings Damage.
- Infrastructure Damage.
- Damage to other areas, other impacts.
- Environmental impacts.
- Social Impacts.
- Impact on Meridian.

Being able to 'ground truth' the desktop assessment and information was very useful and is highly recommended!

Asset Class	Sub-Category	Unit	Spatial Element Type
Building	Commercial - Accommodation	No.	Point
	Commercial - Business	No.	
	Education	No.	
	Emergency Services - Civil Defence	No.	
	Emergency Services - Fire	No.	
	Emergency Services - Police	No.	
	Government (central, regional or local)	No.	
	Health (hospital, clinic, pharmacy, etc)	No.	
	Industrial - Chemical, Electrical, Hazardous	No.	
	Industrial - Forestry, mining	No.	
	Industrial - Manufacturing, Storage	No.	
	Other	No.	
	Meridian Energy building (power station, etc)	No.	
	Public facility (community hall, library, etc)	No.	
	Religious	No.	
Residential	No.		
Rest-home	No.		
Transportation - (airport, bus terminal, etc)	No.		
Non-Building Asset	Meridian Energy asset (dam, canal, etc)	No. or m	Line
	Salmon Farm raft (in canal)	No.	
	Power line	m	
	Railway - bridge	m	
	Railway - line	m	
	Road - bridge	m	
	Road - sealed	m	
	Road - State Highway	m	
	Road - unsealed	m	
	Walking path	m	
	Cycle path	m	
Open Space	Botanical/Zoological garden	km ²	Polygon
	Camp Ground area	km ²	
	Car parking area	km ²	
	Cemetery	km ²	
	DOC land	km ²	
	Farm	km ²	
	Forestry area	km ²	
	Other	km ²	
	Park/Recreational reserve	km ²	
	Playground	km ²	
	Quarry/Mining area	km ²	
	Sports area	km ²	
	Wilderness area	km ²	
	Botanical/Zoological garden	km ²	

Consequence Assessment - Population at Risk

Table 4.4 – Summary of Population at Risk estimates

Asset Type	Breach Location Identifier (refer Table 3.2)													
	PK L1	PK L2	PK L3	PK L4	PK L5	PK L6	PK R1	PK R2	PK R3	PK R4	PK R5	OH L1	OH R1	OH A1
Scenario (SD): Summer, Day, Weekend														
Buildings	0	34	30	22	19	7	0	0	0	0	0	12	0	7
Transportation	0	20	18	7	5	0	0	0	0	0	0	1	0	0
Open Spaces	0	102	103	102	102	0	0	104	2	0	0	0	0	100
Total	0	156	150	131	127	7	0	104	2	0	0	13	0	107
Scenario (SN): Summer, Night, Weekend														
Buildings	0	29	30	17	14	7	0	0	0	0	0	12	0	0
Transportation	0	4	3	1	0	0	0	0	0	0	0	0	0	0
Open Spaces	0	100	100	100	100	0	0	104	0	0	0	0	0	100
Total	0	133	133	117	115	7	0	104	0	0	0	12	0	100
Scenario (WD): Winter, Day, Weekend														
Buildings	0	34	30	22	19	7	0	0	0	0	0	12	0	7
Transportation	0	17	17	6	4	0	0	0	0	0	0	0	0	0
Open Spaces	0	6	7	6	6	0	0	4	0	0	0	0	0	4
Total	0	57	53	34	30	7	0	4	0	0	0	12	0	11
Scenario (WN): Winter, Day, Weekend														
Buildings	0	29	30	17	14	7	0	0	0	0	0	12	0	0
Transportation	0	4	3	1	0	0	0	0	0	0	0	0	0	0
Open Spaces	0	4	4	4	4	0	0	4	0	0	0	0	0	4
Total	0	37	37	21	19	7	0	4	0	0	0	12	0	4

- Population at risk was assessed for the various potential breach locations.
- Scenarios included Summer (Day/Weekend), Summer Night/Weekend), Winter (Day/Weekend), and Winter (Night/Weekend).
- Covered buildings: residential, commercial (accommodation and businesses), farm buildings, Ohau A and C Power Stations, Pukaki Airport.
- Open Spaces: Farms, camping areas, freedom camping locations, picnic areas, etc.
- Local sources (DOC rangers, Mackenzie District Council) were contacted and a site inspection was completed to understand building types and occupancy rates (including camp grounds and walking trails).
- For the breach locations considered, the Population at Risk ranged between 0 and 156 (Summer, Day/Weekend, at PKL2 - upstream end of canal, left bank).

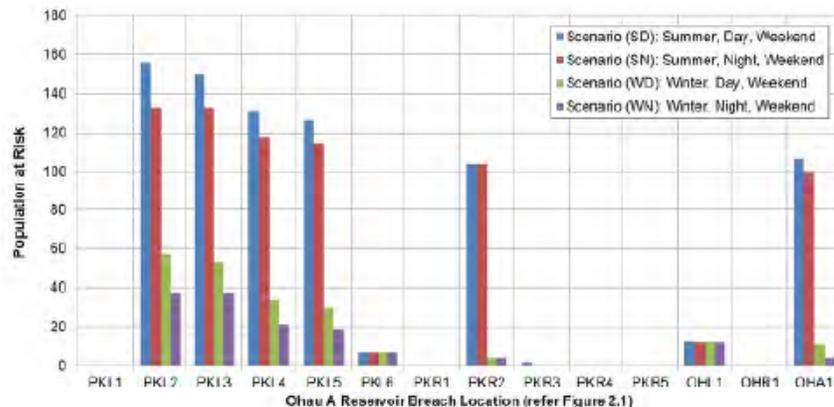


Figure 4.1 – Total Population at Risk estimates as a function of hypothetical breach location and time period

