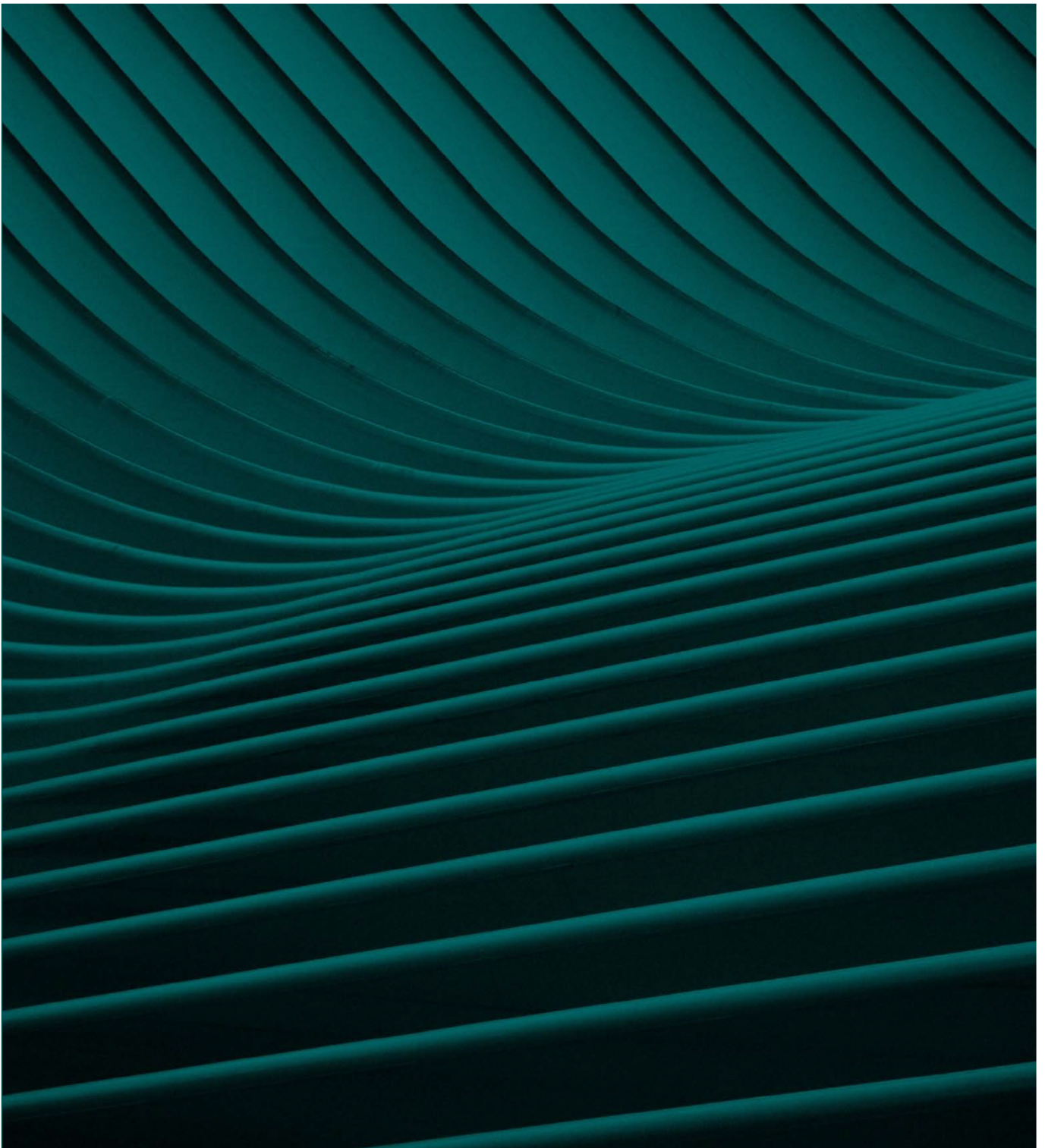


Bendigo Ophir Gold Project

Freshwater Ecology Management and Monitoring Plan
Prepared for Matakanui Gold Limited

23 October 2025





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For any information regarding this report please contact:

[Name] | [Discipline] | [Professional Level] | info@boffamiskell.co.nz

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CONTENTS

1.0	Introduction	1
1.1	Background	1
1.2	Objective	1
1.3	Purpose	1
1.4	Information sources	2
2.0	Responsibilities and Competencies	2
2.1	Purpose	2
2.2	Responsibilities	3
3.0	Existing Ecological Values	3
3.1	Overview	3
3.2	Shepherds Creek	3
3.3	Rise and Shine Creek	4
4.0	Stream Diversions as Effects Management	4
5.0	Design of Stream Diversion	6
5.1	Diversion design principles	6
5.2	Diversion design guidelines	7
5.3	Construction Principles	8
6.0	Post-Construction Monitoring	11
6.1	Overview	11
6.2	Monitoring parameters	11
6.3	Frequency of monitoring	11
6.4	Riparian Planting Monitoring	12
6.5	Indicative Performance Targets	12
6.6	Reporting	12
7.0	References	13

Appendices

Appendix 1: Shepherd Creek Rehabilitation Plan (Growplan 2025)

1.0 Introduction

1.1 Background

Matakanui Gold Limited ("MGL") is seeking approvals for the Bendigo-Ophir Gold Project ("BOGP"), a new gold mine, ancillary facilities and environmental mitigation measures on Bendigo and Ardgour Stations in the Dunstan Mountains of Central Otago. The project site is located approximately 20 km north of Cromwell.

The BOGP is located within the footprint of Minerals Exploration Permit 60311, which overlays several pastoral stations that have grazed sheep and cattle in the area for over 100 years. MEP60311 is held by MGL under the Crown Minerals Act 1991. MGL has land access agreements with Bendigo and Ardgour Stations. The BOGP is located adjacent to land administered by the Department of Conservation ("DOC"), including the Bendigo Historic Reserve, the Bendigo Conservation Area and the Ardgour Conservation Area. BOGP mineral extraction activities will not occur in these areas.

Ecological work will include rehabilitation on direct disturbed areas, ecological uplift activities and pest exclusion area(s) adjacent to the footprint on nearby areas such as Ardgour and Bendigo Stations. A full description of the various activities comprising the establishment, operation and rehabilitation within the BOGP is provided in the Assessment of Environmental Effects prepared by Mitchell Daysh Limited.

To manage effects on freshwater values the BOGP will divert watercourses to divert clean water from disturbed areas. This plan sets out the purpose, principles, design and monitoring of the diversion channels.

1.2 Objective

The objective of the Freshwater Ecology Management and Monitoring Plan (FEMMP) is to provide details for the design and development of ecologically functional diversion channels as remedy for the loss of watercourses from the construction and operation of the BOGP.

1.3 Purpose

This management and monitoring plan is proposed for the construction and operation of the stream diversions. The purpose of the management and monitoring is to set out:

- Responsibilities and competencies.
- Protocol for effects minimisation.
- Diversion design principles.
- Diversion design.
- Monitoring.
- Reporting.

1.4 Information sources

This plan draws on the existing information set out in:

- Bendigo Ophir Gold Project: Assessment of Effects on Aquatic Habitat. Report prepared by Water Ways Consulting, June 2025.
- Bendigo Ophir Gold Project: Assessment of Freshwater Ecology Effects. Report prepared by Boffa Miskell, October 2025.

2.0 Responsibilities and Competencies

2.1 Purpose

The Environment Manager holds overall accountability for implementation of and compliance with all ecology management plans (including this freshwater plan) (Figure 1). Additional roles and responsibilities are detailed where relevant in the various individual plans. The Project Ecologist has specific responsibilities for the freshwater plan as set out below

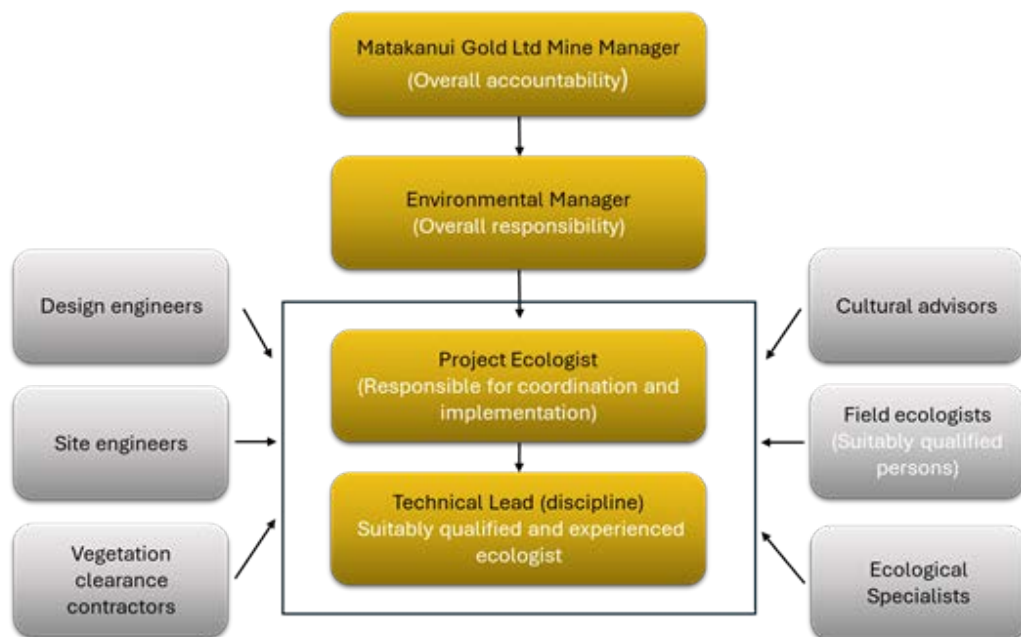


Figure 1. Overview of roles and responsibilities for the environment management at BOGP.

2.2 Responsibilities

The responsibilities of the Project Ecologist are:

- Confirming and approving the FEMMP.
- Briefing contractors on the purpose and content of the FEMMP.
- Undertaking or contracting visual inspections and monitoring
- FEMMP reporting

3.0 Existing Ecological Values

3.1 Overview

In their assessment of effects, Water Ways (2025) characterised each of the watercourses and their catchments, in particular Shepherds Creek and Rise and Shine Creek. In general, the study found that the ecological value of the Shepherds and Rise and Shine Creeks and associated tributaries varied from moderate-to-high in the upper reaches to moderate-to-low in the lower reaches. It is not our intention to repeat the findings here, but we summarise the ecological values below.

3.2 Shepherds Creek

The presence of the Ardgour Conservation Area in the headwaters provides a clean water supply to the stream and there is a low level of nitrogen increase in the farmed perennial reach of Shepherds Creek indicating that stock impacts are more limited to physical damage than to declines in water quality.

Shepherds Creek has several tributaries that, aside from Jean Creek, can be divided into two groups: the perennial flowing spring fed streams and the ephemeral streams that have very short duration flow periods. Shepherds Creek is considered representative of a low gradient Dunstan Mountains perennial small stream. This assessment indicates that Shepherds Creek can be divided into reaches:

- The upper reaches of Shepherd Creek: moderate to high ecological value. From the Ardgour Conservation Area boundary to at least the downstream gorge section in the middle of the project area. This reach has good water quality, low to moderate habitat diversity and no introduced aquatic species.
- Downstream of the gorge section: moderate ecological value. Habitat modification increases with various impacts including water abstraction, channel modifications (e.g., the dam), crack willow, and stock impacts are evident.

Water Ways (2025) report that most of the main stem of Shepherds Creek is a gentle gradient single channel stream 0.5 - 1.0 m wide flowing along a 10 - 100 m wide valley floor.

