



# Moutoa Gates – Model build report to support 2025 Operational upgrades (Task 6, FVA)

February 2026

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# MOUTOA GATES – MODEL BUILD REPORT TO SUPPORT 2025 OPERATIONAL UPGRADES

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FINAL



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## MOUTOA GATES MODEL BUILD REPORT

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# EXECUTIVE SUMMARY

WSP was engaged by Horizons Regional Council (HRC) to refine and simulate a detailed hydraulic model to assist with maintenance and upgrades for the Moutoa sluice gates.

The aim of this report was to describe the proposed impacts to flood risk as a result of operational sensitivity testing of the Moutoa sluice gates during a large event. The following conclusions were made by comparing to the Baseline 9 gates fully operational scenario:

- Moutoa Gate Scenarios which had the smallest maximum gate opening (for example Scenario G – 6 gates open and 3 gates closed) showed the greatest increase in flood extents on Floodplain South (approximately 22 km<sup>2</sup> in Scenario G compared to baseline 11 km<sup>2</sup>) and Floodplain East (approximately 16 km<sup>2</sup> in Scenario G compared to baseline 5 km<sup>2</sup>). In these scenarios, there was slightly reduced flooding on the Manawatū left-bank near Foxton. The scenarios of smallest maximum gate opening also resulted in greatest increase in floodplain depths, from a Baseline maximum of approximately 1.4 m on the Southern Floodplain to greater than 2 m in Scenario G.
- Moutoa Gate Scenarios which had the greatest maximum gate openings (for example Scenario F) showed the smallest increase in flood extents on Floodplain South (approximately 14 km<sup>2</sup> in Scenario F compared to baseline 11 km<sup>2</sup>) and Floodplain East (approximately 6 km<sup>2</sup> in Scenario G compared to baseline 5 km<sup>2</sup>). The scenarios of greatest maximum gate opening also resulted in the smallest increase floodplain depths, from a Baseline maximum of approximately 1.4 m on the Southern Floodplain to approximately 1.55m in Scenario F.
- The Manawatū stopbanks overtopped in 13 identified locations downstream of (and including) the Moutoa Gates, eight on the right bank and five on the left bank. Overtopping bank lengths varied from approximately 3.5 km (right-bank downstream of Moutoa) to smaller 150 m reaches with minor breaches. Maximum overtopping depths at each location varied from approximately 10 cm to 40 cm.
- Overall, the results indicated that the greater the restriction on overall gate capacity, the lower the volume of flow that enters the Moutoa Floodway. This results in more overtopping from the Manawatū River with greater flood extents and depths in Floodplain South and Floodplain East.

# REFERENCES

- Ball J, B. M. (2019). *Australian Rainfall Runoff - A Guide to Flood Estimation*. Commonwealth of Australia (Geoscience Australia).
- Doull, G. (2015). *Lower Manawatu Scheme Comprehensive Design Report*. Horizons Regional Council.
- Horizons Regional Council. (n.d.). *Moutoa Sluice Gates and Floodway - Helping keep our Region safe*. Retrieved from <https://www.horizons.govt.nz/HRC/media/Media/Flood%20protection/Moutoafloodgates.pdf?ext=.pdf>
- LINZ. (2025, February 15). *LINZ Data Service*. Retrieved from LINZ Data Service: <https://data.linz.govt.nz>

# 1 BACKGROUND

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## 1.1 INTRODUCTION

WSP was engaged by Horizons Regional Council (HRC) to refine and simulate a detailed hydraulic model to assist with maintenance and upgrades for the Moutoa Gates. HRC are required to undertake physical maintenance of the floodgates, thereby seeking to understand the flooding impact of having multiple gates closed at any one time during large flow events. This refined 'Moutoa Gates Model' fits within a wider Lower Manawatū Model development programme, within which the wider goal is to develop and calibrate a regional-scale hydraulic model for the Lower Manawatū catchment.

In the immediate term, the outputs of this work will identify locations of additional inundation during closed-gate maintenance periods. In future, the development of this work (and hydraulic model) will assist with operational management planning and procedures for HRC.

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## 1.2 PURPOSE AND DRIVERS

The purpose for an updated, detailed representation of the Moutoa Gates was driven by the following factors:

- HRC requirement to address uncertainties associated with the modelling of radial gates in the original DHI MIKE11 model, which is summarised in the 2015 Lower Manawatū Scheme Comprehensive Design Report ('LMS Report'). Significant underestimation of modelled gate flow, particularly at higher flows such as those experienced in February 2004, reduced HRC's confidence in understanding the gate hydraulics and associated system response. This was in part addressed by modelling only 3 gates whilst mimicking 3x the capacity to improve stability, as well artificially increasing gate dimensions to achieve expected gate flow.
- Over the years, new and updated information has become available including LiDAR, survey and recent high-flow events (such as February 2023). An updated model would benefit from the inclusion of this data.
- Recent advancements in computational efficiencies of hydraulic modelling engines have highlighted the superior benefits of 1D-2D schematisations for large catchments like the Lower Manawatū, compared to the 1D-only models developed in the past.
- As a key operational asset in the catchment, developing the Moutoa Gates area in detail directly enhances the development of the wider regional-scale Lower Manawatū model.

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## 1.3 AIM AND SCOPE

The overall aim of this report is to:

*understand the nearby flood risk as a result of gate operation sensitivity testing of the Moutoa Gates during a large flow event, to reflect the potential impacts associated with reduced gate capacity during Moutoa upgrade works*

The following scope was developed to achieve this aim:

- Generate a refined model extent from the Manawatū River at Teachers College and the Ōroua River at Kopane Bridge down to the Manawatū River mouth at Foxton Beach.
- Incorporate a detailed representation Moutoa Sluiceways, informed by Drawing 2809 (HRC) and HRC survey data.
- Extract inflow data for three events: two medium-sized, closed-gate events for the purposes of validation (June 2021 and February 2022) and one large gates-open scenario for operational gate testing (February 2004).
- Validate the model to two key system dynamics, firstly travel time from Teacher's College to Moutoa Gates and secondly water levels at Moutoa Gates.
- Simulate the February 2004 event as an example of a high-flow scenario, without the requirement to validate or calibrate to the February 2004 event. Simulate 8 variations of gate operation scenarios for the February 2004 inflows.
- Evaluate the impact of the gate operation scenarios on flood risk compared to the baseline scenario (9 gates fully operational), specifically flood depths to approximate hazard and the change in flood extent

## 2 MOUTOA SLUICE GATES

The following sections provide a brief introduction of the Moutoa Sluice Gates and Floodway. This is intended to give sufficient technical background to the modelling undertaken as part of this work – the specified references should be consulted for a more detailed overview.

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### 2.1 MOUTOA GATES

The 2015 LMS Report provides a detailed breakdown of the Moutoa Sluice Gates and their importance in the operation of the Lower Manawatū Scheme. Fundamentally the gates are used as a means of flood protection and sediment management by diverting up to 60% of design flows down a ‘shortcut’ known as the Moutoa Floodway.

A summary of the gates is given below:

- 9 no. gates 15.24 m wide and 4.54 m high. The gate inverts are 3.8 m NZVD2016 (4.2 m WLG53) and the top of the closed gate is 8.34 m NZVD2016 (8.74 m WLG53).
- The gates are operated individually on a manual basis, with standard operating procedure increasing the gates by 150 mm increments where water levels at Moutoa Sluice Gates dictate.
- The maximum design water level at Moutoa Gates is 8.25 m WLG53 (7.85 m NZVD2016), below which water levels are intended to be maintained by opening the gates.

Figure 2-1 shows Moutoa Gates during higher flows, at which point the gates are closed until water levels reach the maximum design level (white marker) of 7.85 m NZVD2016.

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### 2.2 MOUTOA FLOODWAY

Once the gates are open, water is diverted down the Moutoa Floodway. This is a 10 km diversion which re-joins the Manawatū upstream of Foxton. Figure 2-2 shows how the Moutoa Floodway diverts flow from the Moutoa Sluice Gates to re-join location downstream on the Manawatū.

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### 2.3 SLUICEGATE OPERATIONS

The 2015 LMS Report gives a detailed breakdown of the history of Moutoa Gate operations, and the planning and forecasting that goes in to optimising the balance between flood risk, scour and sedimentation.



Figure 2-1 Moutoa Sluice Gates during high flows. The white dash against Gate 1 indicates the maximum design water level of 8.25 m MSL (7.85 m NZVD16). Source 'Moutoa Sluice Gate & Floodway – Helping keep our Region safe'

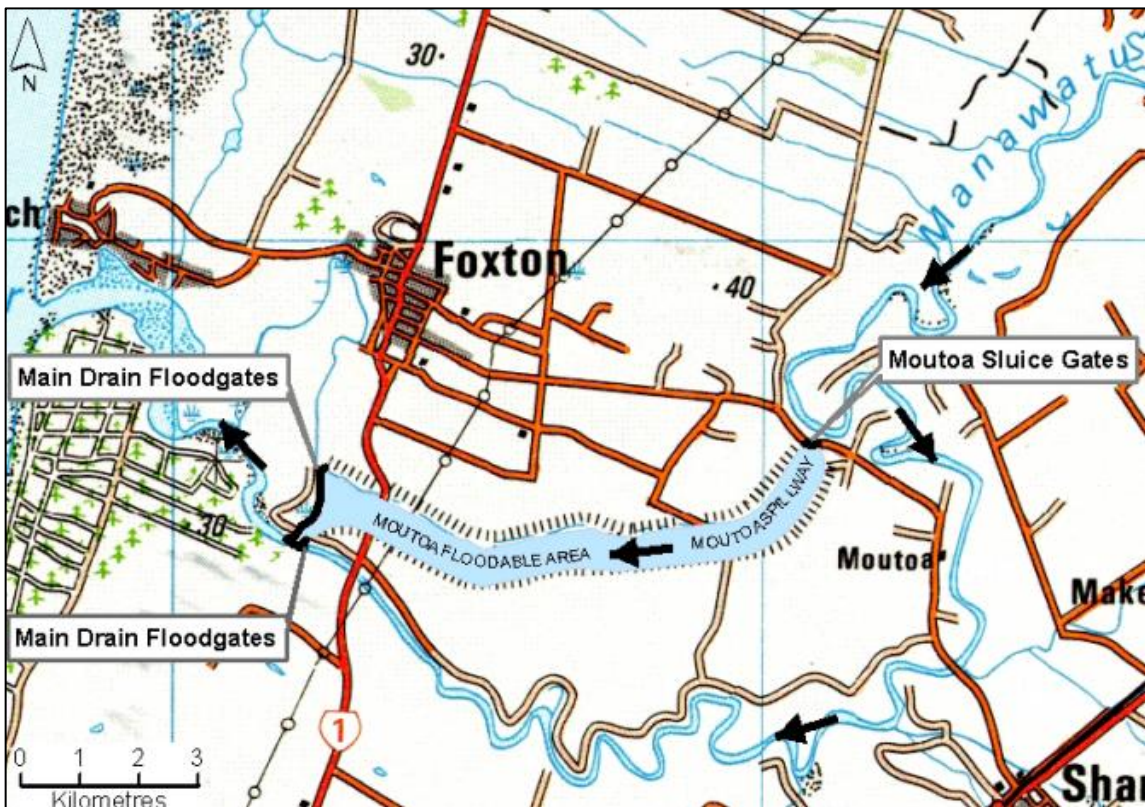


Figure 2-2 Moutoa Floodway downstream of the Sluice Gates. Source 'Moutoa Sluice Gate & Floodway – Helping keep our Region safe'

# 3 MODEL BUILD METHODOLOGY

The following sub-sections summarise the methodology used to develop the Moutoa Gates Model, which was developed primarily to understand the flood risk impact of gate operation sensitivities.

## 3.1 MODEL EXTENT AND OVERVIEW

The upstream model extent was chosen to reflect upstream boundary locations which are sufficiently distanced away from the Moutoa Gates such that any backwater effects of gate operation sensitivities would be nullified. The Manawatū was extended to Teacher's College gauge and the Ōroua River was extended to Kopane Bridge, both of which represent the upstream watercourse limits of the model. The downstream extent of the model is the tidal boundary at Foxton Beach, where the Manawatū River outfalls to the sea.

In total the modelled extent was 364 km<sup>2</sup>, with approximately 80 km of the Manawatū River and 25 km of the Ōroua River.

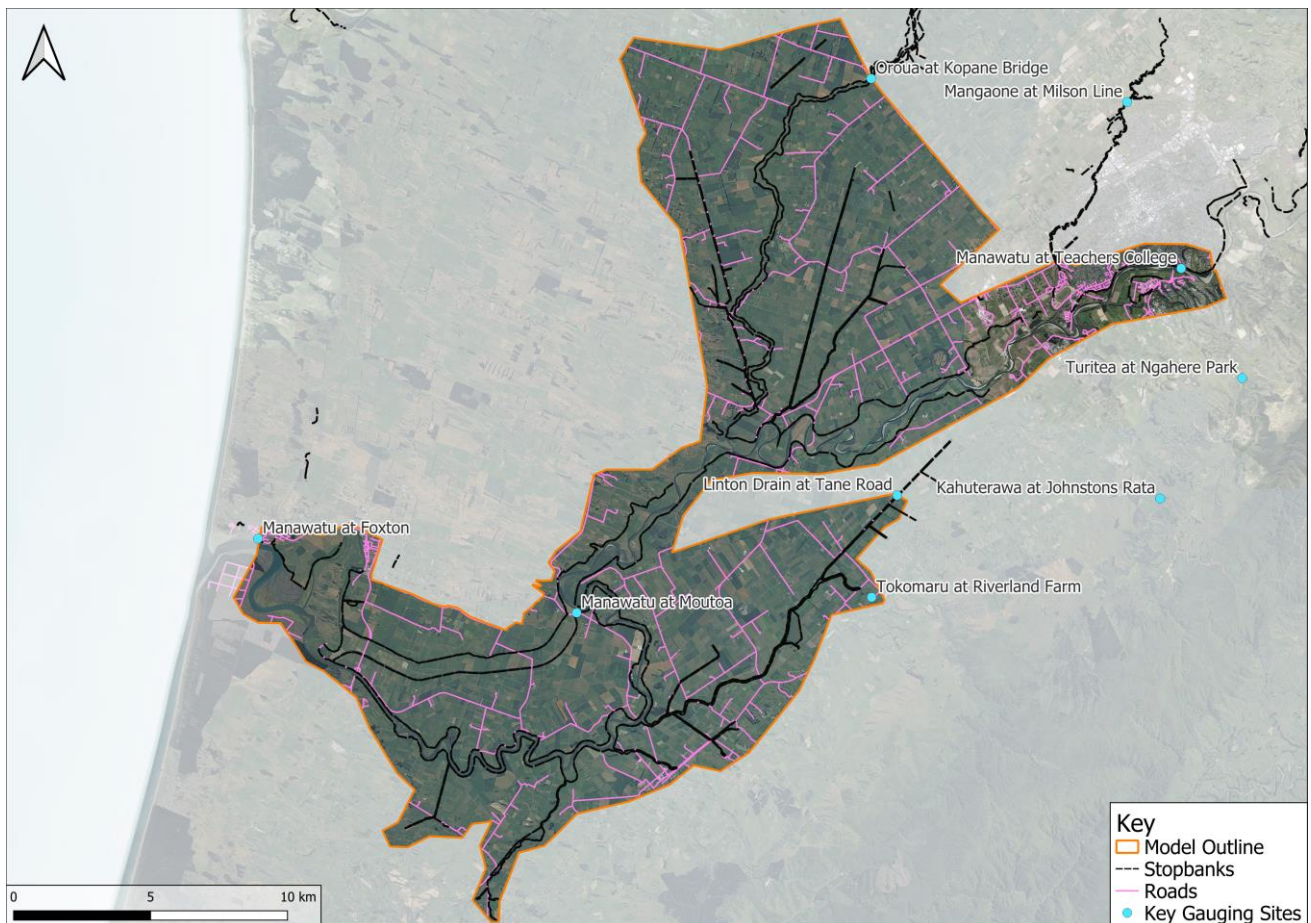


Figure 3-1 Model Extent and Key Features

Figure 3-1 shows the key topographic features, labelled with key flow gauges used in the hydrological inputs (see Section 3.3 Model Inflows and Initial Conditions for information of modelled inflows). The key hydraulic controls and topographic features within the vicinity of the Moutoa Gates include:

- Roads – these often act as de facto spillways and stopbanks that form barriers to flow
- Stopbanks – these act to contain flood waters within the river channel
- Moutoa Gates – these act to divert water down the Moutoa Floodway during large events

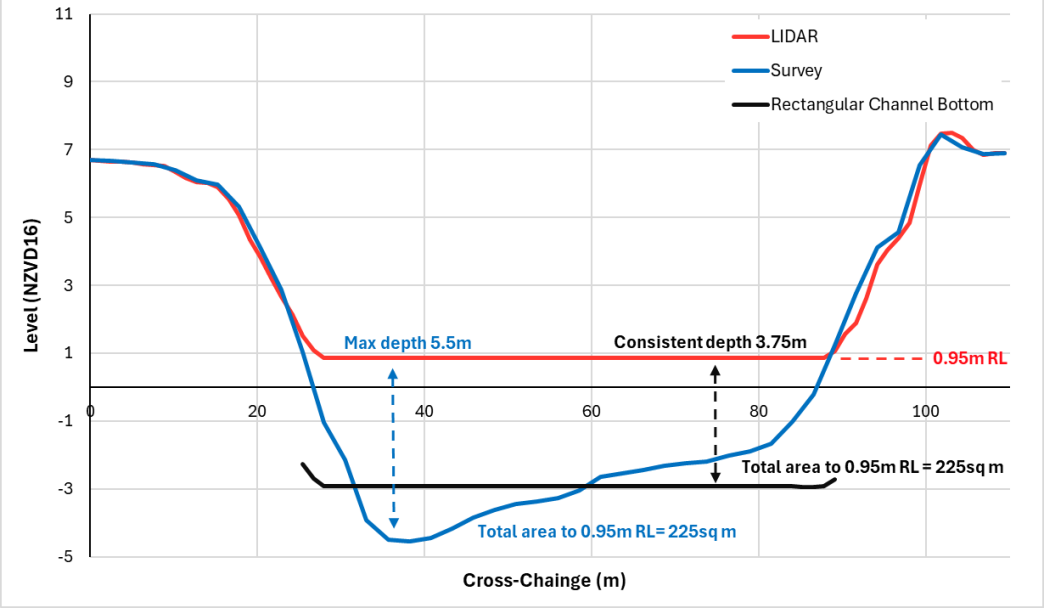
## 3.2 MODEL INPUTS

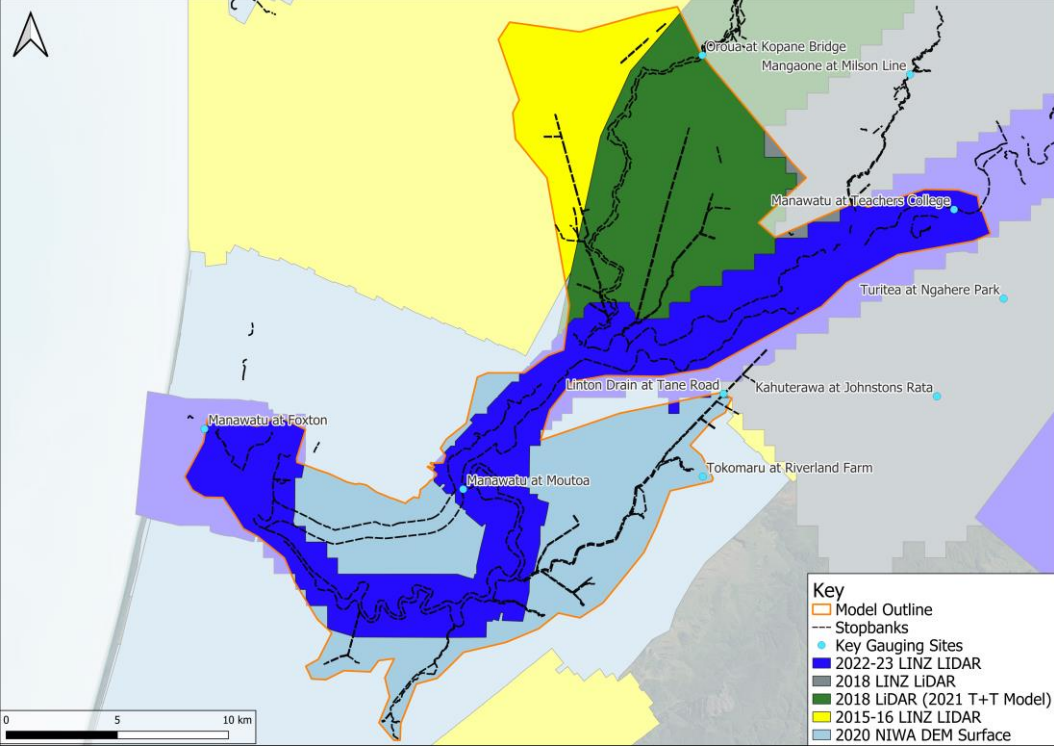
Table 3-1 details the model component and modelling approach used.