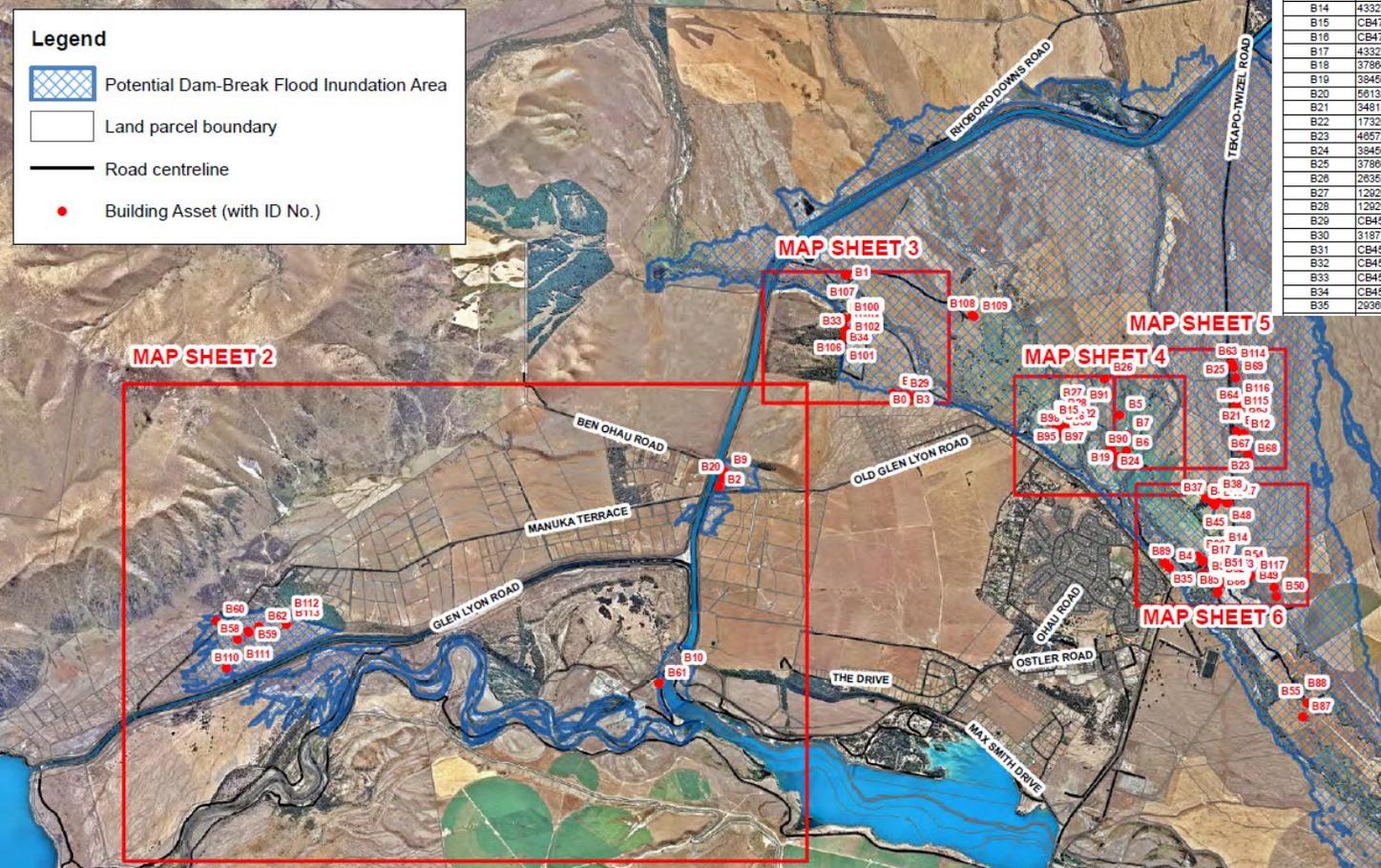
Consequence Assessment - Buildings

Table B1 - Building Assets

ID	Land Parcel Title	Asset Class	Usage Type	Description 1	Description 2	Construction Type
1	2	3	4	5	6	7
B0	CB45C/1231	Building	Commercial - Accommodation	Matuka Lodge and surrounds	Matuka Lodge accomodation	Timber - one storey
B1	659910	Building	Farm Building	Ben Ohau Station	Large Shed	Timber - one storey
B2	561328	Building	Residential	Near Ostler Cutting	Residential dwelling	Timber - one storey
B3	CB45C/1232	Building	Residential	Matuka Lodge and surrounds	Residential dwelling - Lot 2	Timber - one storey
B4	263692	Building	Residential	Near Twizel River Bridge	Residential dwelling	Timber - one storey
B5	263625	Building	Residential	Hooken Lane	Shed/Garage	Timber - one storey
B6	384508	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B7	CB47D/388	Building	Farm Building	Hooken Lane	Large Shed	Timber - one storey
B8	CB45C/1234	Building	Residential	Matuka Lodge and surrounds	Residential dwelling - Lot 3	Timber - one storey
B9	561328	Building	Residential	Near Ostler Cutting	Residential dwelling	Timber - one storey
B10	501418	Building	Meridian Energy asset	Ohau A Power Station	Ohau A Power Station	Concrete - two storey
B11	476656	Building	Meridian Energy asset	Ohau C Power Station	Ohau C Power Station	Concrete - two storey
B12	378651	Building	Commercial - Business	Pukaki Airport	Shed/Hanger (Large)	Timber - one storey
B13	378650	Building	Commercial - Business	Pukaki Airport	Shed (Small)	Timber - one storey
B14	433274	Building	Residential	Near Twizel River Bridge	Residential dwelling	Timber - one storey
B15	CB47D/382	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B16	CB47D/381	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B17	433273	Building	Residential	Near Twizel River Bridge	Residential dwelling	Timber - one storey
B18	378649	Building	Commercial - Business	Pukaki Airport	Office - Air Safans Office	Timber - one storey
B19	384507	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B20	561327	Building	Residential	Near Ostler Cutting	Residential dwelling	Timber - one storey
B21	348134	Building	Commercial - Business	Pukaki Airport	Shed/Hanger (Large)	Timber - one storey
B22	173264	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B23	465727	Building	Commercial - Business	Pukaki Airport	Shed/Hanger (Large)	Timber - one storey
B24	384506	Building	Residential	Hooken Lane	Shed (Large)	Timber - one storey
B25	378662	Building	Commercial - Business	Pukaki Airport	Office - Main Terminal Building	Timber - one storey
B26	263626	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B27	129296	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B28	129296	Building	Residential	Hooken Lane	Shed/Garage	Timber - one storey
B29	CB45C/1233	Building	Residential	Matuka Lodge and surrounds	Residential dwelling - Lot 4	Timber - one storey
B30	318717	Building	Residential	Hooken Lane	Residential dwelling	Timber - one storey
B31	CB45C/1235	Building	Residential	Ben Ohau Station	Residential dwelling	Timber - one storey
B32	CB45C/1235	Building	Farm Building	Ben Ohau Station	Large Shed	Timber - one storey
B33	CB45C/1236	Building	Farm Building	Ben Ohau Station	Shed	Timber - one storey
B34	CB45C/1236	Building	Farm Building	Ben Ohau Station	Shed	Timber - one storey
B35	263690	Building	Commercial - Accommodation	Twizel Accomodation River Cottage	Self Contained House	Timber - one storey