3.3 Rise and Shine Creek

Water Ways (2025) report that the Rise and Shine Creek catchment has a range of ephemeral, intermittent and perennial streams that support a fauna of high to low ecological value:

- The stream draining Mt Moka in the upper Rise and Shine catchment is considered a high-quality habitat area, aside from the lower 200 m where historic and present modifications occur.
- Rise and Shine Creek downstream of the Mt Moka Stream confluence is a perennial stream and is considered to have low to moderate ecological value.
- Rise and Shine Creek and its tributaries upstream of the Mt Moka Stream confluence are intermittent and ephemeral water courses.

Water Ways (2025) report that none of the stream channels are large with a maximum width of 0.5 m and most less than 0.3 m wide.

4.0 Stream Diversions as Effects Management

The assessment of effects of the BOGP on aquatic ecological values is set out in Waterways (2025) and the aquatic effects management in Boffa Miskell (2025). The outcome of the effects management is set out in Table 1. The main outcome is the development of ecologically functional diversions of the watercourses.

Boffa Miskell (2025) confirms that the functional need of the proposed BOGP activities means that the loss of watercourses is unavoidable. Although loss will be minimised as much as possible, the proposed mine activities will result in the loss of **7,139 m of permanent stream** length whilst **1,631 m of intermittent stream** length will be modified in Shepherd Creek.

Effects management provides **remedy of 9,558 m (9,558 m² of stream area) of created permanent watercourse** through rehabilitation of the proposed diversion of Shepherd Creek, including the reinstated stream across the surface of the TSF at closure. A further 1,196 m length (~957 m² of stream area) of Shepherds Creek will be enhanced to improve aquatic ecological values. This amounts to a total enhancement of **10,754 m of stream length (~10,515 m² of stream area)** of stream values.

Estimates of stream loss and modification in Rise and Shine Creek suggest that some 1,483 m length of stream (~741.5 m²) will be lost and approximately **1,600 m of stream length (800 m² of stream area) will be created** within the catchment, and the equivalent will apply for enhancement of aquatic ecological values.

Table 1: Effects management hierarchy applied to freshwater values for the BOGP.

Effects management		
	Shepherd Creek	Rise and Shine Creek
Ecological values	Moderate to high	Low to moderate
Avoid	Options to locate the project elsewhere are not available due to the location of the gold resource. Unavoidable reclamation of some 7,799 m of perennial and intermittent stream length. This equates to approximately 7,000 m ² of stream area.	Options to locate the project elsewhere are not available due to the location of the gold resource. Unavoidable reclamation of some 1,483 m of perennial stream length (741.5 m ²) and no loss of intermittent stream. Temporary diversion of some 880 m (440 m ²) of perennial Mt. Mocha stream is unavoidable. This amounts to a total of approximately 1,181 m ² of stream area.
Minimise	Diversions to capture water from ephemeral watercourses and transfer it back into the creeks.	Diversions to capture water and transfer it back into the creeks.
Remedy	Creation of some 7,643 m rehabilitated stream diversion (7,643 m ²). Diversion channel to be created in year 1 ahead or at same time as the reclamation of Shepherds Creek. Rehabilitation of 1,196 m of Shepherds Creek retained in existing bed above gorge. Reinstatement of some 1,915 m of stream on surface of TSF at mine closure.	At the completion of mining the temporary diversion of 880 m of the Mt. Mocha Creek line will be remedied and rehabilitated, and with other diversion design requirements leads to creation of some 1,599 m (800 m ²) of stream. Remediation of the connected flow between the SRX pit and SRX ELF.
Offset	Principles of offset cannot be fully satisfied due to lag time from full loss to full gain in values.	Principles of offset cannot be fully satisfied due to lag time from full loss to full gain in values.
Compensation	Additional compensation is proposed in the form of management of existing willows and transformation to native riparian vegetation over some 6,700 m of Bendigo and Clearwater Creeks (Willow concession area). Compensation completes the effects management by providing for the lag time to achieve ecological values.	

5.0 Design of Stream Diversion

5.1 Diversion design principles

The following high-level principles of design will be applied to the permanent and temporary diversion of the affected parts of Shepherds Creek and Rise and Shine Creek (as set out in Boffa Miskell 2025):

- As much as practicable, the diversion should be designed with an average width of no less than 0.8 m, and preferably 1 m for Shepherds Creek, and no less than 0.5 m for Rise and Shine Creek.
- As much as possible, the stream diversion channel must be a similar length and stream area than the channel to be reclaimed. This aims to ensure that there is no loss of extent and values of the watercourse.
- The channel design does not have to replicate the form of the channel to be reclaimed but would benefit from a low-flow (or baseflow) channel, a bank full channel and where available, a floodplain area.
- As much as possible, water flow should mimic the hydrology of the existing watercourse (i.e., flows intermittently or permanently same as existing channel).
- The channel should mimic, as much as practicable, the natural meanders of the stream to be reclaimed.
- Hydrologic heterogeneity and instream habitat complexity can be achieved through the creation of natural features such as runs, riffles and small and large pools.

In addition, we recommend the following:

- As far as is reasonably practicable, the habitat within the diversion is of a similar form and structure to the stream to be reclaimed (and like neighbouring tributaries). The final substrate present should mimic that naturally occurring in similar sized tributaries in the wider catchment to the extent that this is practicable.
- The stream profile should allow the planting of riparian vegetation close to and extending over and into the water surface at the margins to create ample stream edge habitat. This can be low stature planting that provides vegetation overhang over and into the watercourse and to enhance habitat for the aquatic ecosystem.
- To the extent practicable, riparian vegetation is to be planted along the length of the stream diversion. Riparian vegetation plays an important role in the ecological success of a stream diversion. Appropriate riparian species selection will enhance stream ecology through providing shade to the stream, reducing water temperature, producing habitat and providing a food source. As much as possible, riparian vegetation should extend along either side of the diversion channel.

When implemented the recommended principles and actions will provide acceptable remediation for the loss of the extent and values of Shepherds Creek and Rise and Shine Creek.

5.2 Diversion design guidelines

5.2.1 Overview

The design of the stream diversion must be fit for purpose and ensure that stream ecological functions are maintained or improved on. The diversion channels must provide appropriate aquatic habitat for macroinvertebrates and plants, while conveying water. The below are a guideline for the design and construction of the diversion.

5.2.2 Channel length and meander

The stream diversion channel must be the same length, or longer, than the channel to be reclaimed to ensure no loss of stream length (stream extent). The channel should mimic and improve upon, as far as practicable, the natural meanders of the stream to be reclaimed. Where possible, the addition of boulders, submerged logs, etc. will be used to aid meander development and increase flow heterogeneity.

5.2.3 Habitat diversity and channel complexity

Hydrologic heterogeneity and instream habitat complexity can be improved through the creation of natural features such as runs, riffles and small and large pools. These features can be created utilising natural substrates such as rocks, logs and large boulders. Gravels, cobbles and boulders should be used to increase stream heterogeneity and stability.

These should be consistent with the habitat present in the stream to be reclaimed and similar to neighbouring natural tributaries. The final substrate present should mimic that naturally occurring in similar sized tributaries in the wider catchment. The channel complexity and availability will 'naturalise' over time as the new diversion channel becomes established.

We recommend the inclusion of a shallow low flow channel in the initial channel design. The purpose of a low flow channel is to provide flow when climate conditions typically result in dry conditions. The low flow channel extends the period of habitat availability should dry conditions persist.

5.2.4 Stream depth, wetted width and velocity

Stream depth and wetted width affect the total area of habitat that can be utilised by aquatic biota, and the volume of water conveyed during normal flows. Stream width, depth and should mimic that of the channel to be reclaimed. With the design seeking to create a stream that meets an average depth and width, with some localised variation for the creation of large and small pools and meanders. These depths and widths shall be established at the detailed design stage.

As much as practicable, the channel design must create a low flow or baseflow channel, a bank full channel and a floodplain area. The low flow must connect to the seasonal groundwater flow to ensure water flow mimics that of the existing stream (i.e., permanently same as existing channel).

The designed channel should be an average width of no less than 0.8 m, and preferably 1 m for Shepherds Creek, and no less than 0.5 m for Rise and Shine Creek.

5.2.5 Fish Passage

Fish have not been detected as present in the Upper Shepherds Creek or the Rise and Shine Creek and there are several barriers to fish passage upstream and downstream in both Creeks. No provision for fish passage is required.

5.2.6 Riparian Vegetation

Riparian vegetation is to be planted along the length of the stream diversion. Riparian vegetation plays an important role in the ecological success of a stream diversion. Appropriate riparian species selection will enhance stream ecology through providing shade to the stream, reducing water temperature, providing habitat and a food source. Riparian vegetation should mimic the local vegetation and be appropriate for the local bioclimatic conditions.

The stream profile should allow the planting of riparian vegetation close to and extending over the water surface to create ample stream edge habitat. This will provide shading to the water surface, detritus in the form of fallen leaves and potential habitat for macroinvertebrate species.

5.2.7 Key features of the diversion rehabilitation

The key features of the diversion rehabilitation are outlined below and in Table 2:

- Drop structures and/or weirs designed to create series of stream pools and habitat diversity.
- Tree trunks embedded in the stream to provide flow complexity and habitat diversity.
- Mixed substrate diversity (occasional large boulders along with large, moderate and small sized gravels).
- Bund or swale alongside road edge to prevent road silt and materials entering the diversion channel.
- Transplant of plants from Shepherds Creek to diversion channel via holding area.
- Engineered structures may be necessary in more complex or steeper reaches.

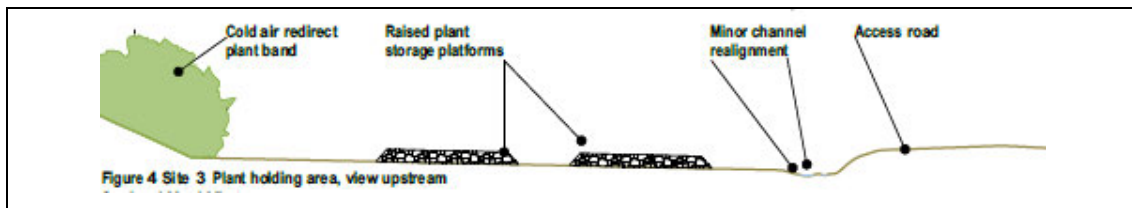
Access for maintenance and other purposes is required alongside the diversion. Example and indicative cross-sections of the proposed landscape diversion channel are shown in Figure 2 and drawn from the rehabilitation plan provided in Appendix 1.

5.3 Construction Principles

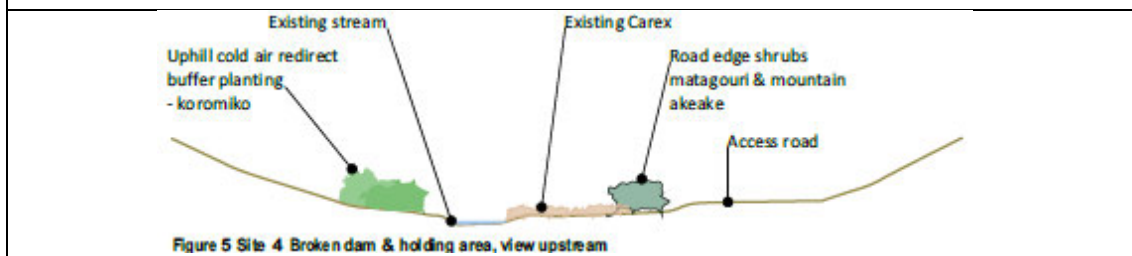
- As much as practicable, the stream diversion channel should be constructed offline and prior to any instream works within the channel to be reclaimed.
- During construction, and at completion of the diversion channel, it should be inspected by a Freshwater Ecologist to ensure ecological principals have been integrated.