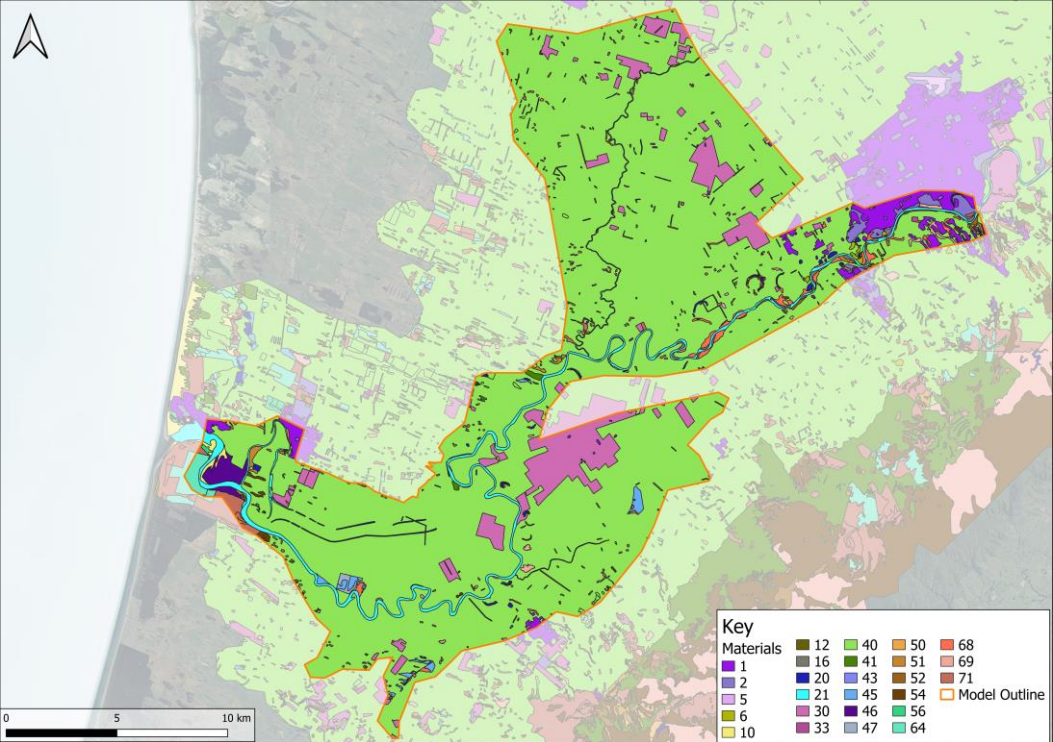
Table 3-1. TUFLOW model overview

COMPONENT	DETAILS
Datums	<ul style="list-style-type: none"> <li>• <b>Vertical Datum</b> – The model was built in New Zealand Vertical Datum 2016 (NZVD2016). All values used throughout the report are NZVD16 unless stated otherwise.</li> <li>• <b>Horizontal Datum</b> – New Zealand Transverse Mercator 2000 (NZTM2000).</li> </ul>
Channel Terrain	<ul style="list-style-type: none"> <li>• Within the channel the wetted channel perimeter is poorly defined by LiDAR by representing the water surface rather than channel terrain. To overcome this, the 2023 watercourse survey cross-sections were made available for the Manawatū River from Foxton up to the Pohangina River confluence. Given the timeframes to deliver the study, survey sections between markers ‘Mile 22’ and ‘Mile 28’ of the Lower Manawatū (Moutoa Gates is at ‘Mile 25’) were prioritised and used to create an interpolated channel surface within the wetted channel perimeter. Figure 3-2 below shows the final surface as a result of including the interpolated cross-sections with the LiDAR.</li> <li>• Outside of these mile ranges (i.e. from ‘Mile 22’ to ‘Mile 0’ and from ‘Mile 50’ to ‘Mile 28’), the LiDAR surface between the wetted channel banks was lowered using the ‘rectangular equivalent depth method’. This involves calculating the surface area of the channel below the water surface level at each cross-section, and back-calculating the equivalent depth for that same area by assuming a rectangular channel shape rather than a typical ‘V’ shape. As an example, a 60 m wide wetted cross-section has a 225 m<sup>2</sup> area below the water surface with a maximum depth of 5.5 m at the thalweg and a depth tending towards 0 m at the water surface. The rectangular-equivalent section with a width of 60 m has a consistent depth of 3.75 m, meaning the total area below the water surface (LiDAR) is identical (225 m<sup>2</sup>). Figure 3-3 below shows how this concept works.</li> </ul>

COMPONENT	DETAILS
	<ul style="list-style-type: none"> <li>An average depth was calculated along two distinct reaches of similar rectangular depth, the 'lower' Manawatū River from Moutoa Gates to Foxton (3.78 m), and 'upper' Manawatū River from Teacher's College to Moutoa (1.50 m). To approximate the channel capacity below the LiDAR level, the LiDAR surface was dropped by these average depths within these two reaches.</li> <li>For this model, which is interested in flood flows (as opposed to low flows), this approximation is appropriate on the basis of the channel capacity filling up in a very similar mechanism with both section types. Sensitivity tests were conducted by removing the interpolated channel surface from Mile 22-28, instead using only the rectangular-depth surface for the entire channel. The June 2021 showed that that maximum water level differed by up to 2 cm at the Moutoa Channel gauge, demonstrating minimal sensitivity at high-flows.</li> <li>In future iterations of this model, including the Lower Manawatū catchment-scale model, the full interpolated channel surface should be implemented such that the model would be more suitable for all flow conditions, or channel bathymetry could be collected and implemented.</li> <li>Channel survey was not available for any watercourse other than the Manawatū River at this stage of model development.</li> </ul> <div data-bbox="384 1104 1410 1702" data-label="Figure"> </div> <p data-bbox="384 1727 1430 1794">Figure 3-2 Cross-section of the model surface using the interpolated channel compared to the LiDAR surface, at the location of the Moutoa Gates channel gauge)</p>

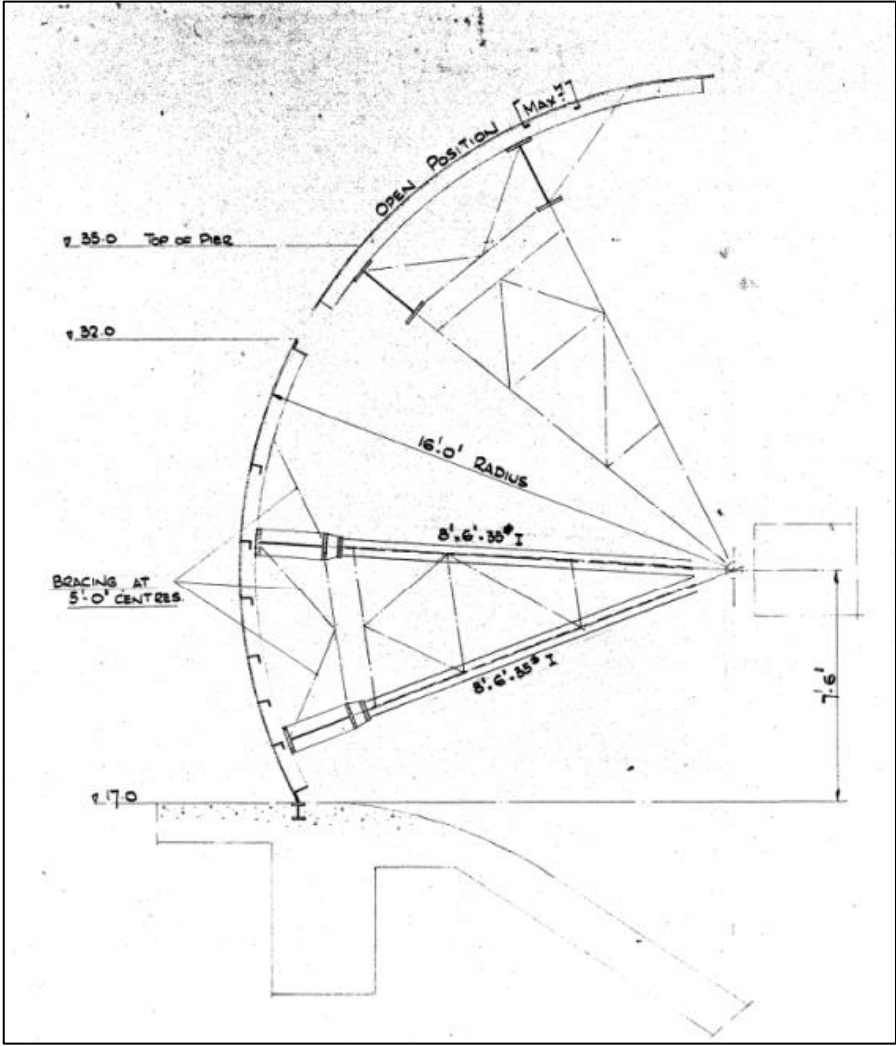
COMPONENT	DETAILS
	 <p data-bbox="379 891 1428 958">Figure 3-3 The rectangular-equivalent channel profile used outside of Mile 22-28 on the Manawatū Channel</p>
<p data-bbox="150 992 355 1099">Model Terrains, Topography, Land Assets</p>	<ul data-bbox="384 992 1428 1603" style="list-style-type: none"> <li data-bbox="384 992 1428 1137">• <b>Model terrain</b> – LiDAR is used to define ground terrain, using the latest available dataset in all locations. Datasets ranged from 2016 to 2024, with prioritisation given to terrains retrieved from the LINZ data service. Figure 3-4 shows the data sources used for the model terrain. <ul data-bbox="432 1167 1428 1603" style="list-style-type: none"> <li data-bbox="432 1167 1428 1234">• 2024 LiDAR was available only for the Pohangina watercourse, but this was outside of the model extent.</li> <li data-bbox="432 1263 1428 1603">• The 2020 NIWA DEM Surface was provided by the NIWA Regional Scale modelling task as part of the Flood Vulnerability Assessment (2025). A histogram of the difference between the two surfaces showed converged to 0.45 m. This was considered reasonably close to the 0.39-0.43 vertical datum difference between WLG53 and NZVD16. The difference also didn't account for differences in LiDAR flown dates or other processing discrepancies. Despite these data quality checks reducing uncertainty associated with the NIWA LiDAR surface, LINZ surfaces were prioritised (Figure 3-4).</li> </ul> </li> </ul>

COMPONENT	DETAILS
	 <p data-bbox="379 1025 1129 1057">Figure 3-4 Terrain Layer Coverage, listed in order of preference</p> <ul data-bbox="384 1081 1442 1787" style="list-style-type: none"> <li>• <b>Stopbanks</b> – HRC provided a layer of all stopbank assets in the region. The layer was reviewed and some minor alignment amendments were made to ensure the crest of the stopbank was covered. All stopbanks were modelled as ‘thin’ breaklines representing the crest of the stopbank, using LiDAR data to define the levels. At this stage of model development, survey data was not available for the stopbanks. <ul data-bbox="427 1330 1442 1480" style="list-style-type: none"> <li>• Levels were enforced by searching for the maximum elevation within a 10 m radius along the bank. The frequency of bank points was determined by vertex spacing, ranging from 10 m around bends to 100 m along straight alignments.</li> </ul> </li> <li>• <b>Roads</b> – road centrelines were extracted from the ‘NZ Road Centrelines 1:50k’ layer from LINZ. Roads were modelled as ‘thin’ breaklines representing the crest of the stopbank, using LiDAR data to define the levels. <ul data-bbox="427 1637 1442 1787" style="list-style-type: none"> <li>• Levels were enforced by searching for the maximum elevation within a 20 m radius along the road centreline. The frequency of bank points was determined by vertex spacing, ranging from 10 m around bends to 100 m along straight alignments.</li> </ul> </li> </ul>
Land Cover	<ul data-bbox="384 1827 1442 1921" style="list-style-type: none"> <li>• The Land Cover Database (LCDB) v5.0 was used to define Manning’s <i>n</i> roughness for the model grid, representing the resistance to flow within the model terrain (Table 3-2).</li> </ul>

COMPONENT	DETAILS
	<ul style="list-style-type: none"> <li>Figure 3-5 shows the spatial coverage of the material roughness implemented within the model</li> </ul>  <p data-bbox="379 1144 932 1178">Figure 3-5 Land Cover Materials (LCDBv5)</p> <p data-bbox="379 1240 1078 1274">Table 3-2 Land Cover material and Manning's n roughness</p>

COMPONENT	DETAILS		
	MATERIAL	LCDB V5.0 ID	MANNING'S N
	Built-up area	1	0-0.05 m Depth – 0.015 >0.1 m Depth – 0.05
	Urban parkland/open space	2	0.033
	Transport infrastructure	5	0.016
	Surface mine	6	0.028
	Coastal sand and gravel	10	0.025
	Landslide - bare surfaces	12	0.025
	Alpine gravel and rock	15	0.039
	River and lakeshore gravel and rock	16	0.039
	Lake and pond	20	0.02
	River	21	0.035
	Estuarine open water	22	0.022
	Short-rotation cropland	30	0.1
	Orchard and other perennial crops, vineyard	33	0.06
	High producing exotic grassland	40	0.05
	Low producing grassland	41	0.09
	Herbaceous freshwater vegetation	45	0.1
	Herbaceous saline vegetation	46	0.1
	Flaxland	47	0.1
	Fernland	50	0.16
	Gorse and broom	51	0.125
Manuka and or kanuka	52	0.1	

COMPONENT	DETAILS		
	Broadleaved indigenous hardwoods	54	0.1
	Mixed exotic shrubland	56	0.08
	Forest harvested	64	0.16
	Deciduous hardwoods	68	0.125
	Indigenous forest	69	0.15
	Other Exotic Forest	71	0.15
	Manawatū Gates Upstream Floodplain	903	0.03
Moutoa Sluice Gates	<ul style="list-style-type: none"> <li>9 no. sluice gates individually represented as 15.24 m wide as 1D objects, all of which are connected to the 2D domain via SX connections both sides of the structure. The invert of the sluice gates was taken as the platform level immediately upstream of the closed gates, 3.8 m RL.</li> <li>Gate Operations defined through the .TOC (TUFLOW Operational Control) file – this controls the opening of the sluice gates from the ground level to the bottom of the gate.</li> <li>The February 2004 simulation opens each gate using HRC-recorded data for opening height. At the time of modelling, the gate opening height when 'Fully Open' was estimated to be 4.54 m on the assumption that the gate-bottom lifts to the crest of the closed gate (measured by HRC in 2025). However, based on historic design drawings, it is possible that this gate opening height could be higher (Figure 3-6).</li> <li>The current height of 4.54 m serves the purposes of this modelling exercise as all scenarios use the same maximum gate height, allowing for a like-for-like comparison.</li> </ul>		

COMPONENT	DETAILS
	 <p data-bbox="384 1323 1422 1391">Figure 3-6 Indicative gate opening height when 'fully open'. Dimensions are in feet and inches. Source: Drawing Set No. 979 'Original Design Drawings', 1956.</p>
Other Structures	<ul style="list-style-type: none"> <li data-bbox="384 1424 1378 1570">• <b>Bridges</b> – explicit representation of bridges has not been included. Abutments adjacent to the banks are automatically represented by the terrain grid, but losses associated with piers and bridge decks is not included.</li> <li data-bbox="384 1581 1378 1805">• <b>Floodgates</b> – there are four main floodgate structures in the catchment vicinity of Moutoa Gates: <ul style="list-style-type: none"> <li data-bbox="480 1659 959 1693">○ Rangiotu Gates (Sluggish Drain),</li> <li data-bbox="480 1697 1193 1731">○ Makerua Drain Floodgates (and pumping station),</li> <li data-bbox="480 1736 754 1769">○ Brady Koputaroa</li> <li data-bbox="480 1774 1217 1807">○ Buckley Gates, Burkes Gates (and pumping station).</li> </ul> </li> <li data-bbox="384 1827 1437 1939">• At this stage of modelling, a simplified representation was used by blocking the channels off up to the level of the adjacent bank elevations. This simulates the scenario in which no gravity drainage occurs and</li> </ul>

COMPONENT	DETAILS
	<p>pumping is not available, which is reflective of typical high-flow conditions on the Manawatū.</p> <ul style="list-style-type: none"> <li>• <b>Culverts</b> – floodplain connection structures have not been included.</li> </ul>
TUFLOW Model Components and Parametrisation	<ul style="list-style-type: none"> <li>• BMT's TUFLOW version 2023-03-AE</li> <li>• 2D grid solver used for rivers, floodplains and overland flowpaths. 1D solver used for Moutoa Sluice Gates structure only.</li> <li>• HPC and SGS-enabled for the model grid.</li> <li>• Cell Size – the Quadtree control file determines variable mesh cell sizing, which gives smaller, more detailed cells near key features such as Moutoa Sluice Gates and at stopbanks. Cell size convergence testing was undertaken to balance sufficient topographic detail with computational run time considerations.</li> </ul>

## 3.3 MODEL INFLOWS AND INITIAL CONDITIONS

### 3.3.1 INFLOWS

For the purposes of this assessment, a hydrological assessment was not scoped, instead gauged inflows were used and assumptions made where data availability necessitated. The hydrometric data was provided by HRC. Model inflows are described in Table 3-3 below. The simplifications and assumptions described for each inflow location are recognised in Section 5. The June 2021 and February 2022 events were used for Model validation and calibration, whilst February 2004 event was used as an example of a high-flow event. Hydrographs are presented in Figure 3-7 to Figure 3-11 and Figure 3-12 shows recorded water levels.

Table 3-3 Model Inflows

WATERCOURSE	BOUNDARY LOCATION	INFLOW DETAILS AND ASSUMPTIONS
Manawatū River	600 m upstream of Teacher's College	<ul style="list-style-type: none"> <li>• Gauge data extracted directly from Teacher's College.</li> <li>• Inflow location positioned sufficiently far upstream of Teacher's College to achieve 'normal depth' conditions at Teacher's College, and sufficiently close enough to be representative of inflows.</li> </ul>
Ōroua River	Kopane Bridge	<ul style="list-style-type: none"> <li>• Gauge data extracted directly from Kopane Bridge gauge, available between 2016-2025.</li> </ul>

WATERCOURSE	BOUNDARY LOCATION	INFLOW DETAILS AND ASSUMPTIONS
		<ul style="list-style-type: none"> <li>• Gauge data for the 2004 event was extracted from Almadale at Slackline and applied at the model upstream boundary (Kopane Bridge). This simplification was justified at this stage based on the comparison of the most recent large event February 2023 Cyclone Gabrielle – this showed the peaks at the two gauges to be reasonably close (480 m<sup>3</sup>/s at Slackline, 437 m<sup>3</sup>/s at Kopane Bridge). For the purposes of this work (to <i>understand the nearby flood risk as a result of gate operation sensitivity testing of the Moutoa Gates during a large flow event</i>), the uncertainty associated with this inflow is low because the Manawatū controls water levels on the Ōroua at the peak of large events. This is supported by sensitivity testing to adjust the Ōroua inflows, which indicated the Manawatū to be the dominant mechanism controlling flooding in the surrounding floodplains of the Moutoa Gates.</li> <li>• For the February 2022 and June 2021 events where Kopane Bridge gauge flows were available, hydrographs were multiplied by 1.2 to account for the additional catchment area between Kopane Bridge and the confluence with the Manawatū.</li> <li>• The simplifications and assumptions described above are recognised in Section 5.</li> </ul>
Mangaone Stream	Pioneer State Highway 56 Bridge	<ul style="list-style-type: none"> <li>• Gauge data extracted directly from Milson Line.</li> <li>• Hydrograph multiplied by 2 (for the 2021 and 2022 validation events, as advised by HRC) to estimate additional contribution from the urban catchment to the east of the Mangaone and downstream of Milson Line gauge.</li> <li>• Inflow hydrograph offset by 3 hours to account for approximate travel time from Milson Line.</li> </ul>
Kahuterawa and Turitea Streams	Kahuterawa confluence at Manawatū	<ul style="list-style-type: none"> <li>• Gauge data extracted directly from Johnstons Rata (Kahuterawa), not available from Turitea at Ngahere Park.</li> </ul>

WATERCOURSE	BOUNDARY LOCATION	INFLOW DETAILS AND ASSUMPTIONS
		<ul style="list-style-type: none"> <li>Flow hydrograph taken from Johnstons Rata and area-weighted to the total catchment of the Kahuterawa and Turitea.</li> <li>Inflow hydrograph offset by 5 hours to account for approximate travel time from Johnstons Rata and for the Turitea.</li> <li>Inflows were unavailable for February 2004 event as gauge data was not recorded. No estimation was made for the inflows from these catchments for the February 2004 event. For the purposes of the gate operation scenarios, the dominance of the Manawatū inflow from Teacher's College was assumed to be sufficiently representative of the event so no inflows were required from these watercourses.</li> </ul>
Tokomaru Drain	SH57 Crossing	<ul style="list-style-type: none"> <li>Gauge data extracted directly from Riverland Farm (just downstream of SH57 crossing).</li> </ul>
Linton Drain	Tane Road Crossing	<ul style="list-style-type: none"> <li>During the three events, the recorded hydrographs at the Tane Road gauge showed close to zero volume. Therefore, the peak flow for each event was applied as constant value for conservative representation. <ul style="list-style-type: none"> <li>Peak flows: February 2022 – 2 m<sup>3</sup>/s, June 2021 – 0.5 m<sup>3</sup>/s, February 2004 – 1 m<sup>3</sup>/s</li> </ul> </li> </ul>
Manawatū	Foxton Beach	<ul style="list-style-type: none"> <li>Tidal boundary at outlet of model</li> <li>Gauge data extracted directly from Manawatū at Foxton.</li> <li>RL0 (WLG53) set to -0.877 m. Converted to NZVD16 vertical datum by subtracting 0.423 m.</li> </ul>