Buildings identified in the flood inundation area were listed (map overview and sheets).

Buildings Assets Information:



- ID.
- Land Parcel/Title.
- Usage (residential, commercial, farm).
- Descriptors.
- Construction Type.

Consequence Assessment - Buildings

The maximum depth at each building was used with the damage ratio, and numbers of each summarised.

Note only maximum depth was available from the previous dam break flood mapping (no velocity, hence no depth x velocity (DV)).

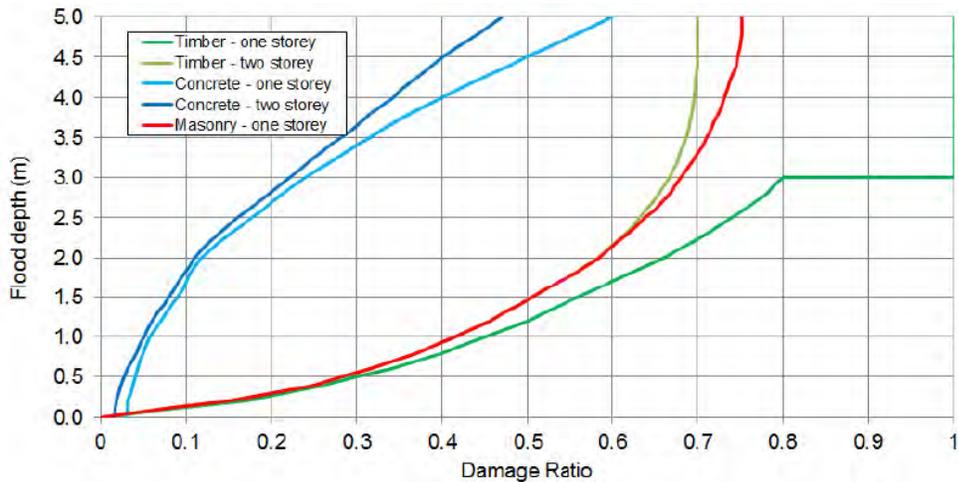


Figure 4.2 – Average damage ratio curves for various building types as a function of maximum flood inundation depth (after NIWA, 2010)

Table 4.5 – Building damage states as a function of damage ratio (after NIWA, 2010)

Damage Ratio	Damage State	Description
0 to 0.02	DS0	Insignificant
0.02 to 0.1	DS1	Light — Non-structural damage, or minor non-structural damage
0.1 to 0.5	DS2	Moderate — Reparable structural damage
0.5 to 0.95	DS3	Severe — Irreparable structural damage
> 0.95	DS4	Collapse — Structural integrity fails

Table 4.6 – Summary of building damage

Breach Location Identifier (refer Table 3.2)	Number of Buildings by Damage State (refer Table 4.4)							
	Commercial			Farm Building	Industrial	Meridian Power Station Building	Residential	
	Accommodation	Business (office, retail)	Business (other)				Dwelling	Shed, Garage
PKL1	*	*	*	*	*	*	*	*
PKL2	DS0 = 1 DS2 = 1	DS2 = 3	DS2 = 7	DS0 = 1 DS1 = 2 DS2 = 3	DS2 = 1	*	DS0 = 1 DS2 = 4	DS0 = 2 DS2 = 4
PKL3	DS0 = 3 DS2 = 3	DS2 = 1	DS0 = 0	DS1 = 1 DS2 = 22	*	*	DS0 = 1 DS1 = 1 DS2 = 8 DS3 = 2	DS0 = 1 DS1 = 3 DS2 = 4 DS3 = 5
PKL4	DS2 = 1	*	*	DS2 = 22 DS3 = 1	*	*	DS0 = 1 DS2 = 8 DS3 = 2	DS2 = 10 DS3 = 5
PKL5	DS2 = 2	*	*	DS0 = 1 DS1 = 1 DS2 = 30 DS3 = 1	*	*	DS1 = 3 DS2 = 8 DS3 = 2	DS0 = 1 DS2 = 8 DS3 = 5
PKL6	*	*	*	*	*	*	DS2 = 3	*
PKR1	*	*	*	*	*	*	*	*
PKR2	*	*	*	*	*	*	*	*
PKR3	*	*	*	*	*	*	*	*
PKR4	*	*	*	*	*	*	*	*
PKR5	*	*	*	*	*	*	*	*
OHL1	*	*	*	*	*	*	DS2 = 1 DS3 = 2 DS4 = 3	DS3 = 1 DS4 = 1
OHR1	*	*	*	*	*	*	*	*
OHA1	*	*	*	*	DS2 = 1	DS1 = 1	*	*