Table 2: Key features of the Shepherds Creek and Rise and Shine Creek diversions and applied to Diversion principles.

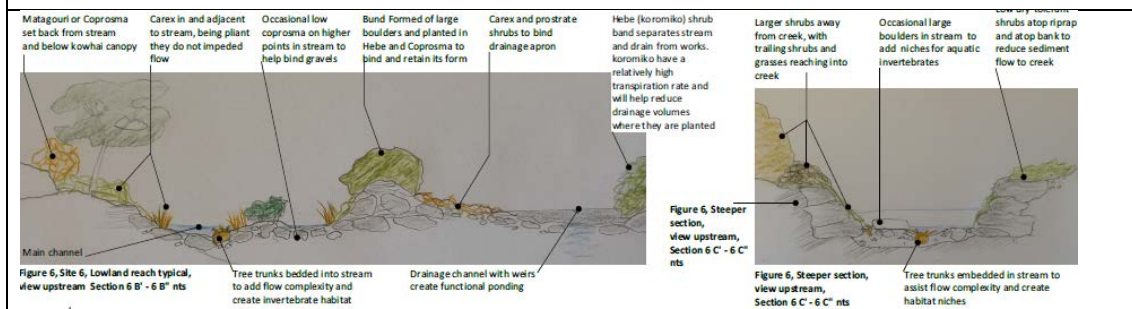
Diversion Principle	Shepherds Creek	Rise and Shine Creek
• To the extent practicable, the diversion should be designed with an average width of no less than 0.5 m, and preferably 1 m.	The diversion is expected to be formed with an average width of no less than 0.8 m, and preferably 1 m.	The diversion is expected to be formed with an average width of no less than 0.5 m, and preferably 1 m.
• To the extent practicable, the steam diversion channel must be a similar length and stream area than the channel to be reclaimed. This aims to ensure that there is no loss of extent and values of the watercourse.	The steam diversion channel length and stream area of the diversion does not meet the equivalent of loss and compensation is proposed.	The steam diversion channel length and stream area of the diversion does not meet the equivalent of loss and compensation is proposed.
• The channel design does not have to replicate the form of the channel to be reclaimed but would benefit from a low flow (or baseflow) channel, a bank full channel and where available, a floodplain area.	The proposed design features a low flow (or baseflow) channel, a bank full channel and where available, a floodplain area.	The proposed design features a low flow (or baseflow) channel, a bank full channel and where available, a floodplain area.
• To the extent practicable, water flow should mimic the hydrology of the existing watercourse (i.e., flows intermittently or permanently same as existing channel).	Hydrological conditions of the diversion channel are expected to mimic the hydrology of the existing watercourse, or features will be designed to accommodate modified hydrology.	Hydrological conditions of the diversion channel are expected to mimic the hydrology of the existing watercourse, or features will be designed to accommodate modified hydrology.
• The channel should mimic, as much as practicable, the natural meanders of the stream to be reclaimed.	The diversion channel will mimic natural stream character to the extent it is practicable.	The diversion channel will mimic natural stream character to the extent it is practicable.
• Hydrologic heterogeneity and instream habitat complexity can be achieved through the creation of natural features such as runs, riffles and small and large pools.	The diversion channel will mimic natural stream character.	The diversion channel will mimic natural stream character.



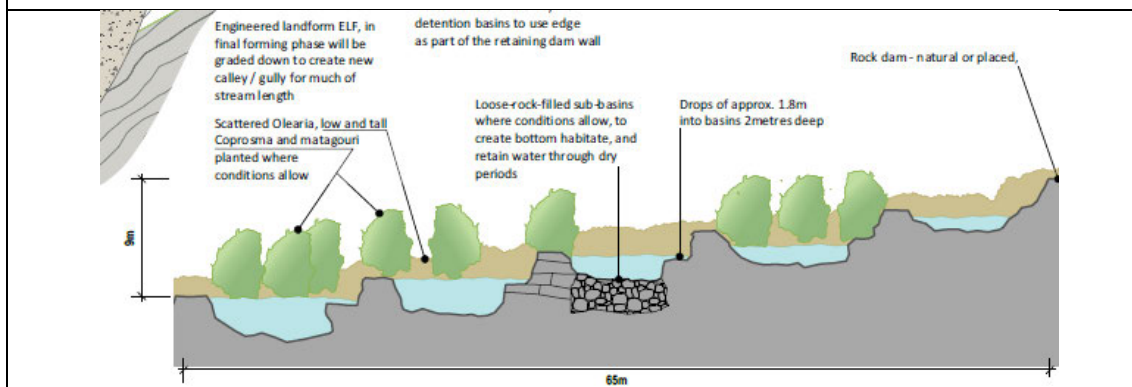
a) Plant holding area



b) Broken Dam and holding area



c) Indicative lowland and steeper sections



d) Drop series

Figure 2: Indicative cross-sections of the proposed rehabilitated Shepherds Creek diversion (from Growplan, Appendix 1).

6.0 Post-Construction Monitoring

6.1 Overview

Immediately following the livening of the diversion channel and inspection should be undertaken by a suitably qualified Freshwater Ecologist. It should ensure that the diversion channel is operating as intended.

To measure the overall success of the diversion channel ongoing monitoring is required. The success is to be measured using habitat and macroinvertebrate community composition metrics. These are detailed below.

6.2 Monitoring parameters

The following monitoring parameters and methods will be undertaken as set out in Table 3.

Table 3. Proposed monitoring parameters and methods, BOGP.

Monitoring attribute	Method	Metrics	Protocol (where appropriate)
Habitat	Rapid Habitat Assessment (RHA)	HQS	Clapcott et al. (2020)
Settled sediment	In-stream visual estimate of % sediment cover	Fine sediment cover (%)	Sediment Assessment Method 2 (Clapcott et al. 2011)
Algal cover	Periphyton cover (%)	• No algae • (bare substrate) • Films • Mats, • Filaments.	National Environmental Monitoring Standards for Periphyton (NEMS 2022a)
Macroinvertebrates	Benthic macroinvertebrates	• Taxa number • MCI, • EPT, • %EPT	National Environmental Monitoring Standards for Macroinvertebrates (NEMS 2022b)
Riparian planting	Cover% Planted success%	Cover% Planted success%	

6.3 Frequency of monitoring

Ecological Monitoring of the stream channel should be undertaken after years 1, 2 and 5 post-livening to ensure the channels are meeting ecological objectives.

6.4 Riparian Planting Monitoring

The riparian vegetation planting should be inspected at least every six months by a suitably qualified person in the year following the planting. The plants should be inspected to assess plant health. Where any plants appear to be in poor health or dying, the plants shall be removed and replanted, or care measures implemented as soon as is practicable.

Pest plants shall be assessed within the riparian planting. Where pest plants are considered to be dominating the vegetation and/or smothering desired plants then control activities shall be undertaken as soon as is practicable.

6.5 Indicative Performance Targets

The indicative targets for the performance of the diversions are set out in Table 4. These performance targets have been drawn from the existing ecological values as assessed by Waterways (2025) report, NOF from the NPS-FM and related metrics (i.e., RHA).

Table 4. Indicative thresholds for diversions at BOGP.

Diversion	Shepherd's Diversion	Rise and Shine Diversion(s)
Metric		
Habitat		
Habitat Quality Score band	Good	Good
Deposited fine sediments NOF Table 16	Band B	Band B
Macroinvertebrates		
Taxa number	10-13	8-10
MCI	>90	>90
EPT	5-7	3-5
MCI Band NOF Table 14	Band C	Band C

6.6 Reporting

A report summarising the ecological monitoring will be prepared and submitted to Council in November in the year of sampling.

7.0 References

- Boffa Miskell (2025). Bendigo Ophir Gold Project: Assessment of Freshwater Ecological Effects. Report prepared by Boffa Miskell Ltd., October 2025.
- Clapcott, J., Casanovas, P., & Doehring, K. (2020). Indicators of freshwater quality based on deposited sediment and rapid habitat assessment (3402). 31 p.
<https://environment.govt.nz/assets/Publications/Files/indicators-of-freshwater-quality.pdf>
- Clapcott, J., Young, R., Harding, J. S., Matthaei, C., Quinn, J., & Death, R. (2011). Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. 108 p.
- NEMS (2022a). National Environmental Monitoring Standards: Periphyton. Sampling and Measuring Periphyton from Wadeable Rivers and Streams. Version 1.0.0, July 2022. Ministry for the Environment.
- NEMS (2022b). National Environmental Monitoring Standards: Macroinvertebrates. Collection and Processing of Macroinvertebrate Samples from Rivers and Streams. Version 1.0.0, June 2022. Ministry for the Environment.
- Water Ways (2025). Bendigo Ophir Gold Project: Assessment of Effects on Aquatic Habitat. Report prepared by Water Ways Consulting, June 2025.

Appendix 1: Shepherd Creek Rehabilitation Plan (Growplan 2025)

Approach and outline

Plant selection and planting design is a combination of ecological function for the particularities of the site, with aesthetic elements primarily as cues for care

To increase understanding and valuing of the planted landscape it is essential planting makes sense and is not seen as 'just weeds'. Patterns and forms that look 'designed' are cues for care and inquisitiveness - this increases staff buy-in and can help toward having qualified staff to manage the two-decade closure phase

The overarching approach is to design, construct, revegetate and maintain for a no-net-loss outcome

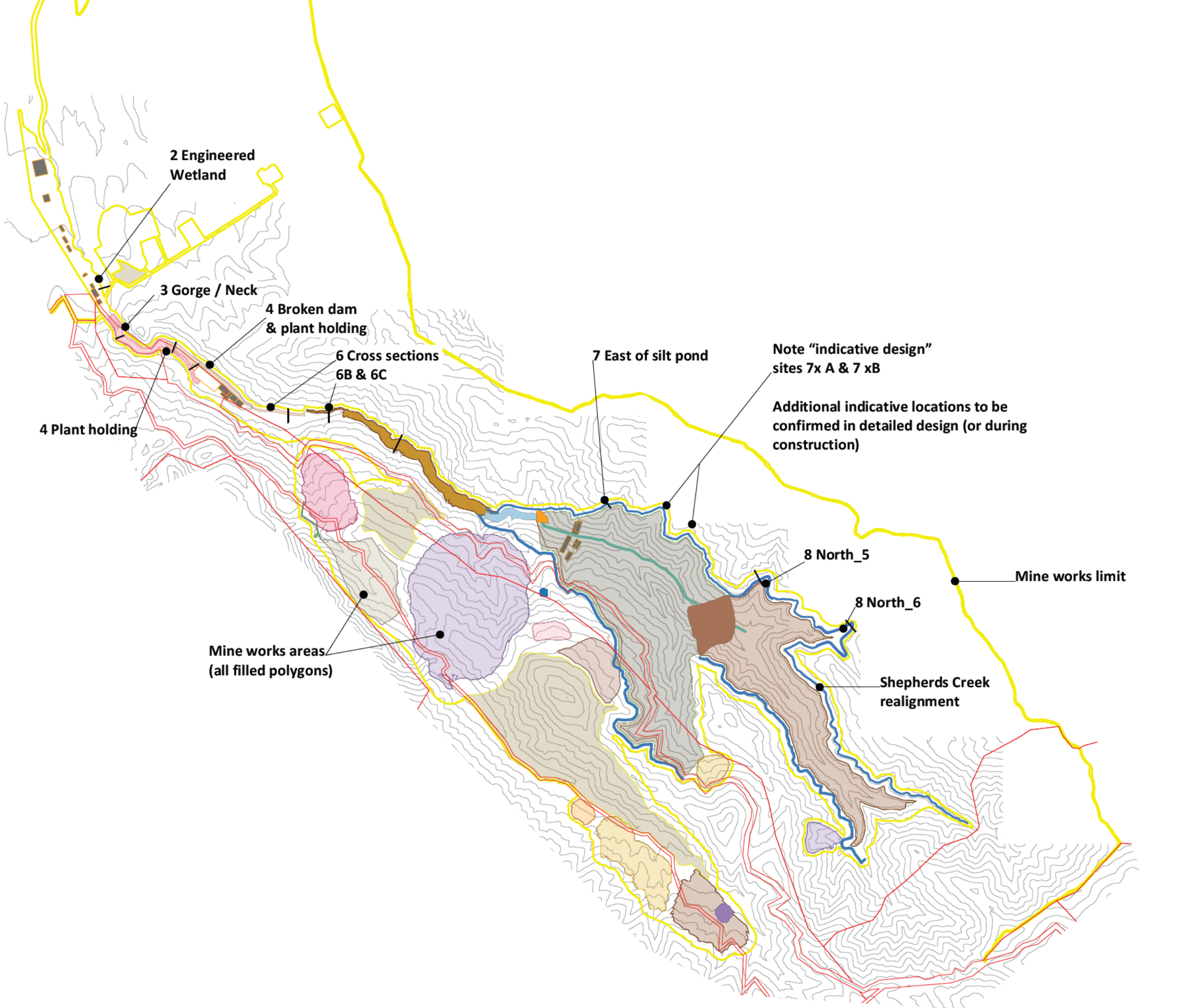
Plant selection is based on several factors:

- Known to occur on-site now, or within circa 15Km from site, or known to have been present within the last 5000 years
- Beneficial to and supportive of wildlife - birds, skinks and geckos, and terrestrial and aquatic invertebrates
- Weighted towards aesthetic value
- Valued by Maori
- Will withstand local climate and site conditions
- Lower palatability plants where possible to lessen effects of grazing pests, and eventually sheep post closure

Trees and/or shrubs overhanging creeks help sustain invertebrates via leaf breakdown products entering the water, shading also helps keep water cooler

Utilizing hard materials from site (or local area), and transplanting plants where practicable

Depending on site conditions and site context the water drop structures may be partly formed in basement rock, and constructed in boulders, sheet piling, or precast concrete, or a combination thereof and the forms naturalised



Situation

Shepherd's Creek leaving the hills
Height change upstream to down approx. 8 metres

Approach

An engineered wetland as a final polishing and monitoring stage, including aquatic species as living sensors e.g koura (a forest fire-fighting pond practice) and *Daphnia* species
Channel enters and exits wetland in its natural position and flows through five detention basins / ponds

Stream realigned above existing ground and channel invert, with pond depth a maximum of 1.5 m above invert

Existing channel filled with loose angular rock to maintain some dry weather flow. This would also reduce the deep incision / erosion of this channel

Ponds lined with oxidized brown loess - a ubiquitous local soil mineral used to line local orchard irrigation ponds. Flow exits ponds over a low drop of approx. 1m on to a rock rubble base and exits pond into a slow flowing channel to the next basin

Plant selection for ability to thrive in riparian and wet zones of dryland areas

Planting layout and pattern leaves the channel and ponds in low grasses and sedges occasionally planted to fenceline to enable views into the space

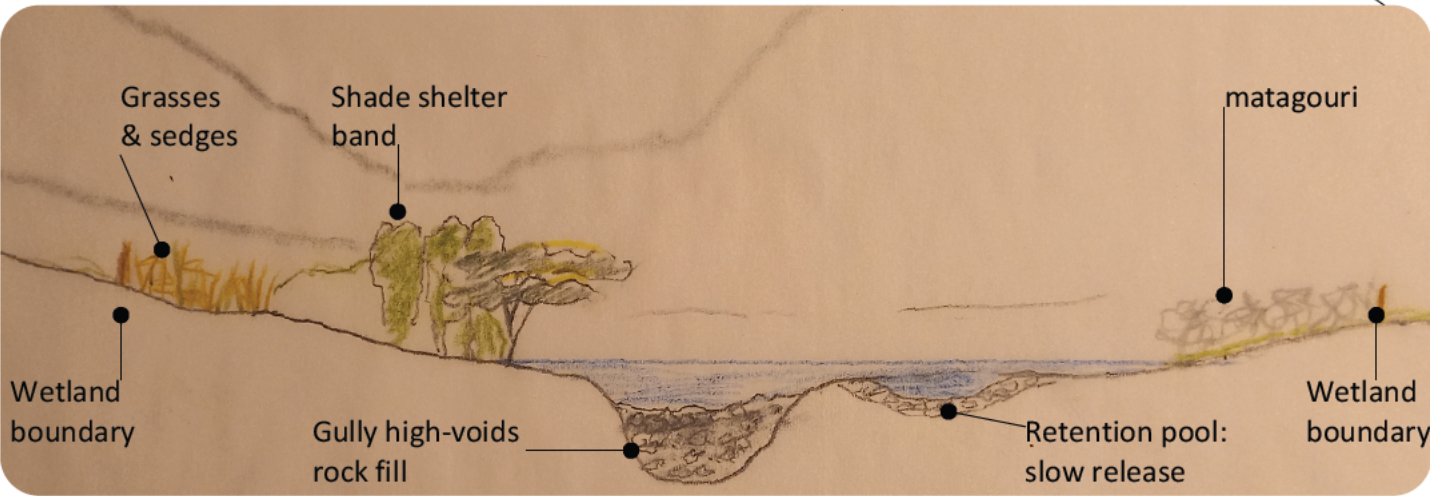
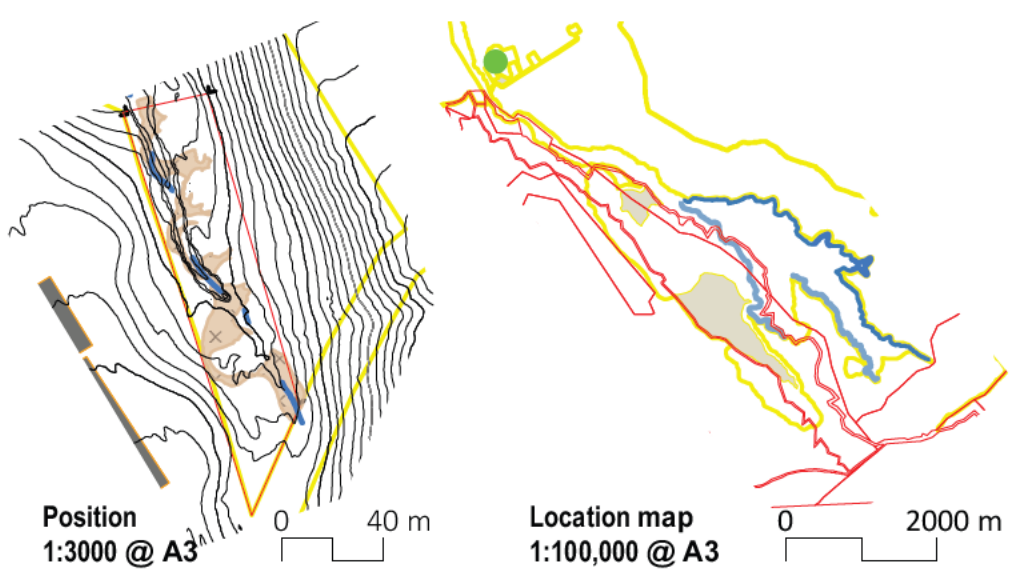
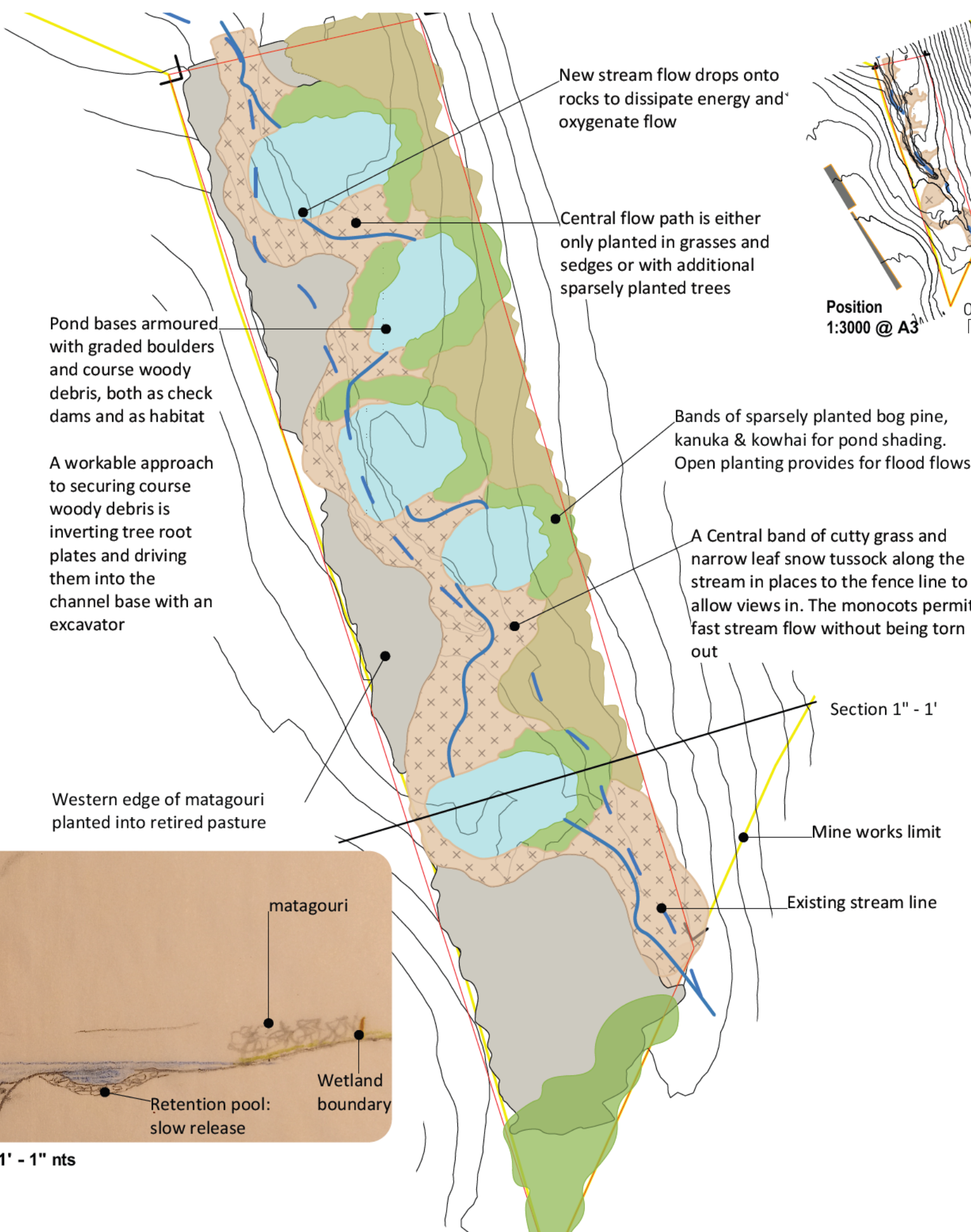