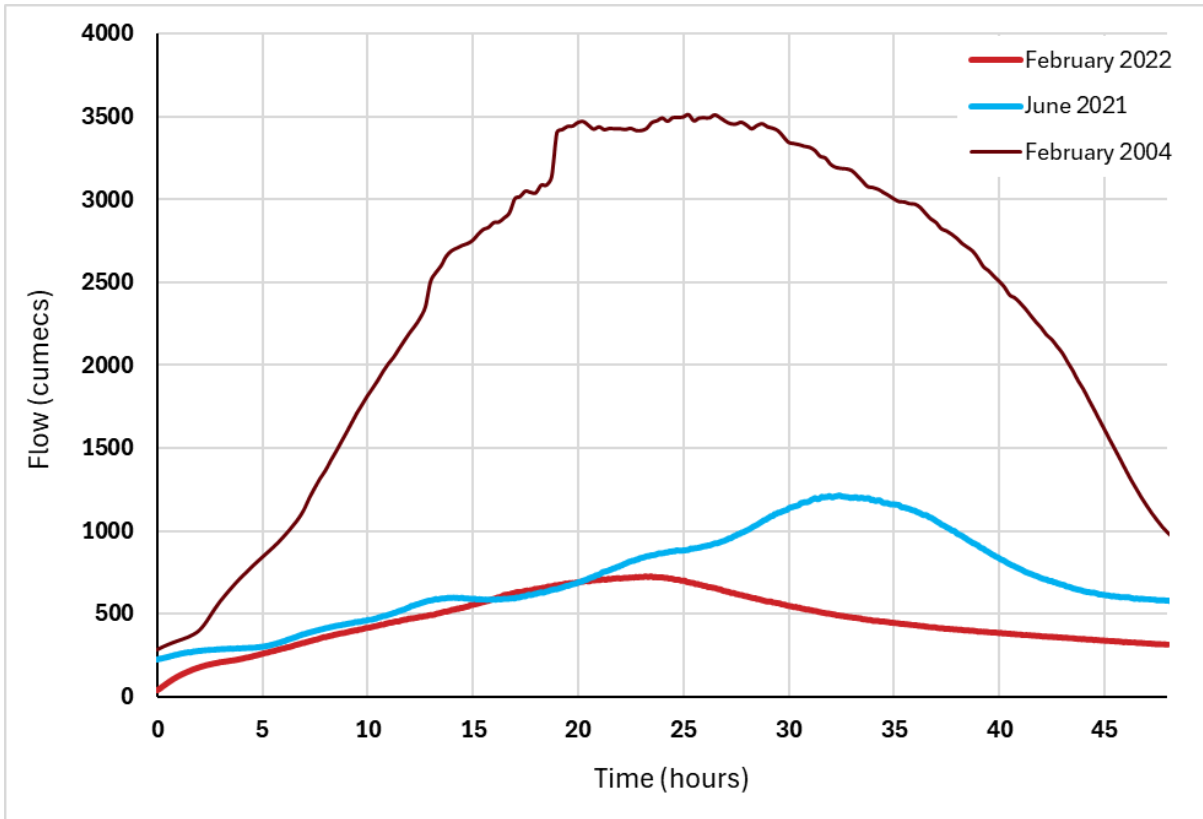


Figure 3-7 Manawatū at Teacher's College

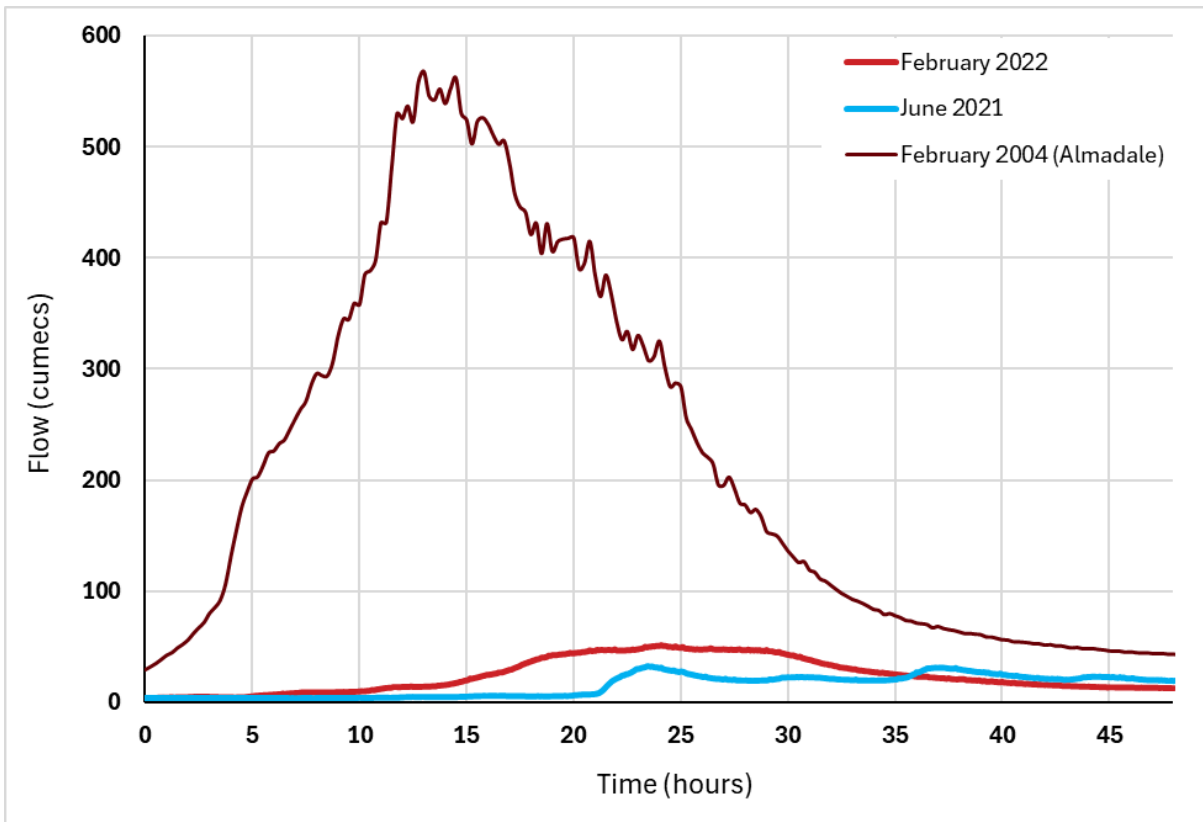


Figure 3-8 Ōroua at Kopane Bridge

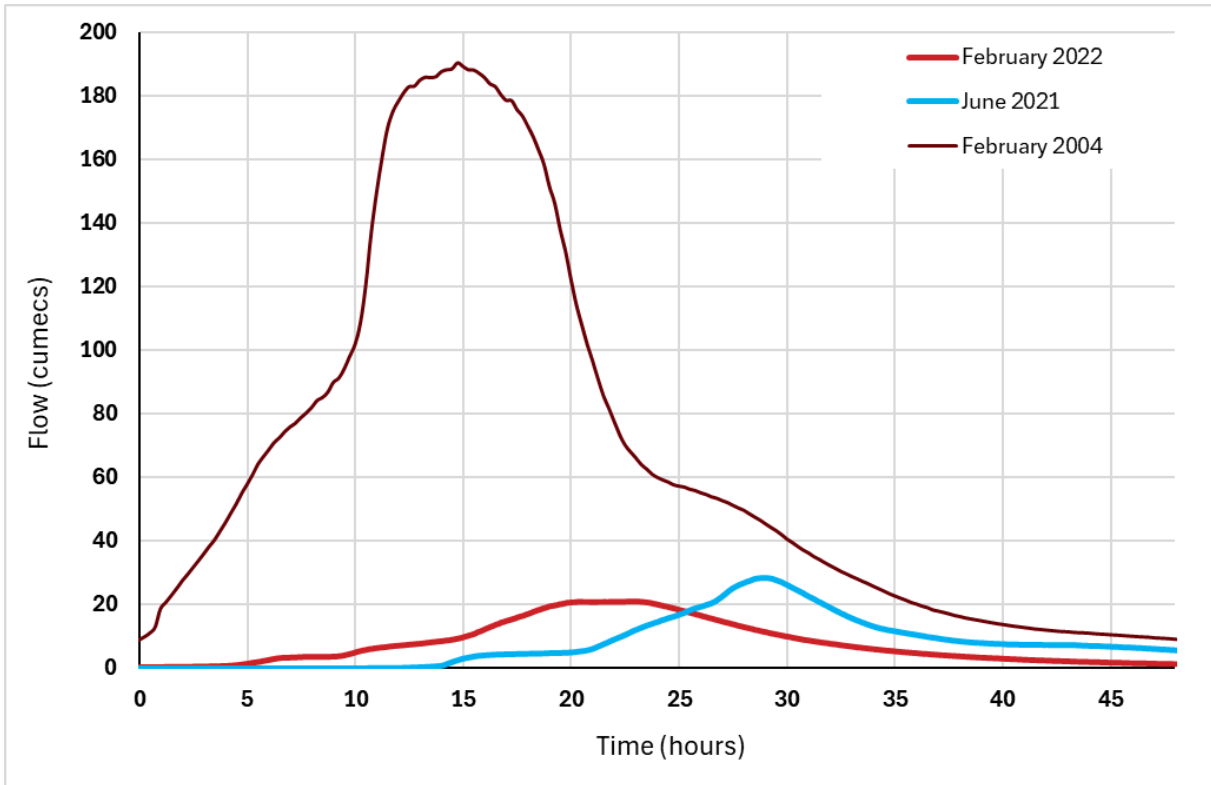


Figure 3-9 Mangaone at Pioneer State Highway 56 Bridge

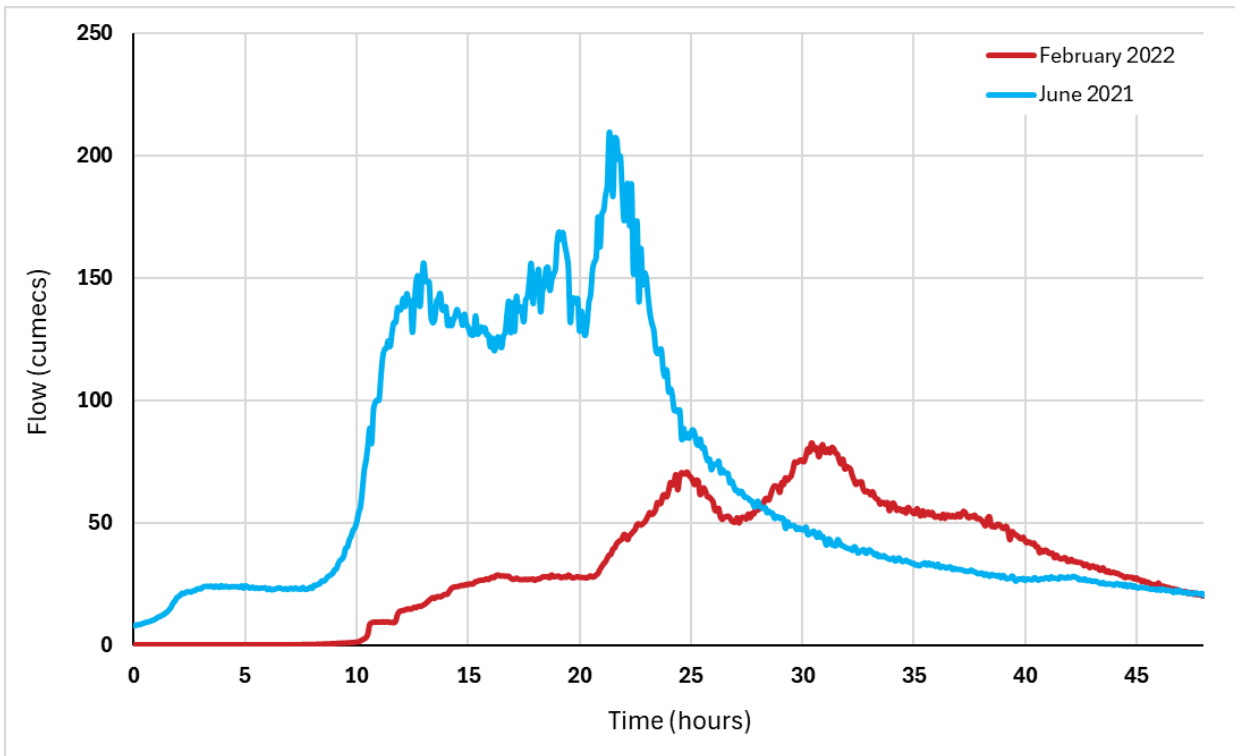


Figure 3-10 Kahuterawa and Turitea joint inflow, Kahuterawa confluence at Manawatū

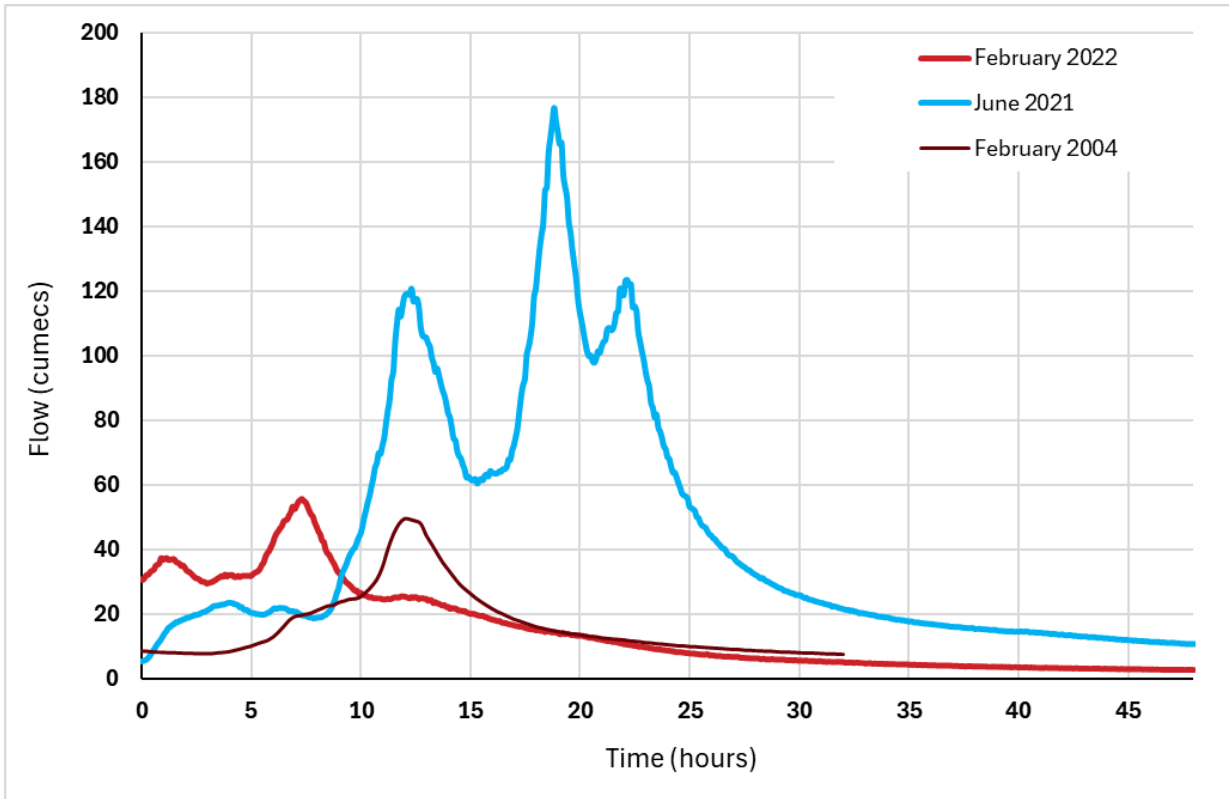


Figure 3-11 Tokomaru at SH57 Crossing

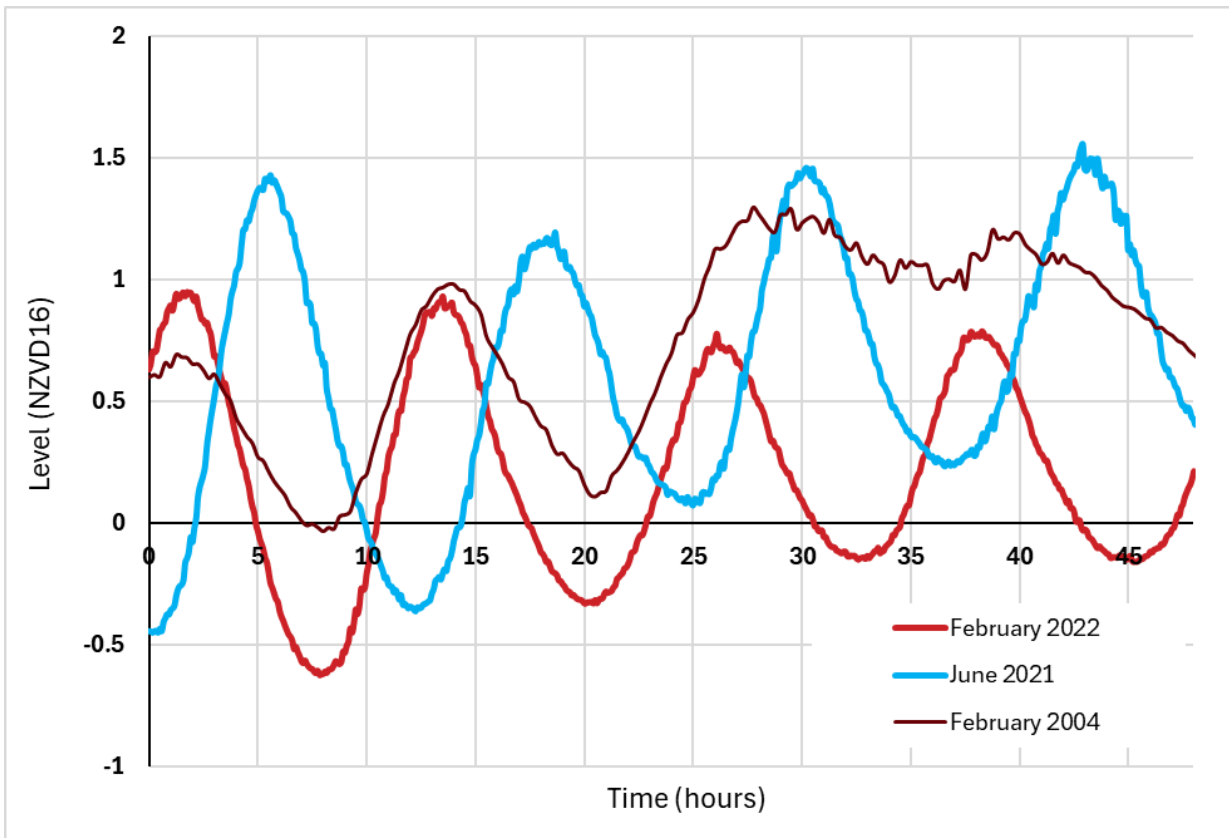


Figure 3-12 Manawatū at Foxton gauged water levels

### 3.3.2 INITIAL CONDITIONS

Basic initial conditions were represented by adding initial water levels at the downstream boundary and within the reach upstream and downstream of Moutoa Gates (as the key area of interest). Low flows were also added just upstream of Moutoa using the Moutoa Gauge, which were reduced to 0 m<sup>3</sup>/s when the upstream floodwave reached Moutoa after approximately 7-8 hours for each event. Although not a detailed hydrological assessment, the basic estimation of initial levels and flows were intended to represent approximate antecedent conditions.

Table 3-4 Initial Conditions applied in the downstream area of the model

EVENT	INITIAL TIDAL LEVEL (NZVD2016)	INITIAL MOUTOA LEVEL (NZVD2016)	INITIAL MOUTOA FLOW RANGE – 0-8 HOURS
February 2004	0.6	3.03	0 m <sup>3</sup> /s *
June 2021	-0.44	2.55	206-323 m <sup>3</sup> /s
February 2022	0.63	0.35	25-121 m <sup>3</sup> /s

\*Initial flow not included due to gauge data showing minus inflow rate.

Sensitivity tests indicated that the rising limb hydrograph at Moutoa Gates was sensitive to initial conditions, but peak flows and levels are not sensitive to initial conditions. This is because at the peak of the storm, the initial conditions are 'flushed' out of the system and peak flows and levels are controlled almost entirely by upstream storm-related flow. For the purposes of this assessment, this limitation was accepted because the focus was to understand the relative impact of closed gates at Moutoa Gates at the peak of the event.

## 3.4 MODEL VALIDATION

Model validation was undertaken to increase confidence in the model methodology, with the aim of the exercise to finetune key parameters to better represent the fundamental behaviour of the catchment being modelled. The model was validated to June 2021 (26-29 June 6pm-6pm) and February 2022 (6-8 February 12am-12am) events, both of which were single peaks hydrographs. Neither event required the Moutoa Sluice Gates to open, allowing this model component to remain fixed and therefore removing the uncertainty associated with the estimation of gate opening timings and flow rates. Figure 3-13 shows the inflow hydrographs at the Teacher's College gauge.

### 3.4.1 MODEL VALIDATION PARAMETERS

Forecasting flood peaks at Moutoa Gates by monitoring river levels at the Teacher's College gauge is a crucial component of catchment flood risk management undertaken by HRC. This reflects two of the most important dynamics of the Lower Manawatū catchment:

- 1 The **travel time** of the flood wave from Teacher's College to Moutoa Gates,
- 2 Gauged **river levels**. Given that the model's upstream boundary is located at Teacher's College, the matching gauged river levels was focussed on Moutoa Gates channel gauge.

At the whole model scale (364 km<sup>2</sup> area), the key controls on travel time and water levels at Moutoa were determined to be watercourse roughness and turbulence formulation (controlled by Wu formulation 3D parameter). Manning’s roughness determines the surface resistance to flow, whilst the Wu 3D parameter determines the impact of turbulence-induced losses with respect to water depth and velocity.