* No buildings identified in dam-break flood inundation zone

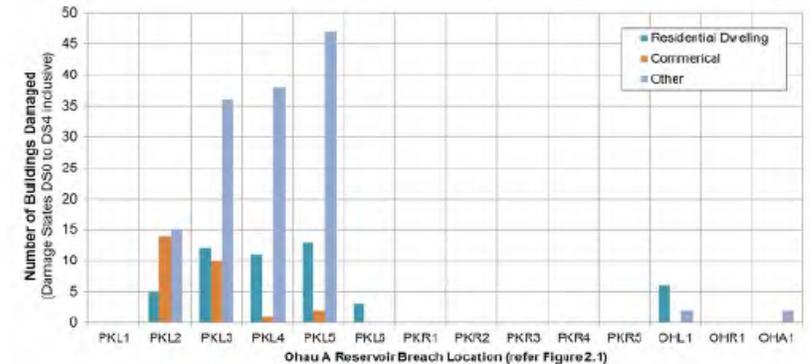


Figure 4.3 – Estimates of number of buildings damaged as a function of hypothetical breach location

Consequence Assessment - Infrastructure

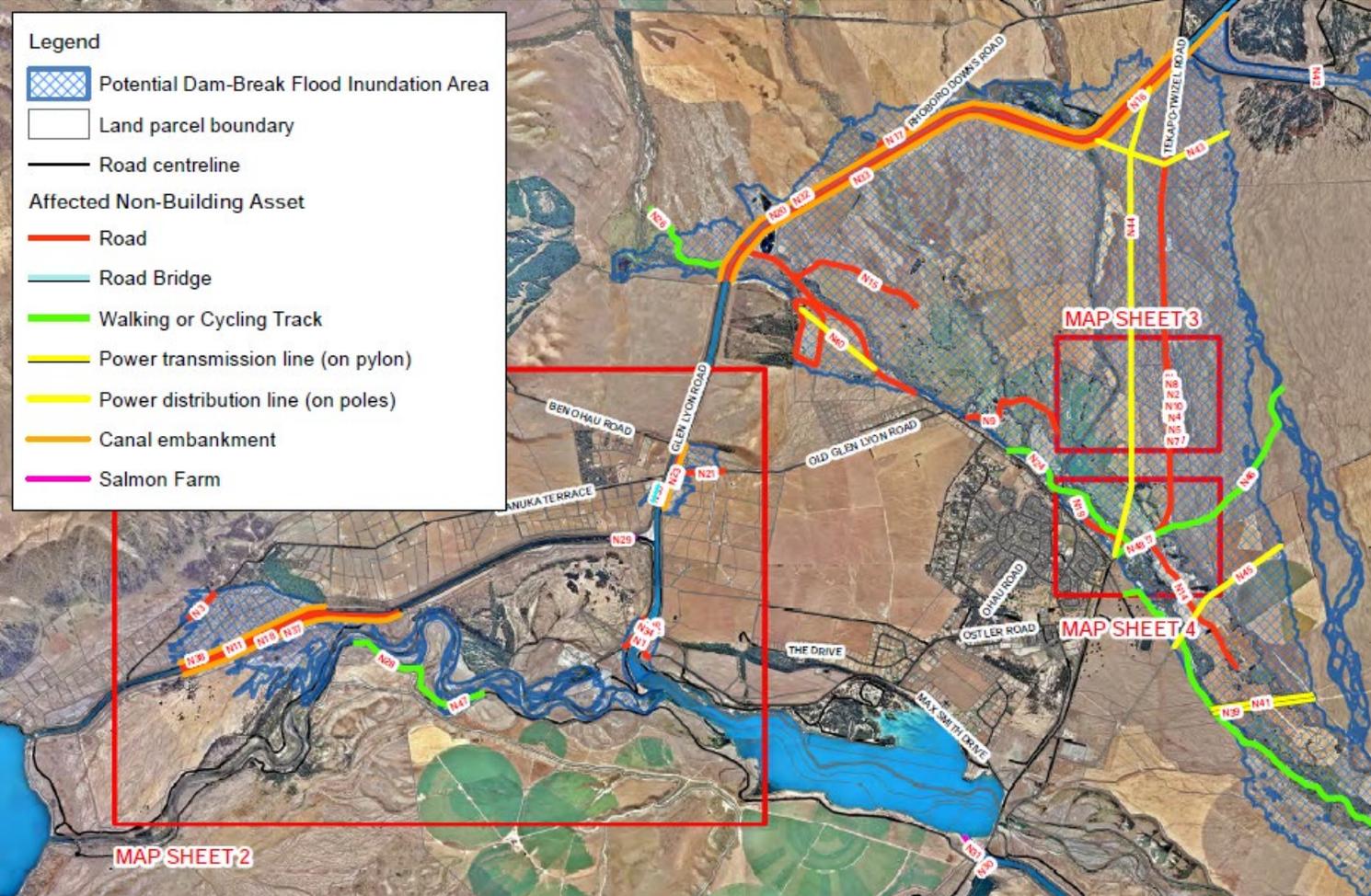


Table 4.7 – Summary of infrastructure damage

Breach Location Identifier (refer Table 3.2)	Length of Asset Affected (m)							
	State Highway	State Highway Bridge	Local Road – Sealed	Local Road – Unsealed	Cycling Path	Walking Path	Powerline on Poles	Powerline on Pylons
PKL1	*	*	30	*	*	*	120	*
PKL2	6170	*	1858	2830	1850	7000	2280	2600
PKL3	5460	95	1858	4500	900	8900	7710	2500
PKL4	990	95	30	6880	800	8900	1790	2400
PKL5	*	95	2960	7480	800	8900	2990	2400
PKL6	*	*	130	*	*	*	*	*
PKR1	*	*	*	30	*	*	*	*
PKR2	*	*	*	30	*	*	*	*
PKR3	*	*	*	30	*	*	*	*
PKR4	*	*	*	30	*	900	*	*
PKR5	*	*	*	30	*	*	*	*
OHL1	*	*	30	580	350	*	*	*
OHR1	*	*	30	*	*	*	*	*
OHA1	*	*	590	*	*	*	*	*