Figure 2, Site 1 Engineered Wetland, view upstream Section 1' - 1" nts



Plants for engineered wetland	
Chionochloa rigida	narrow-leaf snow tussock
Carex coriacea	cutty grass
Discaria toumatou	matagouri
Halocarpus bidwilli	bog pine
Kunzea ericoides	kanuka
Sophora microphylla*	kowhai



Halocarpus bidwilli bog pine

Situation

Shepherd's Creek passing through The Neck

Approach

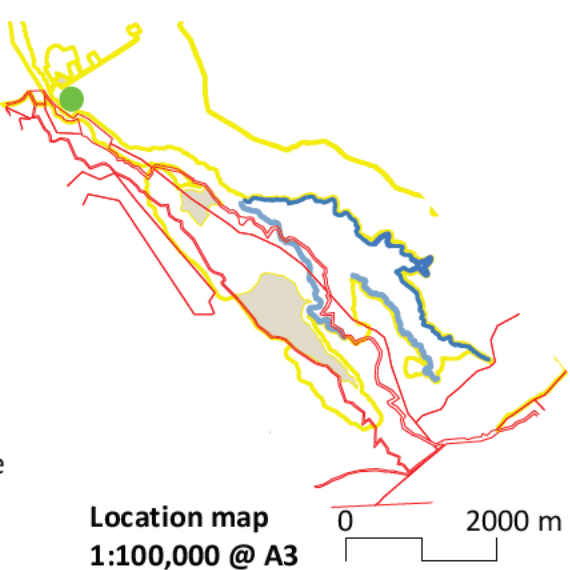
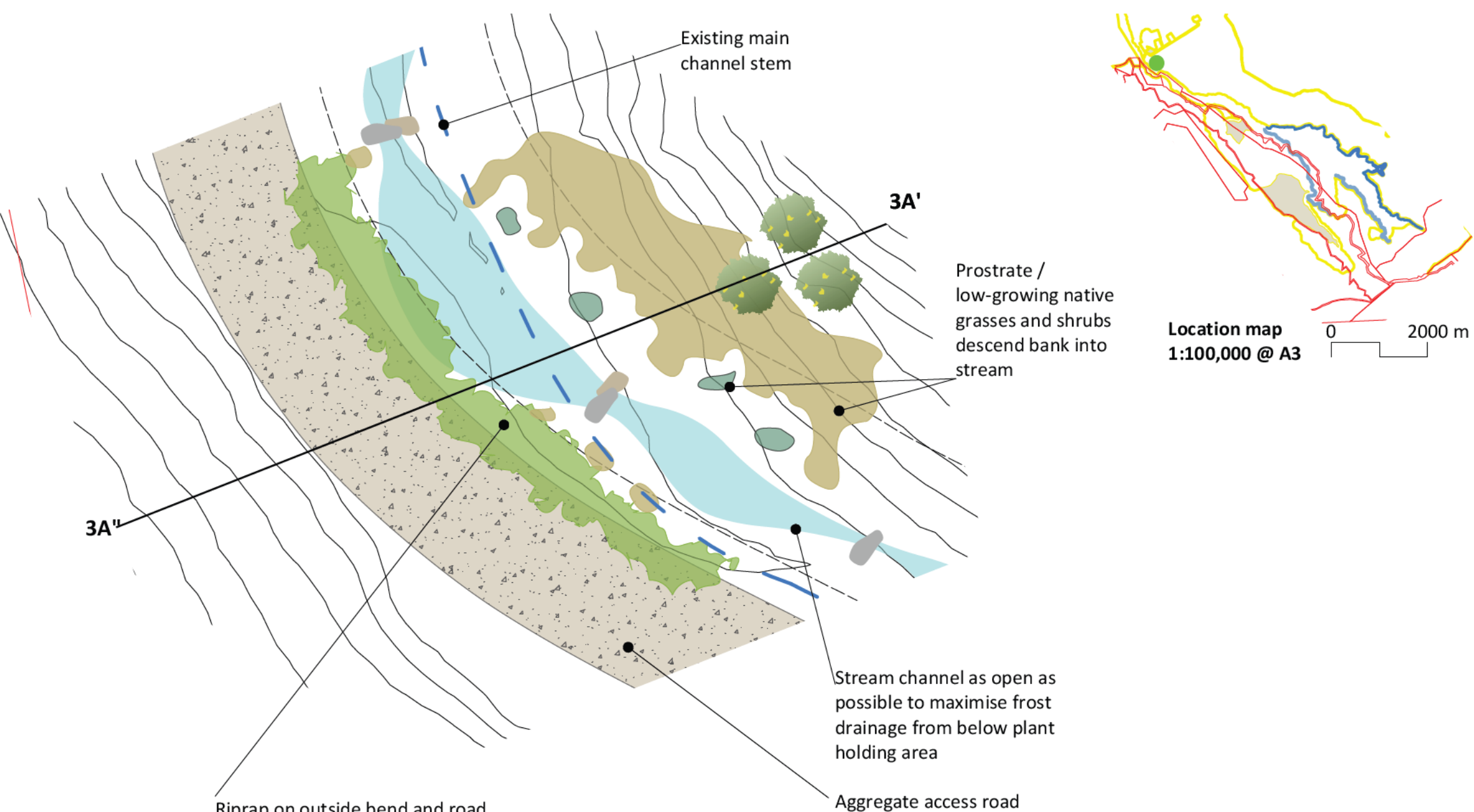
Channel remains at its existing height, but moved towards slope with some minor slope cut to facilitate this

Continuation of pool rifle sequence as designed into reaches upstream

Low shrubland planting atop riprap adjacent access road

Planting able to thrive in riparian and wet zones of dryland areas

Planting is low and sparse to maximize stage flow



Scattered medium shrubs and occasional kowhai on bank, well outside channel

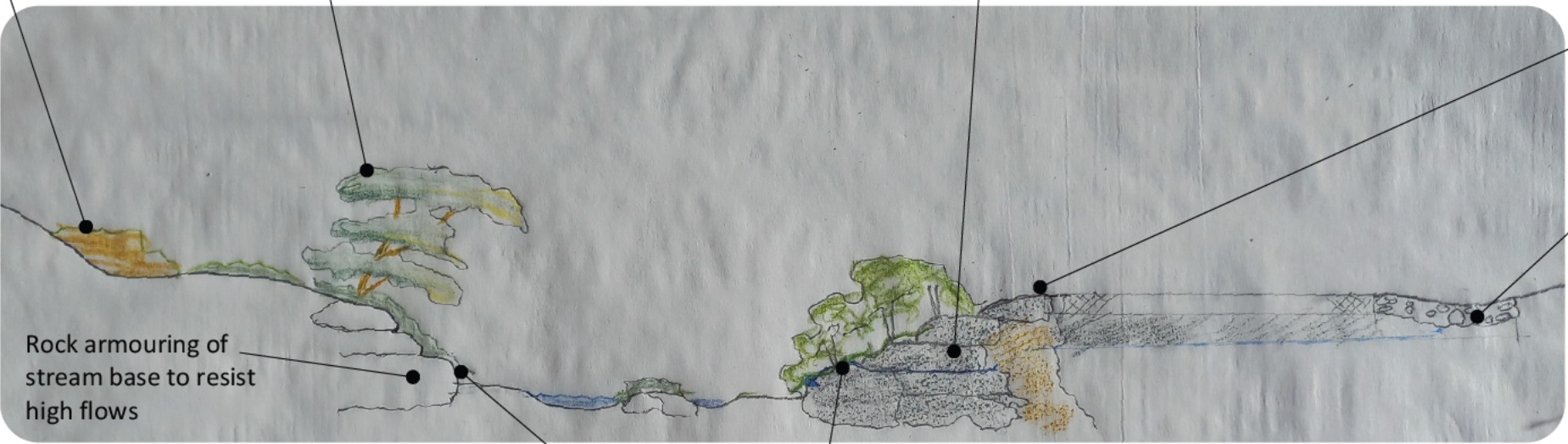


Figure 3 Site 2 Gorge at the Neck, view upstream
Section 3A' - 3A'' nts

Plants for the Gorge at the Neck

- Carex dipsacea
- Carmichaelia sp.
- Hebe salicifolia
- Hebe subalpina
- Pimelea notia
- Sophora microphyla

Situation

Shepherd's Creek plant transplant holding* and staging area, and for re-vegetation plant handling

Approach

Plant storage planforms using a ridge and wide base 'furrow' for vehicle access and frost drainage, and to keep above high flow levels

Create planted uphill cold air redirect / buffer

To maximise frost drainage limit downstream shrub planting to ground covers and trailing plants, with shrubs only as scattered plants well back from the main channel

Site will require access - not shown

* Not a nursery. A perception may exist that site-grown plants are more robust but growth is very slow with high mortality that it is not worthwhile

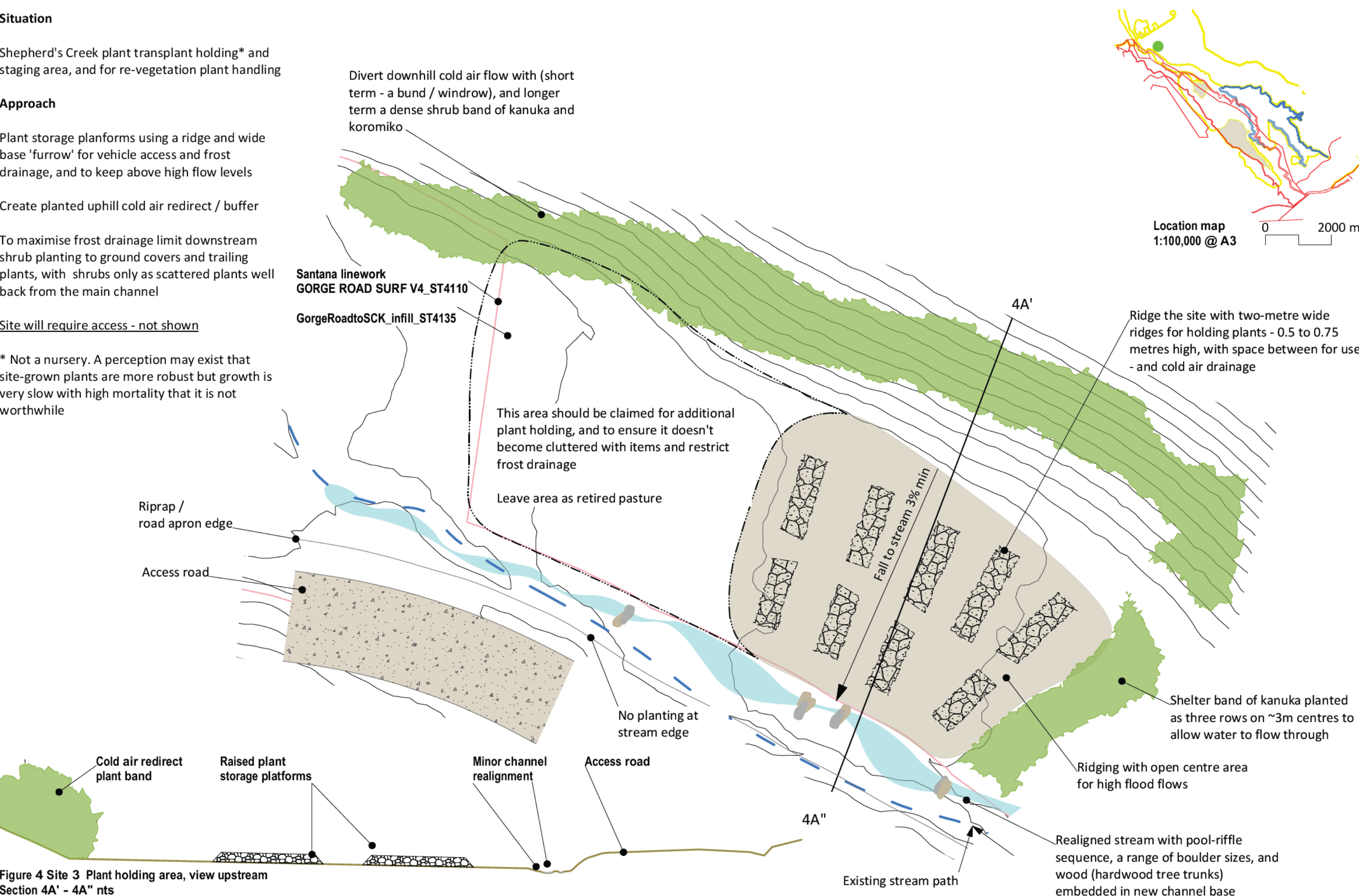


Figure 4 Site 3 Plant holding area, view upstream Section 4A' - 4A'' nts

Situation

Slow-moving sinuous stream immediately downstream from broken dam, and also need for a second plant holding area