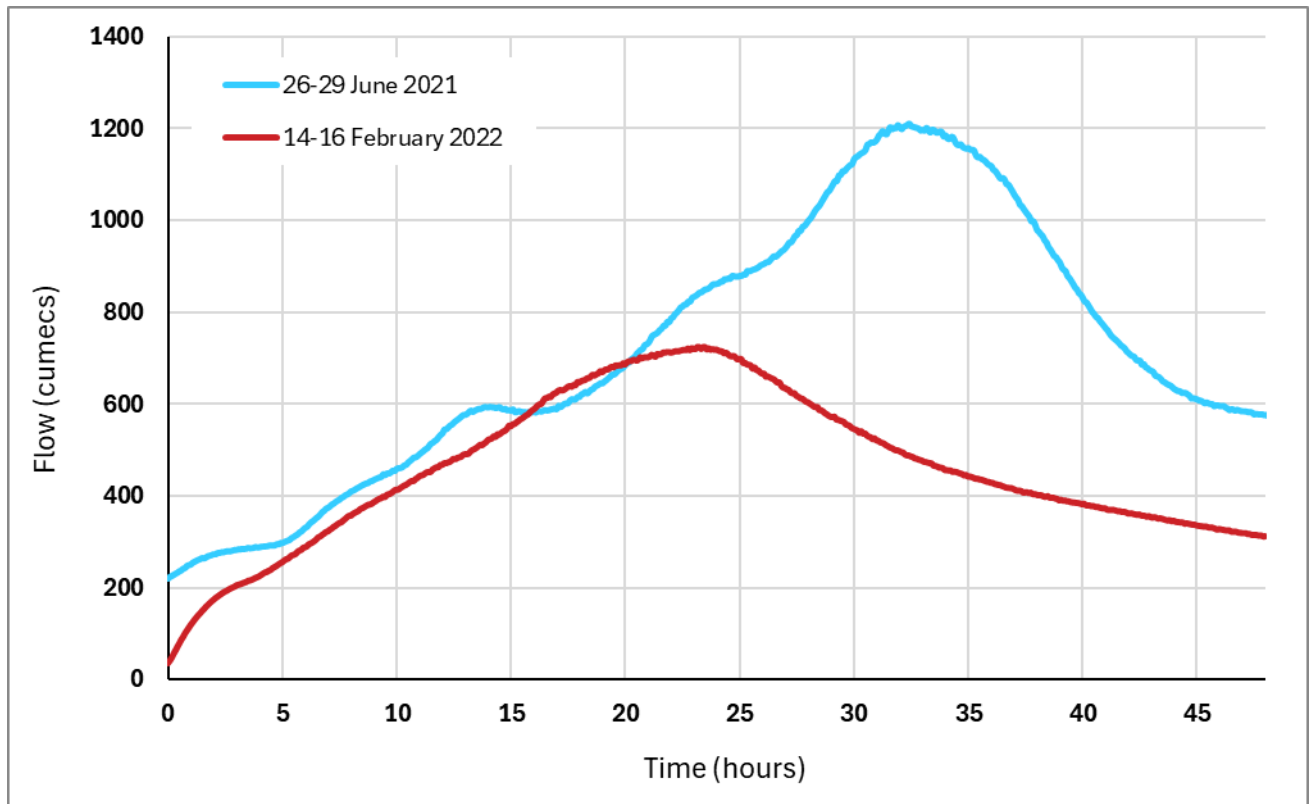


Figure 3-13 Teacher’s College inflow hydrographs for Model Validation

The final model used 0.035 as Manning’s *n* channel roughness, and the Wu 3D component was selected as 3 (default 7) for the viscosity formulation to represent turbulence. Table 3-5 below indicates how the channel roughness and turbulence formulation impacted the travel time and Moutoa Levels during validation.

Table 3-5 Model Validation parameters – overall findings

VALIDATION	CHANNEL ROUGHNESS	TURBLUENCE (VISCOSITY FORMULATION)
Travel Time (Teacher’s College to Moutoa)	<ul style="list-style-type: none"> <li>The primary influence on travel time</li> <li>0.028 underestimated total travel times by 1-2 hours.</li> <li>0.04 overestimated total travel times by 1-2 hours,</li> </ul>	<ul style="list-style-type: none"> <li>Less effect on travel times overall, particularly between Teacher’s College and Opiki (consistently 3 hours for February 2022 and 5 hours for June 2021 across all Wu parameter sensitivities). Slightly more sensitive from Opiki to Moutoa, underestimating travel time by 1 hour</li> </ul>

VALIDATION	CHANNEL ROUGHNESS	TURBLUENCE (VISCOSITY FORMULATION)
		<p>with a 3D value of 1 compared to 7 (for the same roughness).</p> <ul style="list-style-type: none"> <li>Turbulence required to balance effect of channel roughness after achieving good travel times, by varying turbulence to address channel levels.</li> </ul>
Moutoa Levels	<ul style="list-style-type: none"> <li>Channel levels sensitive to roughness – Manning’s <math>n</math> increasing from 0.028 to 0.035 increased water levels by 80 cm at Moutoa channel gauge for the February 2022 event.</li> <li>0.035 found to be sensible value to balance travel time and channel levels</li> </ul>	<ul style="list-style-type: none"> <li>Channel levels slightly less sensitive to Turbulence compared to roughness – 3D component of 1 to 7 increased levels by 30 cm for the February 2022 event (for the same roughness).</li> </ul>

### 3.4.2 MODEL VALIDATION RESULTS

Table 3-6 below indicates how the final model validation compared to observed events. Modelled levels at Moutoa were 0.37 m lower than observed for the February 2022 event – given the strong match to travel times, this difference likely could be attributed to uncertainties in total inflows, or less likely to channel representation and location specific roughness (see 5.2 Limitations). Overall, the following conclusion was made from the model validation results:

*Across the two events assessed against two validation parameters (roughness, turbulence formulation) the model matches closely, demonstrating a reasonable reflection of the Lower Manawatū system’s hydraulic behaviour. Although some uncertainties remain (inflows, channel representation, location-specific roughness), the results give good confidence that the model setup is well-represented at the broader catchment-scale of the model.*

Figure 3-14 and Figure 3-15 below show the hydrographs of the observed events compared to the modelled levels. The cross on the x-axis indicates the time (not level) of the peak at Teacher’s College Gauge. In both events, sensitivities showed that underestimation of initial conditions and baseflow did not impact water levels at the peak of the event.

Table 3-6 Model Validation parameters – comparison to events

VALIDATION	JUNE 2021	FEBRUARY 2022
Travel Time	<ul style="list-style-type: none"> <li>Modelled 11.5 hours vs. observed 12 hours</li> </ul>	<ul style="list-style-type: none"> <li>Modelled 7 hours vs observed 7 hours</li> </ul>
Moutoa Levels	<ul style="list-style-type: none"> <li>Modelled 8.23 m RL vs. 8.2 m RL observed</li> </ul>	<ul style="list-style-type: none"> <li>Modelled 6.38 m RL vs. 6.75 m RL observed</li> </ul>

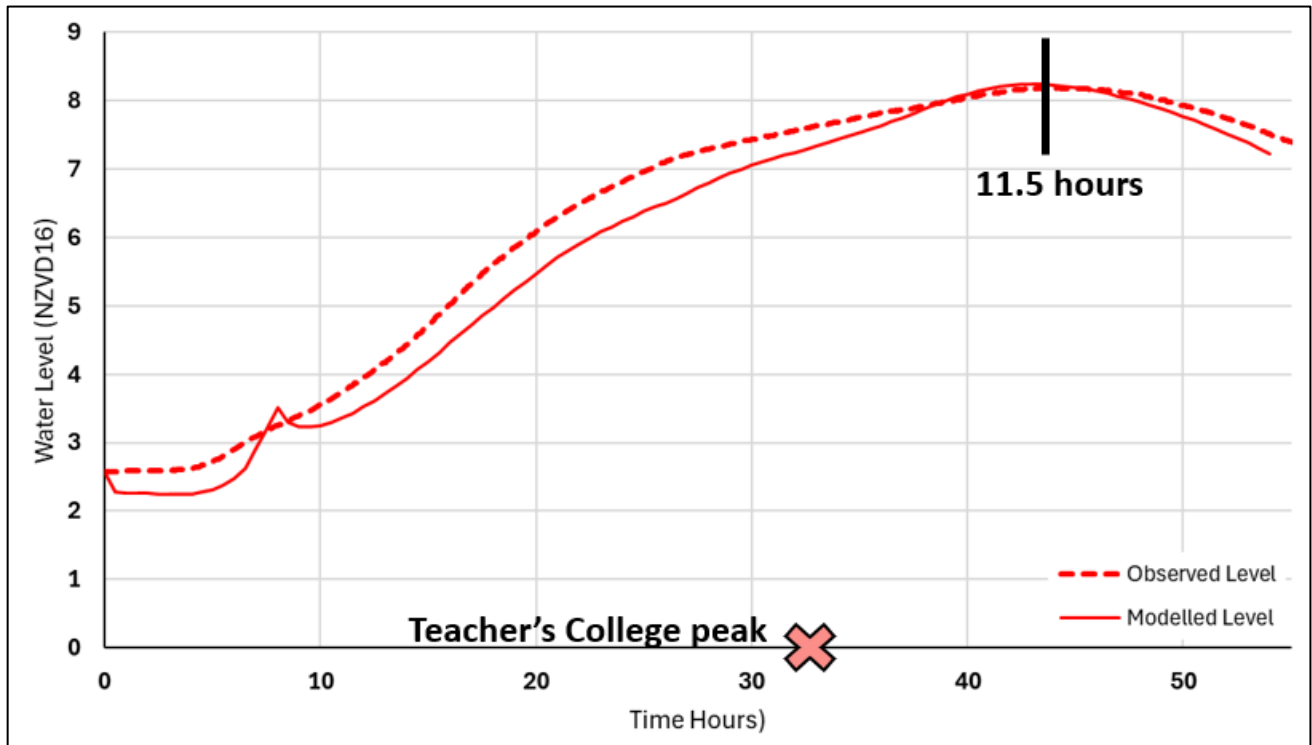


Figure 3-14 June 2021 Observed vs. Modelled Water Levels at Moutoa Gates (Channel) (cross indicating time of peak upstream at Teachers College)

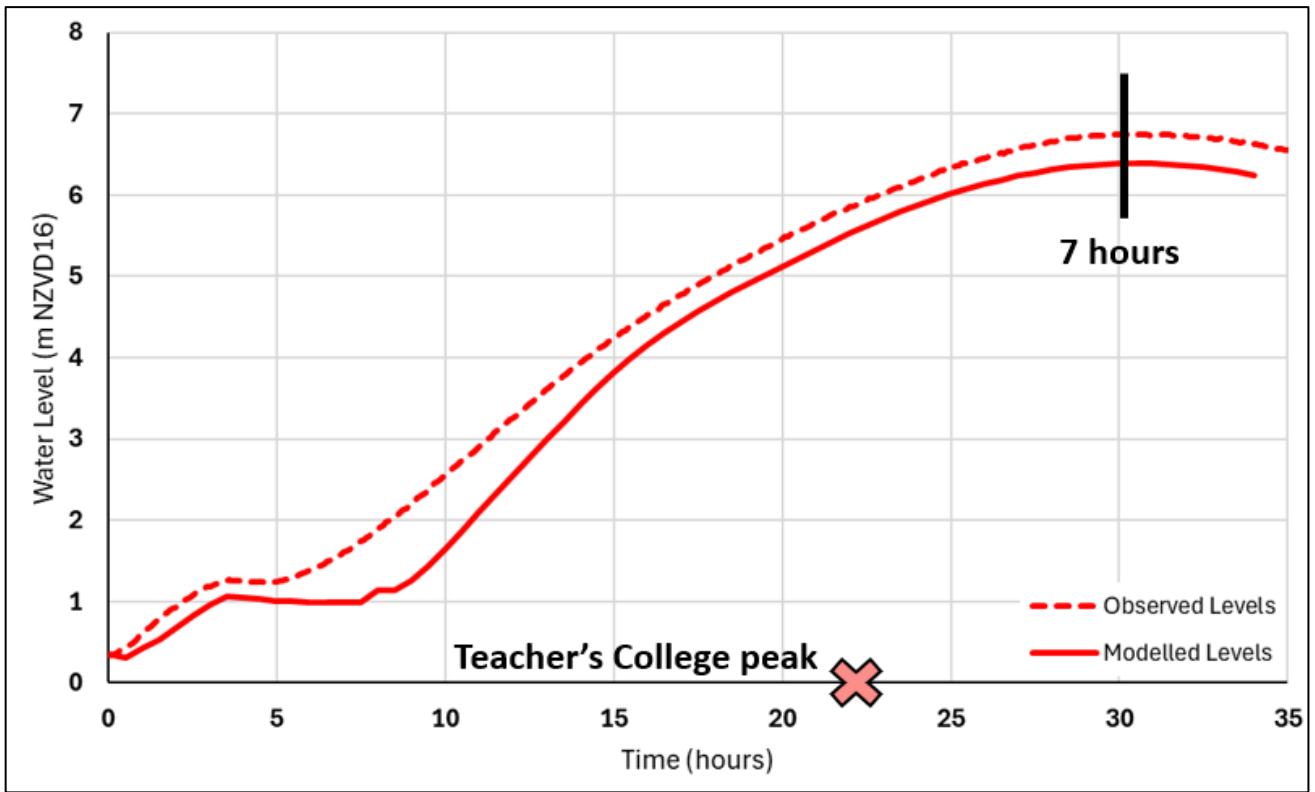


Figure 3-15 February 2022 Observed vs. Modelled Water Levels at Moutoa Gates (Channel) (cross indicating time of peak upstream at Teachers College)

# 4 SIMULATIONS AND RESULTS

## 4.1 FEBRUARY 2004 – BASELINE GATE OPERATIONS

To understand the impact of the Lower Manawatū catchment to closed gate scenarios, it was proposed to simulate a series of different openings and closures of 3 sluice gates. The 9-gate fully open scenario was used as the baseline event against which to compare all gate operation tests.

The Baseline event represents the model as described in Section 3 Model Build Methodology. The following features were notable to the February 2004 inflows:

- Inflows and tidal boundaries were as described in section 3.3 Model Inflows and Initial Conditions.
- All 9 sluice gates open and operate exactly as they did in the February 2004 event. This data was provided by HRC and represents individual gate operations, with gate opening increments set to 150 mm. Figure 4-1 shows Gate 1 openings – all other gates opened in unison with very similar timings and increments.

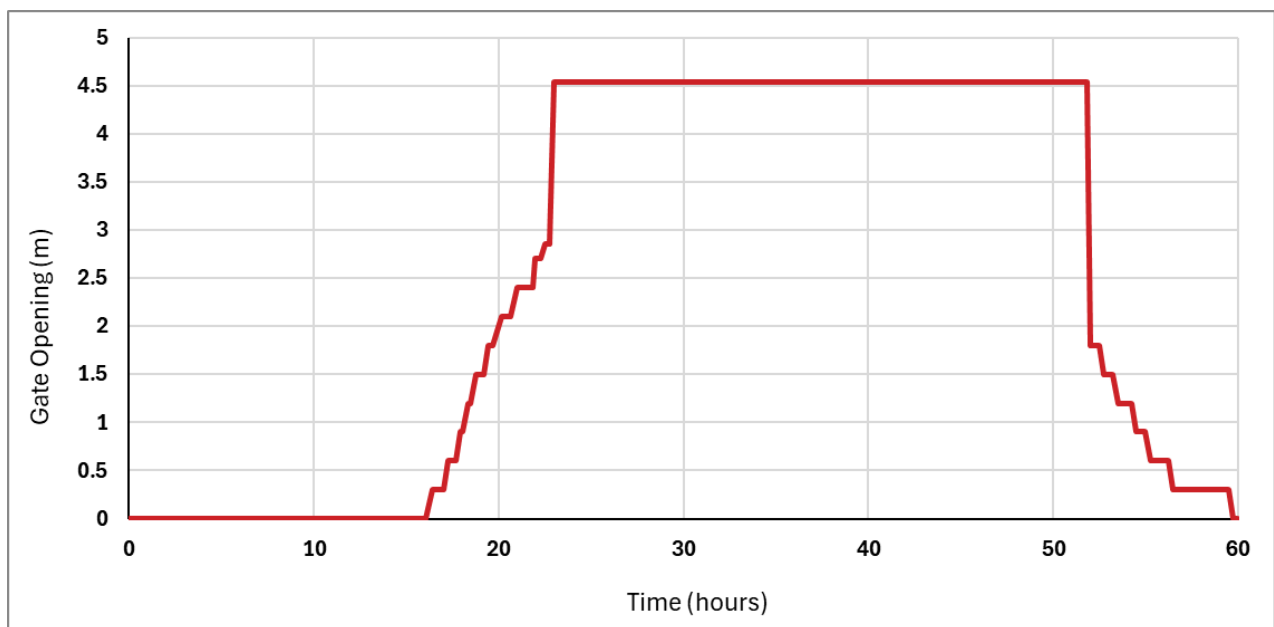


Figure 4-1 Gate 1 openings from 4pm 15th February 2004 (Model hour 0) to 4am 18th February 2004 (Model Hour 60)

To determine the impact of gate operation testing, the model was simulated for the February 2004 inflows to indicate the potential impact for an event of this magnitude. At this stage the aim was not to validate or calibrate against the 2004 event, for the following reasons:

- This model was built with up-to-date terrain data including LiDAR, stopbanks and roads. This means that terrain elevations, features and post-2004 stopbank upgrades were not reflective of conditions in February 2004.
- This model has not included event specific mechanisms such as stopbank breaches.

- A detailed hydrological analysis has not been undertaken to quantify the confidence and/or uncertainty associated with the gauged inflows used.
- The base model was validated against closed-gate scenarios (June 2021, February 2022). Additional calibration to open-gate hydraulics would have required more extensive modelling.

Instead, to achieve the aim was of understanding the impact of the Lower Manawatū river to closed Moutoa gate scenarios, flow conditions of the same magnitude as February 2004 were deemed suitable. Calibration to events such as February 2004 is planned in later stages of development for the wider Lower Manawatū model. Confidence in the existing model representation of the fundamental system hydraulics is described in Section 3.4.

## 4.2 SIMULATIONS AND SCENARIOS

The Baseline scenario is described in Section 4.1 February 2004 – Baseline Gate Operations. Table 4-1 shows the maximum opening of 3 centrally located sluice gates for all 8 scenarios. All gate opening increments are simulated as per the February 2004 event, with the maximum opening height capped as per the scenario. For example, in Scenario A the first gate (Gate 5) opens as per observed procedure until it reaches 1.2 m, remaining at this height until the observed level drops below 1.2 m again on the falling limb of the storm hydrograph.

Table 4-1 Sluice Gate Operation Scenarios

MAXIMUM OPENINGS	ALL OTHER GATES	GATE 5	GATE 4	GATE 3
Baseline	4.54 (Fully Open)	4.54 (Fully Open)	4.54 (Fully Open)	4.54 (Fully Open)
Scenario A	4.54 (Fully Open)	1.2	0	0
Scenario B	4.54 (Fully Open)	1.2	1.2	0
Scenario C	4.54 (Fully Open)	1.2	1.2	1.2
Scenario D	4.54 (Fully Open)	2.4	0	0
Scenario E	4.54 (Fully Open)	2.4	2.4	0
Scenario F	4.54 (Fully Open)	2.4	2.4	2.4
Scenario G	4.54 (Fully Open)	0	0	0
Scenario H	4.54 (Fully Open)	4.54 (Fully Open)	0	0

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## 4.3 RESULTS

The results are focussed on the Moutoa Gates area in the downstream extent of catchment where maximum flooding impact occurs. Notably, flooding is particularly prevalent on the floodplain to the south of the Floodway which is enclosed by the Manawatū right-bank ('Floodplain South') and to the floodplain east of the stopbanks downstream of Moutoa Gates ('Floodplain East') on the left-bank.

### 4.3.1 FLOODWAY FLOW

Results indicated that the lower the maximum gate openings (e.g. Scenario C, Scenario A), the lower the volume of water that is diverted down the Floodway and therefore the greater the proportion of flow directed downstream on the Manawatū channel. This results in increased flow in the Manawatū channel downstream of Moutoa Gates, increasing water levels and therefore increasing overtopping to Floodplain South and Floodplain East. Figure 4-2 shows the locations of flow outputs at Moutoa Gates, which are lines digitised as perpendicular to flow.