* No infrastructure identified in dam-break flood inundation zone

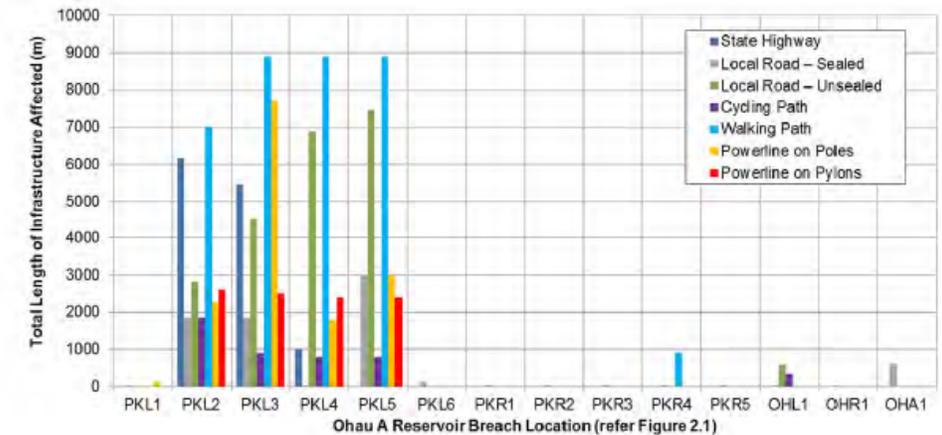


Figure 4.4 – Estimates of length of infrastructure asset affected as a function of hypothetical breach location

Table 4.8 – Summary of other areas affected

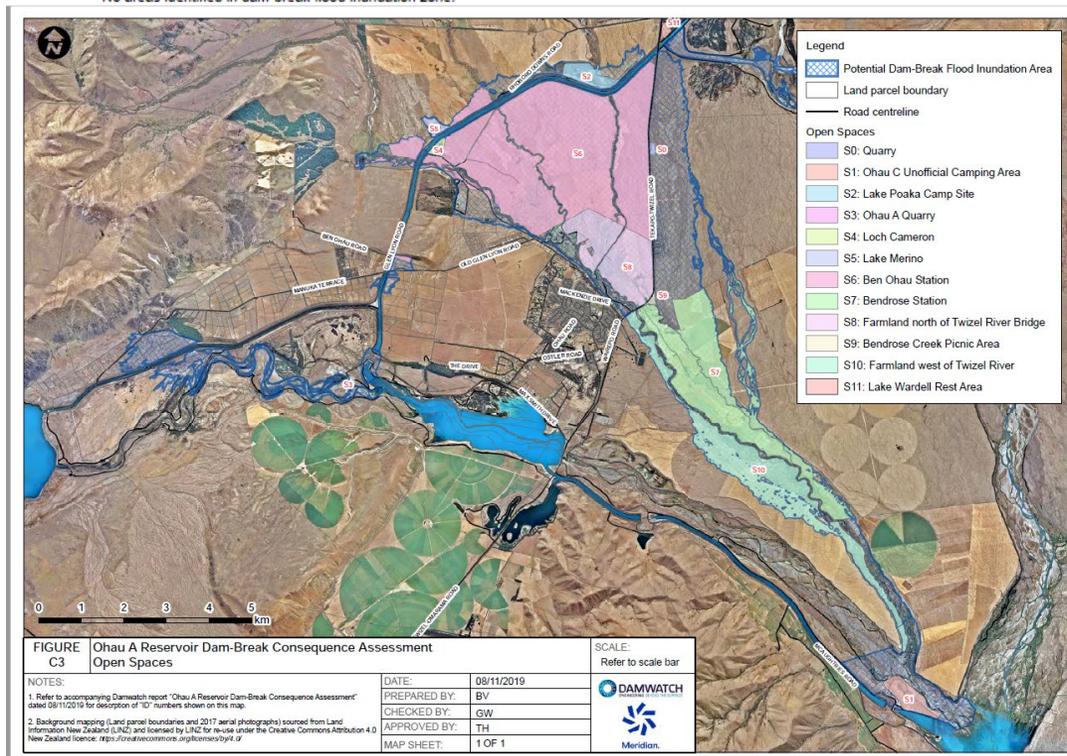
Breach Location ID (refer Table 3.)	Farmland	Ben Ohau Station	Bendrose Station	Lake Poaka Camping Area	Ohau C Camping Area	Bendrose Creek Picnic Area	Loch Cameron	Lake Merino	Lake Wardell Rest Area	Tekapo-Twizel Road Quarry	Ohau A Quarry
PKL1	*	*	*	*	*	*	*	*	*	*	*
PKL2	3.8 km ²	*	5.18	*	Y	Y	*	*	*	Y	*
PKL3	6.2 km ²	3.5 km ²	3.51	*	Y	Y	*	*	*	*	*
PKL4	4.6 km ²	2.9 km ²	3.51	*	Y	Y	*	*	*	*	*
PKL5	4.4 km ²	1.4 km ²	3.51	*	Y	Y	Y	*	*	*	*
PKL6	*	*	*	*	*	*	*	*	*	*	*
PKR1	*	*	*	*	*	*	*	*	Y	*	*
PKR2	*	0.29 km ²	*	Y	*	*	*	*	*	*	*
PKR3	*	*	*	*	*	*	*	Y	*	*	*
PKR4	*	0.35 km ²	*	*	*	*	*	*	*	*	*
PKR5	*	*	*	*	*	*	*	*	*	*	*
OHL1	*	*	*	*	*	*	*	*	*	*	*
OHR1	*	*	*	*	*	*	*	*	*	*	Y
OHA1	*	*	*	*	Y	*	*	*	*	*	*

+ Area of farmland listed in km².

