Managing geomorphological drivers of river hazards in the rapidly aggrading Waiho River, Franz Josef / Waiau, Aotearoa New Zealand

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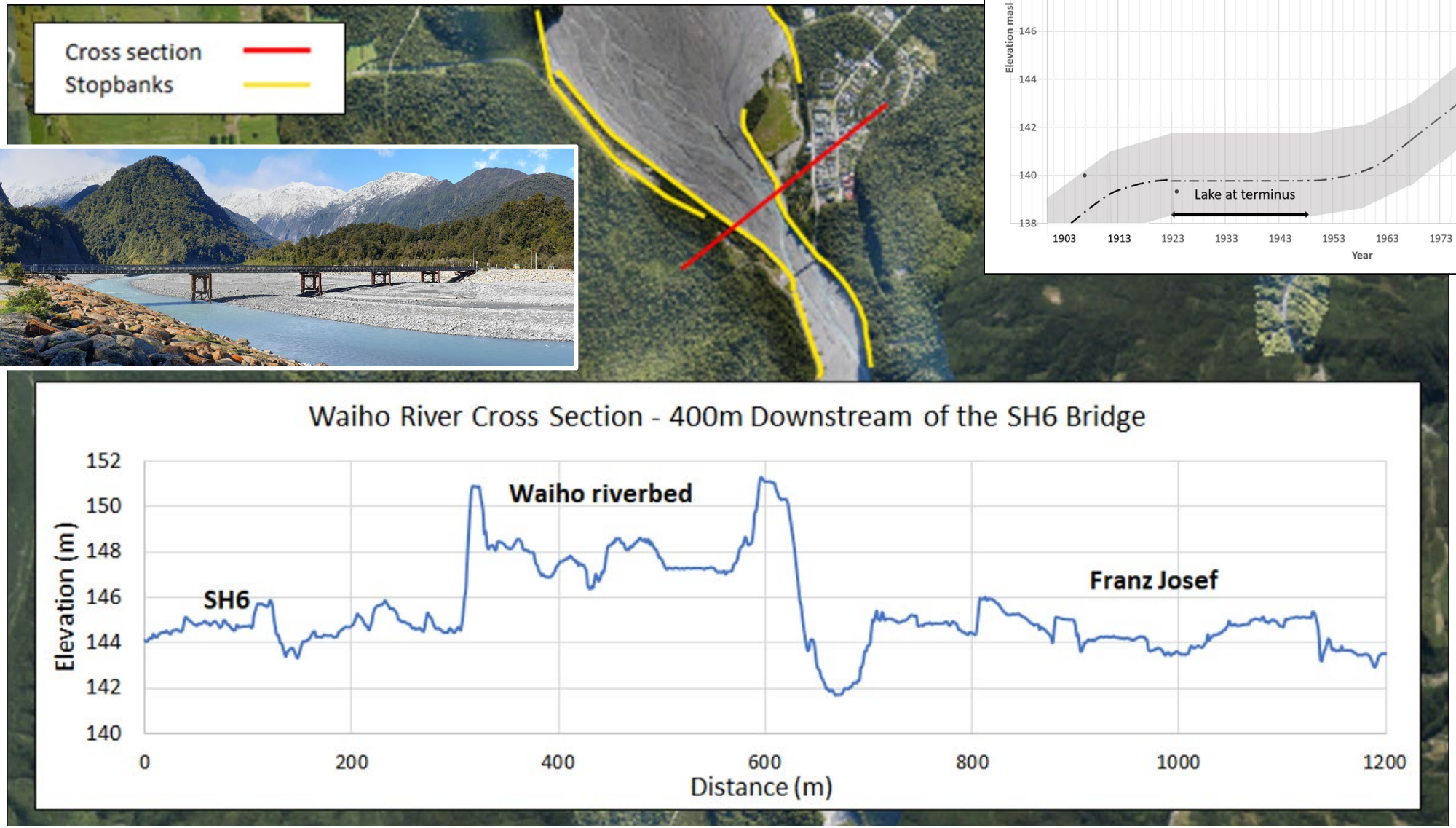
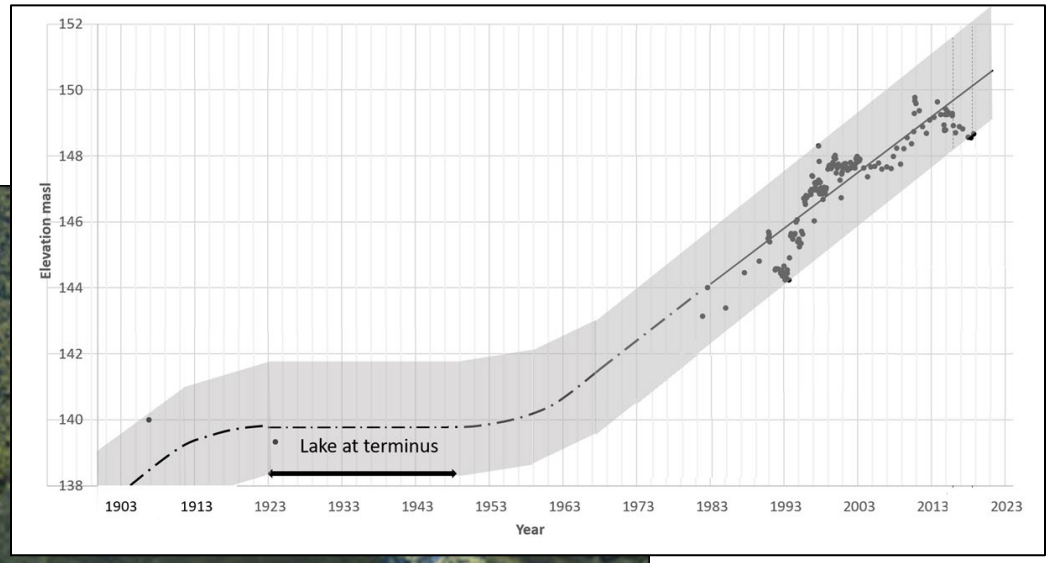
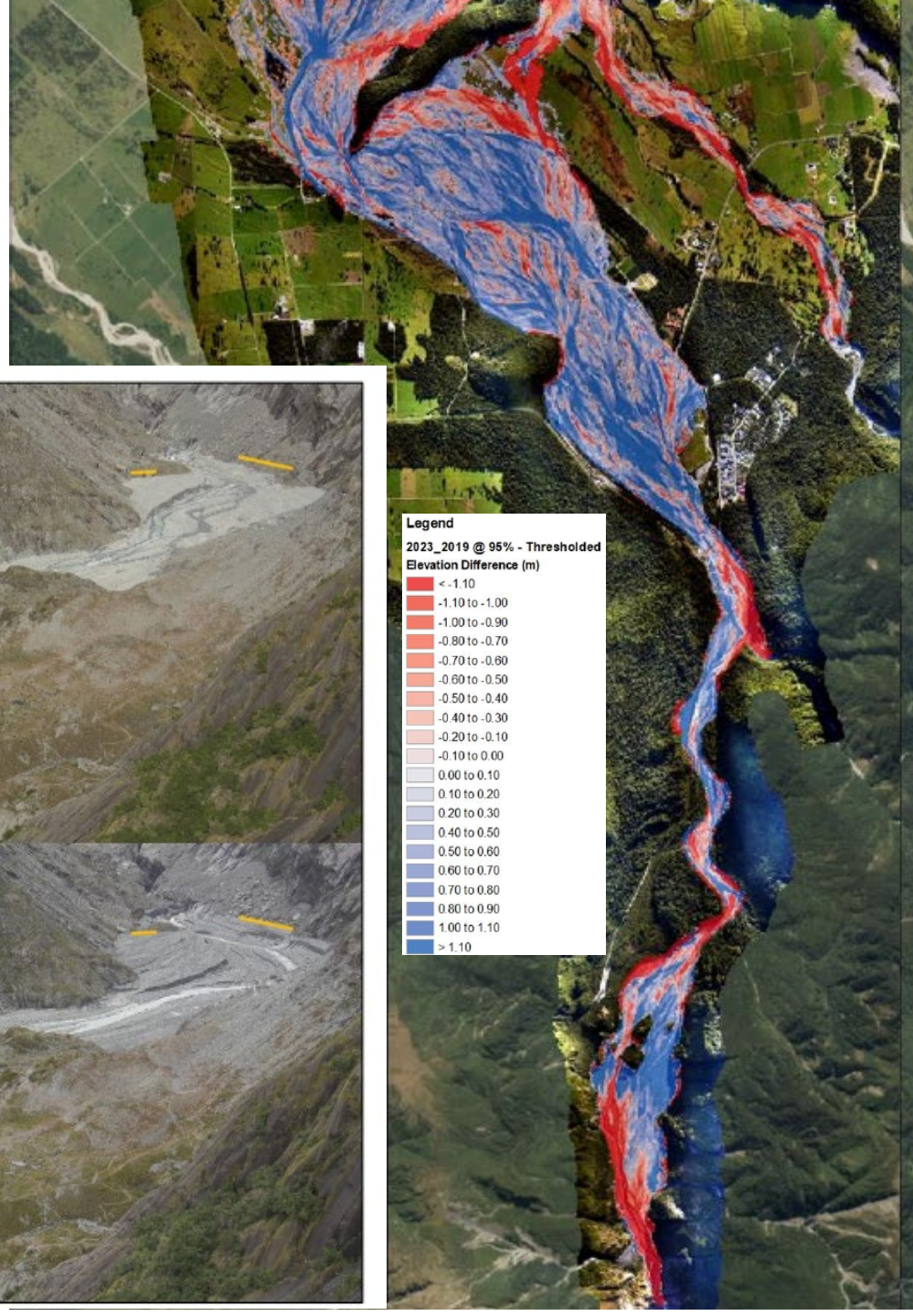
wsp
THE WEST COAST REGIONAL COUNCIL

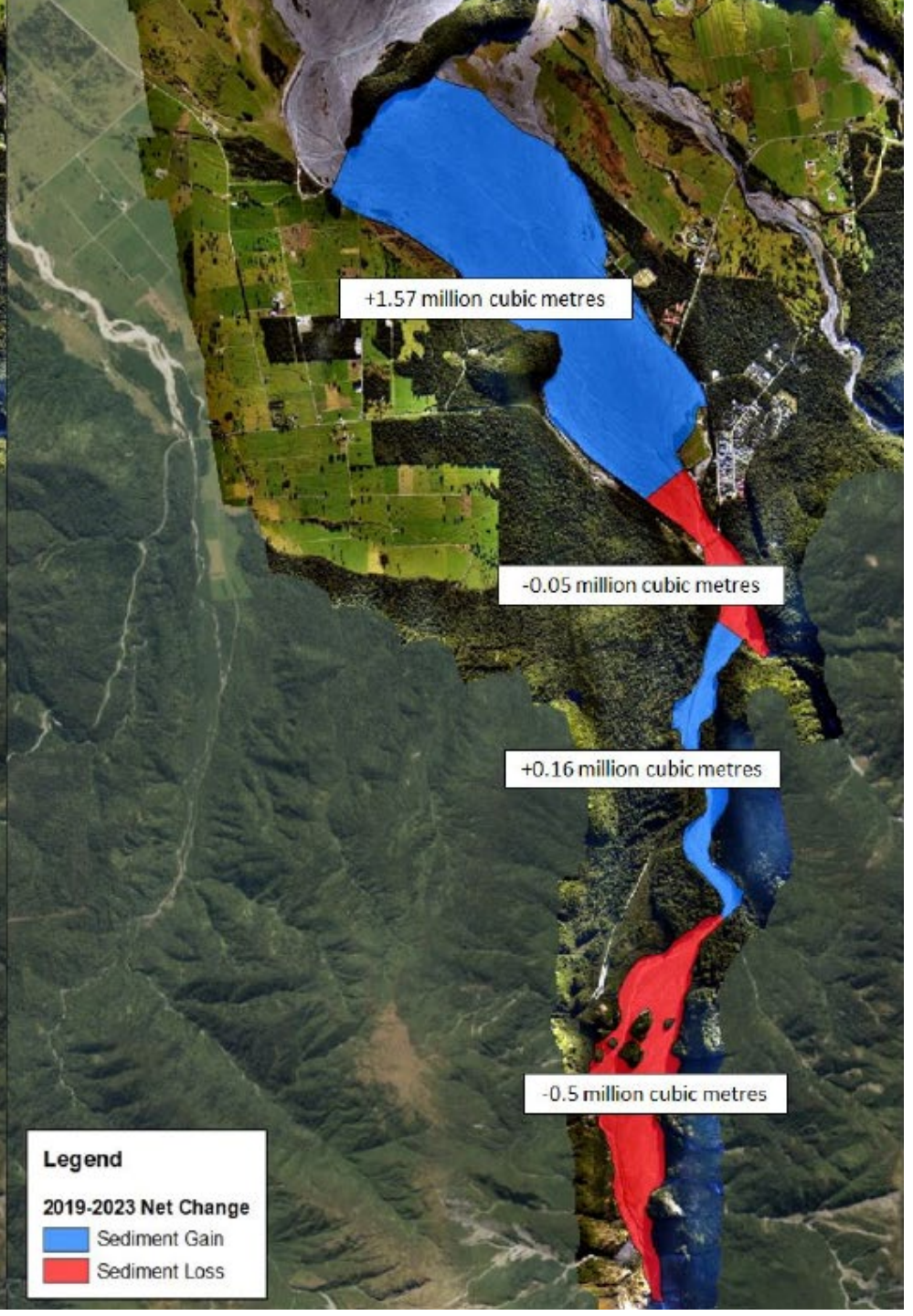
- Long-term aggradation trend
- Currently 0.2 m yr^{-1}