- **Moutoa Total Upstream** – the total flow upstream of Moutoa
- **Moutoa Channel** – the pass-forward flow in the Manawatū channel downstream of Moutoa Gates
- **Moutoa Gate Upstream** – the water level 10m upstream of the gates
- **Moutoa Floodway** – the total flow down the Moutoa Floodway

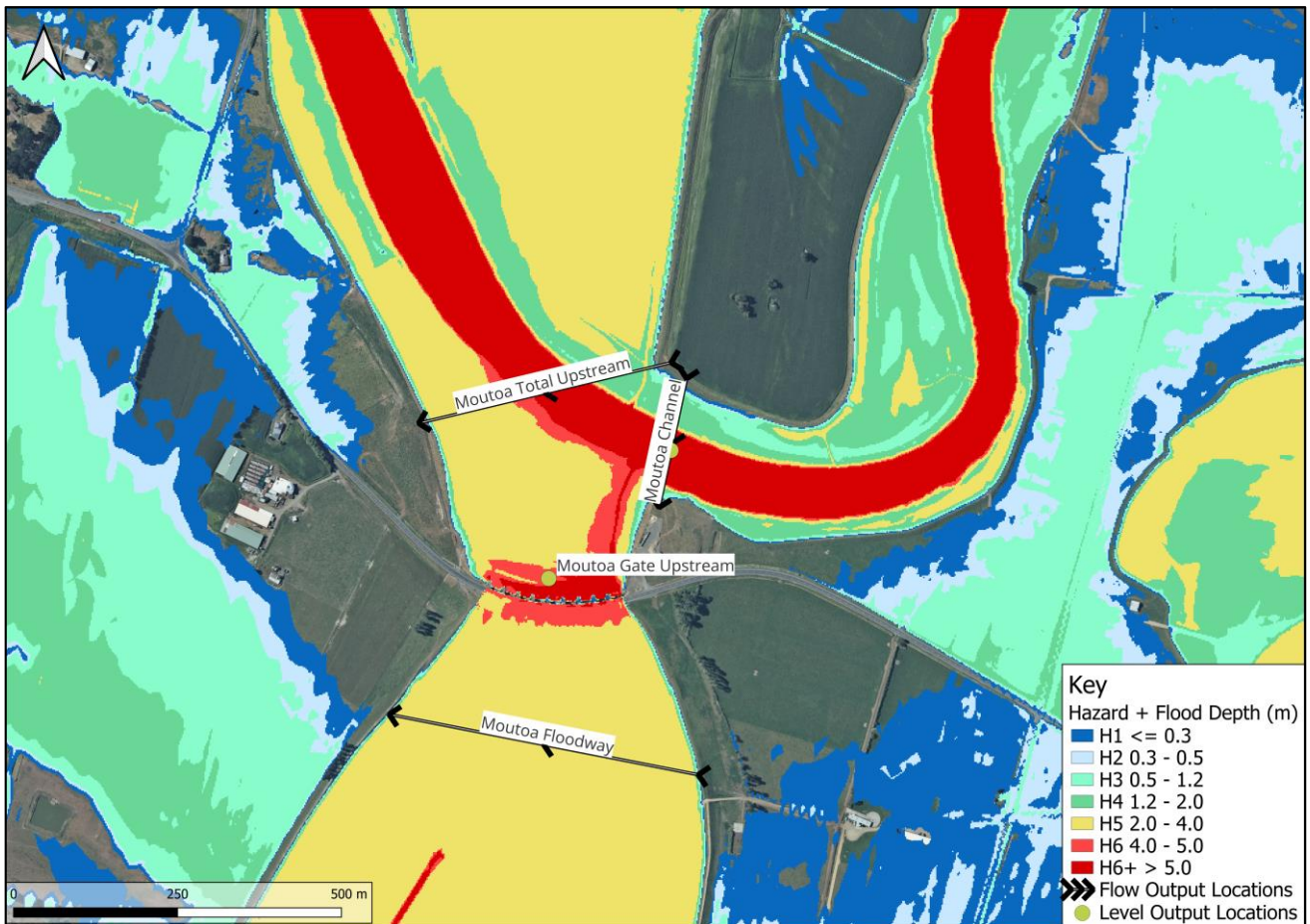


Figure 4-2 Flow Output Locations at Moutoa overlaid on the Baseline maximum flood depths (m).

Figure 4-3 and Figure 4-4 indicate how the total flow is partitioned between the Manawatū channel and the Floodway, for the baseline 9-gate fully open scenario (baseline) and 6-gate fully open scenario (Scenario G). For the baseline scenario, 60% of total upstream flow (1920 m<sup>3</sup>/s) was diverted down the Floodway, whilst in Scenario G only 50.5% (1530 m<sup>3</sup>/s) was diverted down the Floodway.

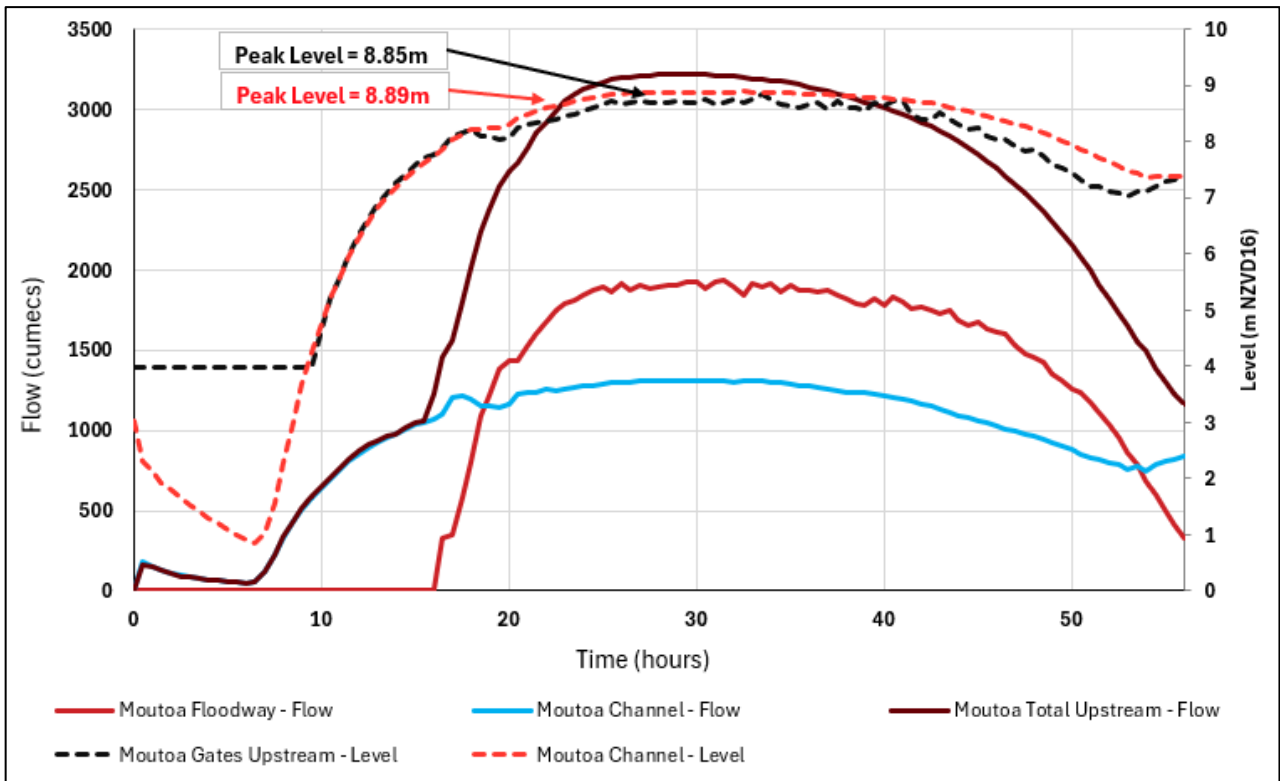


Figure 4-3 Baseline (9 Fully Open Gates) simulation – flow partitions at Moutoa Gates

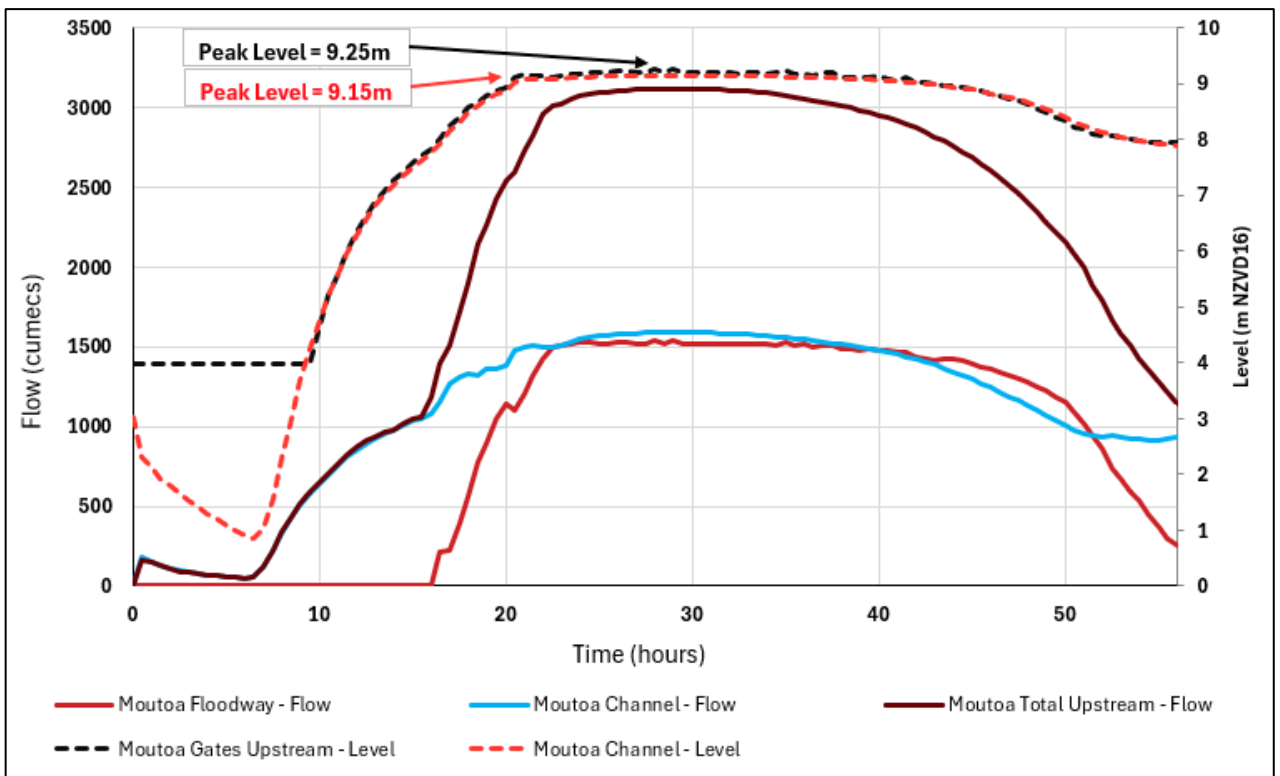


Figure 4-4 Scenario G (6 Fully Open Gates) simulation – flow partitions at Moutoa Gates

### 4.3.2 FLOOD EXTENTS

For each scenario in Table 4-1, flood extents were compared the baseline scenario of 9 gates fully operational. Appendix A contains the maps showing changes to flood extent as a result of the change to the maximum gate opening heights. The scenarios show that:

- The greater the number and height of sluice gate openings, the less change to flood extents is indicated from Baseline. For example Scenario F, which opens the 3 gates to 2.4 m, showed the smallest increase in flood extents on Floodplain South (approximately 14 km<sup>2</sup> in Scenario F compared to baseline 11 km<sup>2</sup>) and Floodplain East (approximately 6 km<sup>2</sup> in Scenario G compared to baseline 5 km<sup>2</sup>). This is because the three flood gates are closer to maximum operating capacity (with greater gate openings) and therefore a higher volume of floodwater is diverted down the Floodway, minimising the increase in water levels in the Manawatū River and therefore the flood extents across the floodplain.
- Scenarios with lower maximum sluice gate openings (e.g. Scenario A, D, G) result in a reduction of flooding on the left bank of the Manawatū River near the downstream boundary at Foxton. This is because there is a reduction in flow down the Floodway and an increase in levels in the vicinity of Moutoa Gates, which has a two-fold effect; firstly, it increases the volume of water overtopping the Manawatū banks immediately downstream of Moutoa; secondly, a reduction in Floodway flows results in lower river levels in the downstream Manawatū, which reduces overtopping from the left-bank in this downstream area.
- The lower the maximum sluice gate opening, the greater the change to flood extent that is indicated. For example Scenario G, which has all 3 gates fully closed, shows significant increases to flood extent on Floodplain South (approximately 22 km<sup>2</sup> in Scenario G compared to baseline 11 km<sup>2</sup>) and Floodplain East (approximately 16 km<sup>2</sup> in Scenario G compared to baseline 5 km<sup>2</sup>). This is because the three flood gates are fully closed and therefore the volume of flow into the Floodway fails to divert a sufficient volume of floodwater out of the Manawatū River directly towards Foxton via the Floodway, maximising the increase in flood extents from overtopping of the Manawatū stopbanks.

### 4.3.3 FLOOD DEPTHS AND HAZARD CLASSIFICATION

For each scenario in Table 4-1, flood depths (m) were produced from the modelled outputs. In general, the floodplains in the lower catchment are flat, low-velocity environments which fill like 'buckets' – that is to say, the floodplains do not imitate flowpaths, instead they behave like storage areas. Appendix B shows the flood depths for each scenario A – H, alongside indicative flood hazard classification (ARR, 2012). The scenarios show that:

- The greater the maximum gate opening, the lower the flood depths on Floodplain South and Floodplain East. For example, in Scenario F depths increased to approximately 1.55 m from a Baseline maximum of approximately 1.4 m on the Southern Floodplain. This is because the three sluice gates are close to maximum operating capacity and therefore the Floodway diverts a sufficient volume of floodwater towards Foxton from the Manawatū River, minimising the volume of water overtopping the Manawatū stopbanks in the vicinity of Moutoa.

- The lower the maximum gate opening, the higher the flood depths on Floodplain South and Floodplain East. This is because the three flood gates are not close to maximum operating capacity and therefore the Floodway fails to divert a sufficient volume of floodwater towards Foxton, increasing the volume of water overtopping the Manawatū stopbanks in the vicinity of Moutoa. For example, in Scenario G depths increased from a Baseline maximum of approximately 1.4 m on the Southern Floodplain to greater than 2 m.
- The scenarios with the greatest gate capacity (Scenario F) had the lowest depth hazard classification, which was mostly limited to H1-H3 on Floodplain South and East. Scenarios with the lowest gate capacity (Scenario G) has the highest depth hazard classification, in which H3-H4 is widespread across the Floodplain South.

#### 4.3.4 STOPBANK OVERTOPPING

The Manawatū stopbanks overtopped in 13 identified locations downstream of (and including) the Moutoa Gates, eight on the right bank and five on the left bank. The overtopping bank lengths varied from approximately 3.5 km (right-bank downstream of Moutoa) to smaller 150 m reaches with minor breaches. Maximum overtopping depths at each location varied from approximately 10 cm to 40 cm.

The last map of Appendix B (Drawing Number 1-E0118.00-DRW-0017) indicates the stopbank overtopping locations for Scenario G (3 Sluice Gates fully closed). Locations of overtopping are available via Appendix C Digital Archive, which indicates the approximate maximum depth for each location.

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## 4.4 SENSITIVITY TESTING

During a HRC-WSP workshop held on 1<sup>st</sup> April 2025, it was agreed to undertake some inflow sensitivities for the Ōroua and the Manawatū when modelling the flows from 2004. The primary intention was to understand the sensitivity of catchment flooding to inflow variability, as opposed to seeking a closer match to the February 2004 extents (see section 4.1 February 2004 – Baseline Gate Operations for a breakdown of the February 2004 event). The following two simulations were undertaken to test the sensitivity of the model to inflow variability. Both were simulated for the 2004 inflows and the 2004 Moutoa Gates operating schedule.

### 4.4.1 5% REDUCTION IN TEACHER'S COLLEGE INFLOW

A 5% reduction in flows on the Manawatū at Teachers College equated to a drop of nearly 170 m<sup>3</sup>/s from the upstream boundary at Teacher's College. Results indicated that:

- Flood extents mostly unchanged at catchment scale, some reduction in flooding on the true right-bank down to Opiki Bridge.
- Levels dropped by 20 cm downstream of Teacher's College.
- Downstream of the Ōroua confluence, the difference in flow on the Manawatū River reduced from 170 m<sup>3</sup>/s to 60 m<sup>3</sup>/s.
- Levels at Moutoa (channel) reduced by 2 cm. This is because there is approximately the same amount of pass-forward flow downstream on the Manawatū. The difference in flow

upstream of Moutoa Gates ( $60 \text{ m}^3/\text{s}$ ) is re-directed through the gates down the floodway. This is as a result of using the 2004 operating schedule for the gates, whereby fully open gates dictate that the floodway is the preferential flowpath for the additional  $60 \text{ m}^3/\text{s}$ .

#### 4.4.2 25% REDUCTION IN ŌROUA KOPANE BRIDGE

A 25% reduction in flows on the Ōroua equated to a drop of nearly  $142 \text{ m}^3/\text{s}$  from the upstream boundary at Kopane Bridge. Results indicated that:

- Flood extents reduced on the Ōroua floodplains.
- Levels dropped by 10 cm downstream of Kopane Bridge, noting the results indicate less out-of-bank flows lost to the floodplain
- At the downstream end of the Ōroua River, levels are unchanged because the Manawatū River peak controls water levels
- Levels at Moutoa (channel) reduced by 2 cm. This is because there is approximately the same amount of pass-forward flow downstream on the Manawatū River. The difference in flow upstream of the Moutoa Gates ( $50 \text{ m}^3/\text{s}$ ) is mostly accounted for in the difference in flows through the sluice gates down the floodway. This is an artefact of using the 2004 operating schedule for the sluice gates.

Overall, the results indicate that small changes to inflows results in minimal changes in the levels flood extents in the vicinity of Moutoa Gates.

# 5 ASSUMPTIONS, LIMITATIONS AND CONCLUSIONS

## 5.1 ASSUMPTIONS

The following assumptions were made in the Moutoa Model build:

- The maximum gate opening height above the design maximum of 2.7 m (HRC Drawing 2809) was assumed to be 4.54 m, which lifts the gate out of the water. This maximum opening level was used only in the February 2004 flow event.
- Hydrological assumptions – there are some inflows in the model which are positioned close to their confluence with the Manawatū River, but which use gauge data from upstream of this location. It has been assumed that the time offsets and multiplication factors used to offset this are appropriate for this level of assessment.
  - It is assumed that using Ōroua Slackline data for the Ōroua inflows for the 2004 event is adequately representative on the basis that Kopane Bridge data was not available in 2004. This simplification was justified at this stage based on the comparison of the most recent large event February 2023 Cyclone Gabrielle – this showed the peaks at the two gauges to be reasonably close (480 m<sup>3</sup>/s at Slackline, 437 m<sup>3</sup>/s at Kopane Bridge). Future work should seek to analyse the relationship between the two gauges for the February 2004 event, should the need arise.
- The 1D sluice gates representing the Moutoa Gates indicate sensible flows through to the floodway. A sensitivity check was undertaken using HY-8 software – the modelled flows per gate were found to be similar when using the same headwater levels as the 1D TUFLOW gates. For extreme events such as the 2004 inflows when the gates were opened above the water surface at the event peak, gate flow was dictated by the weir equation. In these high-flow conditions, natural fluctuations of water levels upstream of the gates (associated with the dynamic hydraulics of the 'river – sluiceway – floodway' flowpath) were reflected in small oscillations in gate flows. The model results indicated that fluctuations of approximately 10-15 cm of water level could result in fluctuations of approximately 30-45 m<sup>3</sup>/s through the Moutoa Gates. This reality reflects the existing sensitivity of the 1D-2D-1D boundary conditions, which should be assessed in detail and refined in future iterations of modelling.
  - It is assumed that, without more detailed calibration or validation which is planned for later iterations of the model, these gate flows are sufficiently representative of sluiceway hydraulics for the purpose of this study.
- The data provided for this assessment (hydrology, LiDAR, surveys) is of sufficient quality for the purposes of this model for the assessment of impacts of closing the Moutoa Sluice Gates for maintenance in 2025.

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## 5.2 LIMITATIONS

The following limitations are relevant to this stage of the Moutoa Model build:

- Whole reach channel roughness – validation indicated that a Manning's  $n$  of 0.035 applied everywhere resulted in both a strong travel time response from Teacher's College to Moutoa Gates and a good match to water levels. However, using a single channel roughness for all watercourses ( $n = 0.035$ ) represented a catchment-scale approximation that was appropriate at this stage of the model development and validation.
- The model was limited to validation of 2 closed-gate events. Further validation would further increase confidence in the model.
- The hydrology is limited by assumptions made on inflow time delays and uplifts, for example Kahuterawa, Turitea and Mangaone Streams inflows. Future work could undertake a more detailed hydrological assessment to better approximate these, or expand the model to include inflows at their source locations.
- The channel terrain is limited to LiDAR for most of the model, with rectangular-equivalent depths implemented for two reaches upstream and downstream of Moutoa Gates, no specific channel survey was collected as part of this work.
- Stopbank crest levels were limited to LiDAR levels without survey. A quick check was undertaken on more recent survey data which showed a close match to the LiDAR levels within the short survey extent provided.
- Although flow through the Moutoa Gates indicated a sensible modelled representation of the structures, the flow and levels through Moutoa Gates were not calibrated explicitly against rating curves or recorded flood events. Future work should focus on validating and/or calibrating the Moutoa Gates versus historic events, finetuning key elements such as model grid alignment and cell size, 1D parametrisation and 1D-2D boundary setup.
- This assessment did not aim to replicate the 2004 flood event – it sought only to use the February 2004 inflows to be indicative of an event of similar magnitude to understand the impacts of a large event on possible flood extents under different gate operating scenarios during current gate maintenance operations.

---

## 5.3 CONCLUSIONS

The aim of this report was to understand the proposed impacts nearby to flood risk as a result of gate operation sensitivity testing of the Moutoa Gates during a large flow event, to reflect the potential impacts associated with reduced gate capacity during Moutoa upgrade works. The following conclusions (compared to the Baseline 9 gates fully operational scenario) can be made:

- Moutoa Gate Scenarios which had the smallest maximum gate opening (for example Scenario G) showed the greatest increase in flood extents on Floodplain South and Floodplain East. In these scenarios, there was reduced flooding on the Manawatū River left-

bank near Foxton as a result of overtopping the stopbanks upstream into Floodplain South and East. These scenarios also indicated the greatest floodplain depths.

- Moutoa Gate Scenarios which had the greatest maximum gate openings (for example Scenario F) showed the smallest increase in flood extents on Floodplain South and Floodplain East. These scenarios also indicated the lowest floodplain depths.
- Overall, the results indicated that the greater the restriction on overall gate capacity, the less volume of flow enters the Moutoa Floodway, therefore the greater the flood extent and depths from overtopping along the Manawatū River and stopbanks.

---

## 5.4 RECOMMENDATIONS

The following recommendations are made specifically in relation to the work to understand the sensitivity of the Lower Manawatū River to changes in Moutoa Gate capacity. More comprehensive recommendations on the wider Lower Manawatū model will be contained within the Lower Manawatū Model Project report.