Approach

In general work with slow moving stream and planting that is already here, especially cutty grass

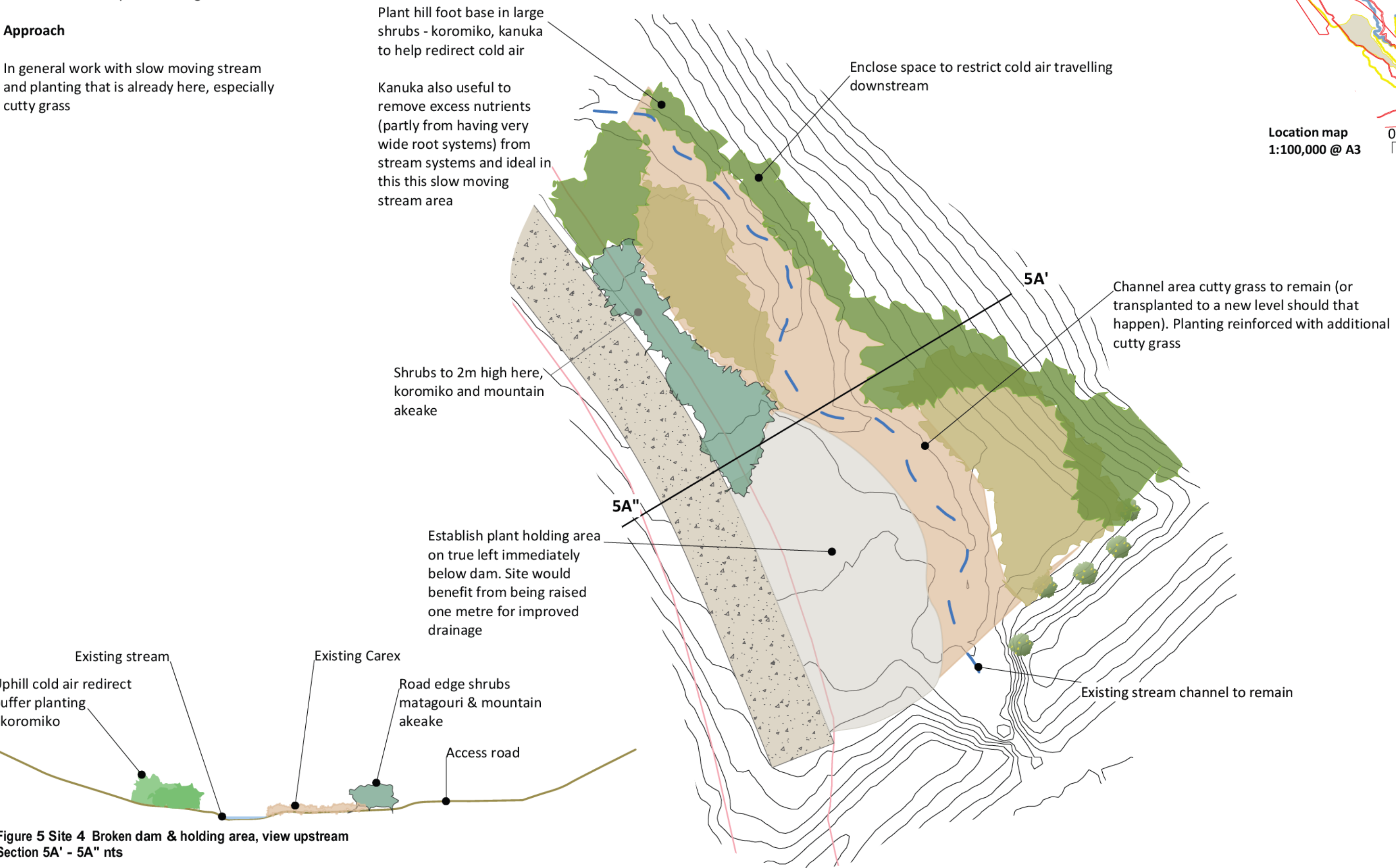
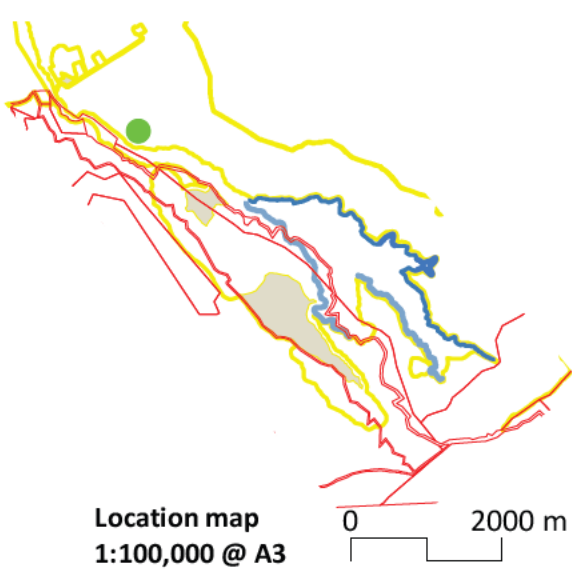


Figure 5 Site 4 Broken dam & holding area, view upstream
Section 5A' - 5A'' nts

Situation

Shepherd's Creek lowland form (with adjacent dirty water channel) east of processing plant, and steeper section at Shepherd's Fill area