- LiDAR DoD
- Pulsed sediment delivery
- Recent storms & glacier retreat

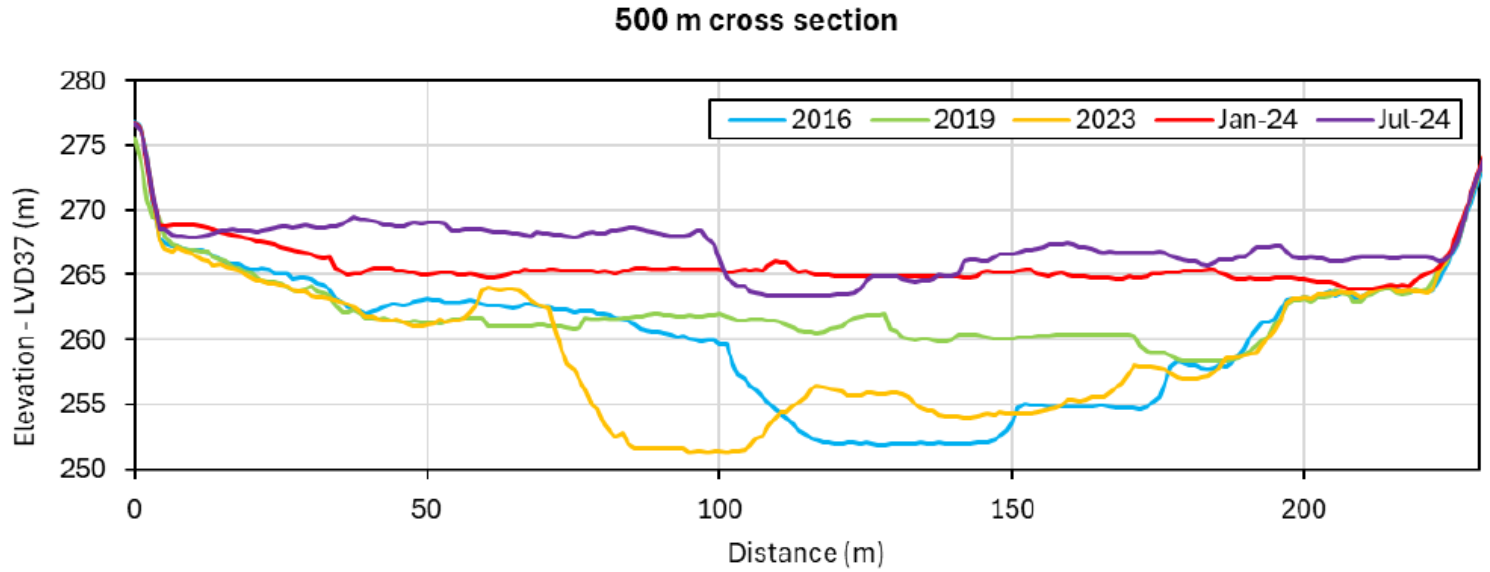


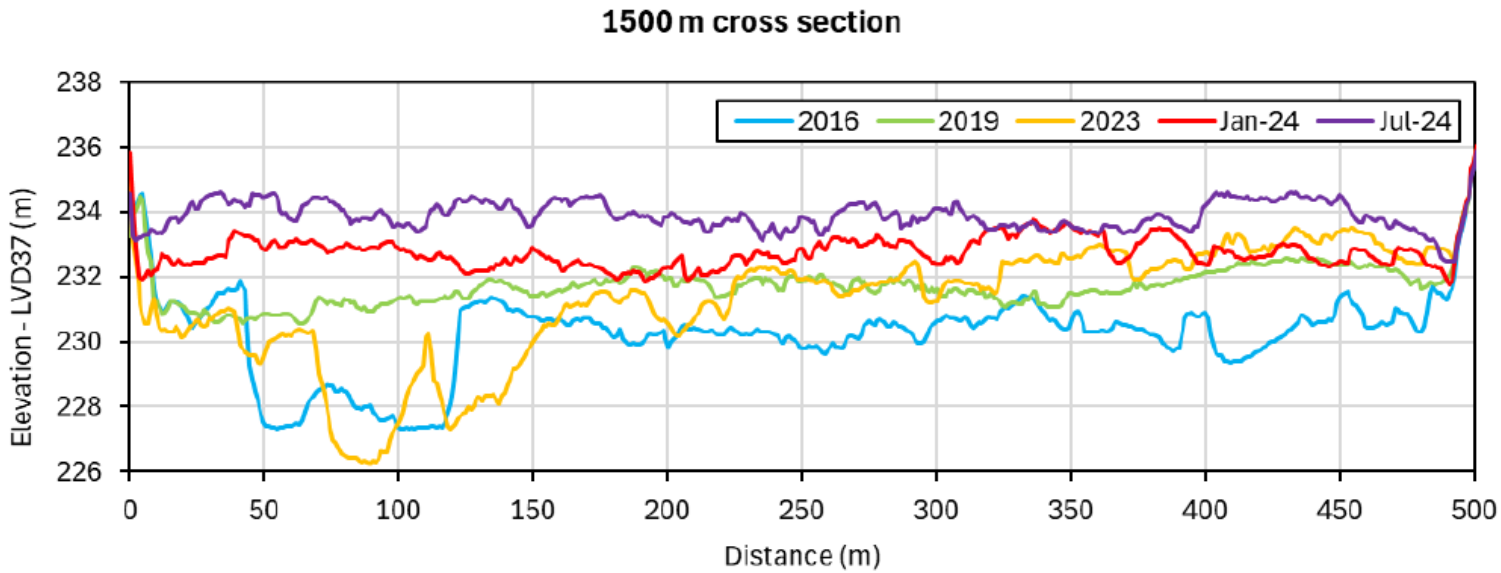


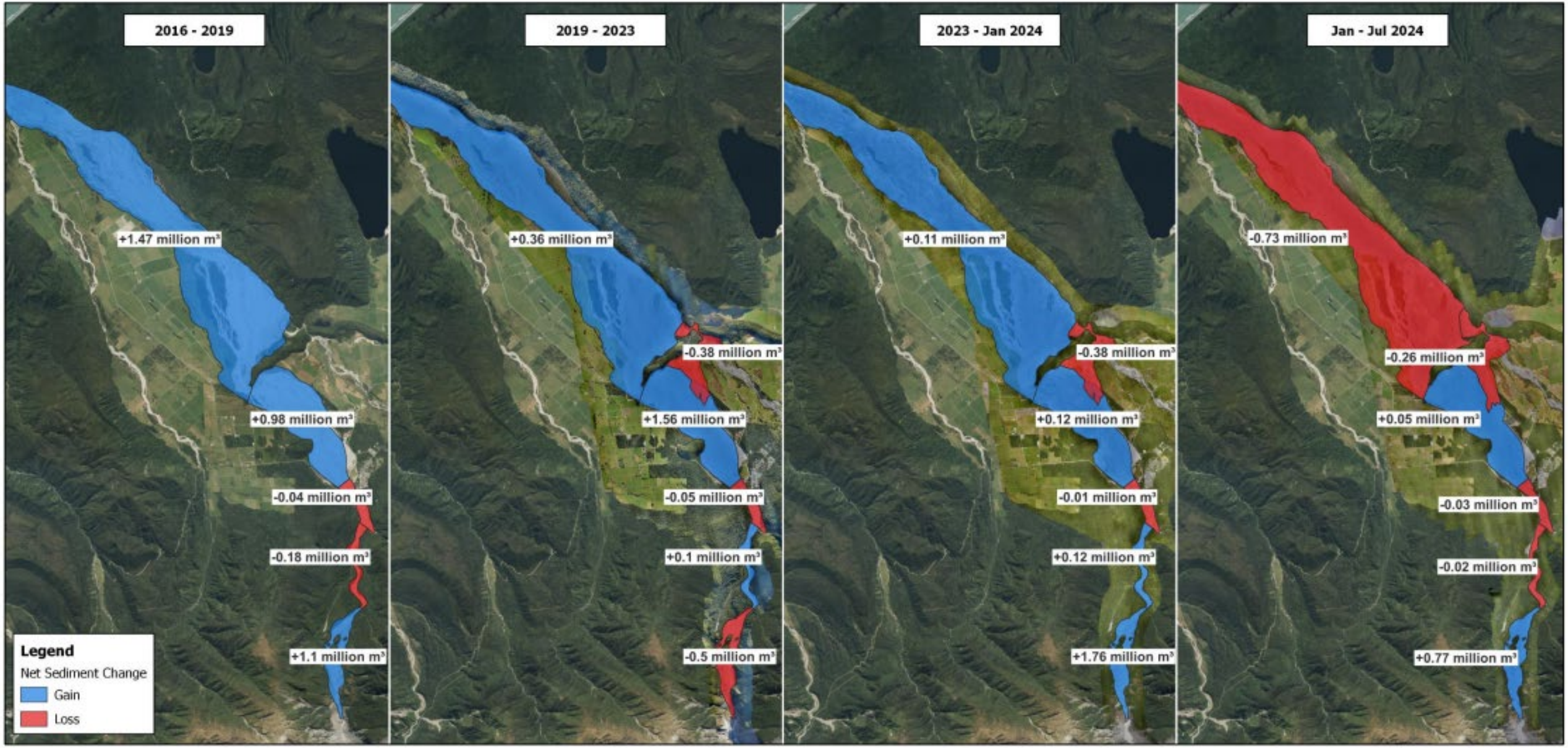

Franz Josef Glacier 2024-04-08 13:49:40
Pre 9-12th April 2024 weather event


Franz Josef Glacier 2024-04-18 13:49:45
Post 9-12th April 2024 weather event

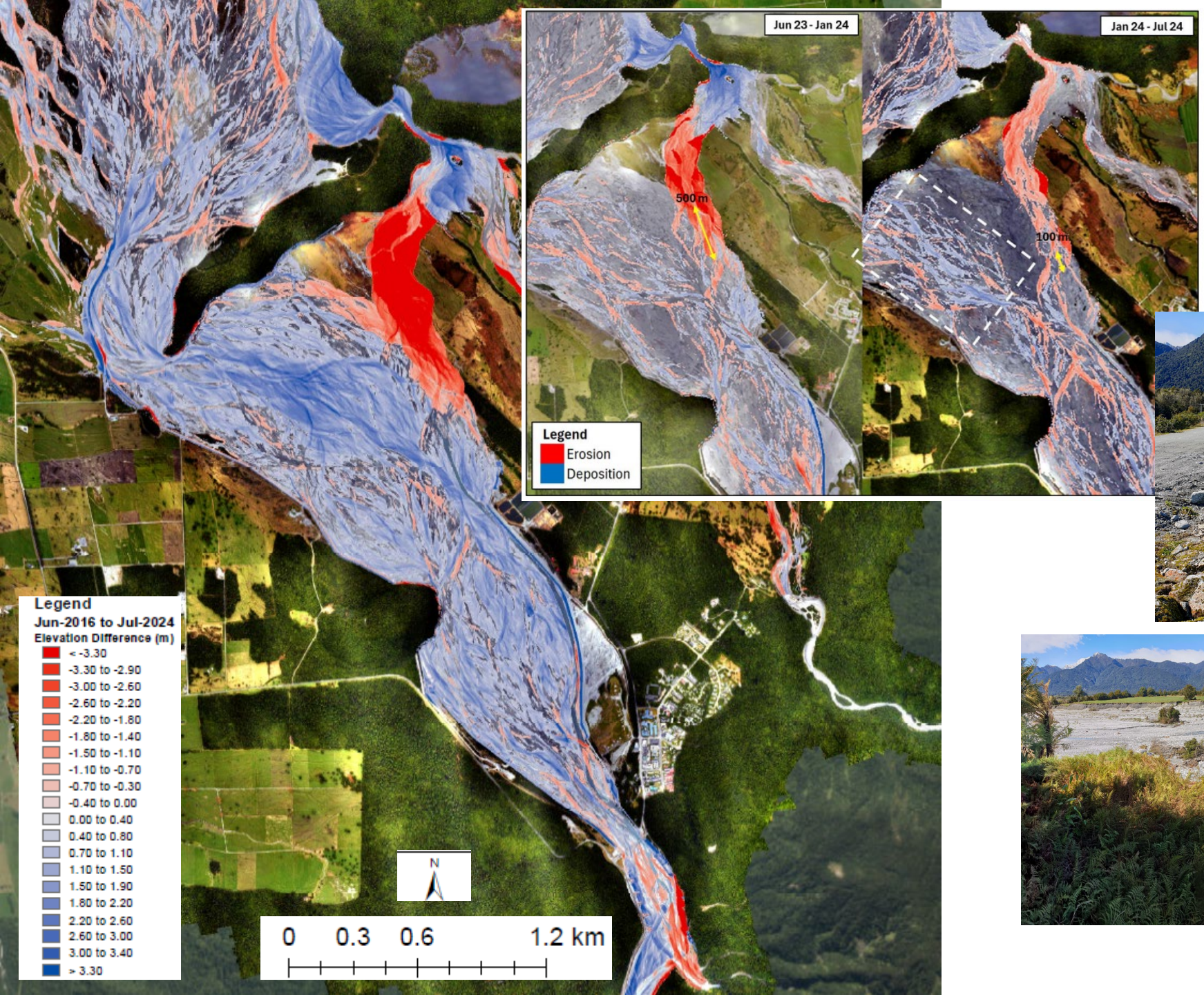

500m
1500m


500 m cross section
Elevation - LVD37 (m)
280
275
270
265
260
255
250
0
50
100
150
200
Distance (m)
2016
2019
2023
Jan-24
Jul-24

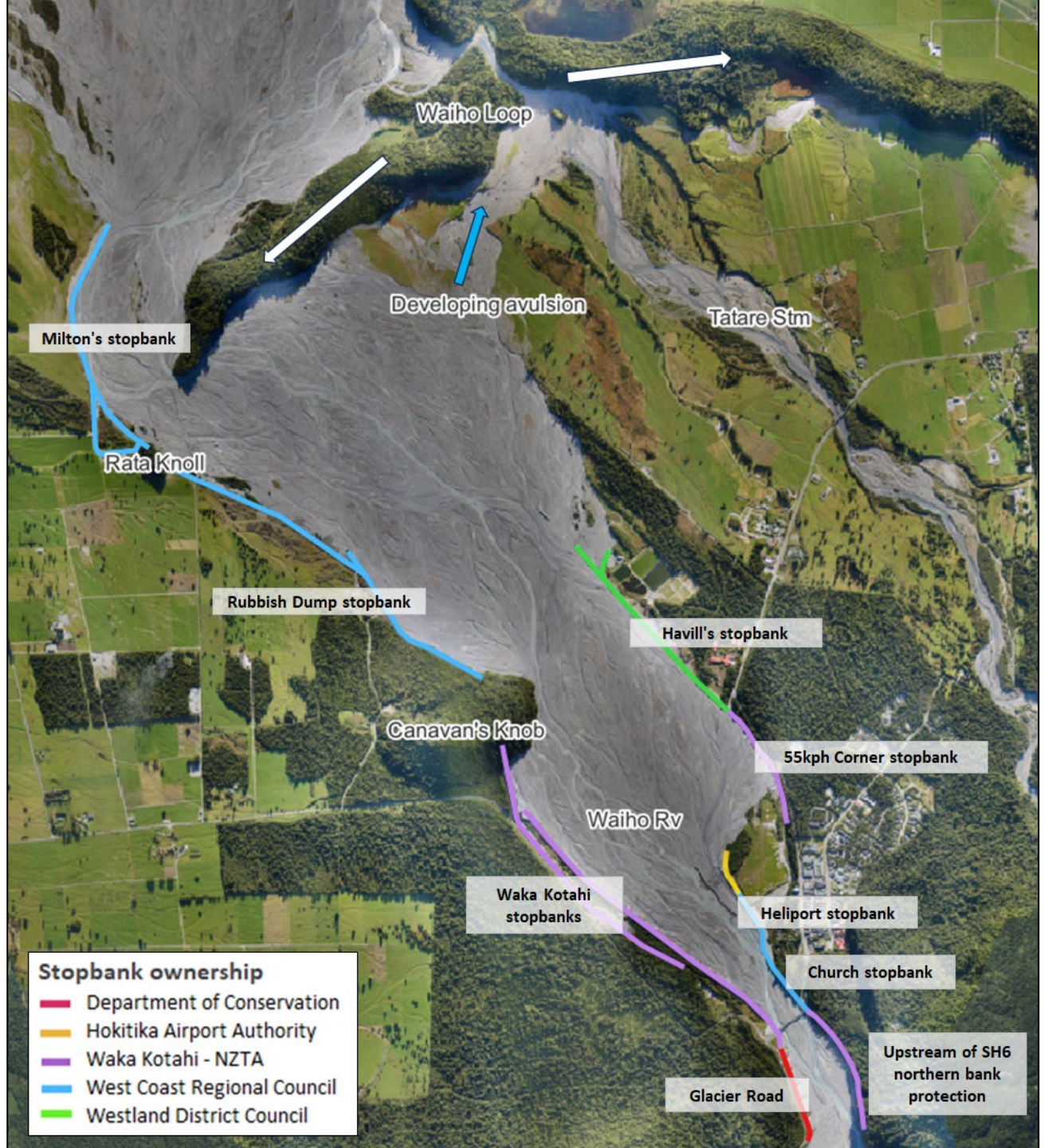

1500 m cross section
Elevation - LVD37 (m)
238
236
234
232
230
228
226
0
50
100
150
200
250
300
350
400
450
500
Distance (m)
2016
2019
2023
Jan-24
Jul-24



- Changes in sediment storage 2016-2024
- Consistent aggradation on Waiho Fan



- Avulsion into Tatare
- Infilling Tatare
- Full switch probable

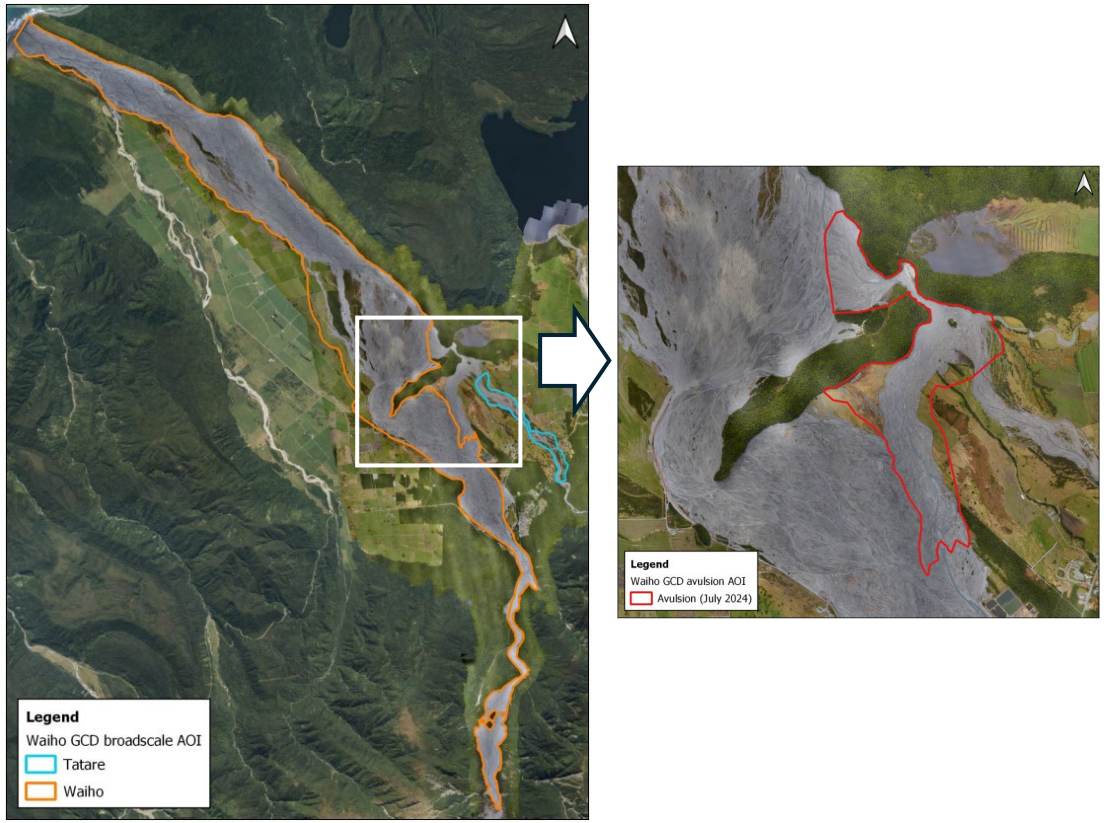

Waiho Loop
Developing avulsion
Tatare Stm
Milton's stopbank
Rata Knoll
Rubbish Dump stopbank
Havill's stopbank
Canavan's Knob
55kph Corner stopbank
Waiho Rv
Waka Kotahi stopbanks
Heliport stopbank
Church stopbank
Upstream of SH6 northern bank protection
Glacier Road
Stopbank ownership
Department of Conservation
Hokitika Airport Authority
Waka Kotahi - NZTA
West Coast Regional Council
Westland District Council

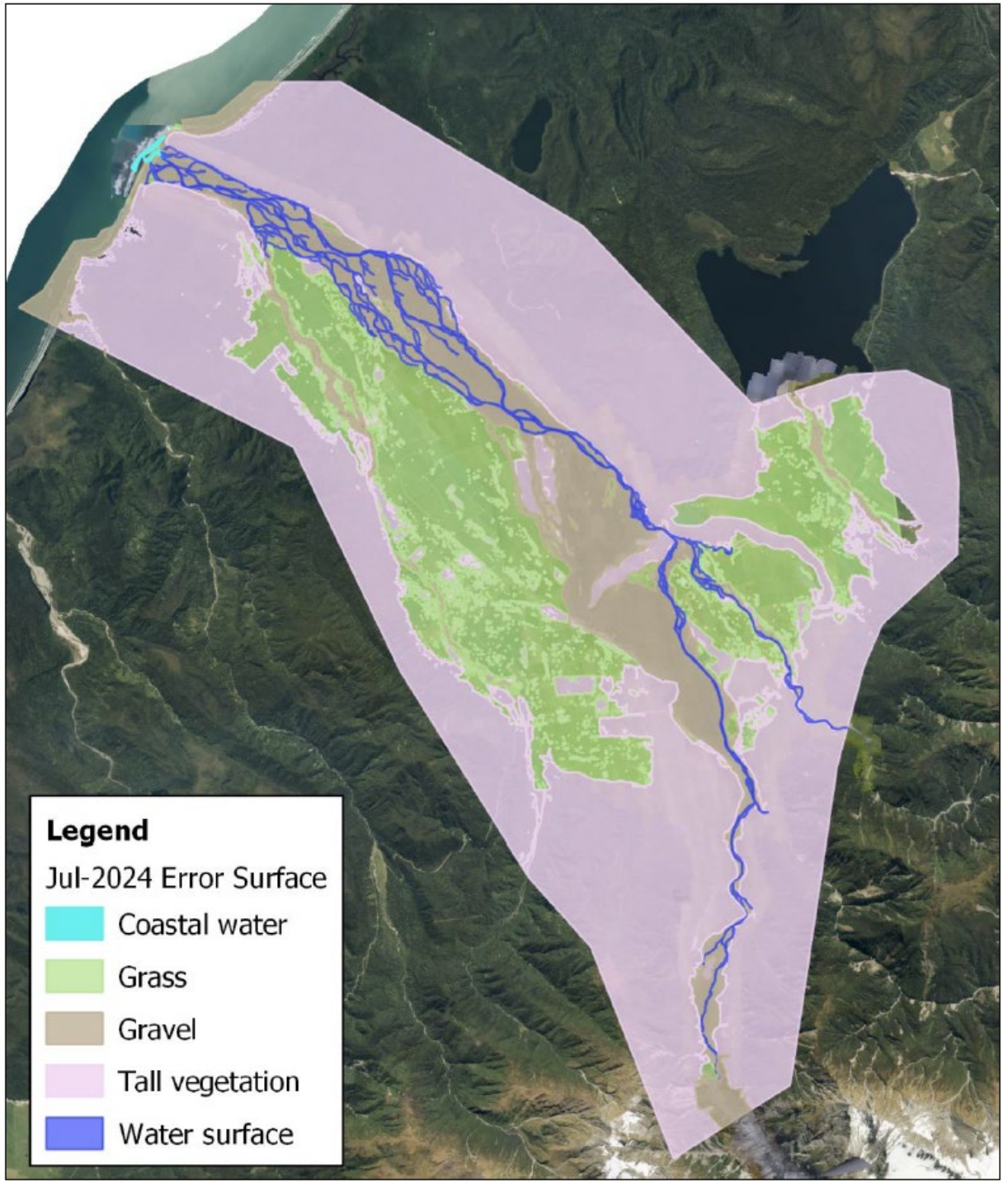
LiDAR Datasets

	2016	2019	2023	2024	
Collection Date	June	16 April	8 June	31 January	31 July
Collected By	New Zealand Aerial Surveys Ltd	Waikato University	University of Canterbury		
Collection Method	Fixed wing aircraft	Helicopter			
Sensor	Optech Orion H300	Riegl VUX-1LR	Riegl VUX240		
Altitude	1190 – 2375 m	350 m	300 m		
No. checkpoint surveys	(Unknown)	97	298	1640	1643
Standard deviation of checkpoint/point-cloud difference	0.016 m	0.017 m	0.051 m	0.047 m	0.026 m
Average checkpoint/point-cloud difference	0.007 m	0.001 m	-0.006 m	0.003 m	-0.002 m
RMS error	(Unknown)	0.017 m	0.051 m	0.047 m	0.034 m