- Further analysis should be undertaken to better understand total inflow contribution from tributaries whose gauges are further upstream than Manawatū confluence (e.g. Mangaone, Turitea, Kahutewara Streams)
- For future design purposes and further validation and calibration, it is recommended a hydrological frequency analysis is undertaken for the Lower Manawatū River and nearby watercourses.
- Further validation/calibration to travel times and calibration for more events, becoming more focussed on reach-specific roughness using photographs, site visits and HRC local knowledge
- Future work should focus on validating and/or calibrating the Moutoa Gates versus historic events, finetuning key elements such as model grid alignment and cell size, 1D parametrisation and 1D-2D boundary setup.
- Survey along stopbanks between Mile 24 and Mile 19.
- Survey of whole channel as bathymetric survey for reach from Foxton Beach to Teachers College
- Structure specifications and operating rules to be provided for:
  - Floodplain culverts
  - Bridges
  - Pumping stations
  - Floodgates
  - Drainage scheme elements (e.g. Sluggish Drain)
  - Urban features

## 6 LIMITATIONS

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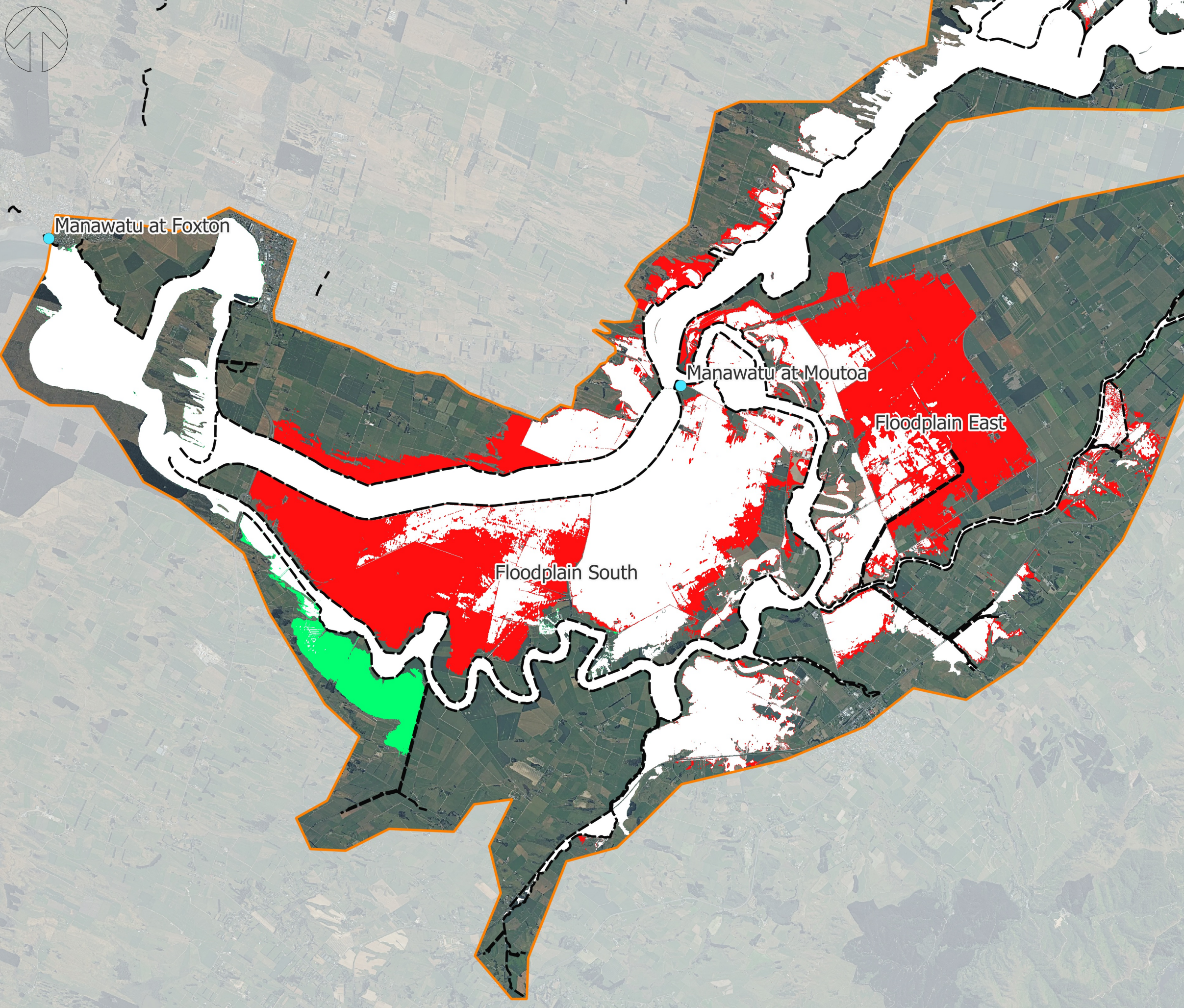
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# Appendix A

## Flood Extent Difference Maps



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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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003	19/05/2023	EH	Issued Draft Version 003	IF	RW
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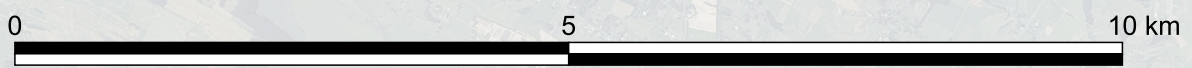


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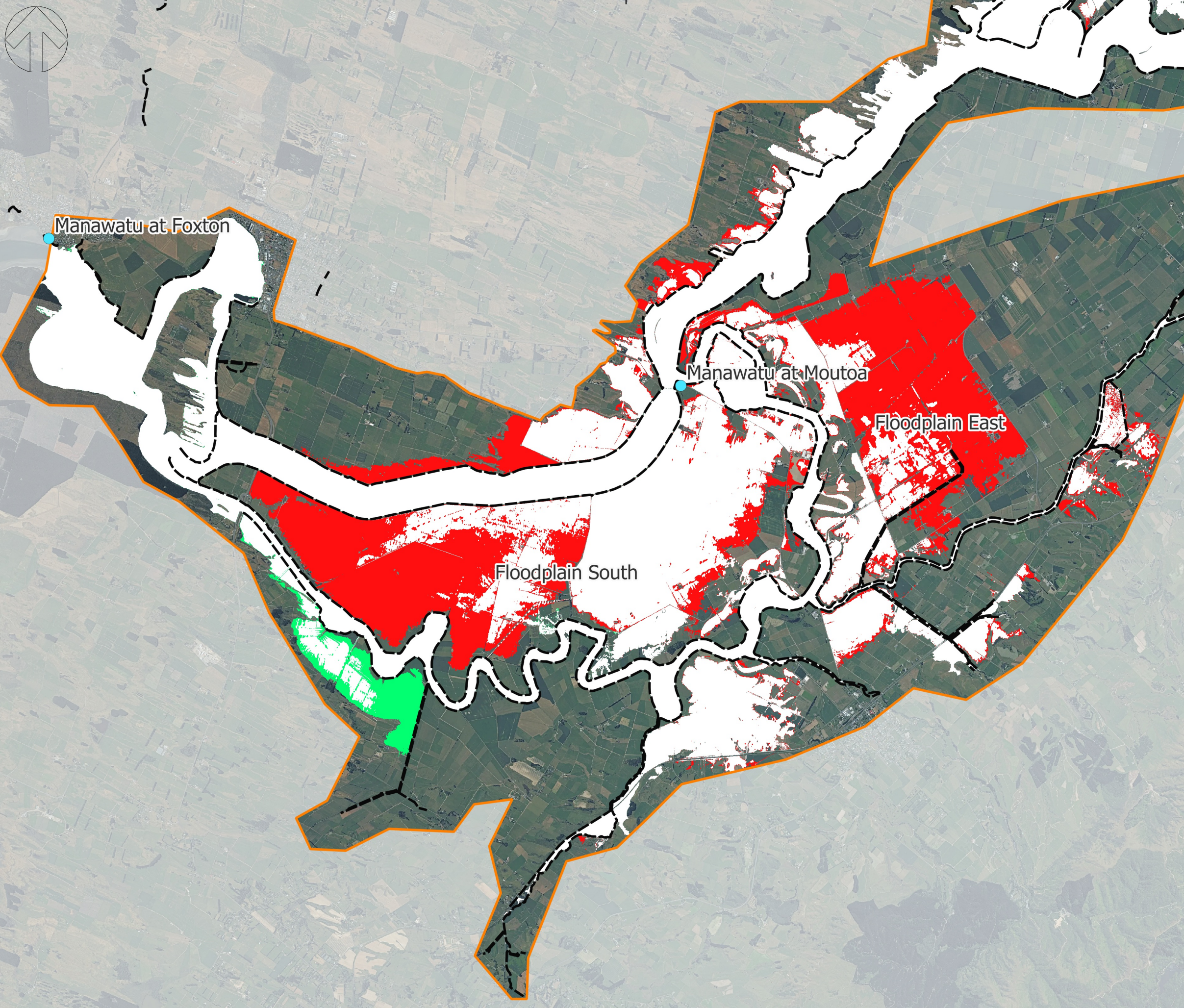
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February 2004 Inflows

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**Key:**

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- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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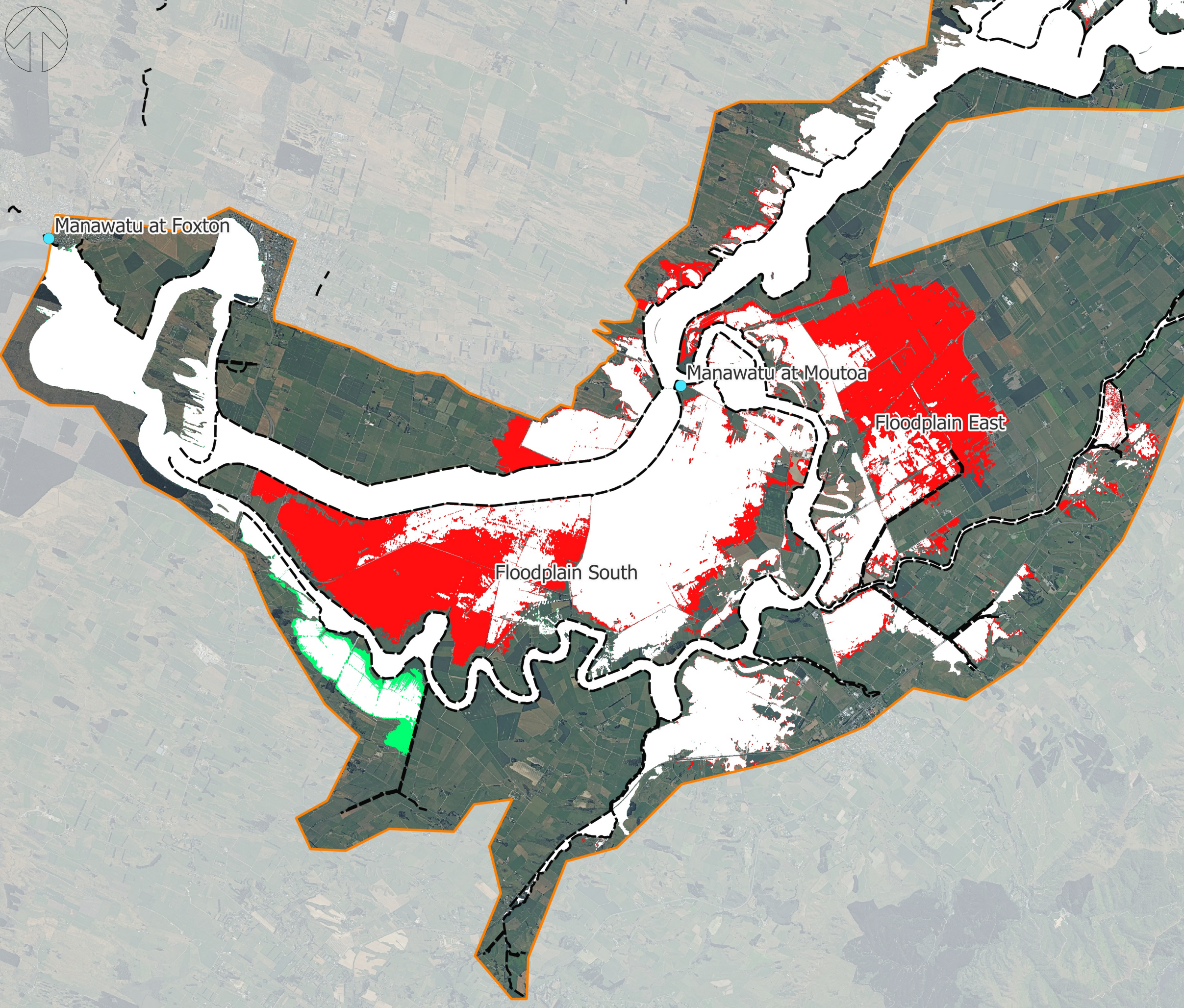
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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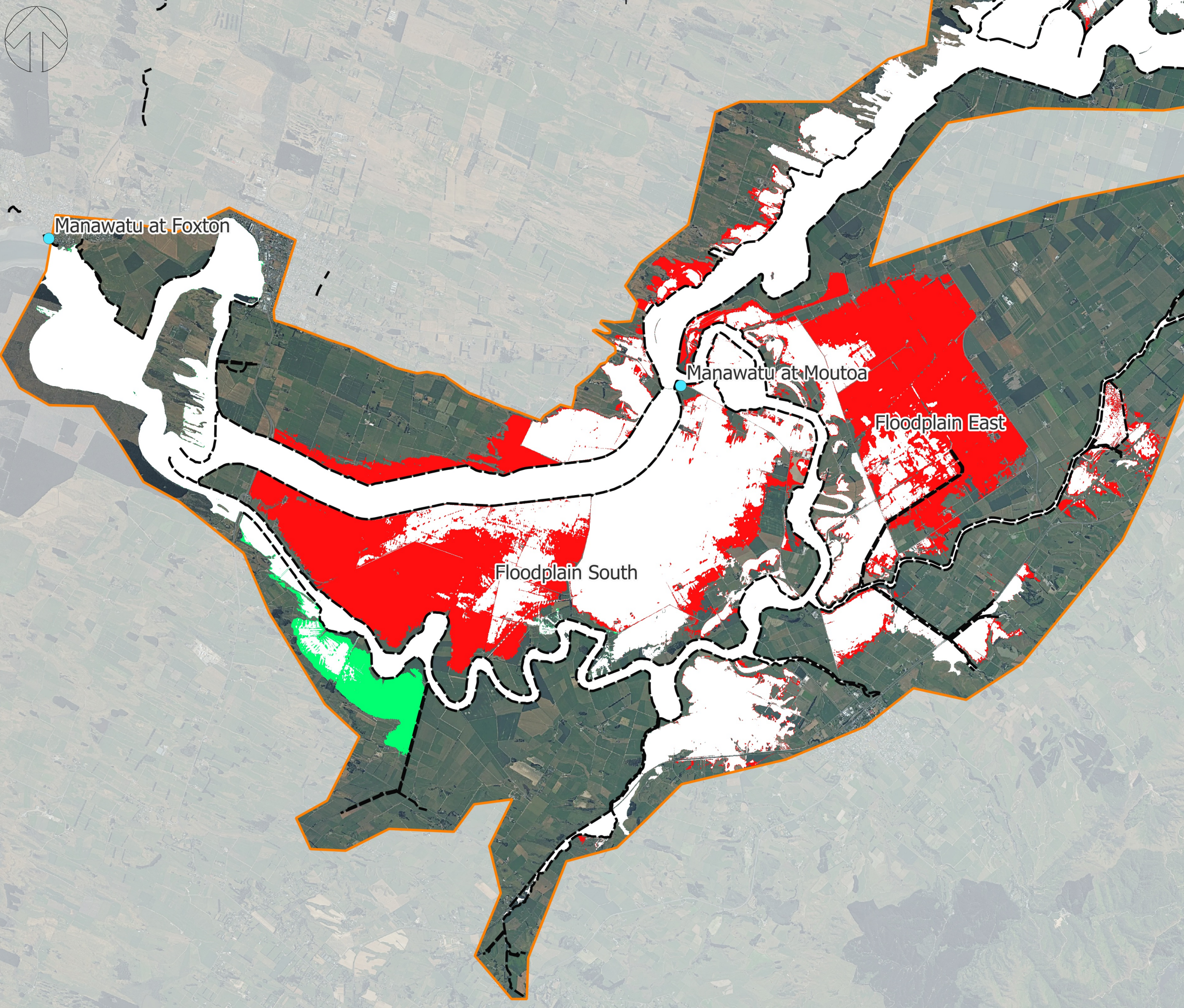
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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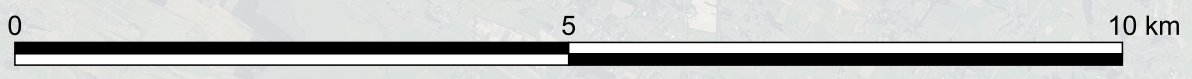


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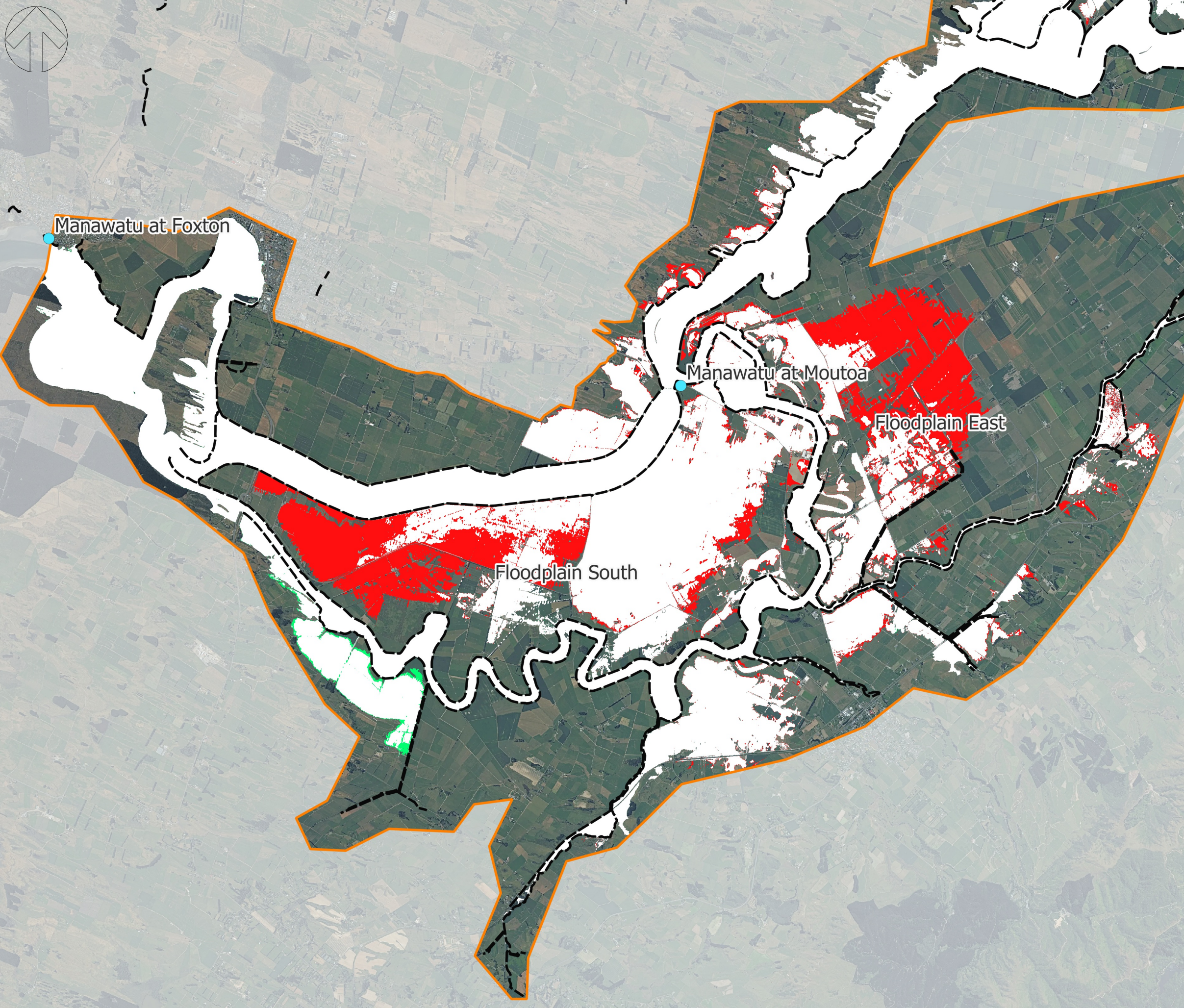
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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003	19/05/2023	EH	Issued Draft Version 003	IF	RW
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TITLE: Scenario E  
Change in Flood Extents from Baseline Scenario  
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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003	19/05/2023	EH	Issued Draft Version 003	IF	RW
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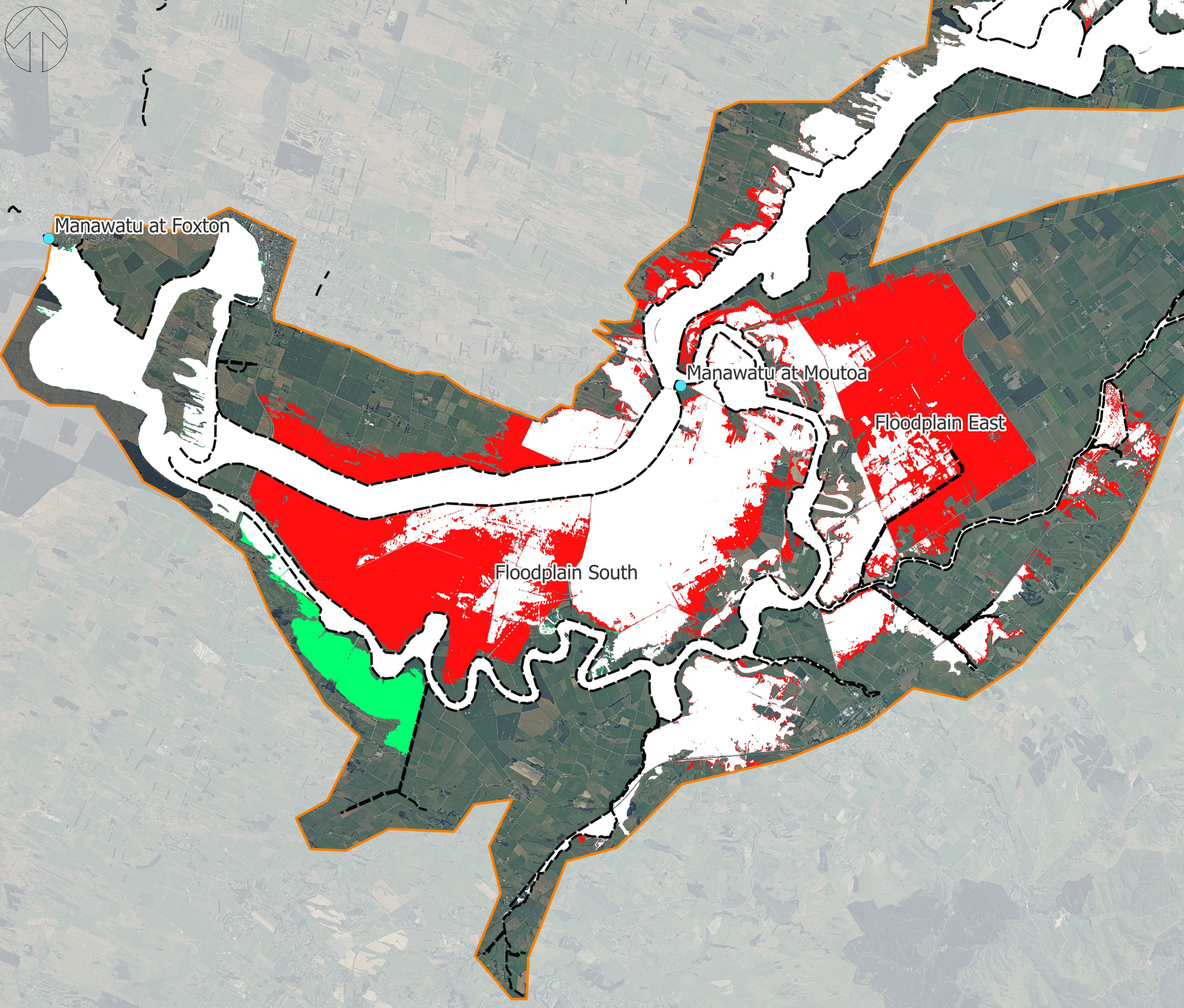
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