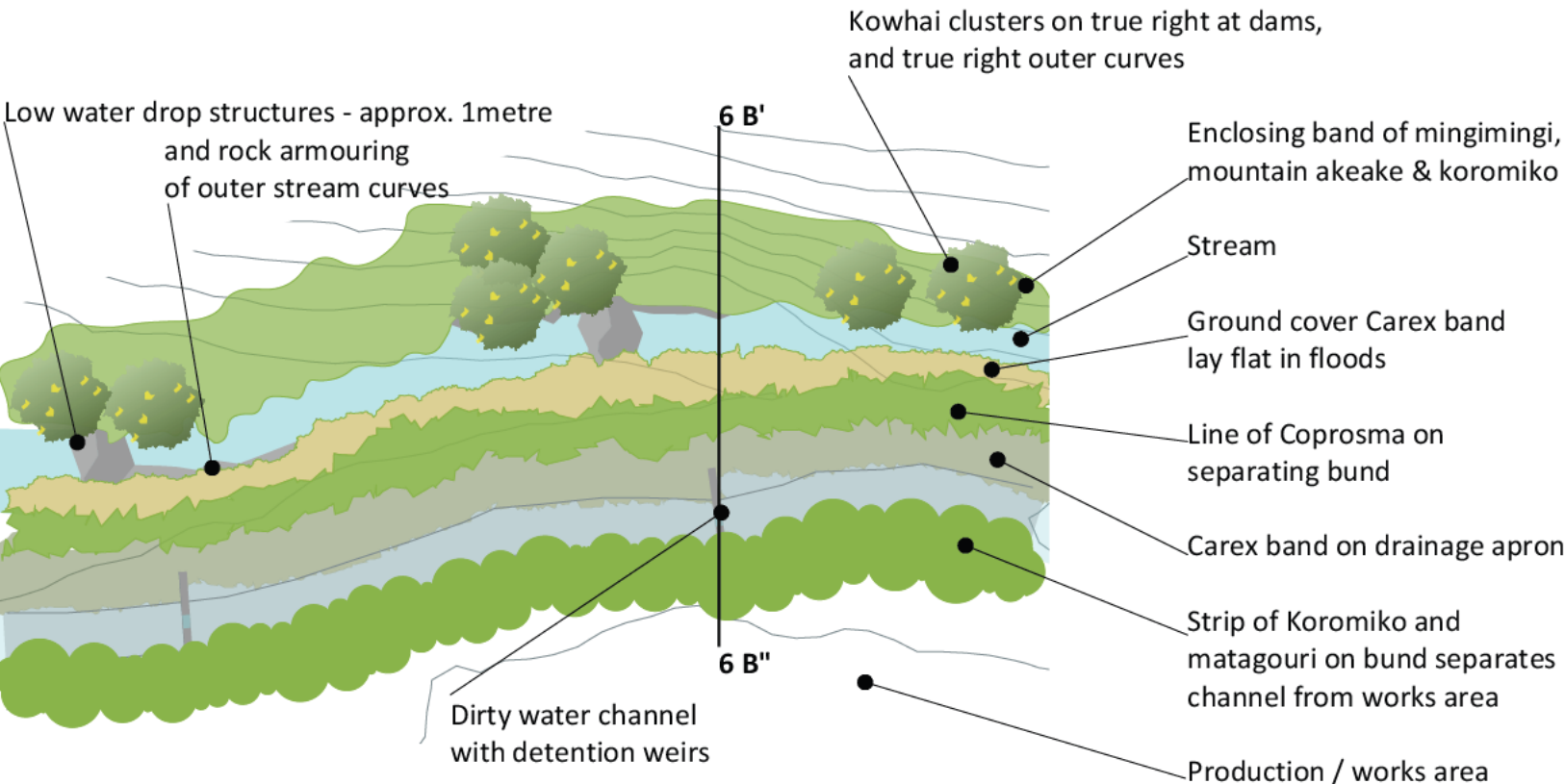


Figure 6, Site 6 B, Lowland reach plan typical, 1:300 @ A3

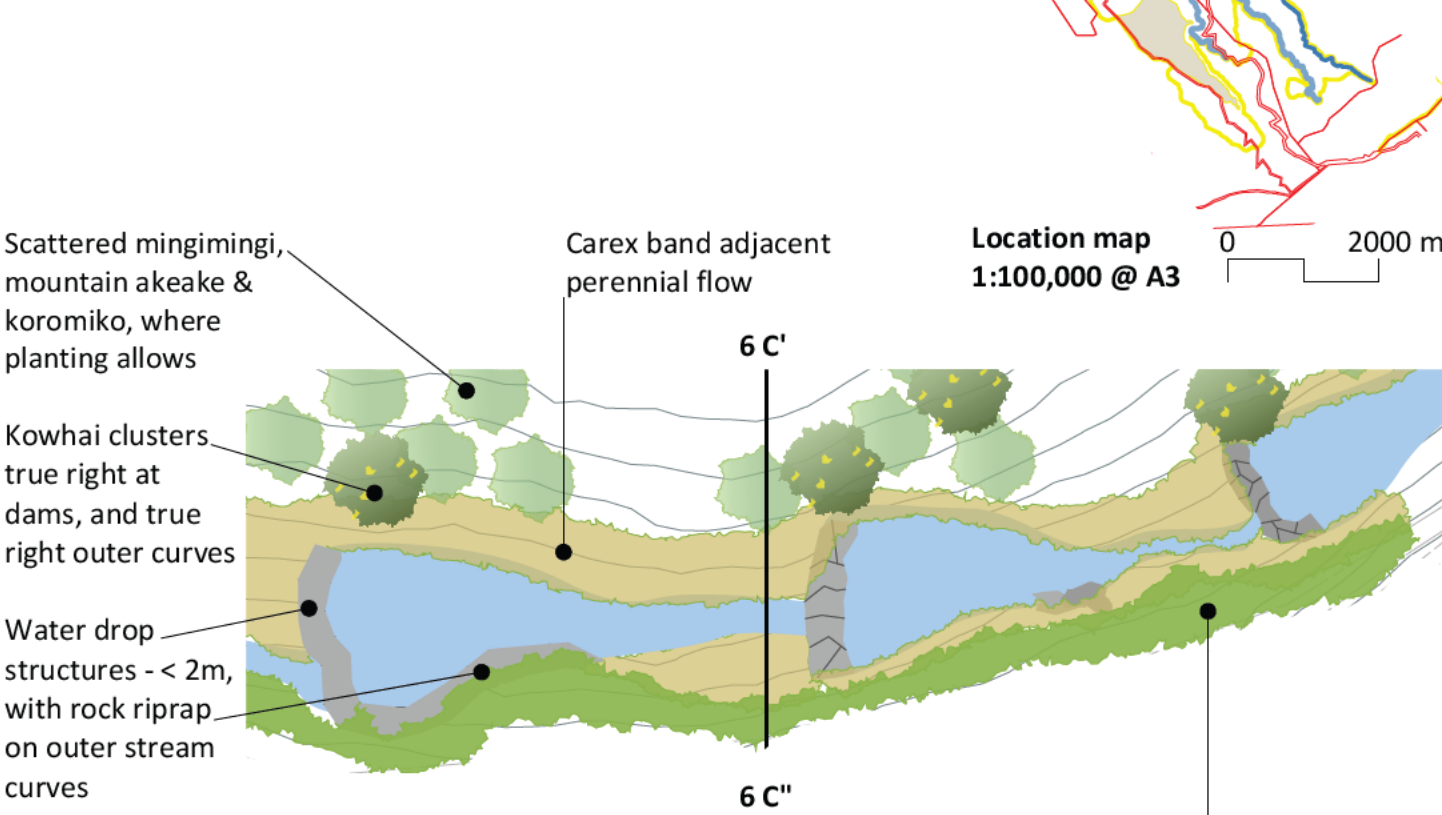


Figure 6, Site 6 C, steeper reach plan typical form, 1:300 @ A3

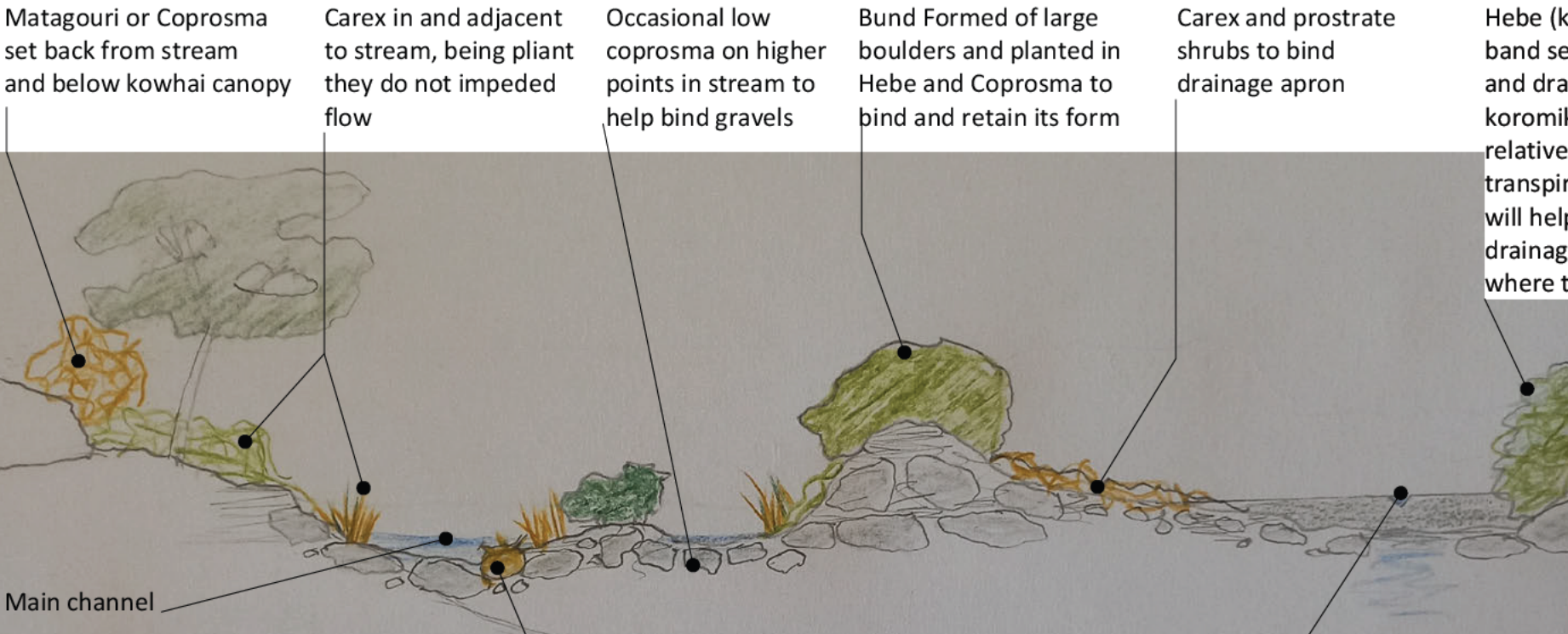


Figure 6, Site 6, Lowland reach typical, view upstream Section 6 B' - 6 B'' nts

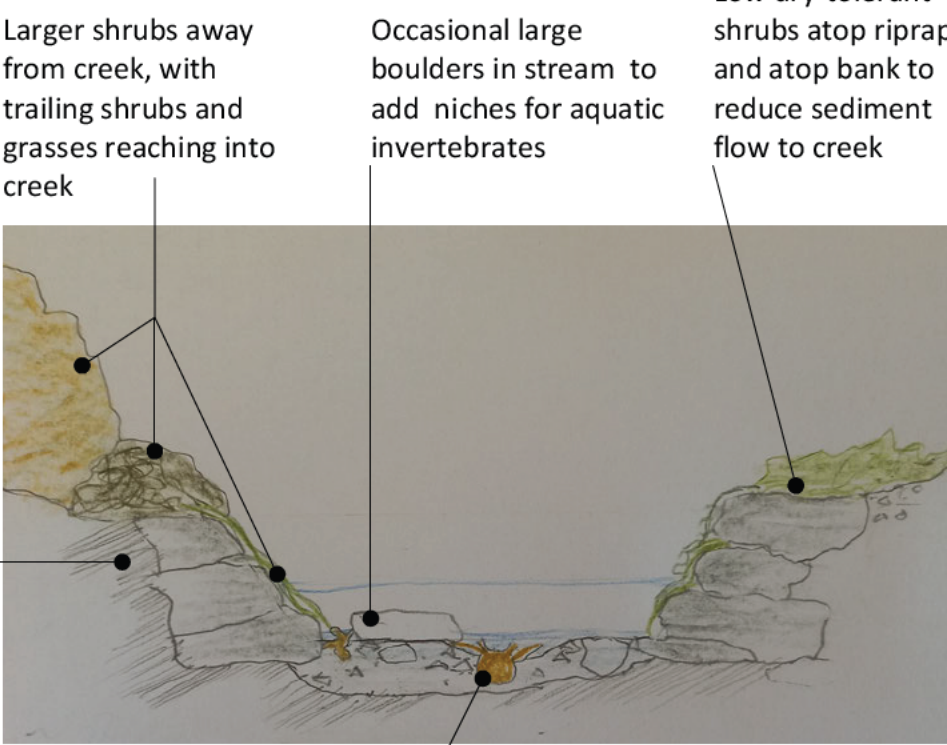


Figure 6, Steeper section, view upstream, Section 6 C' - 6 C'' nts

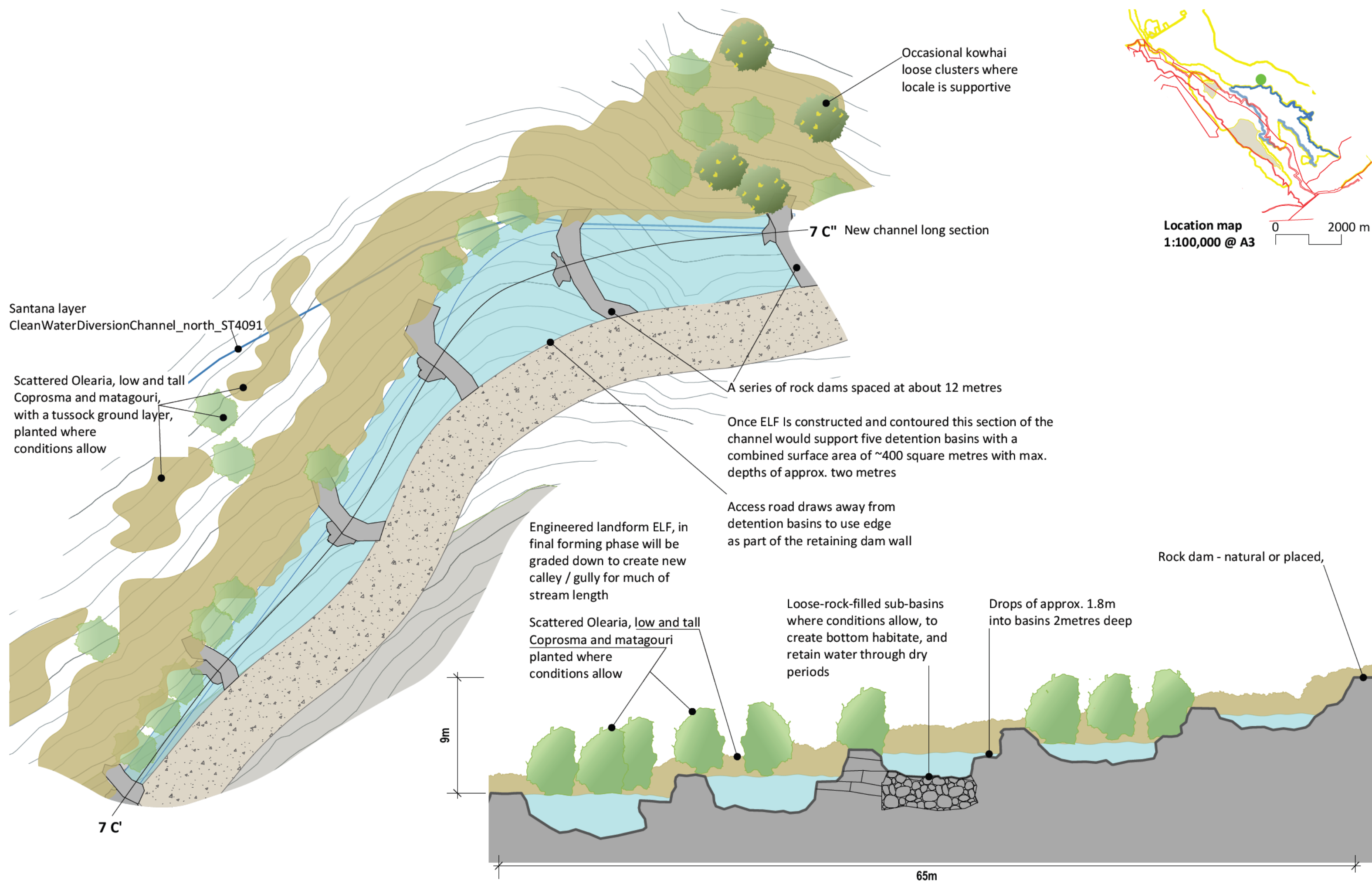


Figure 7, Site 7, drop series typical, view upstream - Long Section 7 B' - 7 B" nts, 1:250 @ A3