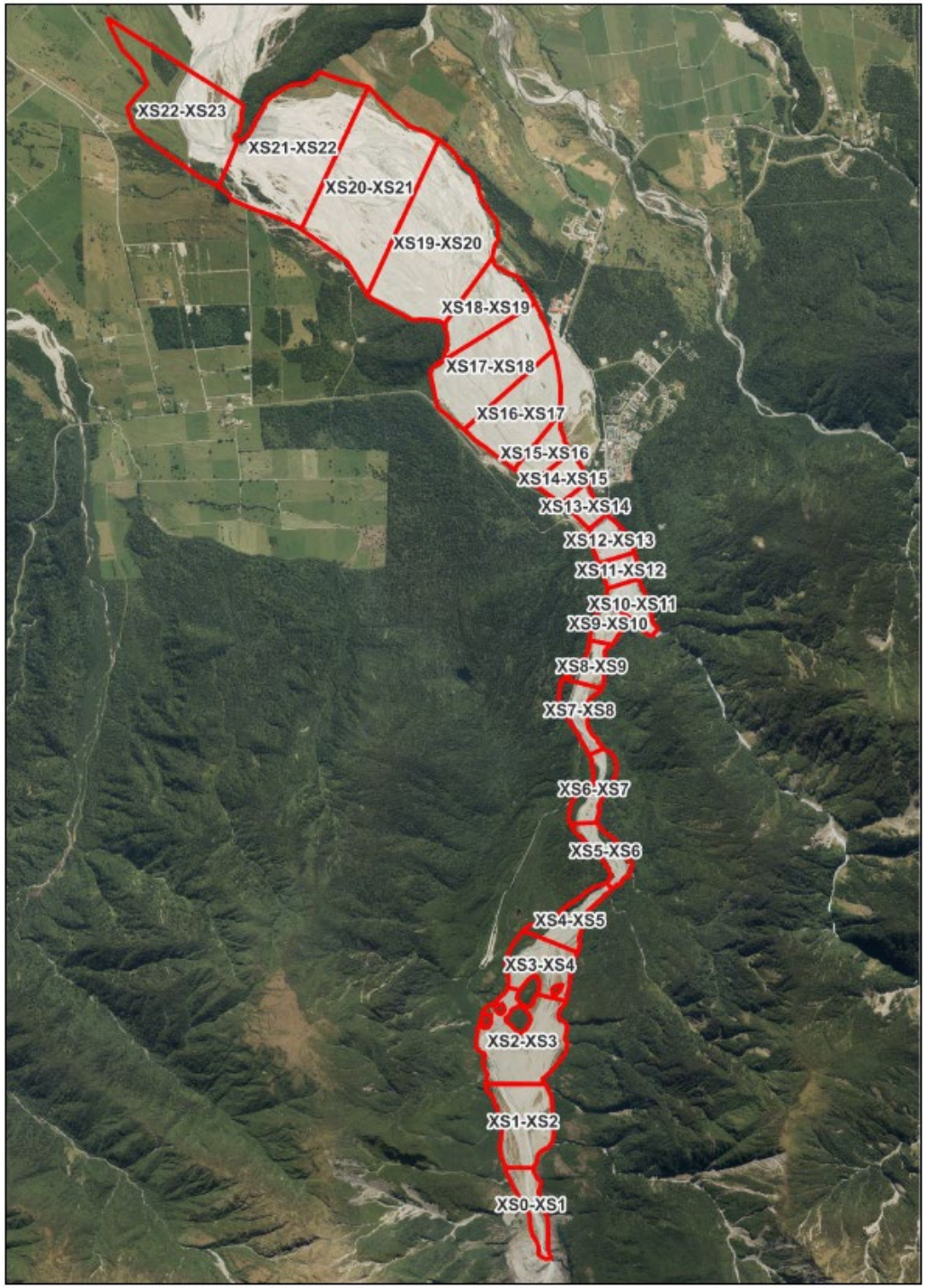
LiDAR uncertainty & AoI

Land Cover Class	Characteristic Vertical Uncertainty (m)
Grass	0.15
Exposed river gravels	0.13
Tall vegetation	0.30
Inundated areas (without correction)	0.50
Inundated areas (with section corrections, 2016 only)	0.25
Coastal water (January and July 2024)	0.75
Deep water (through the Tatare cut in January 2024)	1.00



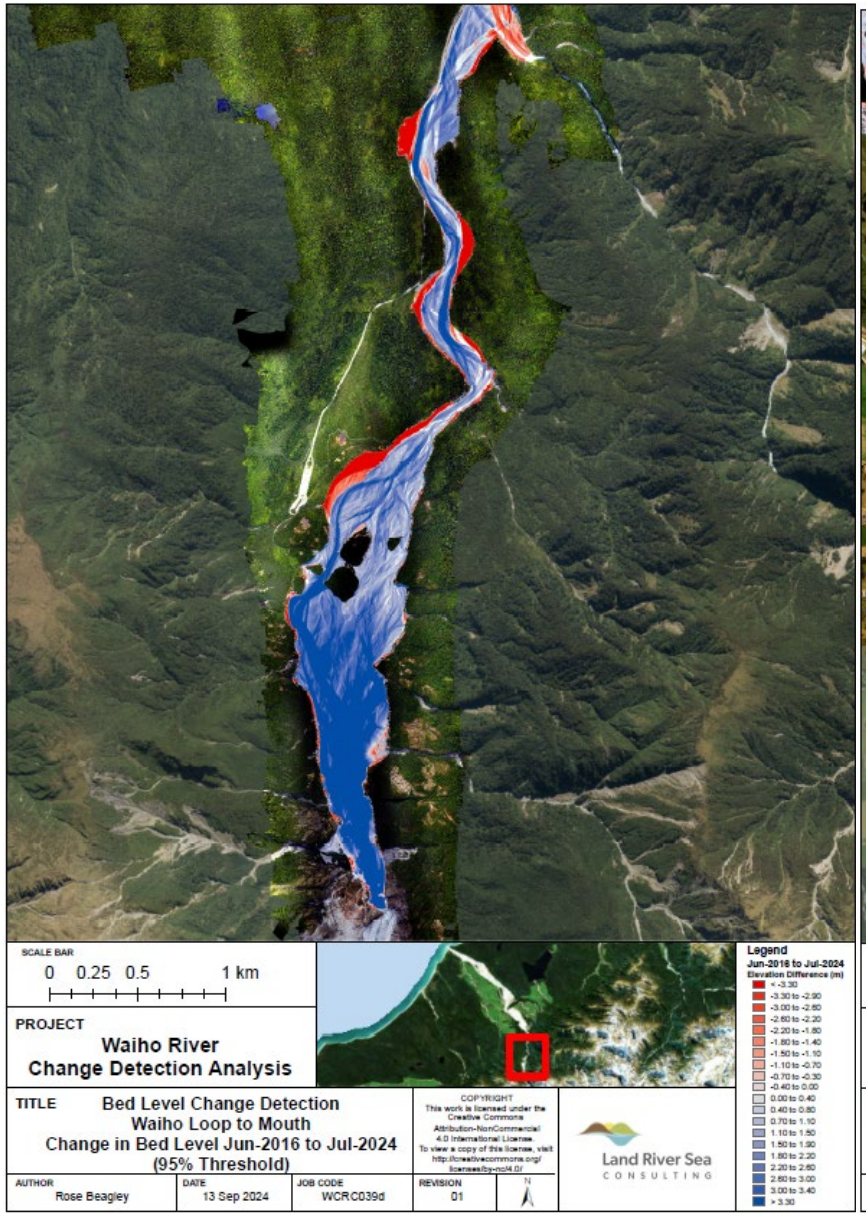


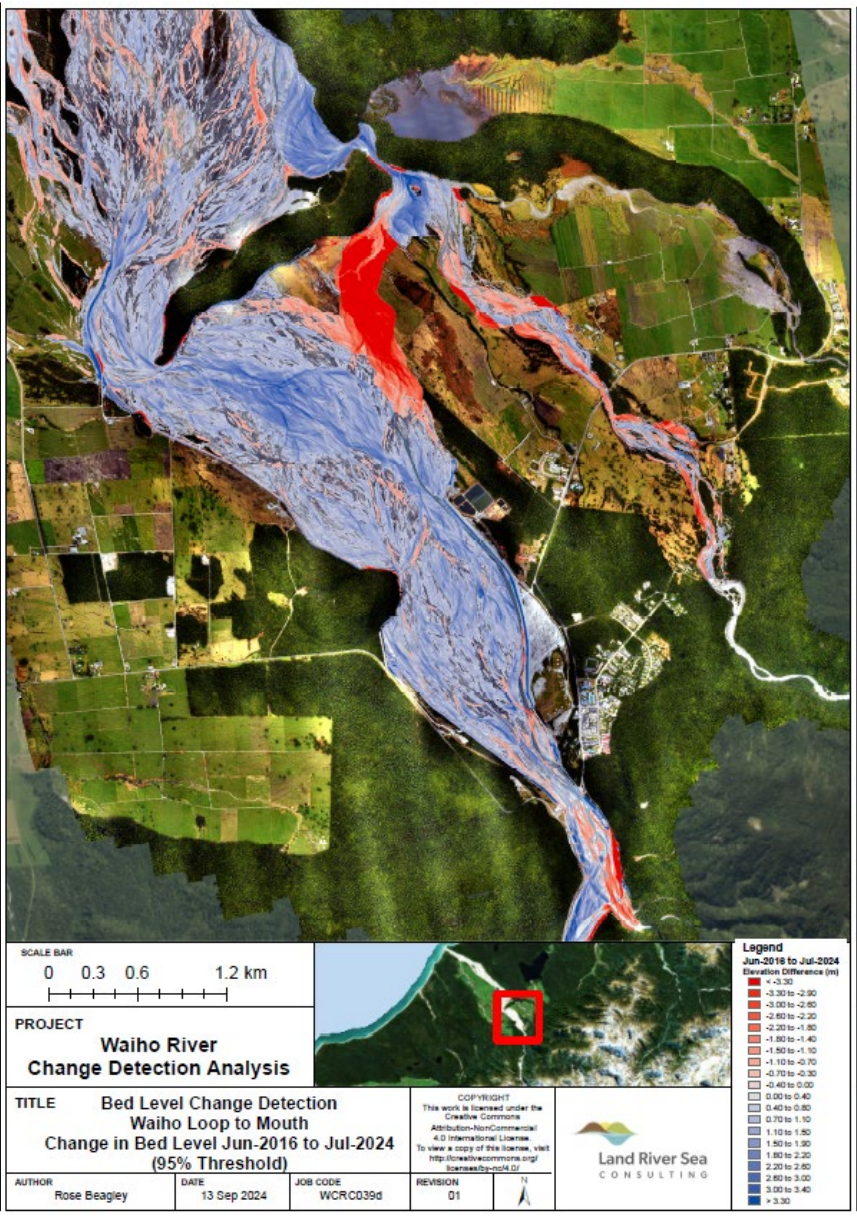
Cross-section locations & GCD budget cells (historic sections)