004	20/06/2025	EH	Accepted and Authorised	IF	RW
003	19/05/2023	EH	Issued Draft Version 003	IF	RW
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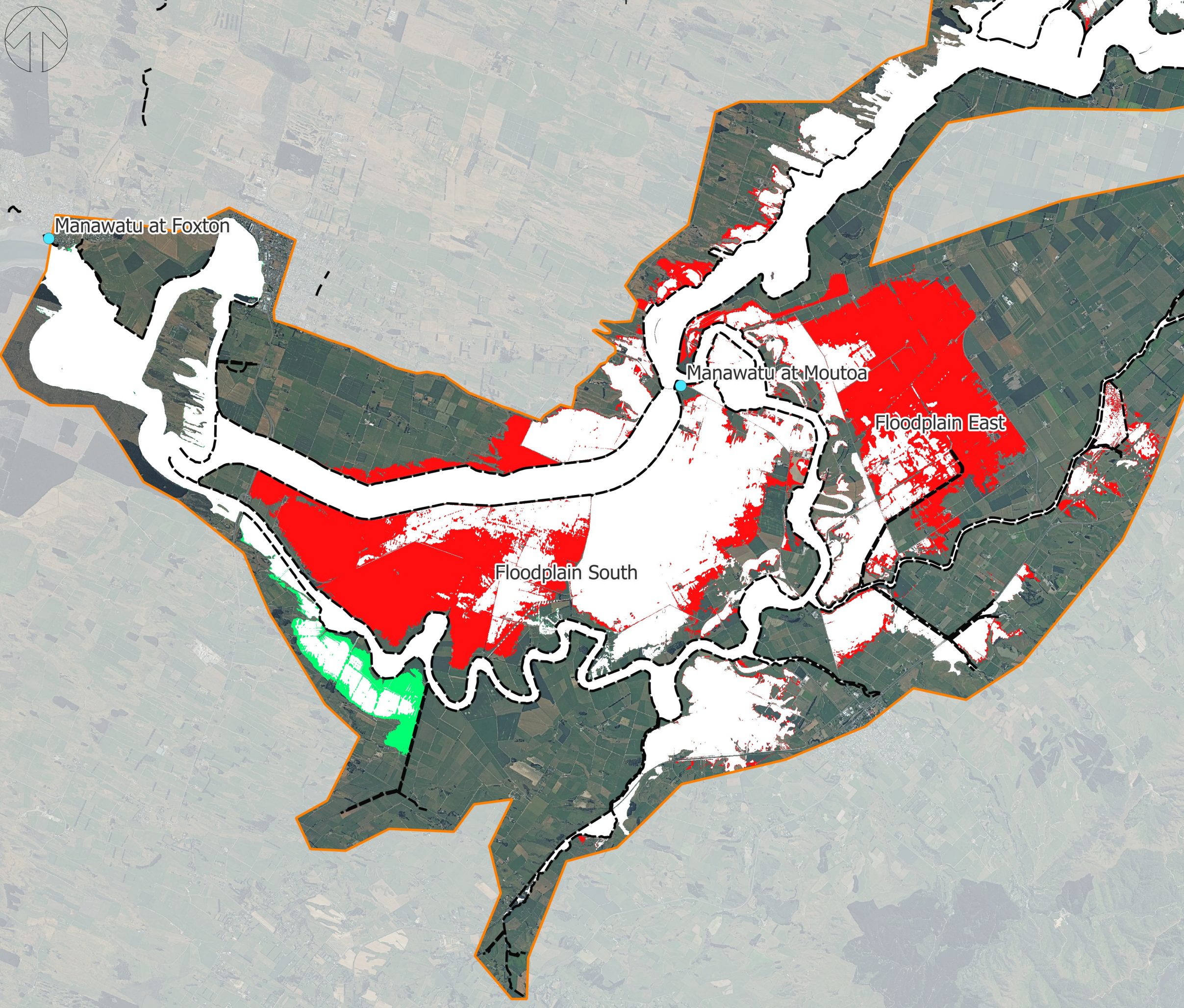
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Change To Flood Extent**

- Was Wet Now Dry
- No Change to Flood Extent
- Was Dry Now Wet

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003	19/05/2023	EH	Issued Draft Version 003	IF	RW
002	09/05/2025	EH	Issued Draft Version 002	IF	RW
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TITLE: Scenario H  
Change in Flood Extents from Baseline Scenario  
February 2004 Inflows

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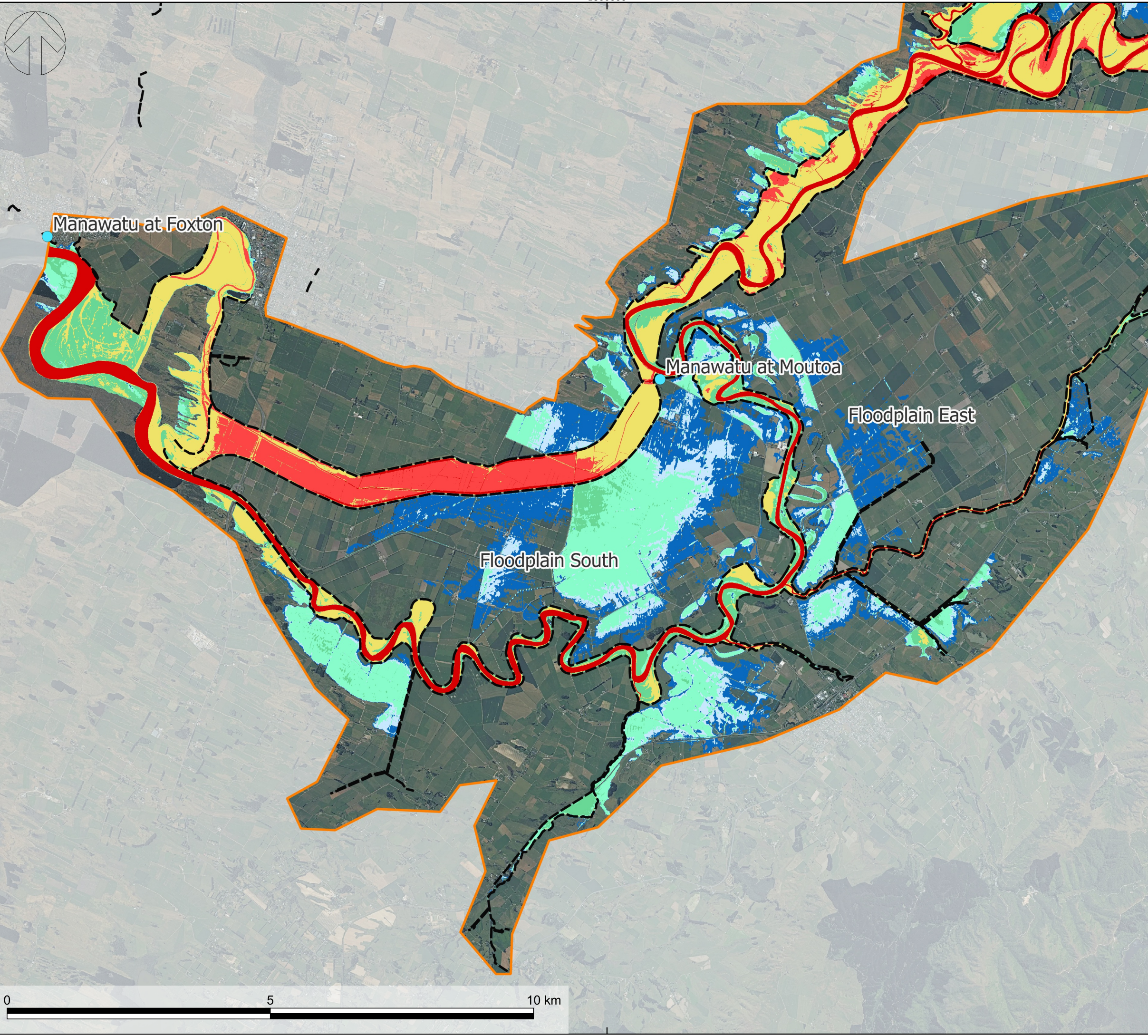
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# Appendix B

## Flood Depth Maps



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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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Appendix B**

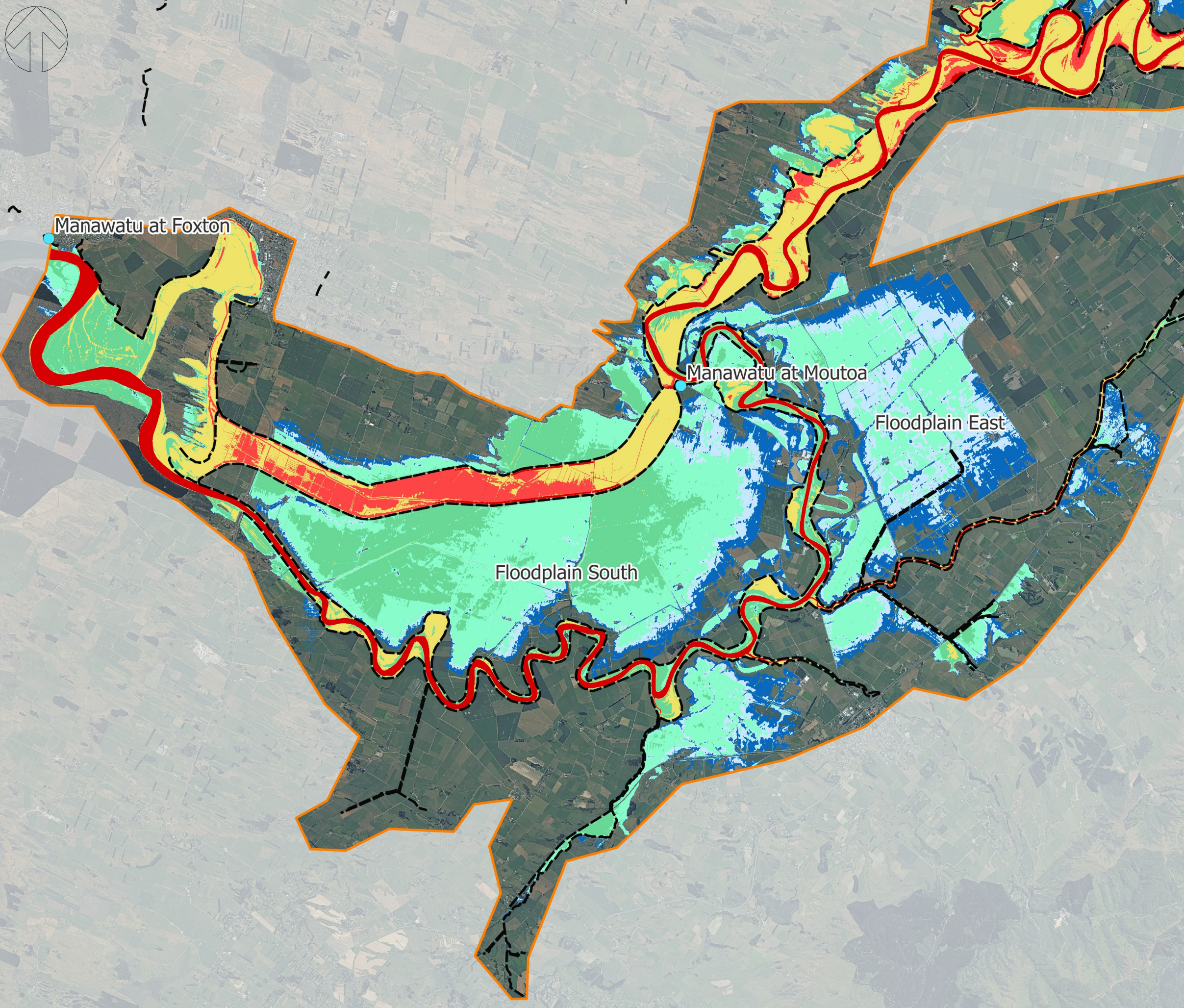
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February 2004 Inflows**

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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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002	19/05/2025	EH	Issued Draft Version 002	IF	RW
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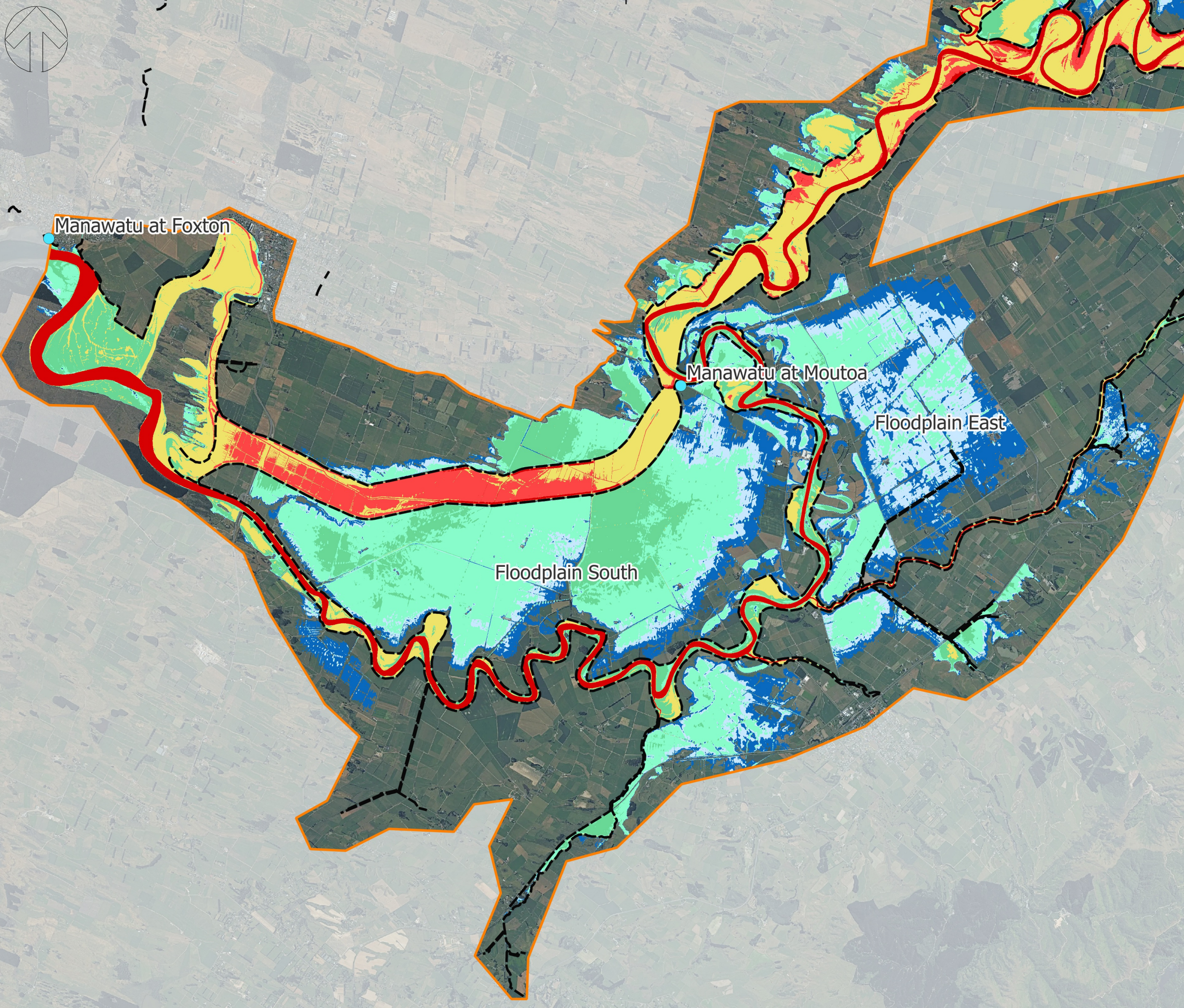
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DRAWING No: <b>1-E0118.00-DRW-0010</b>	REV: <b>003</b>
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**Key:**

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- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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REV	DATE	BY	DESCRIPTION	CHK	APP

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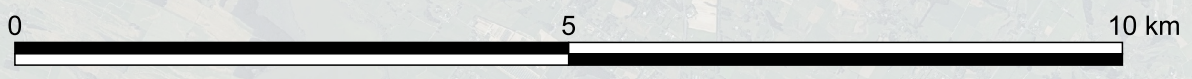
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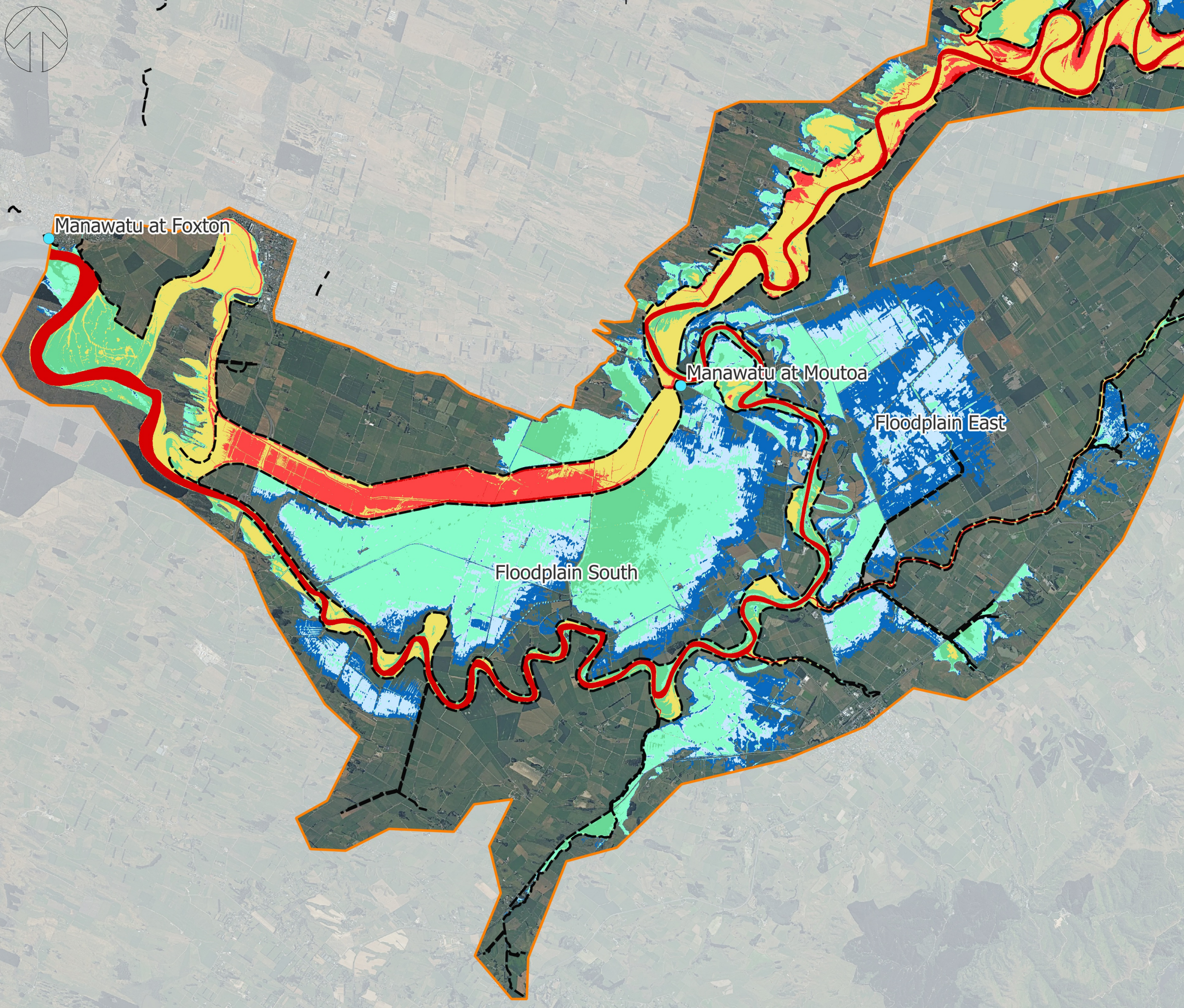
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