* No areas identified in dam-break flood inundation zone.

Consequence Assessment - Other Areas

- Siltation and/or erosion of the Twizel River, Dry Creek, Fraser Stream and Ohau River beds and floodplains.
- Siltation and/or erosion of agricultural land, livestock deaths, damaged fences and other farm utilities.
- Disruption of daily transport routes as diversions would be required until roads affected by a dam-break flood are repaired.
- Power supply could be disrupted if powerlines identified were damaged.
- Business interruption and loss of fish stock from the salmon farms.



Consequence Assessment - Environmental

- Pukaki Canal failures, erosion damage and sedimentation/deposition of materials.
- Ohau River. Mackenzie District Council Site of Natural Significance, and DOC Site of Special Wildlife Significance.
- Twizel River. DOC Site of Special Wildlife Significance.
- Pukaki Flats. DOC land (between Pukaki airport and Pukaki River), Land of National Significance.
- Small lakes and wetlands near the canals in places.
- Meridian inhouse Environmental Specialist completed a separate assessment to support the Consequence Assessment. Sometimes specialist environmental (or planning, cultural, community) would be needed to thoroughly assess the 'non engineering' (buildings, infrastructure) damage categories.

Consequence Assessment - Environmental

- Meridian planning and development areas summary report was prepared to assist in the consequence assessment. This included existing environments, development potential, and natural environment values.

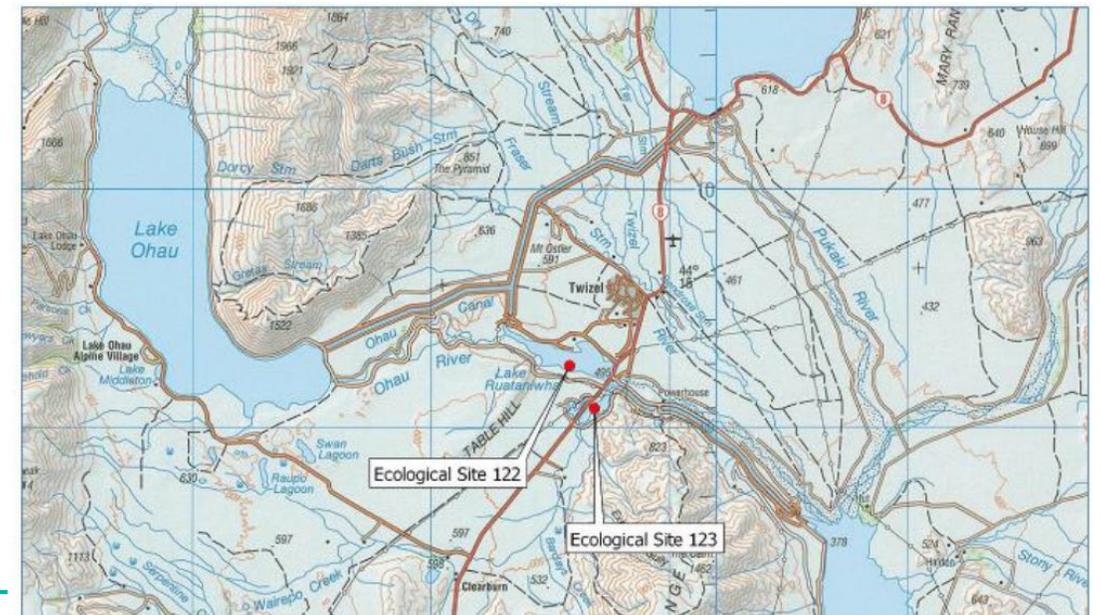
1.1 AREA LOCATION AND VIEWPOINTS PLAN



Figure 11: Location of Pivots as part of Rhoborough Station Resource Consent Application.



Figure 15: Authorised Irrigation Area at Bendrose Station



Location of Ecological Sites 122 and 123

Figure 37: Location of Ecological Site 122 & 123 – Waitaki District Council.

Consequence Assessment - Health and Social (Community)

- Loss of services to the community.
- Cost of emergency management.
- Dislocation of people.
- Disruption to business.
- To understand this in detail, if it's needed, then a specific study by experts/specialist would be required.

Consequence Assessment - Impact on Meridian

- Effects from Ohau A Power Station loss of generation (and possible flow on effects/impacts for the Ohau Chain (Upper Waitaki) system and the rest of Meridian Waikaki Hydro Power System).
- Emergency management.
- Reputation/credibility.
- Financial.

Consequence Assessment - PIC Results

- The PIC results for damages across the various categories, and the Population at Risk, are shown in the table (for the various canal breach locations).
- In red are where the comprehensive assessment was different from the initial PIC review/update, indicating most were refined and a category change affecting the PIC occurred in 6 (out of 14).
- Results in 6 canal breach sections as High PIC, 4 as Low PIC, 2 Medium/High (TBC), and 2 Low/Medium/High (TBC).
- Compared to the latest (2019) PIC review for Ohau A Reservoir, the 5 upstream canal breach locations were High PIC (no change), 4 Low (no change), 1 from Low to L/M/H, 2 from High to M/H, 1 from Medium to L/M/H, 1 from Medium to High.