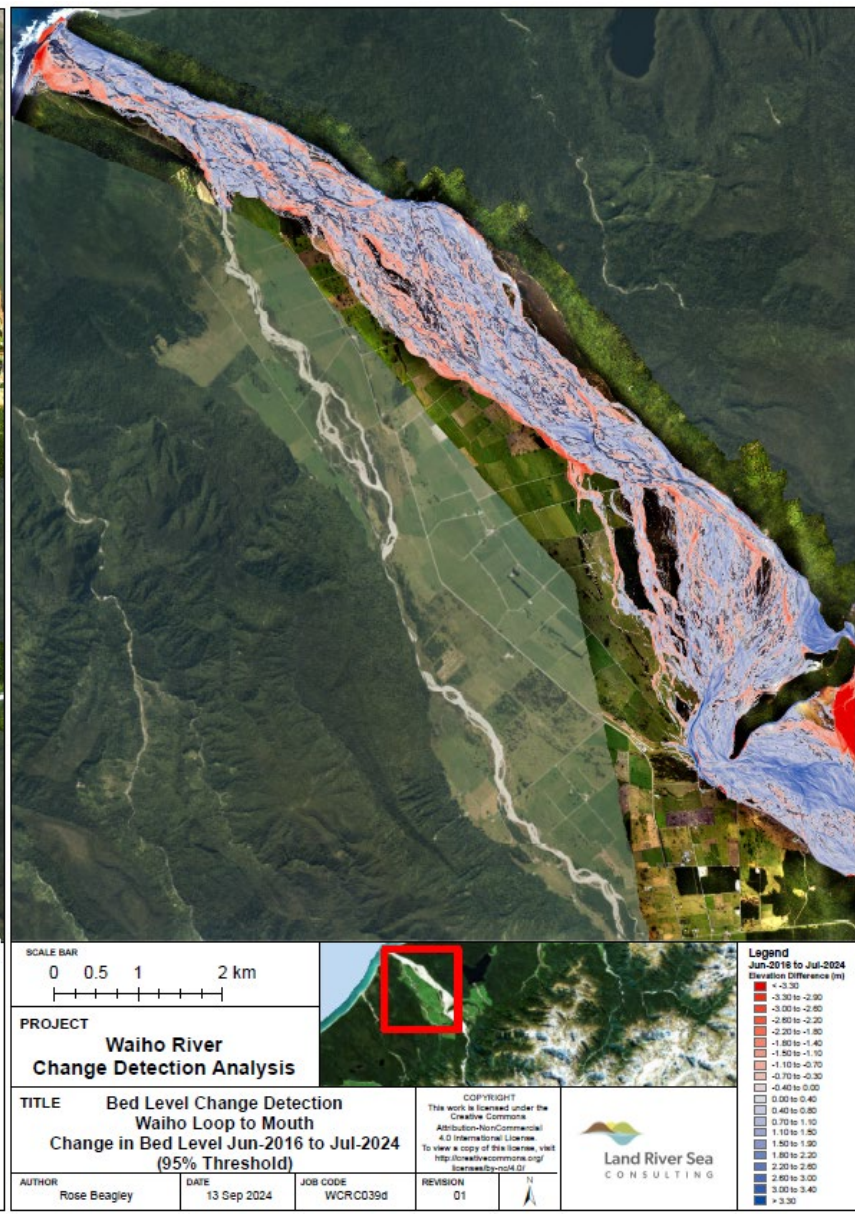


LiDAR DoDs Jan 2024 to Jul 2024

LiDAR DoDs Jun 2016 to Jul 2024

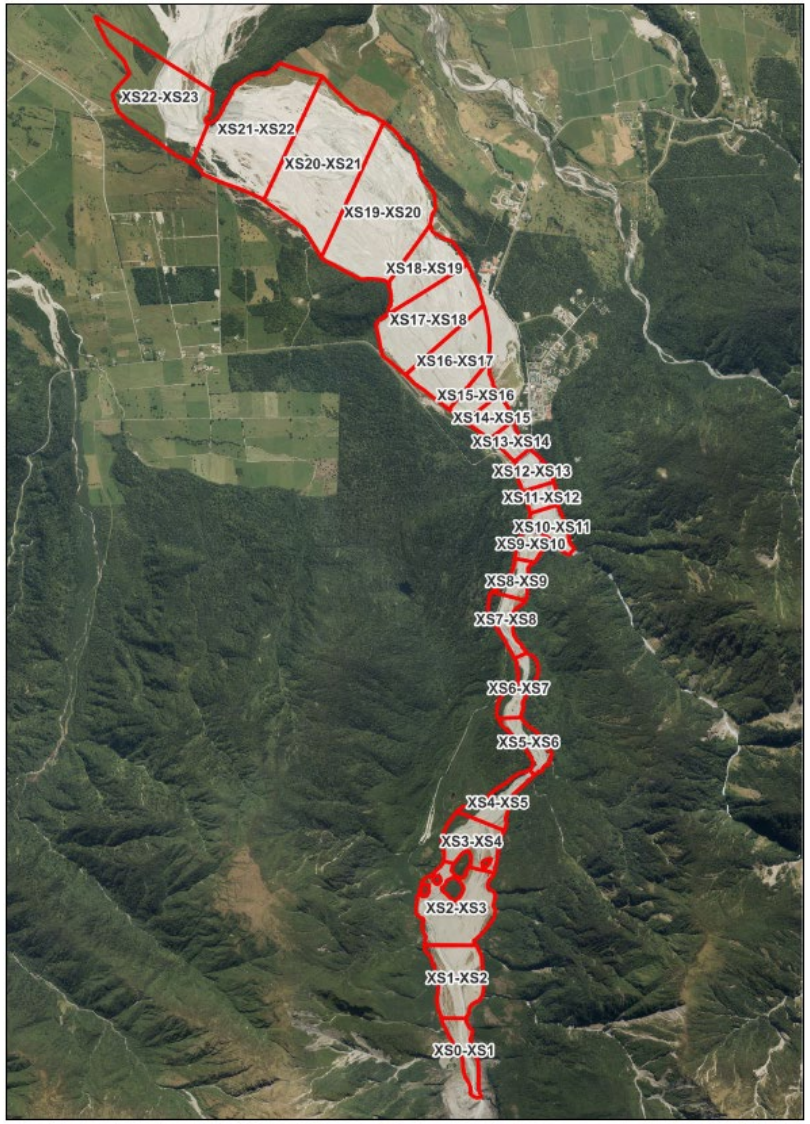






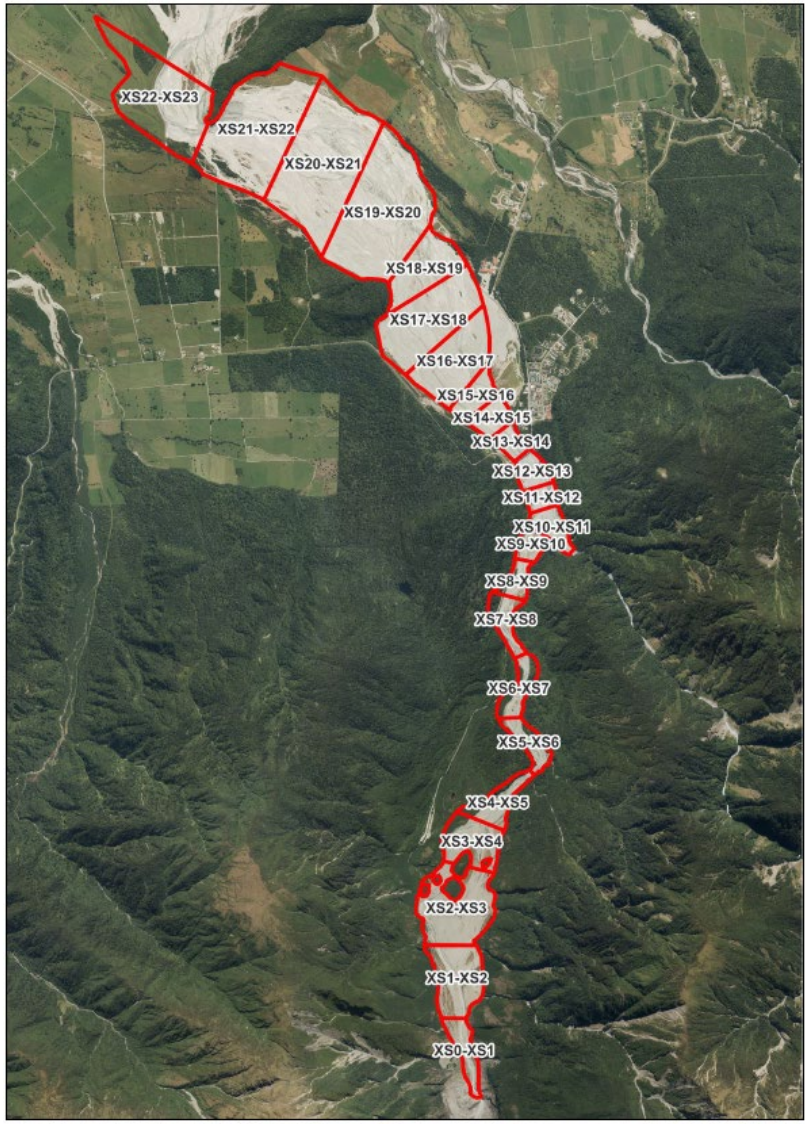
Bed Level and volumetric changes Jan 2024 to Jul 2024

	Cross Section / Cells	Mean Bed Level (m)		Net volume (m^3)		Reach net volume change (m^3)
		Change	Error (m)	Change	Error (%)	
Upper Valley	XS0-XS1	1.53	0.21	171,000	14	
	XS1-XS2	1.8	0.26	415,000	14	
	XS2-XS3	0.66	0.2	160,000	30	
	XS3-XS4	0.23	0.16	22,000	70	
	XS4-XS5	-0.04	0.2	-3,000	-510	765,000
Transport Reach	XS5-XS6	0.66	0.25	31,000	38	
	XS6-XS7	-0.12	0.19	-6,000	-158	
	XS7-XS8	-1.07	0.34	-40,000	-32	
	XS8-XS9	-0.6	0.27	-11,000	-46	
	XS9-XS10	0.06	0.15	2,000	254	-24,000
Callery Confluence to End of Helipad Bank	XS10-XS11	-0.13	0.18	-5,000	-142	
	XS11-XS12	-0.36	0.19	-7,000	-52	
	XS12-XS13	-0.21	0.2	-7,000	-96	
	XS13-XS14	-0.07	0.18	-1,000	-248	
	XS14-XS15	-0.13	0.21	-6,000	-158	-27,000
End of Helipad Bank to Waiho Loop	XS15-XS16	0.25	0.19	14,000	76	
	XS16-XS17	0.05	0.17	9,000	325	
	XS17-XS18	-0.05	0.16	-10,000	-303	
	XS18-XS19	-0.64	0.2	-58,000	-31	
	XS19-XS20	-0.27	0.17	-82,000	-63	
	XS20-XS21	0.21	0.14	59,000	64	
	XS21-XS22	0.22	0.15	68,000	68	1,000
	XS22-XS23	0.02	0.15	3,000	629	



Bed Level and volumetric changes Jun 2016 to Jul 2024

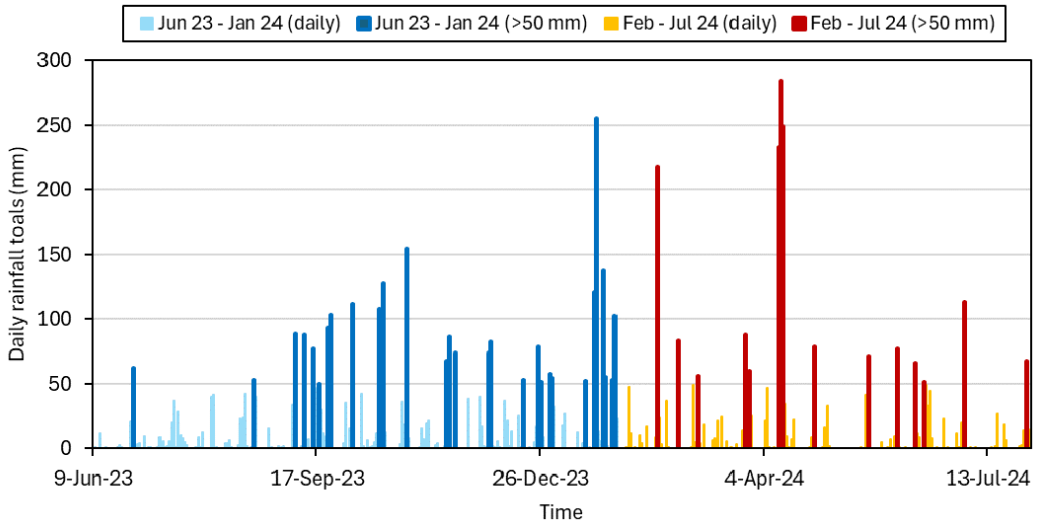
	Cross Section / Cells	Mean Bed Level (m)		Net volume (m^3)		Reach net volume change (m^3)
		Change	Error (m)	Change	Error (%)	
Upper Valley	XS0-XS1	7.38	0.22	932,000	3	
	XS1-XS2	5.19	0.2	1,264,000	4	
	XS2-XS3	2.63	0.2	893,000	8	
	XS3-XS4	1.06	0.2	185,000	19	
	XS4-XS5	-1.08	0.2	-116,000	-18	3,158,000
Transport Reach	XS5-XS6	0.97	0.22	73,000	23	
	XS6-XS7	-0.87	0.2	-75,000	-23	
	XS7-XS8	1.61	0.2	82,000	13	
	XS8-XS9	2.1	0.24	99,000	12	
	XS9-XS10	1.09	0.18	51,000	17	230,000
Callery Confluence to End of Helipad Bank	XS10-XS11	-1.49	0.22	-106,000	-15	
	XS11-XS12	-2.33	0.19	-88,000	-8	
	XS12-XS13	0.32	0.15	17,000	47	
	XS13-XS14	0.85	0.15	26,000	18	
	XS14-XS15	0.54	0.15	29,000	27	-122,000
End of Helipad Bank to Waiho Loop	XS15-XS16	0.75	0.16	49,000	21	
	XS16-XS17	0.92	0.18	218,000	19	
	XS17-XS18	1.19	0.19	438,000	16	
	XS18-XS19	1.1	0.18	192,000	16	
	XS19-XS20	0.67	0.16	395,000	24	
	XS20-XS21	1.05	0.17	673,000	16	
	XS21-XS22	0.99	0.19	578,000	19	2,542,000
	XS22-XS23	0.94	0.19	307,000	21	



Monitoring site	Owner	Elevation	Data	Period
Waiho Rv at SH6	WCRC	146 m	Rainfall/Water level	2009 to current
Waiho Rv at Douglas Hut	NIWA	221 m	Rainfall	1983 to current

Douglas Hut Rainfall

GCD period	Approximate length	Average monthly total (mm)	Time above, at and below the long-term monthly means		
			Drier (%)	Normal (%)	Wetter (%)
2016 – 2019	3 years	497	38	14	49
2019 – 2023	4 years	646	32	15	53
2023 – Jan 2024	8 months	555	43	14	43
Jan – Jul 2024	6 months	463	50	17	33



Emerging management issues

Why did Council commission the report?

Ongoing threat of the Waiho River

Previous workshops in 2000 and 2016 held to develop long-term sustainable management options – outcomes did not gain traction

Since 2016, the situation has worsened:

Continued aggradation (build-up of gravel in the riverbed)

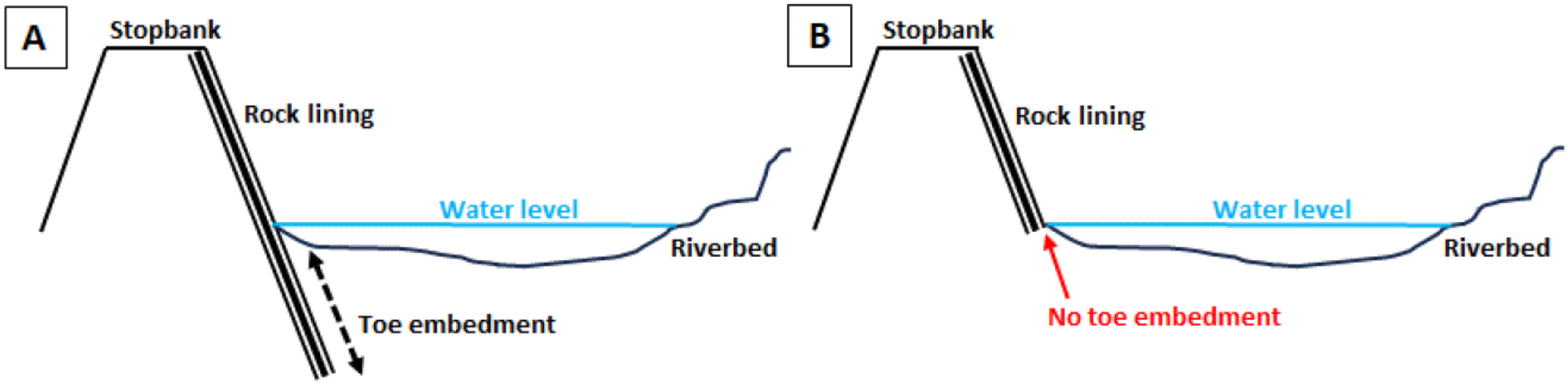
A major break out (avulsion) channel into the Tartare Stream to the north in 2023

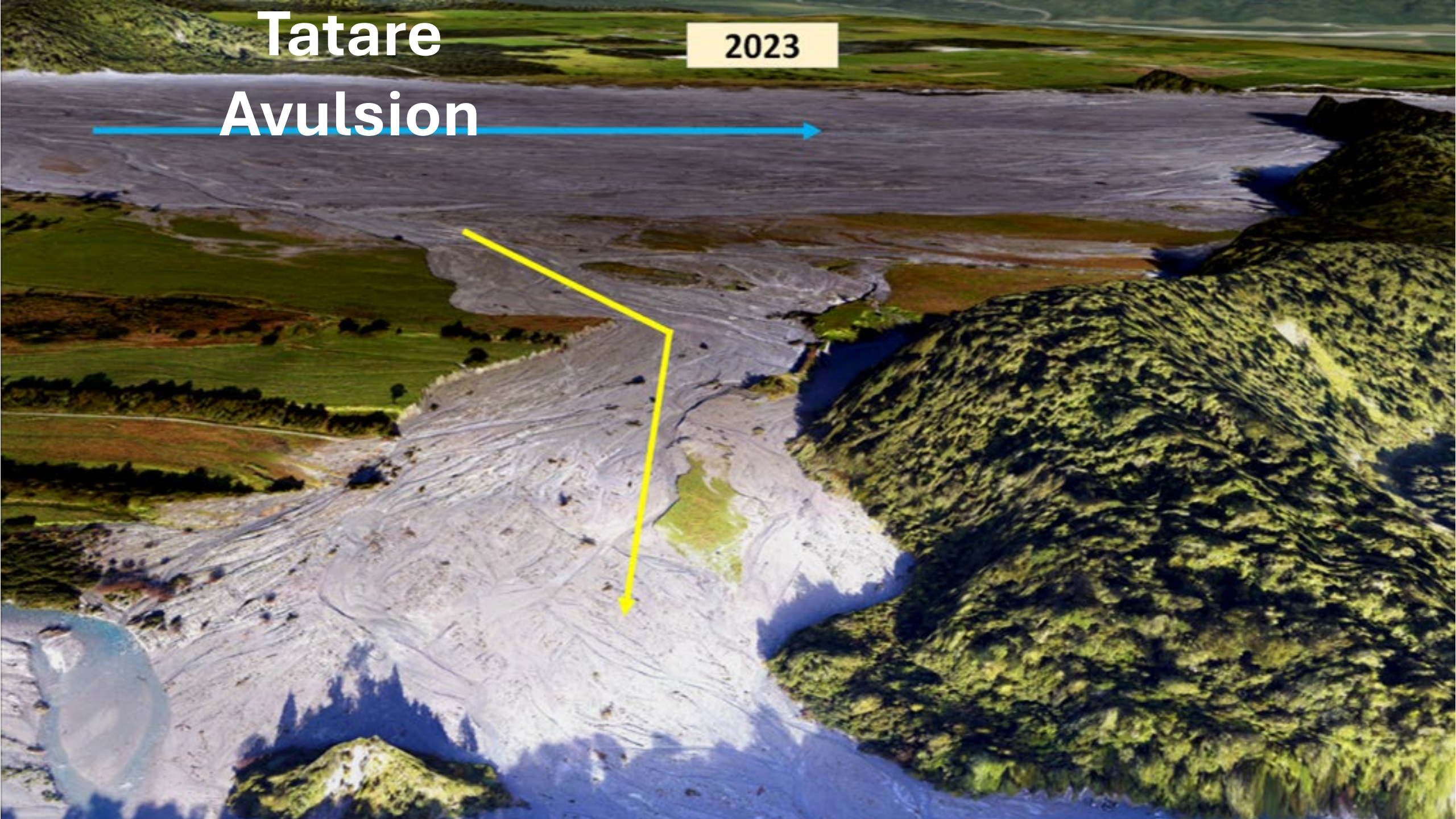
Fundamental change in the behaviour of the river which will have serious consequences on surrounding infrastructure and ecological values

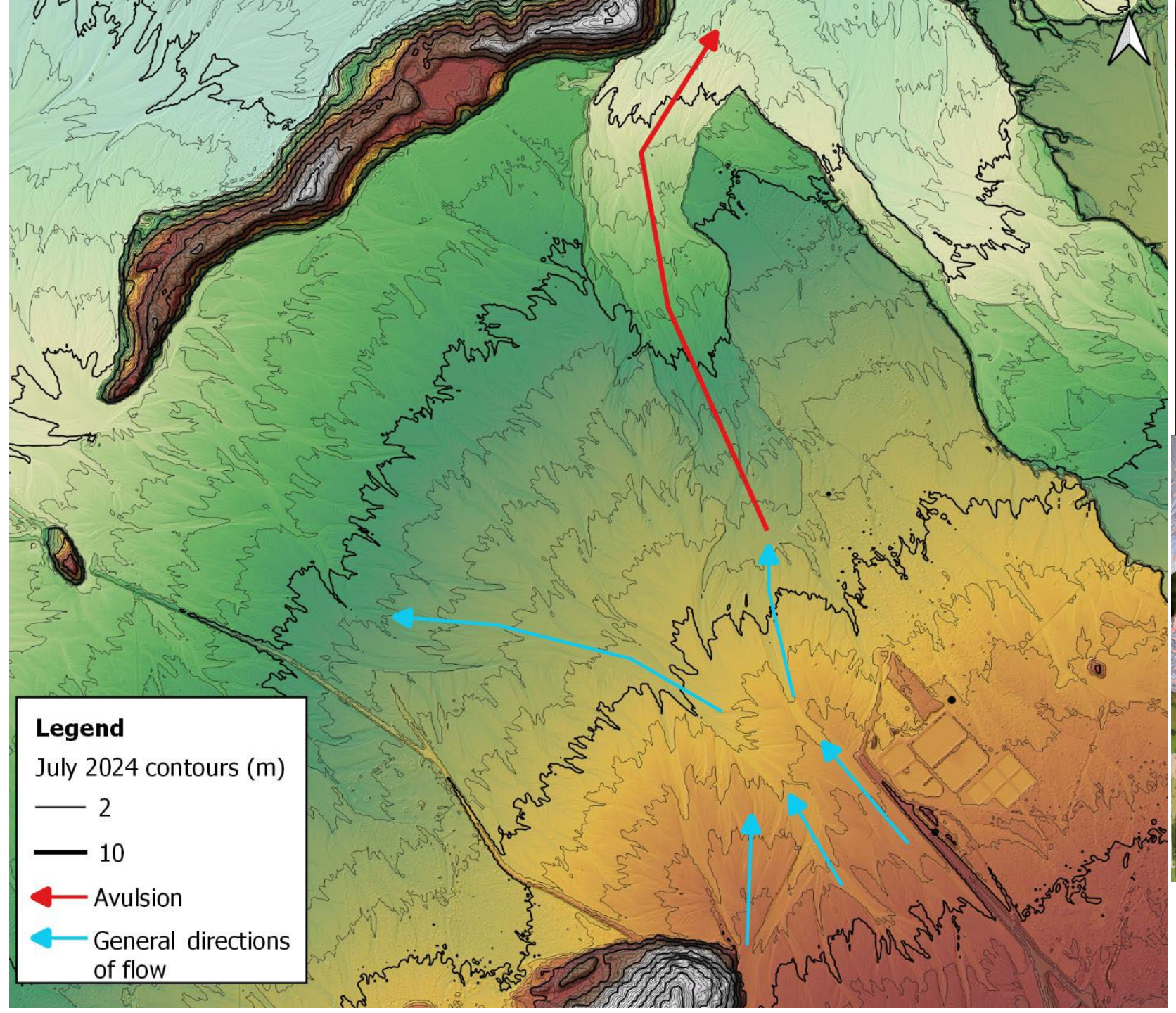
Government funding had been allocated for the South Side. This has been frozen until an acceptable plan formalised for the Waiho.