003	20/06/2025	EH	Authorised and Accepted	IF	RW
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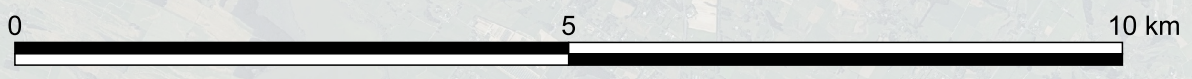


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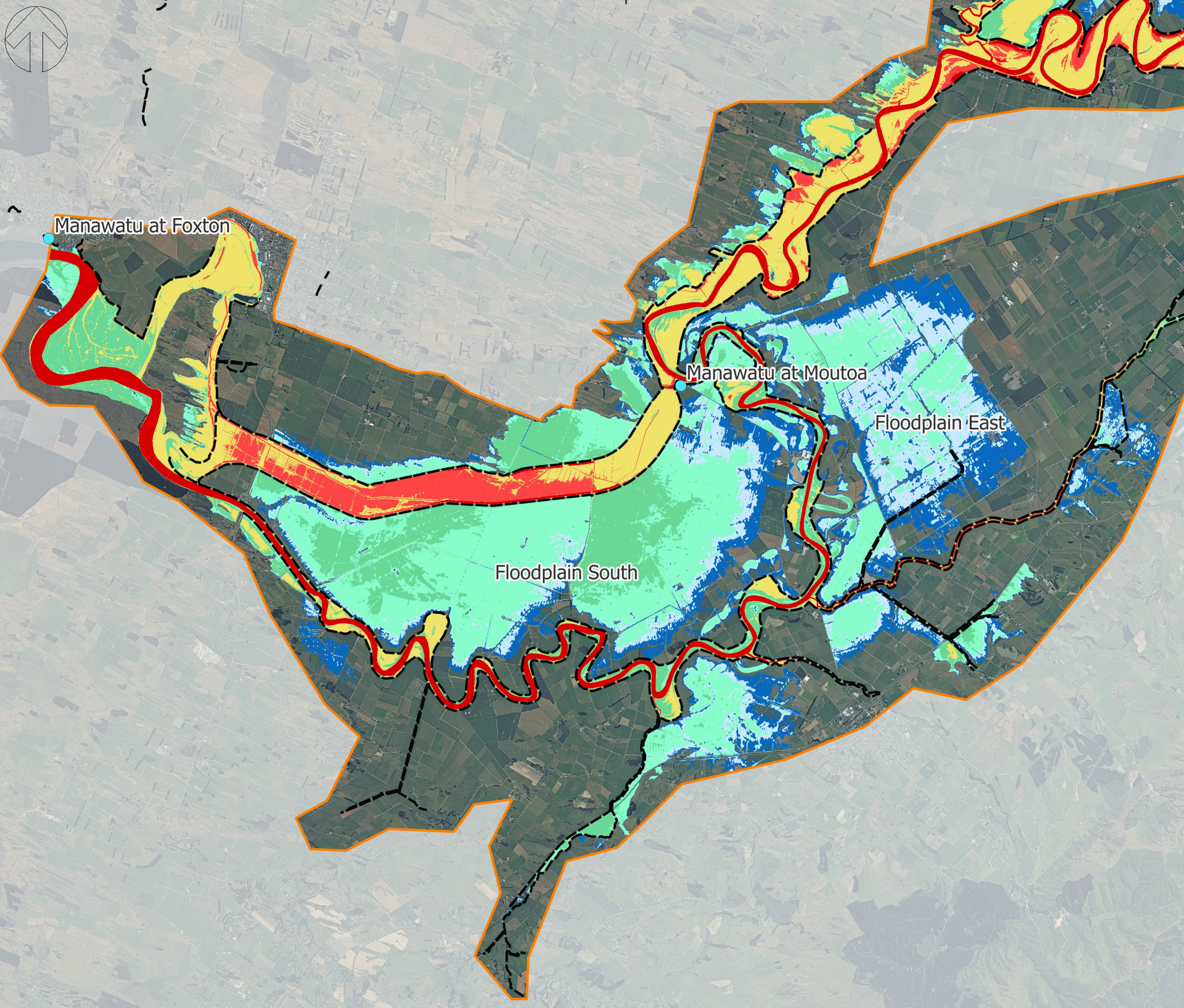
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DRAWING No: 1-E0118.00-DRW-0012	REV: 003
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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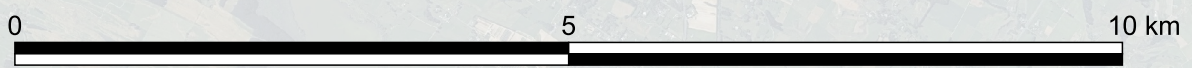
PROJECT:  
**Moutoa Gates Model  
Appendix B**

TITLE:  
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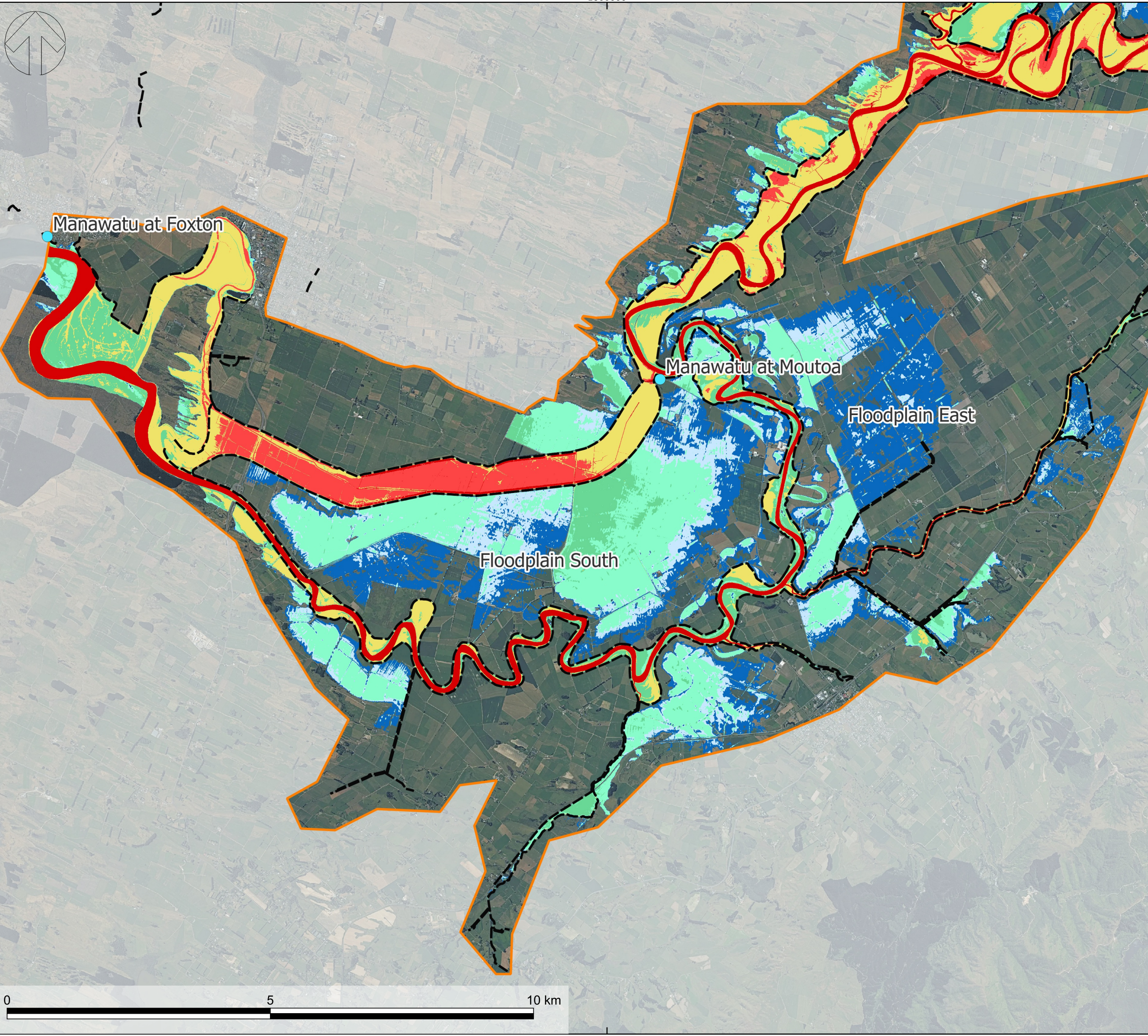
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DRAWING No: <b>1-E0118.00-DRW-0013</b>	REV: <b>003</b>
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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Appendix B**

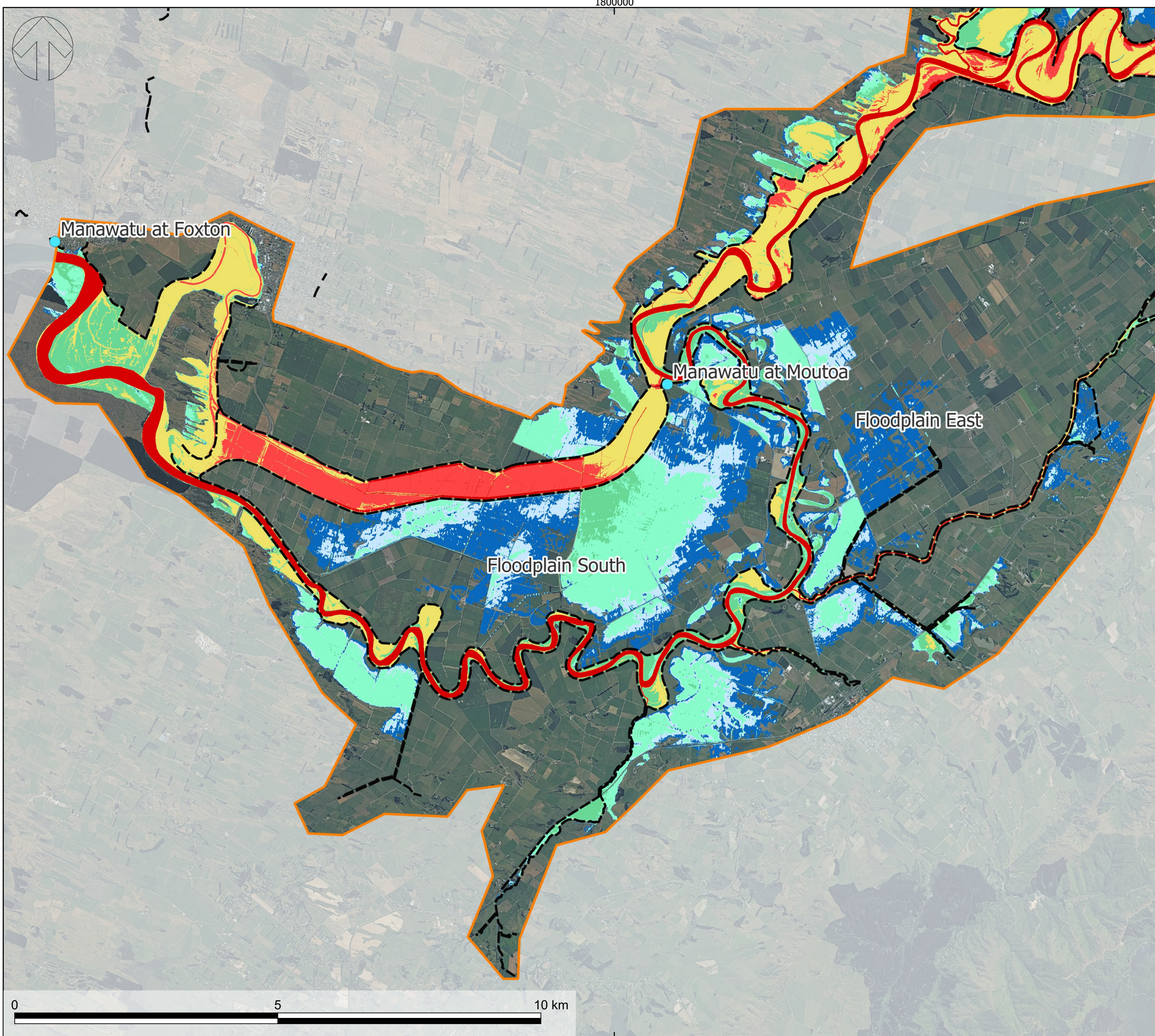
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DRAWING No: <b>1-E0118.00-DRW-0014</b>	REV: <b>003</b>
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**Key:**

- Model Outline
- Stopbanks
- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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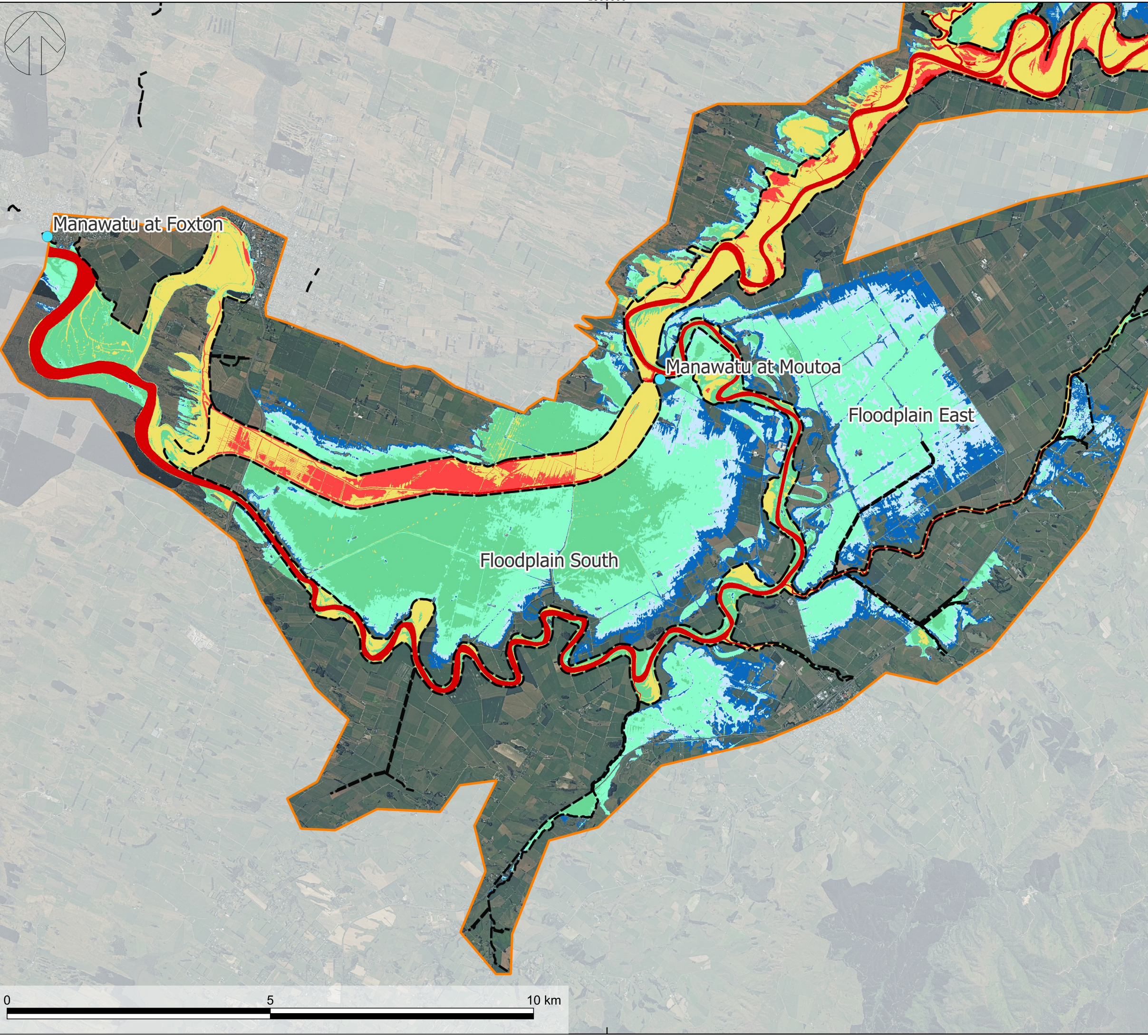
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- Selected Gauges

**Hazard + Flood Depth (m)**

- H1 <= 0.3
- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

003	20/06/2025	EH	Authorised and Accepted	IF	RW
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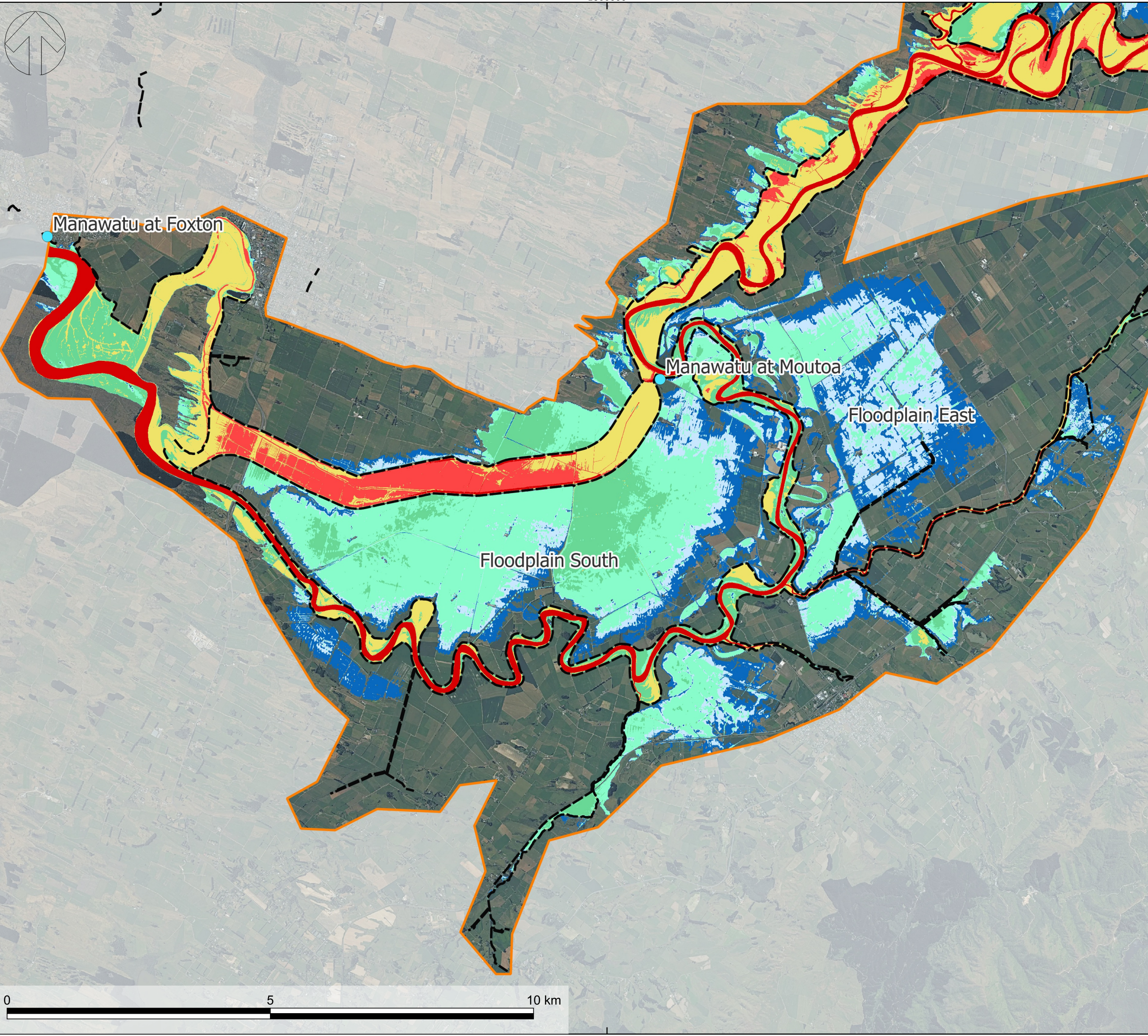
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- Selected Gauges

**Hazard + Flood Depth (m)**

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- H2 0.3 - 0.5
- H3 0.5 - 1.2
- H4 1.2 - 2.0
- H5 2.0 - 4.0
- H6 4.0 - 5.0
- H6+ > 5.0

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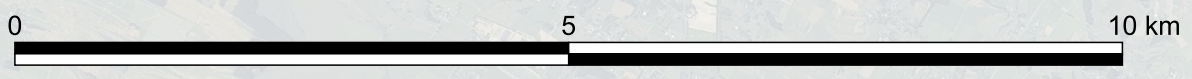
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DRAWING No: <b>1-E0118.00-DRW-0017</b>	REV: <b>003</b>
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# Appendix C

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GIS file migration\20260127\_Task 6\_Moutoa Overtopping Locations



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