CANAL REACH				DAMAGE LEVELS FOR POTENTIAL IMPACT CLASSIFICATION					HIGHEST ASSESSED DAMAGE LEVEL	POPULATION AT RISK*	
Canal	Breach Location	Start Chain-age	End Chain-age	Residential Houses	Critical or Major Infrastructure		Natural Environment	Community Recovery Time			
		(m)	(m)		Damage	Time to Restore Operation					
Pukaki, Left Bank	PKL1	1125	1770	Appurtenant Structure. Assigned same PIC as section of canal with highest PIC.							
	PKL2	1770	2900	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 3 months [MODERATE]	Heavy damage and costly restoration [MAJOR]	Years [MAJOR]	Major	More than 100	
	PKL3	2900	4300	1 to 3 houses destroyed and some damaged [MODERATE]	Extensive destruction of and damage to more than 1 major infrastructure component [MAJOR]	Up to 12 months [MAJOR]	Heavy damage and costly restoration [MAJOR]	Years [MAJOR]	Major	More than 100	
	PKL4	4300	7100	1 to 3 houses destroyed and some damaged [MODERATE]	Extensive destruction of and damage to more than 1 major infrastructure component [MAJOR]	Up to 12 months [MAJOR]	Heavy damage and costly restoration [MAJOR]	Years [MAJOR]	Major	More than 100	
	PKL5	7100	8825	1 to 3 houses destroyed and some damaged [MODERATE]	Extensive destruction of and damage to more than 1 major infrastructure component [MAJOR]	Up to 12 months [MAJOR]	Heavy damage and costly restoration [MAJOR]	Years [MAJOR]	Major	More than 100	
	PKL6	10900	12093	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Minimal	1 to 10	
Pukaki, Right Bank	PKR1	1125	1770	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Minimal	0	
	PKR2	1770	7550	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Significant but recoverable damage [MODERATE]	Days to Weeks [MINIMAL]	Moderate	More than 100	
	PKR3	7550	8100	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Significant but recoverable damage [MODERATE]	Days to Weeks [MINIMAL]	Moderate	1 to 10	
	PKR4	8100	8825	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Minimal	0	
	PKR5	10900	12093	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Minimal	0	
Ohau, Left Bank	OHL1	2000	4300	4 to 49 houses destroyed and a number of houses damaged [MAJOR]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Major	11 to 100	
Ohau, Right Bank	OHR1	2000	5360	Minor damage [MINIMAL]	Minor damage to major infrastructure components [MINIMAL]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Minimal	0	
Ohua A Power Station Intake	OHA1	13308	13308	Minor damage [MINIMAL]	Significant damage to at least 1 major infrastructure component [MODERATE]	Up to 1 week [MINIMAL]	Short-term damage [MINIMAL]	Days to Weeks [MINIMAL]	Moderate	More than 100	

Notes:

Consequence Assessment - Summary

- A comprehensive consequence assessment was completed for the Ohau A Reservoir (Pukaki, Ohau, and Ohau A canals).
- Was needed to refine, confirm, inform, for the PIC from the various considered canal sections modelled previously for potential breach.
- The previous PIC reviews and updates were qualitative to semi-quantitative, with this study more detailed and mostly quantitative.
- Benefits were more than just providing better background and information for the PIC assessments. Includes information on the area across buildings, owners, infrastructure, environment, and community. A wider understanding of potentially affected parties.
- Additional benefits to Meridian were assistance with future updates/revisions to Emergency Response Plans (maps and data). Better information for other Meridian uses (such as community consultation, future consenting, insurance valuations, input to district land planning).

Consequence Assessment - Other?

- NZSOLD Guidelines. Seems that houses and infrastructure are the main sources for damage. Not always. Sometimes it's environmental!
- Don't forget about the dam itself, as for example the 3rd party consequences could result in Medium PIC from PAR and damages, but the loss of the dam (if it is critical to the community and cannot be provided by alternative means) may mean the damage and loss to it drive the damage level (e.g. Major/12 months).
- ANCOLD Guidelines (2012) - good coverage of tables in Appendix B (selection of severity of damage and loss). Infrastructure (cost range), dam owner's business, health and society, environmental. See following slide.
- Dam safety regulations. Consultation was to provide more information/details on vulnerable people e.g. young/disabled/elderly (which should be included in the Population at Risk), and to include heritage/culture (which should be included with environment and community).

Consequence Assessment - ANCOLD 2012

Appendix B: Selection of severity of damage and loss

B1 Total infrastructure costs

Total infrastructure costs are considered for residential and commercial as well as community infrastructure. Costs associated with replacement or repair to the dam are also included.

Type	Minor	Medium	Major	Catastrophic
See Below	< \$10M	\$10M – \$100M	\$100M – \$1B	> \$1B

Explanatory Notes for Infrastructure Costs

Type	Description
Residential	Total number of houses affected, some destroyed and others damaged.
Commercial	Including businesses and agriculture. E.g. retail, manufacturing, resources. Loss of stock and/or produce as a direct result of the flood wave.
Community infrastructure	Such as roads, railways, power, communications, gas, water supply, sewerage, irrigation, drainage, schools, hospitals, community facilities and public buildings.
Dam replacement or repair cost	Repairs to the embankment or wall and appurtenant works which will return the dam to its previous level of service.

B2 Impact on dam owner's business

Type	Minor	Medium	Major	Catastrophic
Importance to the business	Restrictions needed during dry periods	Restrictions needed during peak days and peak hours	Essential to maintain supply	Dissolution of business/entity
Effect on services provided by the owner	Minor difficulties in replacing services	Reduced services are possible with reasonable restrictions	Severe restrictions would be applied for at least one year	Services cannot be replaced or cannot get services from another source
Effect on continuing credibility	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Community reaction and political implications	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Impact on financial viability	Able to absorb in one financial year	Significant with considerable impact in the long term	Severe to crippling in the long term	Bankruptcy
Value of water in the storage	Can be absorbed in one financial year	Loss of income for at least 1 year	Loss of income for more than 1 year	Bankruptcy

Explanatory notes for dam owner's business

Type	Description
Importance to the business	Loss of storage is likely to affect the service provided to some degree. It may be appropriate to increase the severity level because of the importance of the reservoir. However a less vital water resource may lead to a reduction in the severity of the cost of replacement or repair.
Effect on the services provided by the owner	Water supply, power or recreational facility is no longer available or disrupted to a proportion of the community supplied by the agency.
Effect on continuing credibility	Standing or reputation of the organisation in the community.
Community reaction and political implications	There may be community objection to replacement of the dam. Also, the relationship between the dam owner and local, state and federal legislature.
Impact on financial viability	Economic and legal liability; ability to meet the costs of repairs and damage; ability to meet claims from others.
Value of water in the storage	Loss of income from the loss of the stored water.