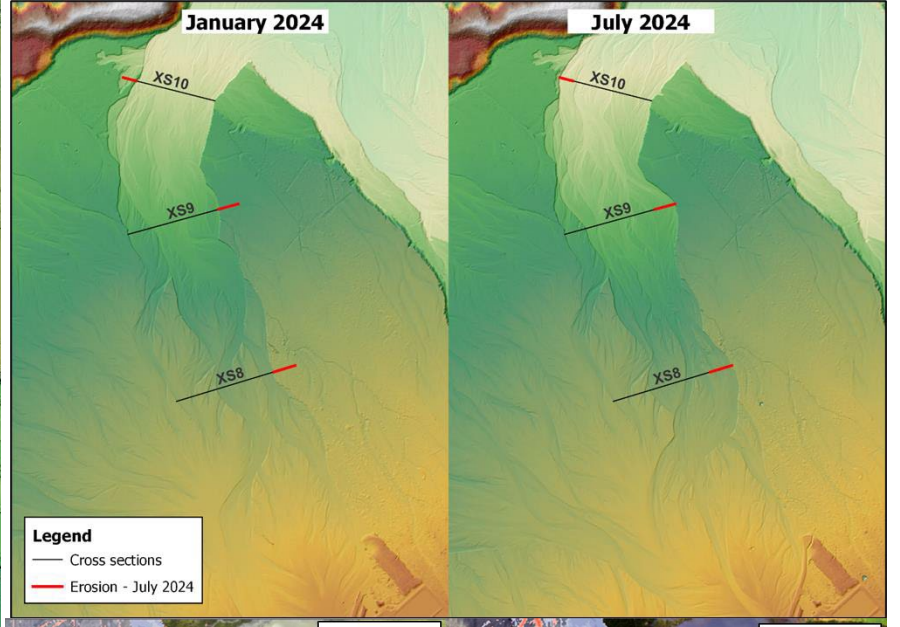
Miltons Bank

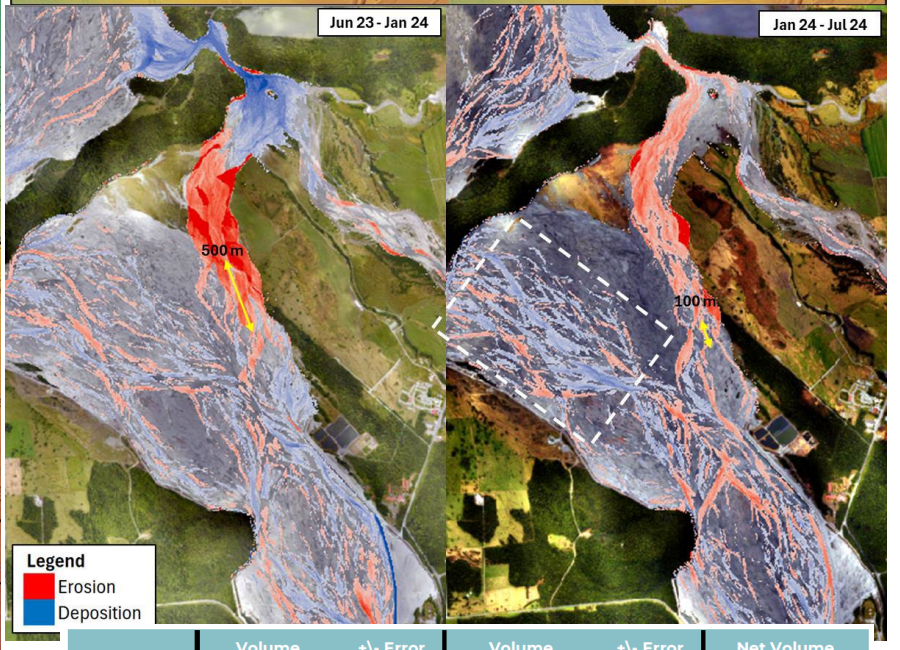
Toe Failure


A
Stopbank
Rock lining
Water level
Riverbed
Toe embedment
B
Stopbank
Rock lining
Water level
Riverbed
No toe embedment

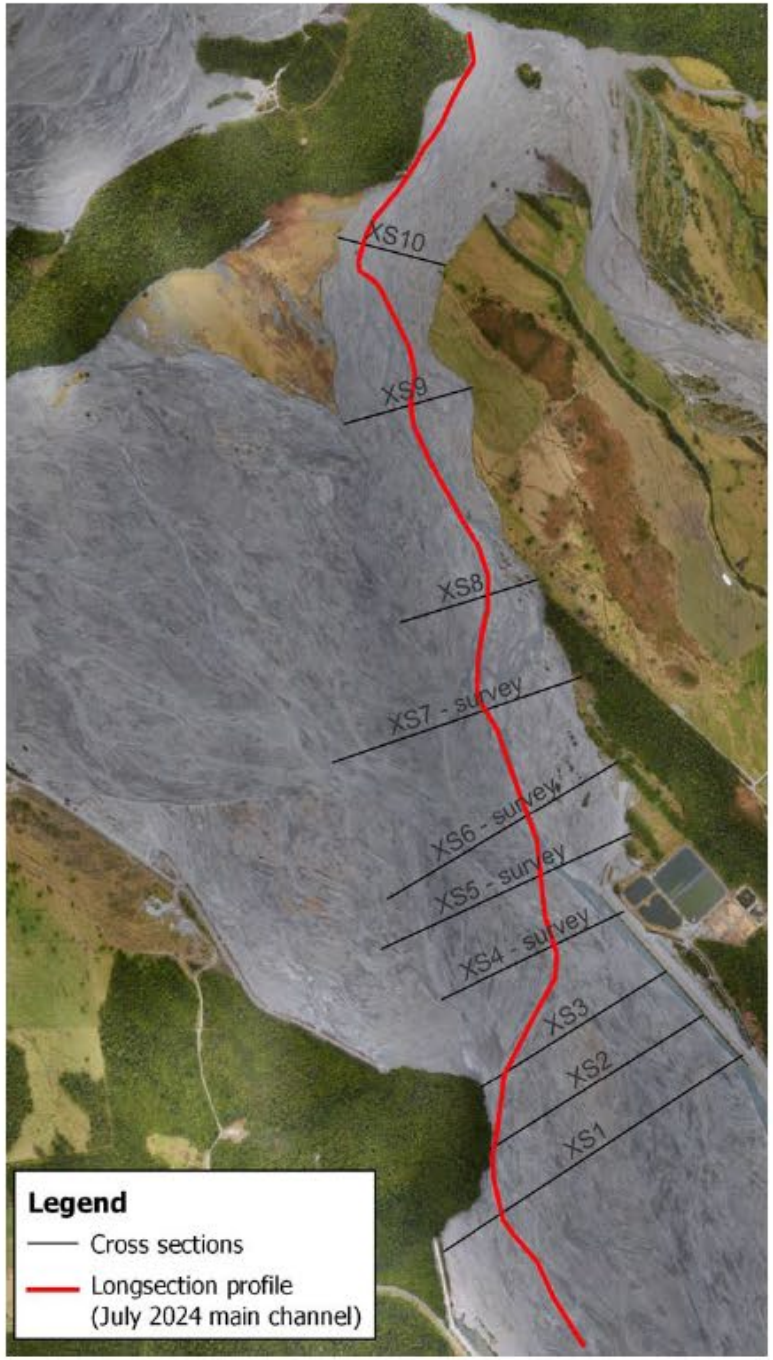

Tatare
Avulsion
2023

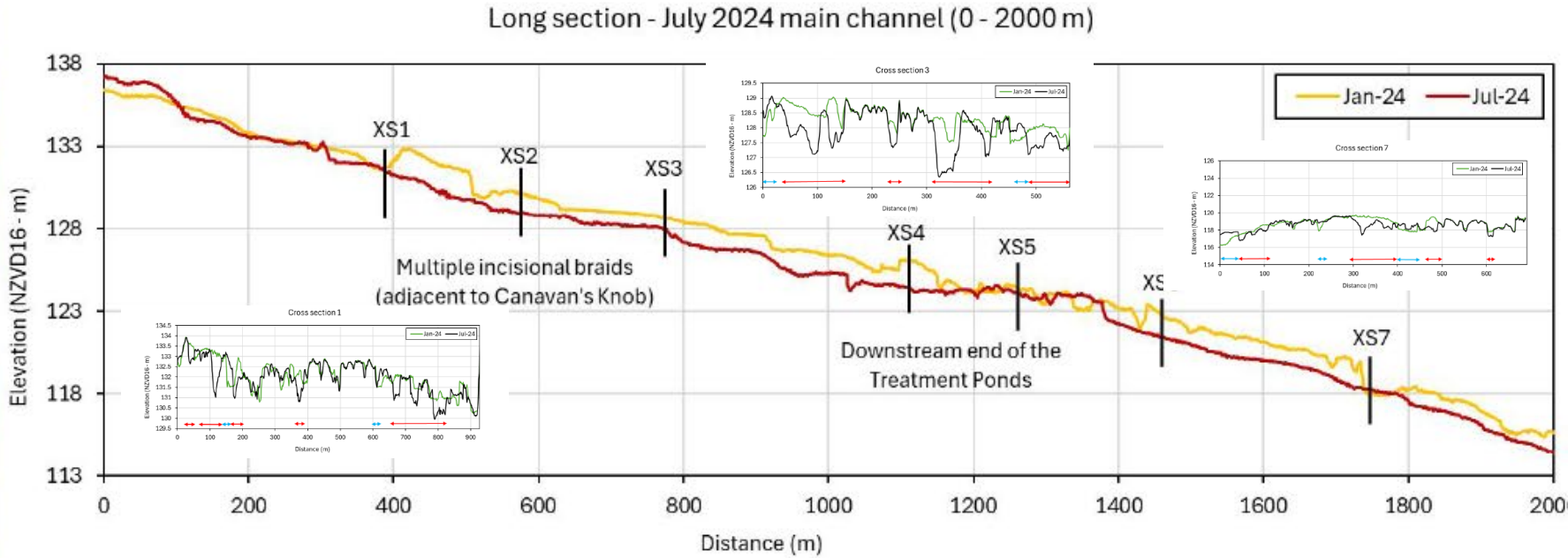


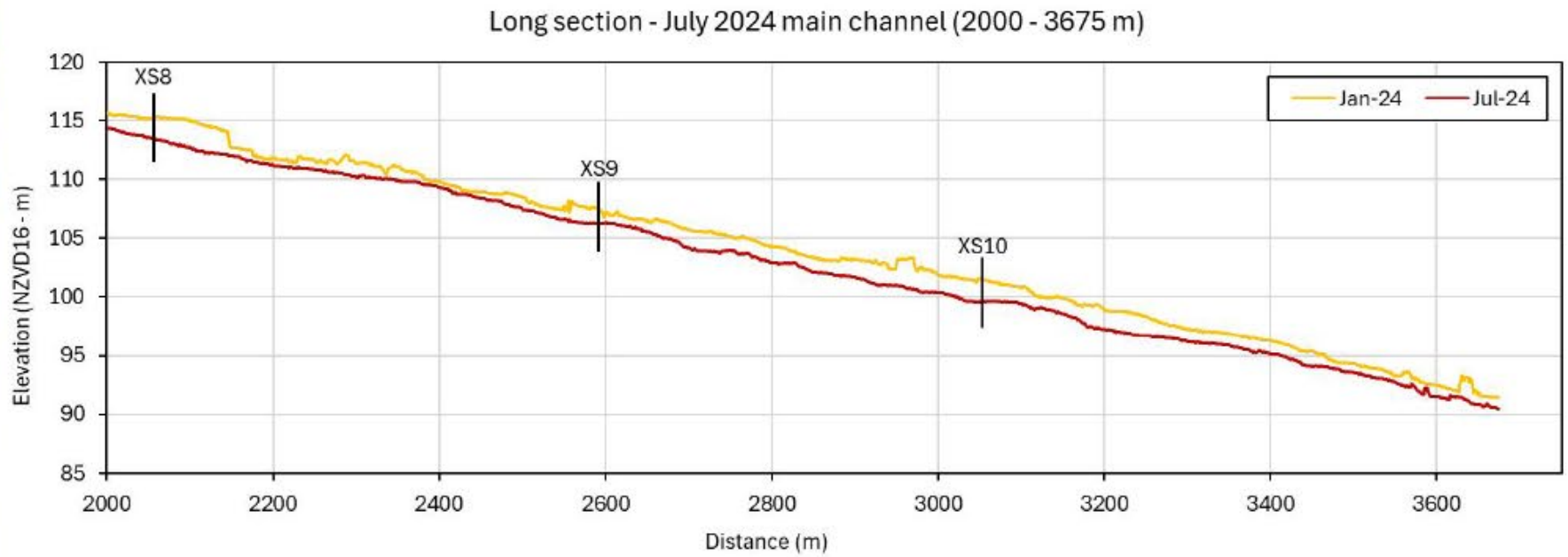


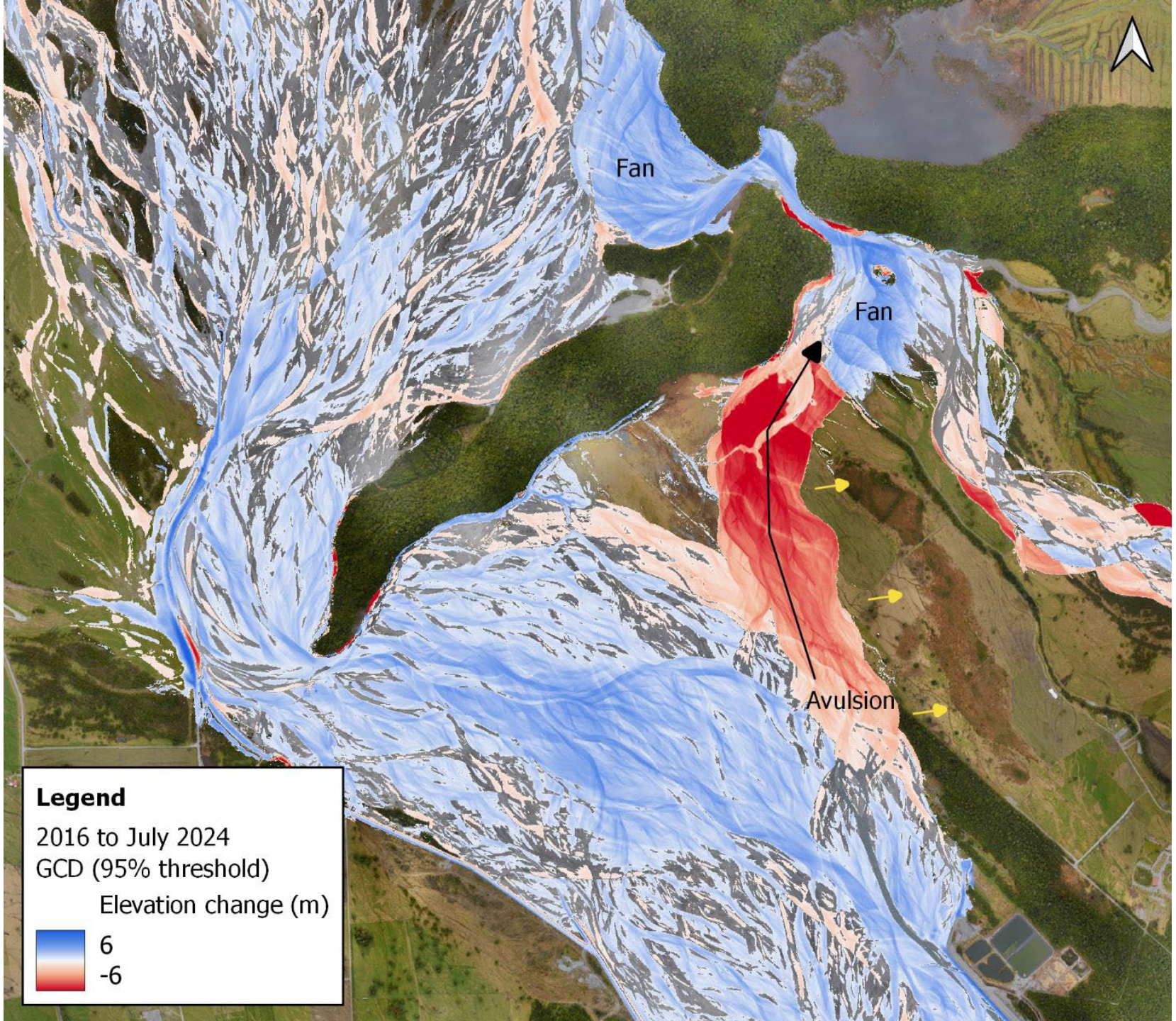


	Volume Erosion (million m³)	+\- Error (million m³)	Volume Deposition (million m³)	+\- Error (million m³)	Net Volume Difference (million m³)
2019-23	0.51	±0.07	0.13	±0.03	-0.38
2023-Jan24	0.70	±0.09	0.42	±0.10	-0.28
Jan24-Jul24	0.41	±0.09	0.15	±0.06	-0.26

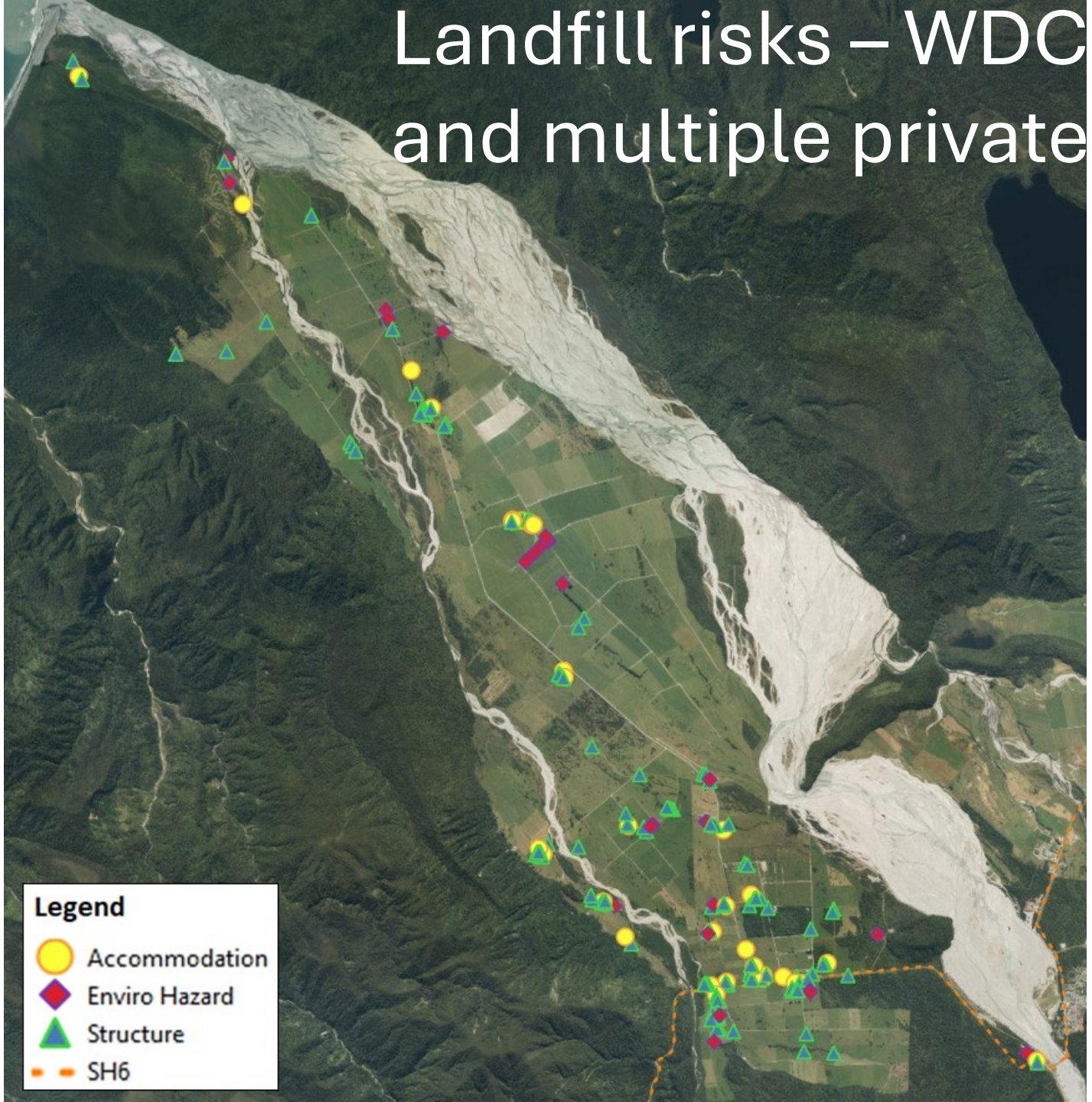

XS10
XS9
XS8
XS7 - survey
XS6 - survey
XS5 - survey
XS4 - survey
XS3
XS2
XS1
Legend
Cross sections
Longsection profile
(July 2024 main channel)

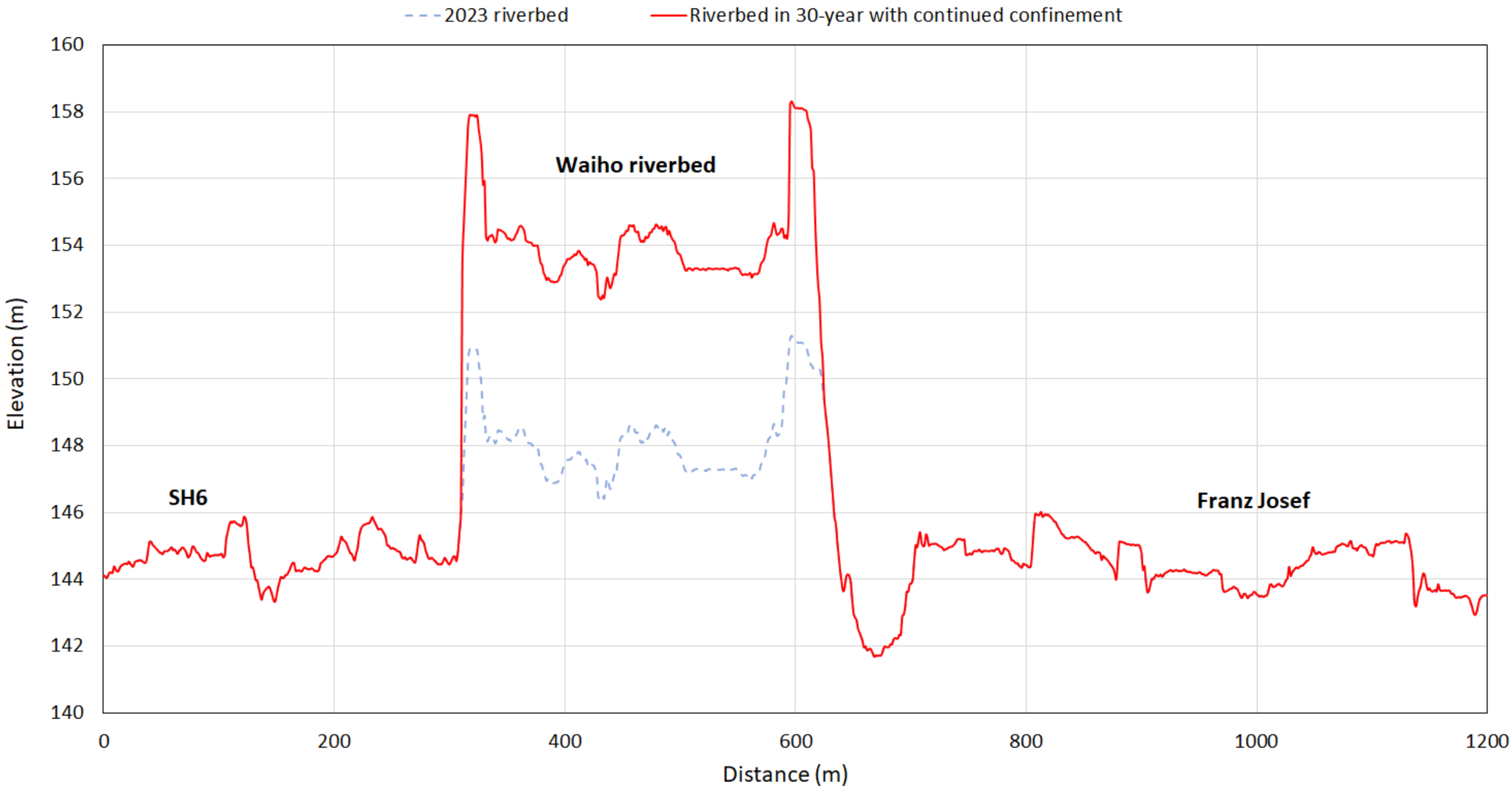

Long section - July 2024 main channel (0 - 2000 m)
Elevation (NZVD16 - m)
Distance (m)
Jan-24
Jul-24
XS1
XS2
XS3
XS4
XS5
XS7
Multiple incisional braids
(adjacent to Canavan's Knob)
Downstream end of the
Treatment Ponds
Cross section 1
Cross section 3
Cross section 7


Long section - July 2024 main channel (2000 - 3675 m)
Elevation (NZVD16 - m)
Distance (m)
Jan-24
Jul-24
XS8
XS9
XS10


Fan
Fan
Avulsion
Legend
2016 to July 2024
GCD (95% threshold)
Elevation change (m)
6
-6

Landfill risks – WDC and multiple private




2023 riverbed
Riverbed in 30-year with continued confinement
Waiho riverbed
SH6
Franz Josef
Elevation (m)
Distance (m)
160
158
156
154
152
150
148
146
144
142
140
0
200
400
600
800
1000
1200

Risk Assessment

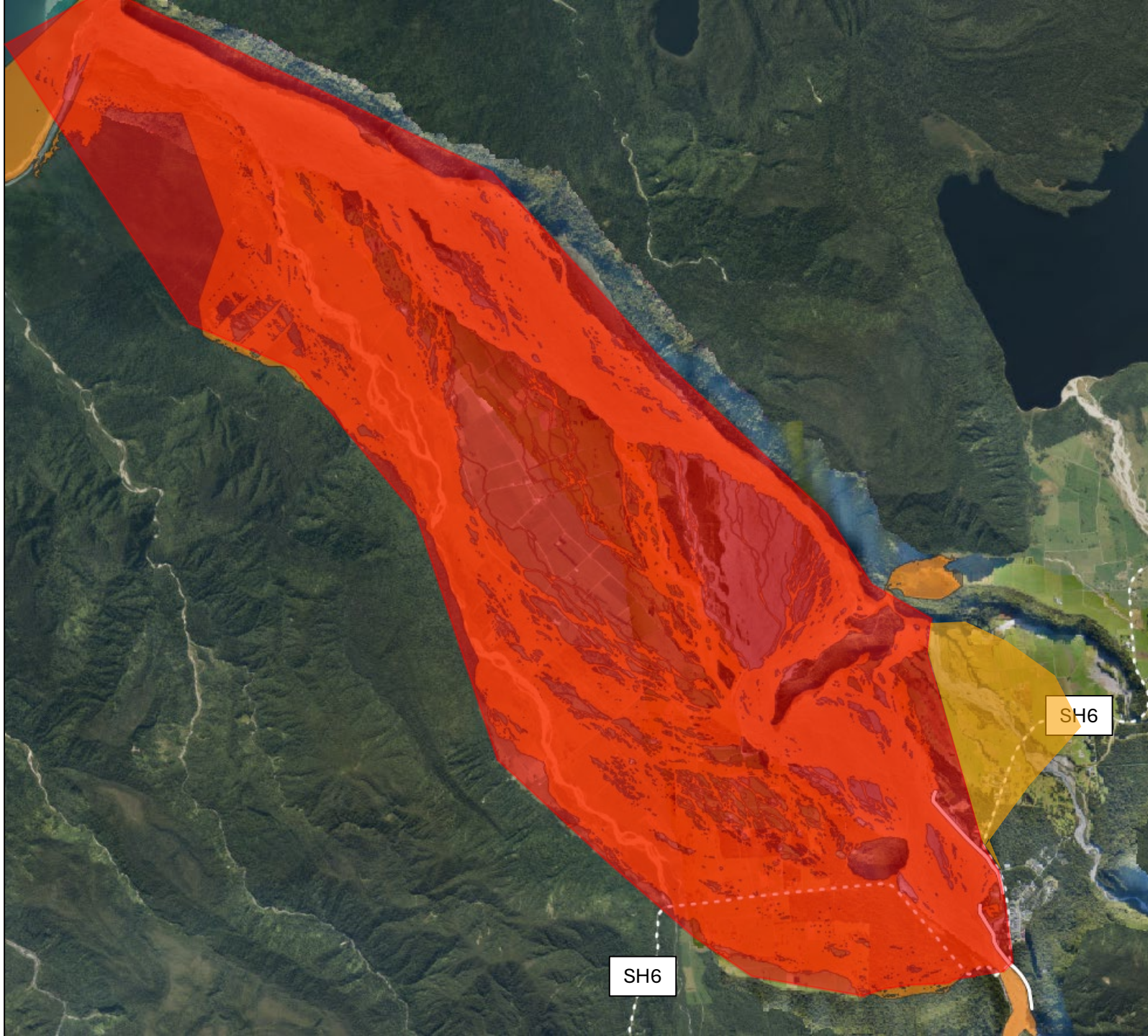
	Asset / Area	Status Quo/Residual *Risk*			Improved/Residual *Risk*				
		Likelihood	Consequences	*Risk*	Scenario	Rough Order Costs (rounded to $0.5 M)	*Likelihood*	Consequences	*Risk*
North	Tatare *avulsion*	Almost certain	Severe	Critical	Build	$15 M+	Possible	Severe	High
	Havill's *stopbank* (without *avulsion*)	Likely	Moderate	High	Upgrade	$5 M	Unlikely	Moderate	Medium
	55 kph Corner *stopbank*	Possible	Severe	High	Build	$3 M	Unlikely	Severe	Medium
	Heliport *stopbank*	Possible	Extreme	Critical	Upgrade	$0.5 M	Possible	Extreme	Critical
	Church *stopbank*	Possible	Extreme	Critical	Upgrade	$0.5 M	Possible	Extreme	Critical
	SH6 Bridge upstream	Rare	Extreme	High	Upgrade	$0.5 M	Rare	Extreme	High
	State Highway 6 Bridge	Possible	Extreme	Critical	Upgrade	$5 M	Rare	Extreme	High
South	Glacier Road	Unlikely	Extreme	High	Upgrade	$2 M	Rare	Extreme	High
	Waka Kotahi stopbanks (SH6 to Canavan's Knob)	Likely	Extreme	Critical	Upgrade	$3 M	Unlikely	Extreme	High
					Build	$3 M	Unlikely	Extreme	High
					Relax	$100 M+	Certain	Insignificant	Low
	Rubbish Dump *stopbank* (Canavan's Knob to Rata Knoll)	Almost certain	Severe	Critical	Upgrade	$5 - 15 M	Possible	Severe	High
					Relax	$50 – 70 M	Certain	Insignificant	Low
	Milton's *stopbank*	Almost certain	Severe	Critical	Upgrade	$2 M	Likely	Severe	Critical
					Build	$5 M+	Possible	Severe	High
					Relax	$30 – 50 M	Certain	Insignificant	Low
	Lower valley (downstream of Milton's)	Likely	Moderate	High	Upgrade	$2 - 5 M	Possible	Moderate	Medium

Release to the south

Land River Sea Consulting – model results

All true left (southern) stopbanks removed

- 2023 DEM
- True right stopbanks shown by white lines
- SH6 shown by white dashed line
- Tatare and Docherty flows not included



Release to the south

Land River Sea Consulting – model results

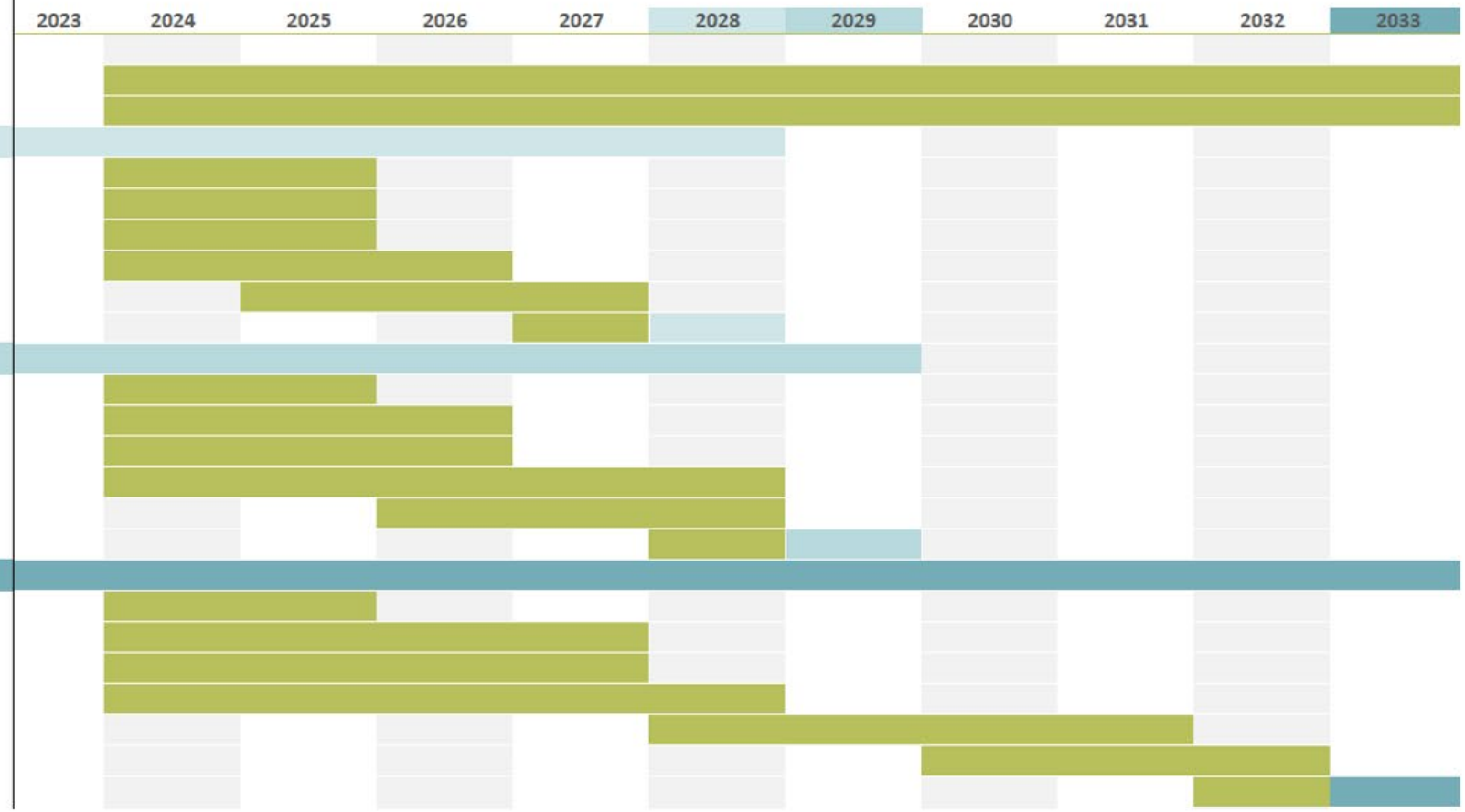
Upgrading and/or building stopbanks would have significant initial and on-going costs while not significantly reducing the *risk* of failure over a ten-year period.