Consequence Assessment - ANCOLD 2012

B3 Health and social impacts

Type	Minor	Medium	Major	Catastrophic
Human health	<100 people affected	100 to 1000 people affected	>1000 people affected for greater than one month	>10 000 people affected for a year or more
Loss of services to the community	<100 people affected	100 to 1000 people affected	>1000 people affected for greater than one month	>10 000 people affected for a year or more
Cost of emergency management	<1000 person days	1000 to 10 000 person days	>10 000 person days	>100 000 person days
Dislocation of people	<100 person months	100 to 1000 person months	>1000 person months	>10 000 person months
Dislocation of businesses	<20 business months	20 to 200 business months	>200 business months and some business failures	Numerous business failures
Employment affected	<100 jobs lost	100 to 1000 jobs lost	>1000 jobs lost	>10 000 jobs lost
Loss of heritage	Local facility	Regional facility	National facility	International facility
Loss of recreational facility	Local facility	Regional facility	National facility	International facility

Explanatory notes for health and social impacts

Type	Description
Human health	Human health could be affected by: <ul style="list-style-type: none"> contamination of drinking water failure or lack of water supplies, sewage treatment works, power. Contamination of services such as food, health, recreation areas and facilities caused by the uncontrolled release of sewage, industrial or toxic waste as a result of a dambreak.
Loss of services to the community	Loss of gas/power/communications and transport. Distribution of medical supplies, food, especially perishable food items.
Cost of emergency management	Police, Emergency Services and volunteers will incur a cost both direct and indirect.
Dislocation of people	People whose homes are destroyed or damaged will need to be re-housed or billeted for various times.
Dislocation of businesses	Businesses will be prevented from trading in the short term and may be affected in the long term.
Employment affected	Loss of employment.
Loss of heritage	Historic sites, both pre- and post-European settlement.
Loss of recreational facility	Many communities rely, to various degrees, on bodies of water for boating, fishing and other recreational aspects, including visual relief. Other recreational facilities may be located downstream of the reservoir, e.g. golf course, sports grounds.

B4 Environmental impacts

Type	Minor	Medium	Major	Catastrophic
Area of impact	< 1 km ²	< 5 km ²	< 20 km ²	> 20 km ²
Duration of impact	< 1 year	< 5 years	< 20 years	> 20 years
Stock and fauna	Discharge from dambreak would not contaminate water supplies used by stock and fauna.	Discharge from dambreak would contaminate water supplies used by stock and fauna. Health impacts not expected.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake and measurable health impacts expected.
Ecosystems	Discharge from dambreak is not expected to impact on ecosystems. Remediation possible.	Discharge from dambreak would have short term impacts on ecosystems with natural recovery expected after one wet season. Remediation possible.	Discharge from dambreak would have significant impacts on ecosystems with natural recovery expected after several wet seasons. Remediation possible over many years.	Discharge from dambreak would have significant permanent impacts on ecosystems. Remediation involves altered ecosystems.
Rare and endangered species	Species exist but minimal damage expected. Recovery within one year.	Species exist with losses expected to be recovered over a number of years.	Rare and endangered species will be severely impacted Recovery will take many years.	Endangered species will be lost from the area. Permanent loss of species will occur.

Explanatory notes for environmental impacts

Type	Description
Area of impact	Land damaged by dam failure exclusive of land prone to natural flooding. For tailings dams, the damage will relate to the toxicity of the material in relation to both area of impact and the depth of penetration of the toxic materials.
Duration of impact	Habitats may take a long time to recover (eg. substantial erosion, deposition of flood borne materials). The duration of the impact will also relate to the toxicity of discharged material (eg saline, tailings, sewerage, cold water, deoxygenated water).
Stock and fauna	Stock and fauna may ingest contaminated water/fodder. Stock may need to be removed from the area or destroyed. Contaminants may cause damage in relation to reproduction cycle. The impact on stock and fauna may not be immediately identified unless testing of food source is carried out.
Ecosystems	Includes organisms and non-living components which interact to form a stable system. Consideration should be given to their environment, habitat, breeding grounds and food chain.
Rare and endangered species	Information can be gained from state and federal government agencies in relation to areas known to contain rare and endangered flora and fauna.

Table 2: Severity of damages and losses

Damage And Loss	Severity Level			
	Minor	Medium	Major	Catastrophic
Total infrastructure costs	COST ESTIMATE			
Residential	\$	-----	----	----
Commercial	\$	-----	----	----
Community Infrastructure	\$	-----	----	----
Dam replacement or repair cost	\$	-----	----	----
Total Estimated Cost	\$			
Impact on dam owner's business				
Importance to the business				
Effect on services provided by the owner				
Effect on continuing credibility				
Community reaction and political implications				
Impact on financial viability				
Value of water in the storage				
Health and social impacts				
Public Health				
Loss of Service to the community				
Cost of emergency management				
Dislocation of people				
Dislocation of businesses				
Employment affected				
Loss of heritage				
Loss of recreational facility				
Environmental impacts				
Stock and fauna				
Ecosystems				
Rare and endangered species				
Highest level of severity of damage and loss				

Questions (for Nathan, Jim, or Bill?)



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