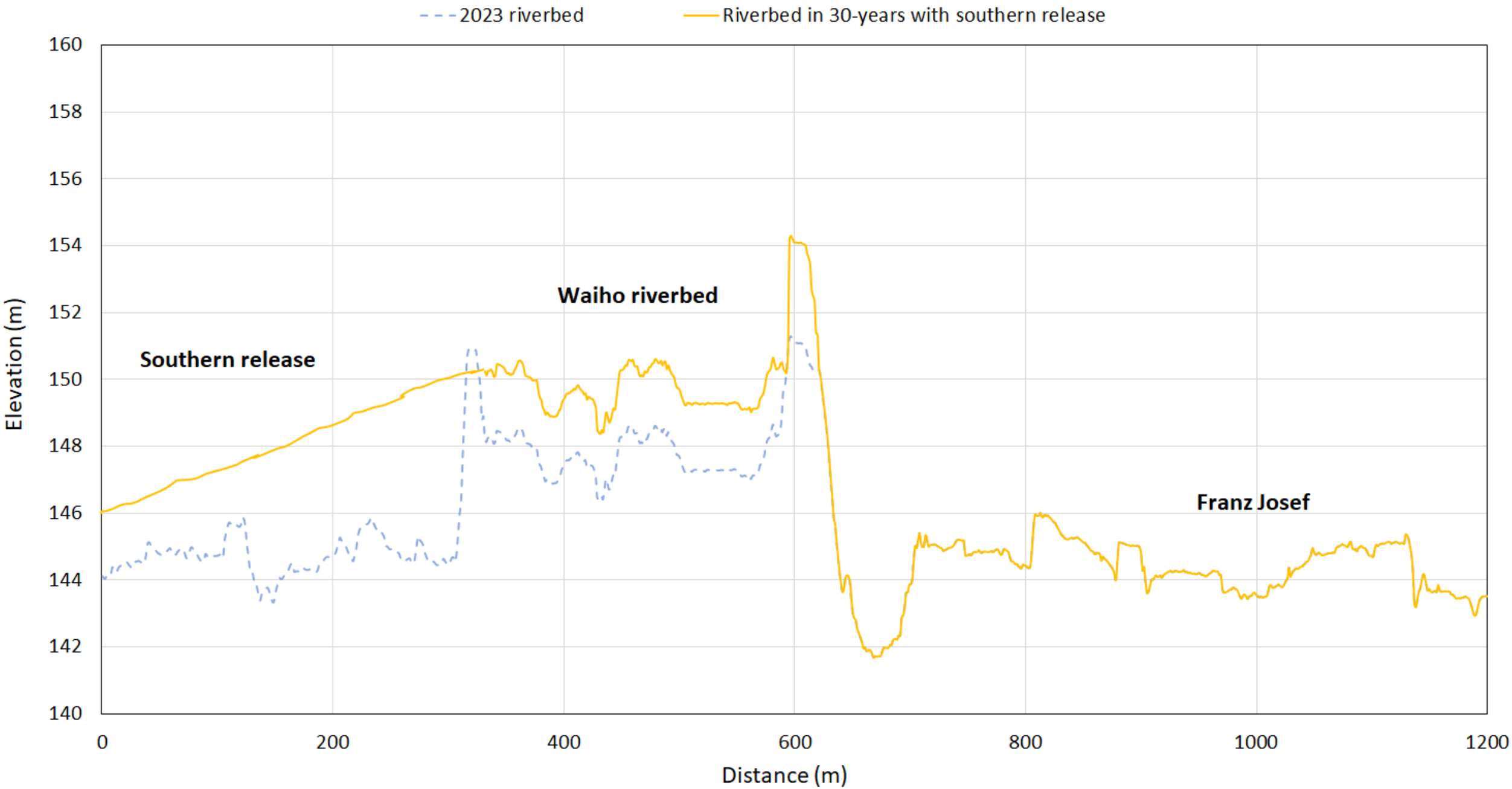
However, removing all of the stopbanks on the south side of the river will:

- Reduce the *risk* of *stopbank* failure.
- Reduce the number of assets exposed to the *flood hazard*.
- Provide the Waiho River with more surface area to deposit sediment (and hence decrease the rate of bed level rise).
- Increase the lifespan of the north stopbanks and reduce their *risk* of failure during *flood* events.
- Reduce the pressure on the overflow path on the north bank upstream of the SH6 Bridge.
- Reduce the pressure of the developing *avulsion* into the Tatare Stream.
- Reduce the impact of the *aggradation* and flooding that will follow an Alpine fault or other earthquake.

Waiho River 10-Year Plan

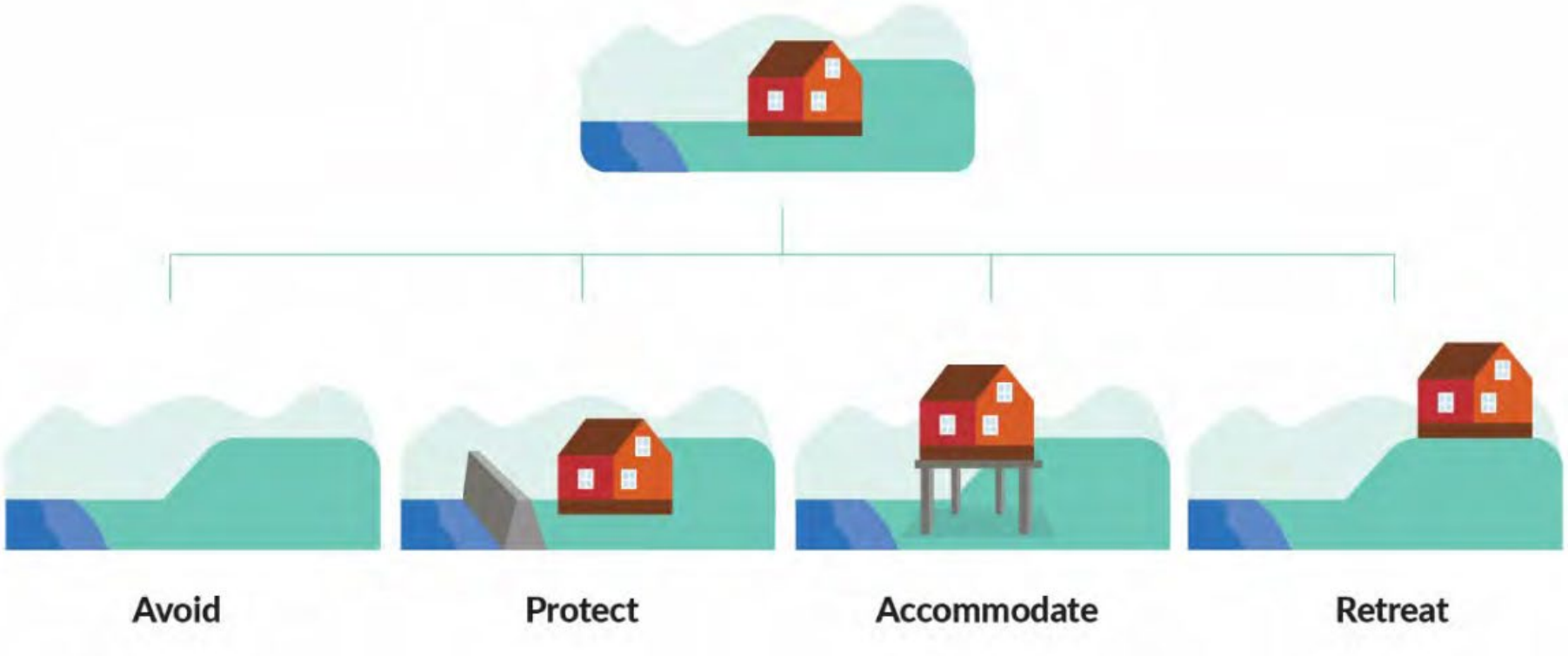
ACTIVITY	PLAN START (YEAR)	PLAN DURATION (YRS)
Project management		
Management, reporting and liaison	2024	10
Landfill / waste strategy and monitoring	2024	10
Milton's and Unlined Rubbish Dump stopbanks		
Investigations	2024	2
Design	2024	2
Consenting	2024	2
Landowner liason	2024	3
Floodplain infrastructure disestablishment	2025	3
Release management / benefit realisation	2027	2
Lined Rubbish Dump stopbank		
Investigations	2024	2
Design	2024	3
Consenting	2024	3
Landowner liaison	2024	5
Floodplain infrastructure disestablishment	2026	3
Release management / benefit realisation	2028	2
SH6 Bridge to Canavan's Knob double stopbanks		
Investigations	2024	2
Design	2024	4
Consenting	2024	4
Landowner liaison	2024	5
Road realignment implementation	2028	4
Floodplain infrastructure disestablishment	2030	3
Release management / benefit realisation	2032	2




2023 riverbed
Riverbed in 30-years with southern release
Elevation (m)
160
158
156
154
152
150
148
146
144
142
140
0
200
400
600
800
1000
1200
Distance (m)
Southern release
Waiho riverbed
Franz Josef

PARA FRAMEWORK

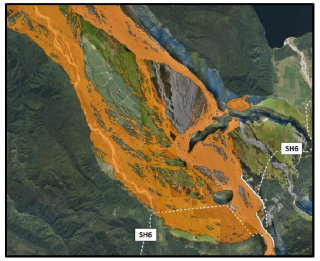
- Protect – Reduce the extent and/or frequency of the *hazard*.
- Avoid – Ensure new development and property and vulnerable assets are not exposed to the *hazard*.
- Retreat – Relocate existing people, property and assets from locations exposed to the *hazard*.
- Accommodate – Reduce the consequences of the *hazard*.



Five Critical Action Areas

1. Emergency Management

and contingency planning



2. Release to South

Commit to and initiate investigation and design

3. Interim Structural Measures

Current works and other key risk areas

“10-year holding work”

4. Risk Management Data & Equip.

Monitoring and modelling

5. Governance & Stakeholder Engagement

Structure and resourcing

WHAT TO DO
NEXT

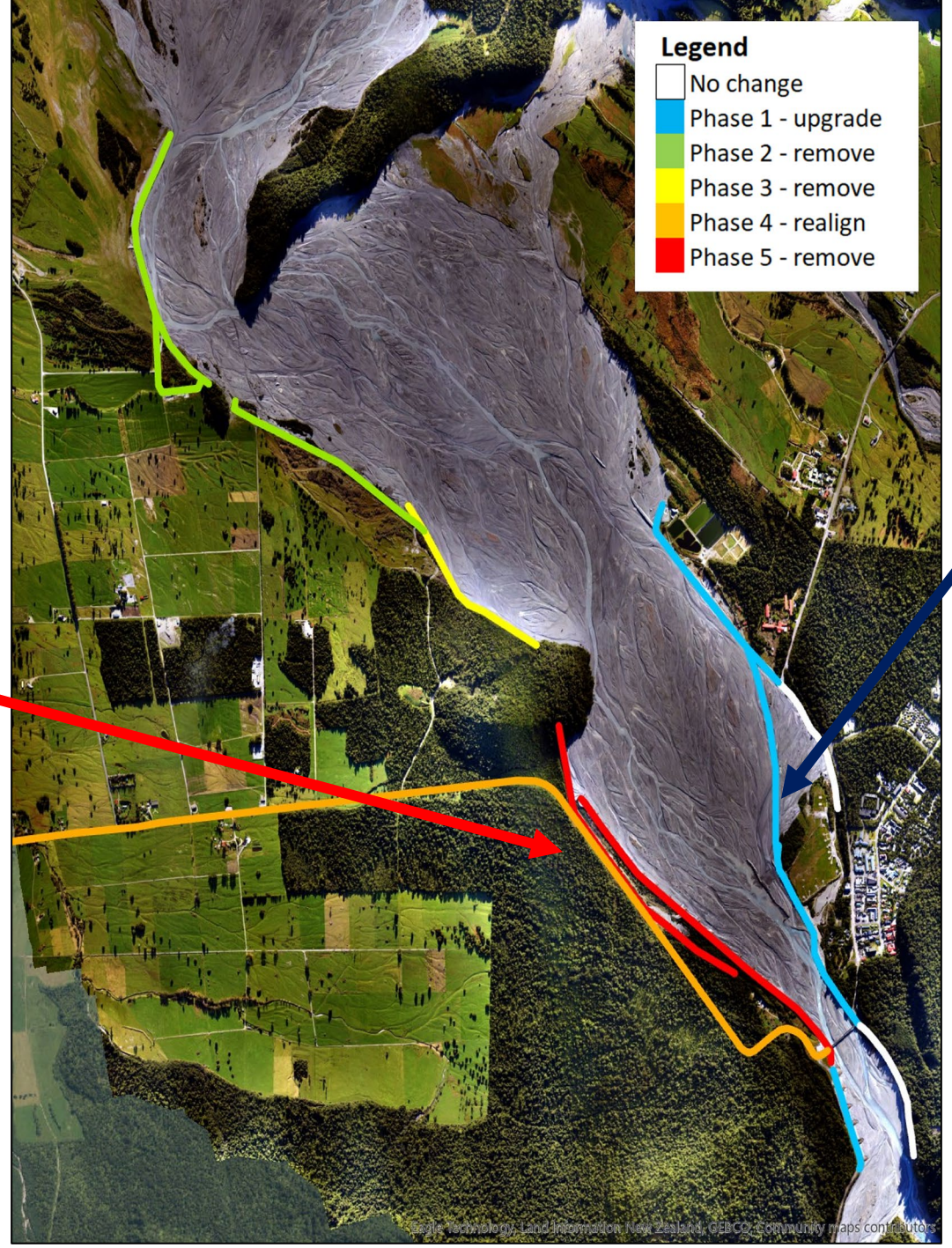
1. Emergency Management & Contingency Planning

- Most likely outcome is failure and damage
- Flooding will not be like it was previously
- Enhanced flood risk comms and planning needed
- Contingency plans are needed for key assets (WDC ponds, roads, stopbanks, etc)

2. Release to South

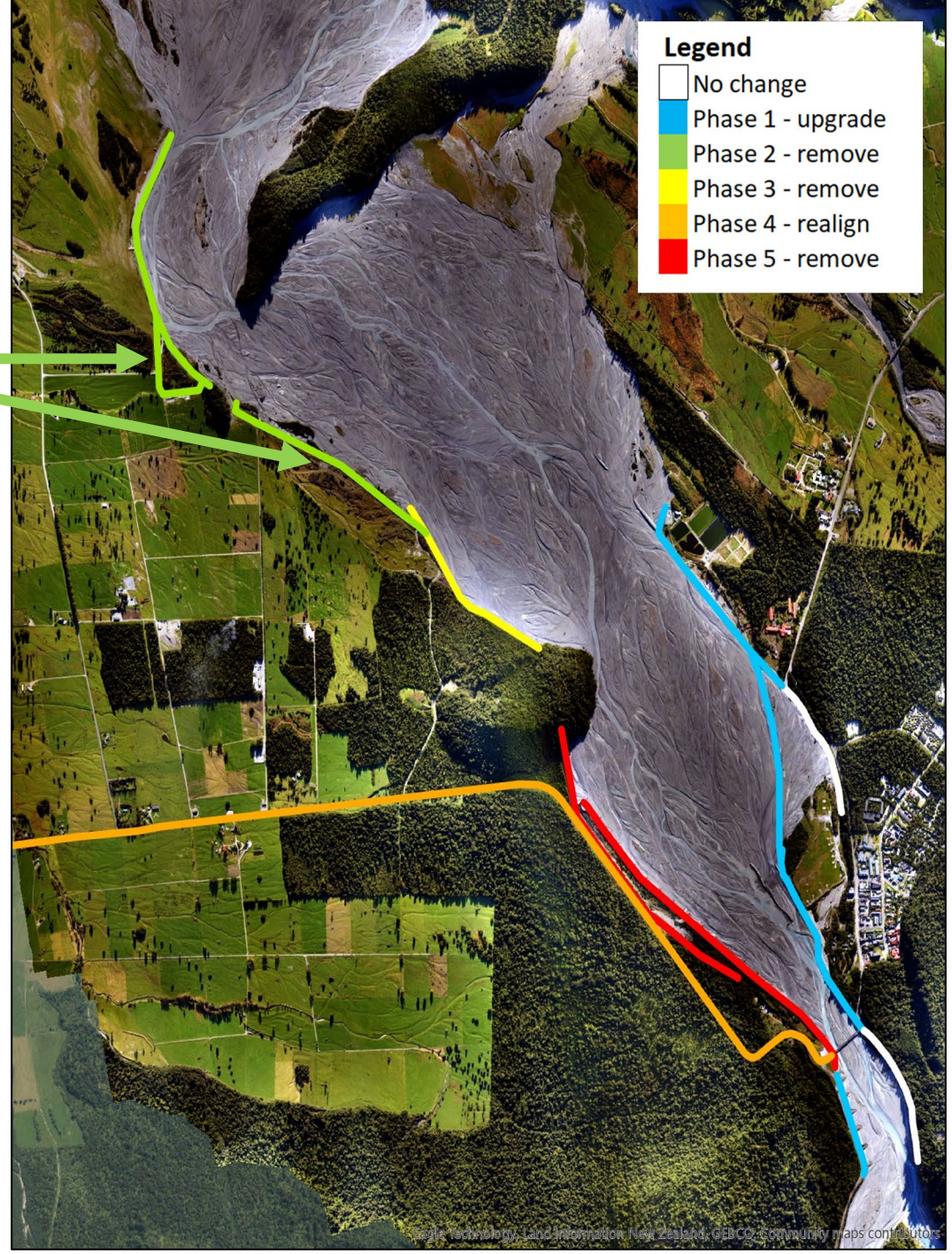
- Secure commitment and funding, and action release to the south and all that entails
- 10-year programme - start now (staged)
- 30 dwellings, landfills, chemical storage, fuel, wastewater, dairy effluent, power, telecom, structures, roads, …
- A lot of consultation
- Develop a staging plan

Undertake holding works along the southern stopbanks and Glacier Road to provide protection for the southern *floodplain* while preparatory works for the release are undertaken.



Upgrade stopbanks on the north side

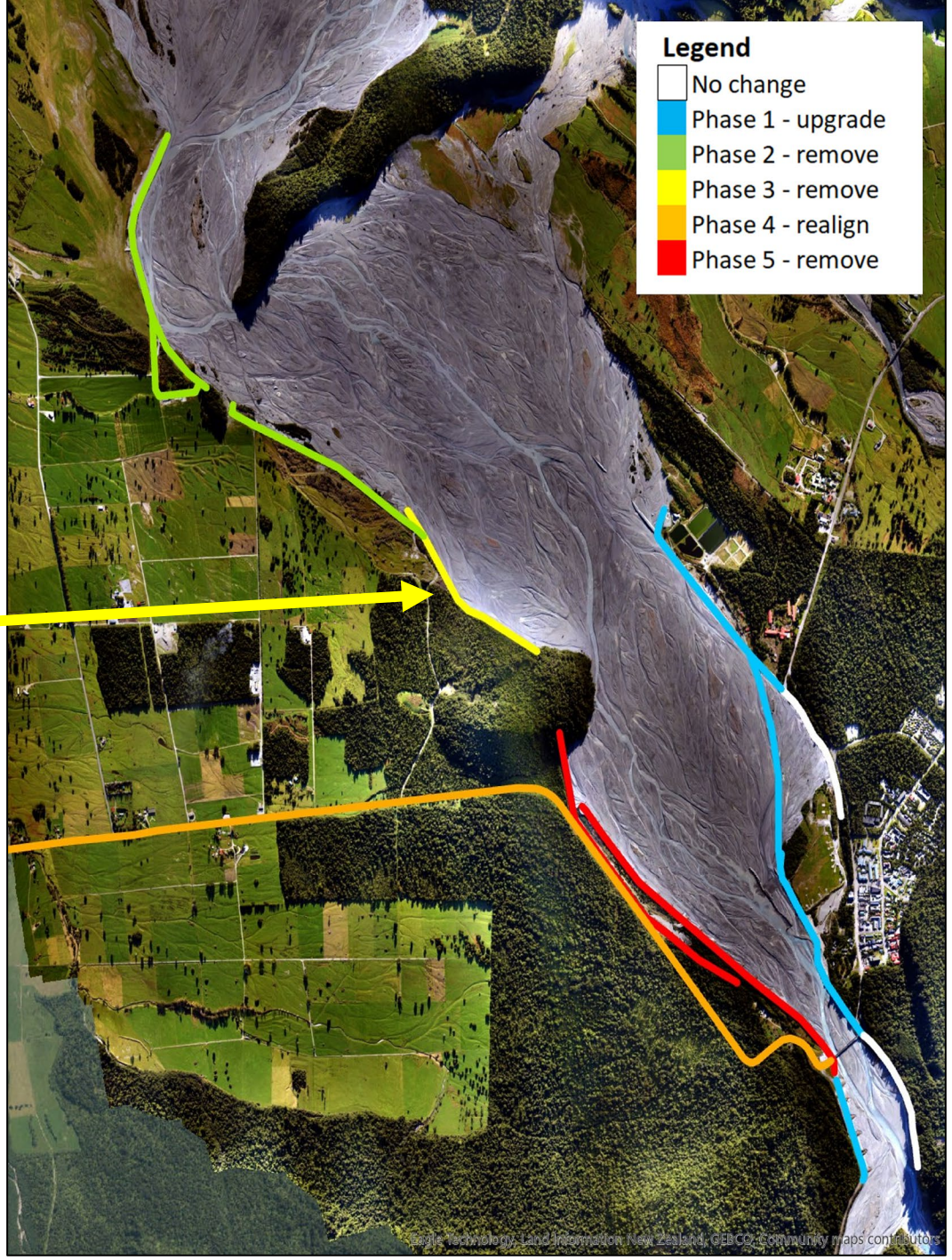
Phase 2: remove Milton's *stopbank* and the unlined Rubbish Dump *stopbank* on the south side.



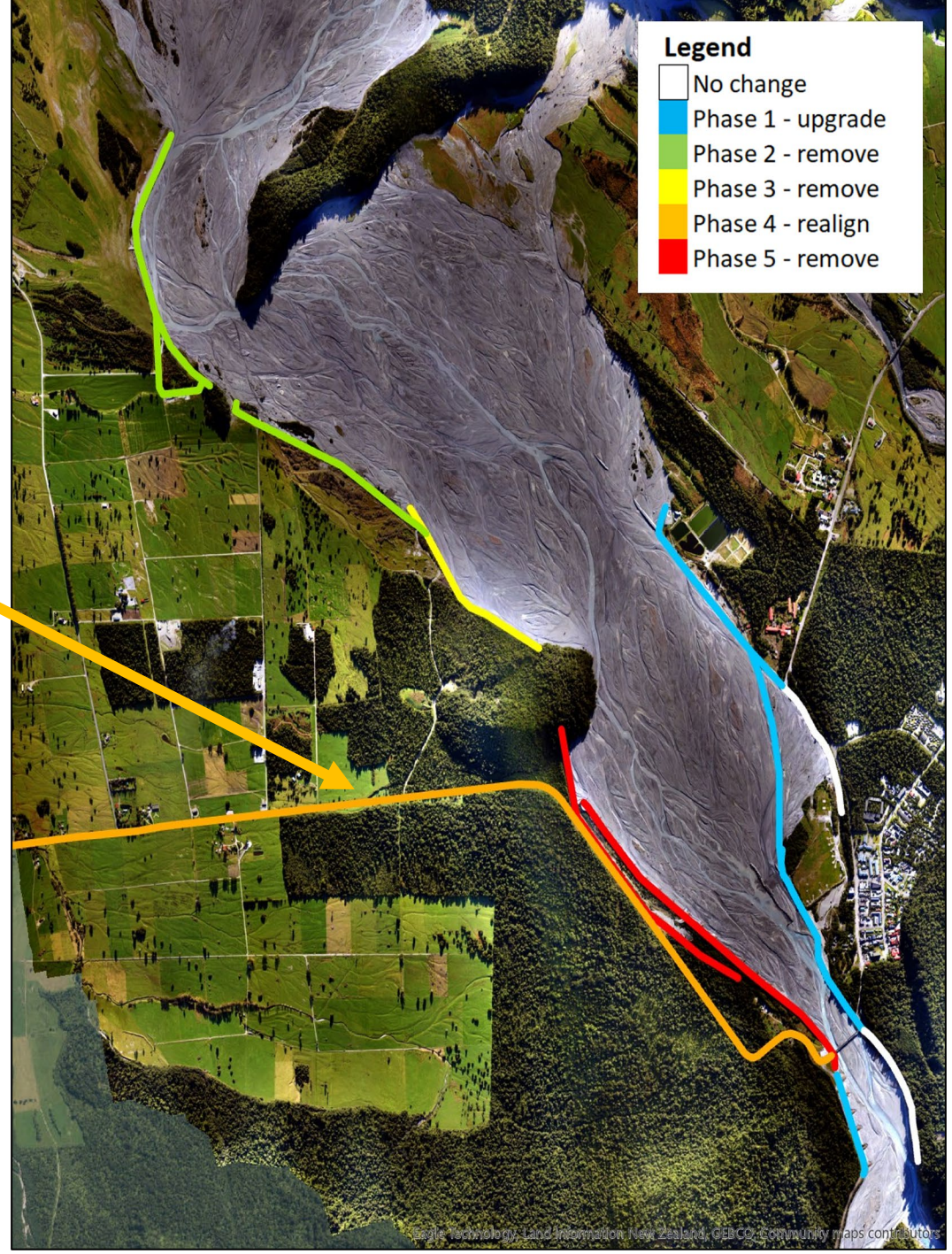
Only true left (southern) stopbanks downstream of Canavan's Knob removed

- 2023 DEM
- True right and upstream of Canavan's Knob true left stopbanks shown by white lines
- SH6 shown by white dashed line
- Tatare and Docherty flows not included

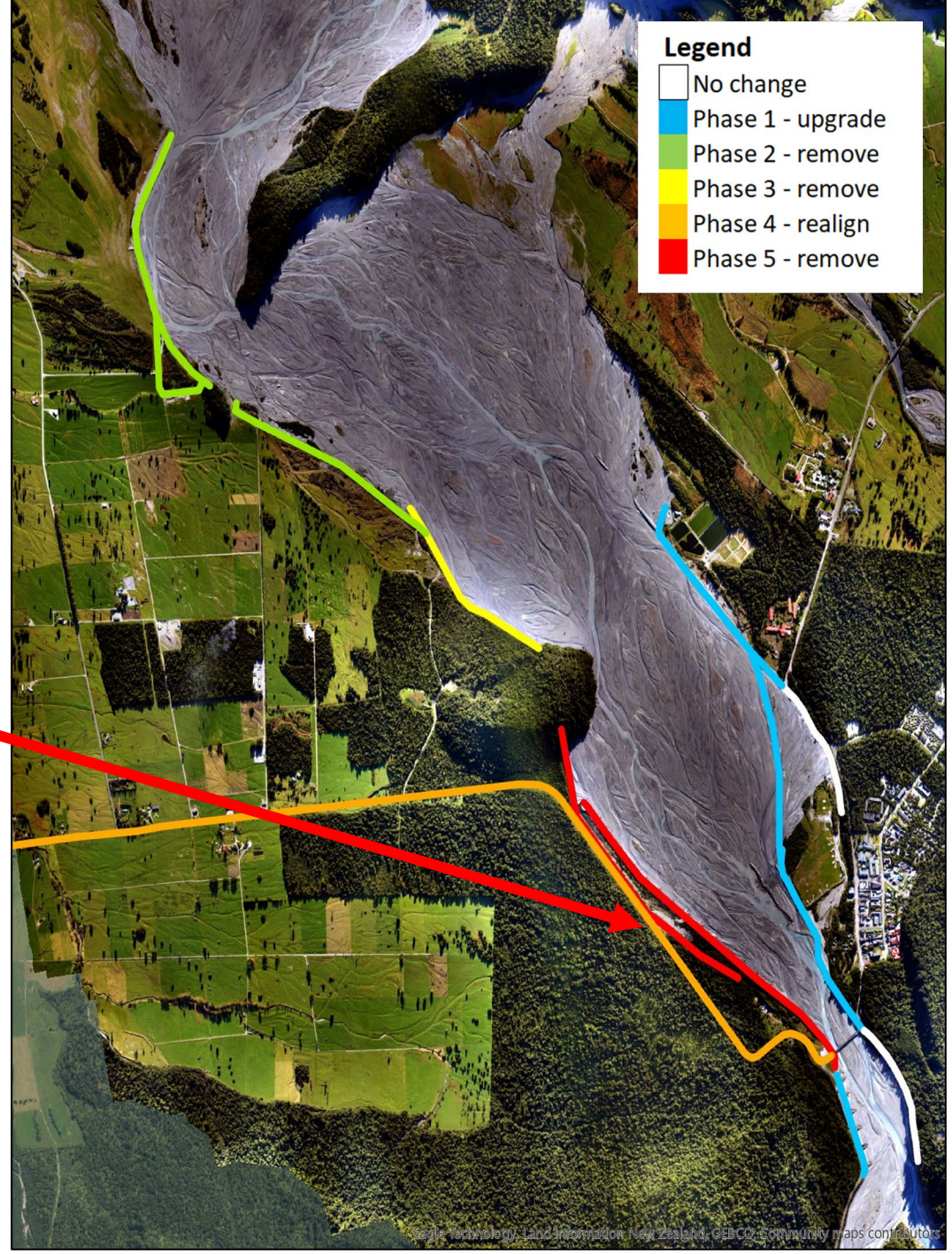
Phase 3: remove lined Rubbish Dump *stopbank* on the south side.



Phase 4: `Realignment and construction of SH6 to the south of the Waiho River.



Phase 5: remove the remaining southern stopbanks between the SH6 bridge and Canavan's Knob.



3. Interim Structural Measures

- Need to try to hold the line while release to south is progressed
- Work programme still being assessed – risk priority – includes:
    - Existing contract works
    - Milton's Bank
- Further assess avulsion to Tatare Stream

4. Risk Management Data and Equipment

- Update 2016 monitoring strategy
  - Flood warning, imagery, survey
- Hydraulic and geomorphic modelling of risks and options

5. Governance & Stakeholder Engagement

- Develop Business Plan
- Consultation / Engagement

Full acknowledgements to the Waiho Technical Advisory Group convened by West Coast Regional Council in 2023 and reports listed below

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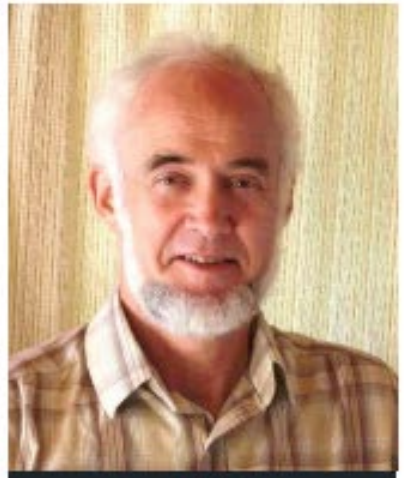
Principal Engineer - Rivers WSP
ME(Nat Res), CMEngNZ, CPEng



Gary Williams

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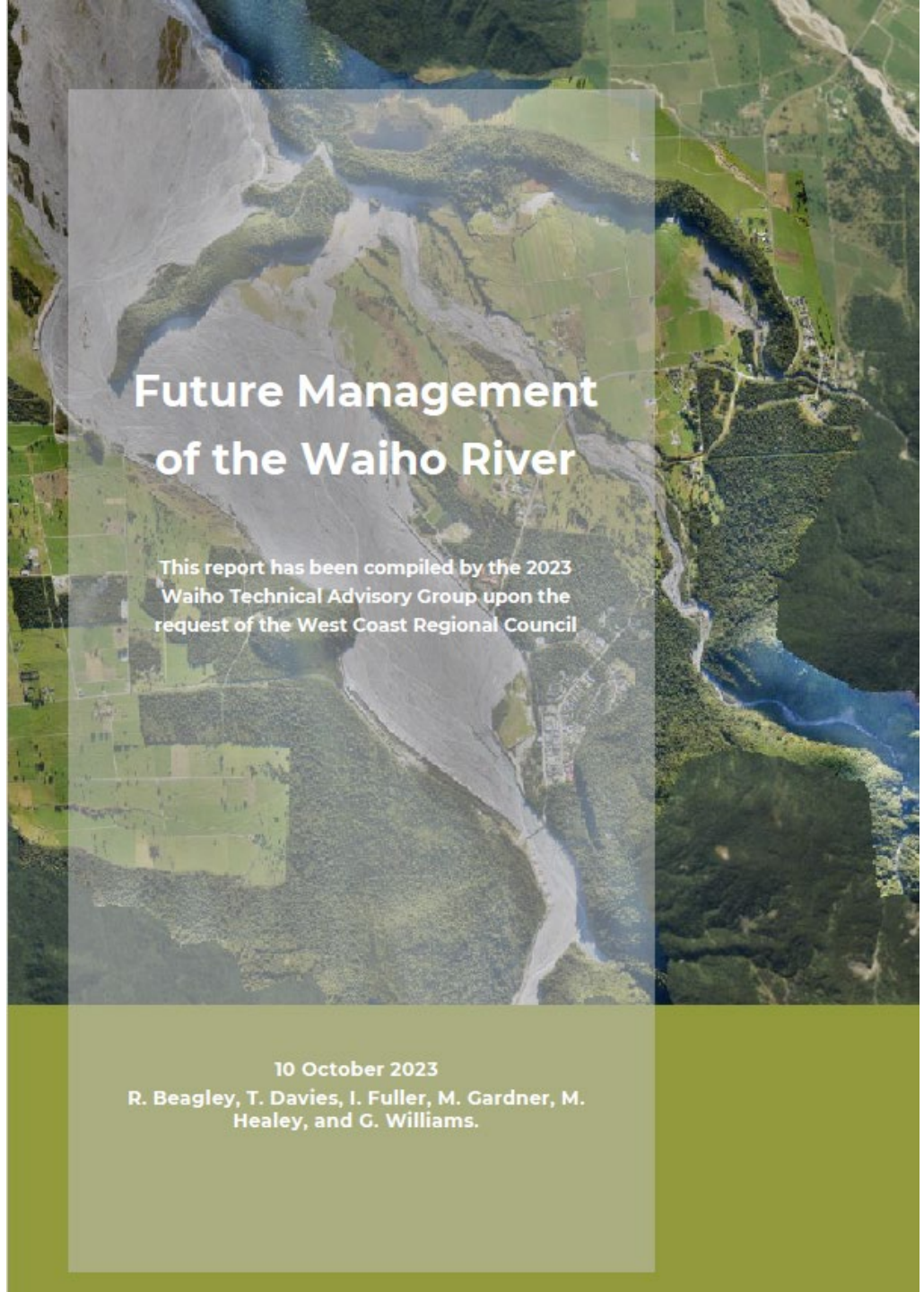
BE (Hons), BSc (Physics), MCom (Hons), FEngNZ

THE WEST COAST REGIONAL COUNCIL

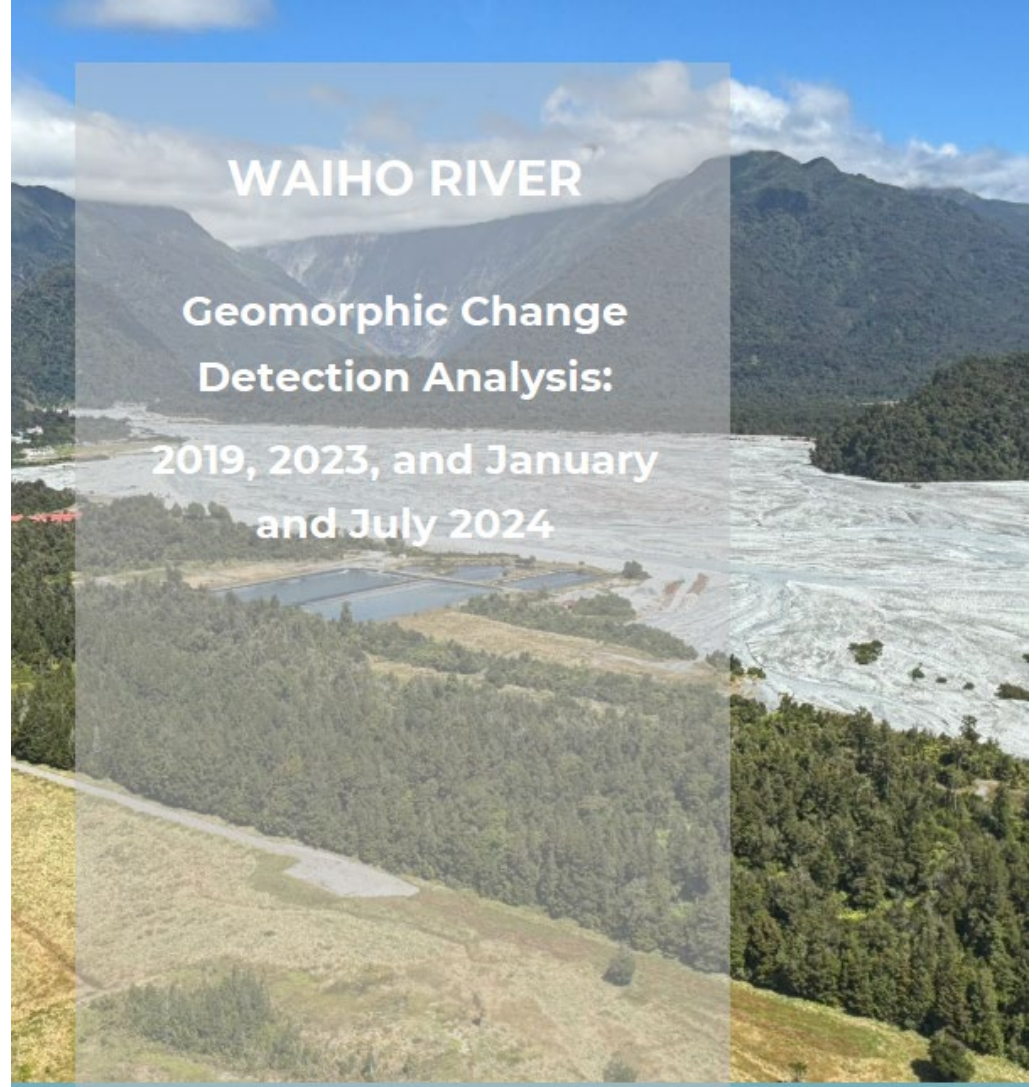


Future Management of the Waiho River

This report has been compiled by the 2023 Waiho Technical Advisory Group upon the request of the West Coast Regional Council

10 October 2023

R. Beagley, T. Davies, I. Fuller, M. Gardner, M. Healey, and G. Williams.



WAIHO RIVER

Geomorphic Change Detection Analysis: 2019, 2023, and January and July 2024

13 September 2024

Client: West Coast Regional Council
Report by: Rose Beagley
Land River Sea Consulting Limited
www.landriversea.com

Land River Sea CONSULTING

WEST COAST REGIONAL COUNCIL