Hillside and diversion channel detention basin and planting concept

Water flows in to basin in high flow state and detained to preserve minumum vernal state - a seasonal wet pond

Porous in-flow wall (e.g. weeping wall) to take and release some low flow

Detention basin would function both to detain flow, and retain some flow for aquatic species and to increase local humidity for plants in a very dry location

Due to uncertainties around final landform potential basin volume is hard to estimate but could range upwards from 400 cubic metres

Note

Indicative design and additional indicative locations to be confirmed in detailed design (or during construction)

Dry shrubland species; Carmichaelia sp., Olearia avicenniifolia, and pockets of kowhai

Trailing and prostrate plants reach into channel

8A'

Hebe bands either side of accessway

8A" Future cross section line

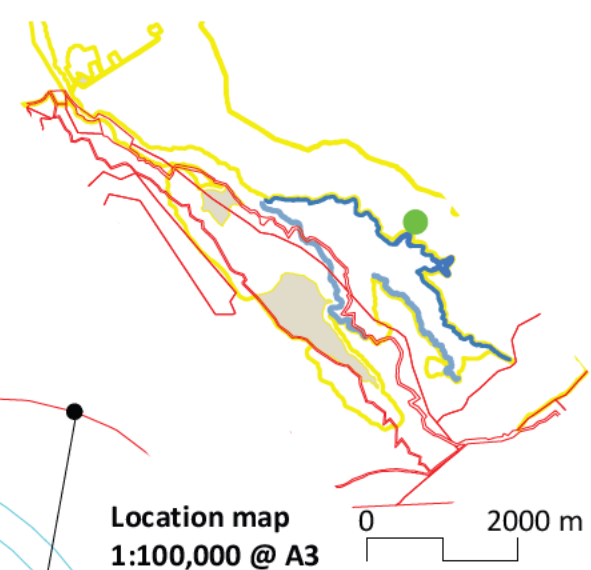
Waste rock stack, expected to be graded down towards new channel area resulting in chanel area becoming a new gully

This could enable a larger dam than shown (and additional habitat), or a future dam expansion should precipitation increase

Road water crossing - a splash or grill preferred, else culvert

Water path through basin, lenhthened with a rock or sheet pile baffle to extend water path length and increase detention time, protecting aqautic species, and settling out fines

Basin lining: competent rock where exists, else oxidized loess lining, and armoured with rock to protect lining from flows



Santana CAD linework items



North_6 Upper Shepherd Creek

Hillside and diversion channel detention basin and planting concept, also results in an easier and safer driving path

Water inflow to basin in high flow state and detained to preserve minimum vernal state - a seasonal wet pond

Basin is a run-of-stream approach with (anchored) boulder placement to direct flow
- not shown pending discussion

Detention basin would function both to detain flow, and retain some flow for aquatic species and to increase local humidity for plants in a very dry location

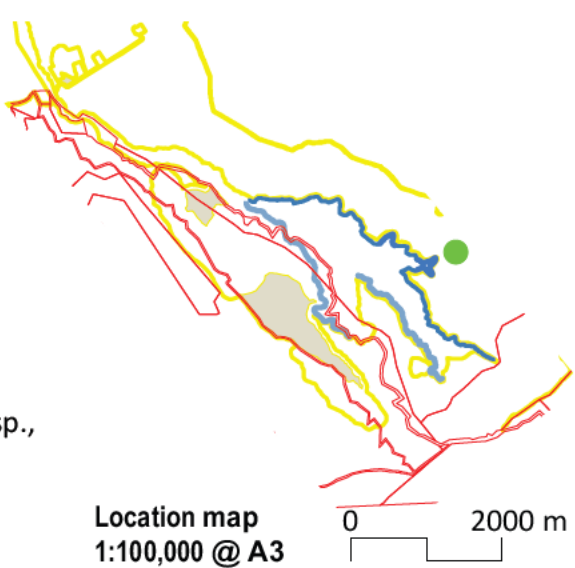
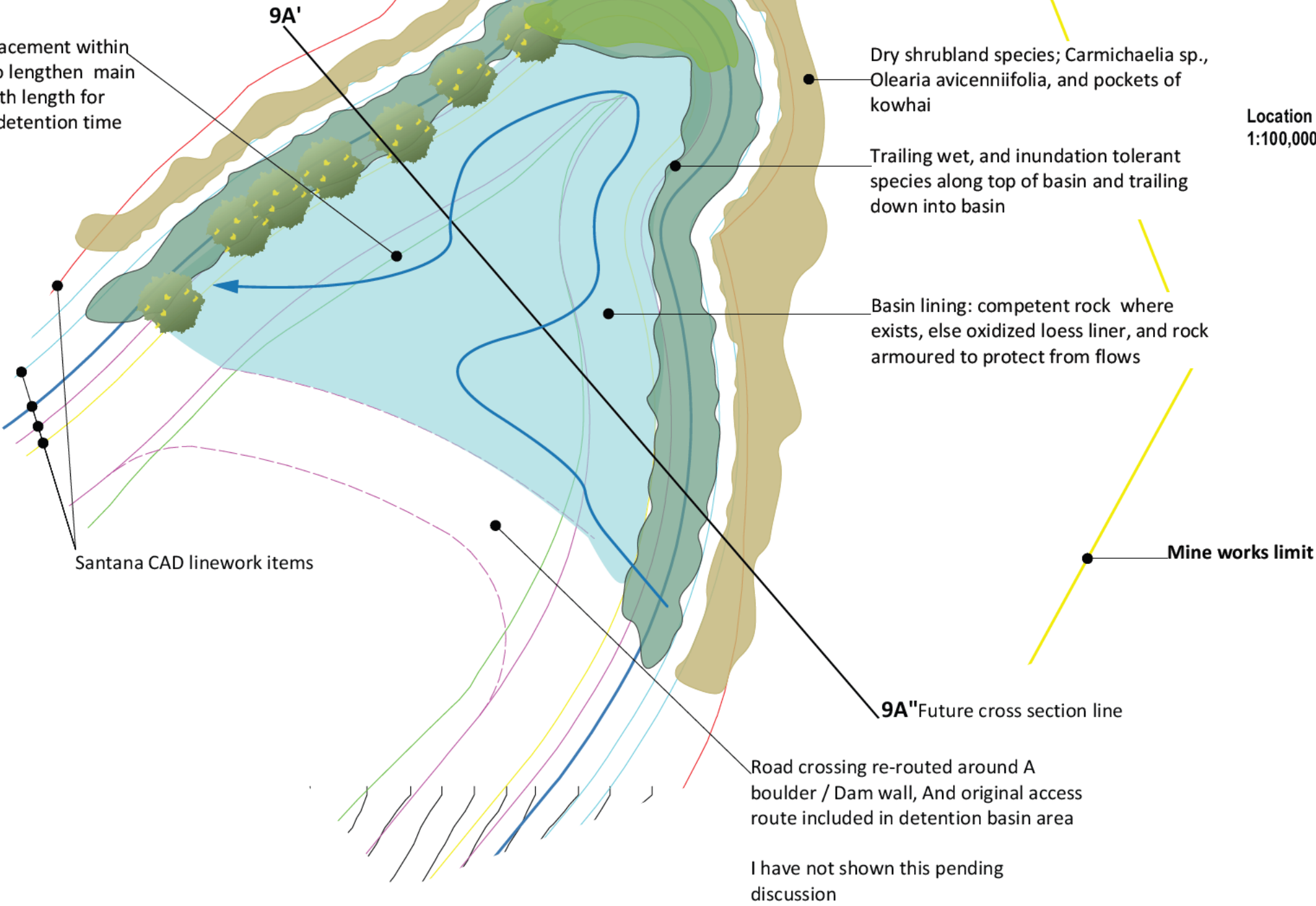
Volume would range upwards from 500 cubic metres

Data issue
No contours as data missing, need DEM file

Note

Indicative design and additional indicative locations to be confirmed in detailed design (or during construction)

Rock placement within basin to lengthen main flow path length for longer detention time



Height	botanical name	common name	Position	Wildlife	in cult.	Authority	Form & notes
1.0	<i>Carmichaelia compacta</i>	native broom	dry sites		Y	Walker 2004	
1.0	<i>Chionochloa rigida</i>	narrow-leaf snow tussock	wet tolerant		Y	Exists to North & South	
1.5	<i>Chionochloa rubra</i>	red tussock	stream margins		Y	Occurs on site	
0.7	<i>Coprosma cheesemanii</i>	-	-	birds	Y	Grove 2002	Spreads post grazing
2.0	<i>Coprosma propinqua</i> *	mingimingi	-	skinks	Y	Walker 2004	Low palatability
0.5	<i>Carex dipsacea</i>	teasel sedge	stream sides		Y	Dunstan ED	
0.7	<i>Carex comans</i>	sedge	stream sides		Y	Dunstan ED	
0.7	<i>Carex coriacea</i>	cutty grass	wet tolerant		Y	Occurs on site	
2.0	<i>Discaria toumatou</i>	matagouri	-	inverts. ¹	Y	Occurs on site	1 - inverts. attract birds
7.0	<i>Festuca matthewsii</i> *	southern blue fescue	wet edge		Y	Has existed in area	Size highly variable
4.0	<i>Halocarpus bidwilli</i>	bog pine	wet tolerant	birds	Y	Walker 2004	
1.5	<i>Hebe subalpina</i>	-	dryland wet flushes		Y	Walker 2004	Spreading farm avail.
1.5	<i>Hebe odora</i>	-	-		Y	Dunstan ED	
2.0	<i>Hebe salicifolia</i>	koromiko	wet tolerant		Y	Has existed in area	
5.0	<i>Kunzea ericoides</i>	kanuka	wet tolerant		Y	Occurs on site	
3.0	<i>Olearia avicenniifolia</i>	mountain akeake	-	inverts.	Y	Walker 2004	
0.5	<i>Pimelea aridula aridula</i>	pimelea	-	inverts.	Y	Exists in locale	Wide low shrub
0.3	<i>Pimelea oreophila lepta</i>	pimelea	stream sides	inverts.	Y	Exists in locale	Sprawls, low palat.
0.3	<i>Pimelea prostrata ssp. prostrata</i>	pinātoro / NZ daphne	stream sides	inverts.	Y	Exists in locale	Sprawls, low palat.
0.5	<i>Pimelea notia</i>	pimelea	stream sides	inverts.	N	Has existed in area	Sprawls, low palat.
4.0	<i>Pseudopanax ferox</i>	horoeka	-	inverts.	Y	Has existed, Pole 2022	
5.0	<i>Sophora microphylla</i> *	kowhai	stream sides	birds	Y	Occurs on site	3 metre tall shrub forms exist
1.5	<i>Teucrium parviflorum</i>	teuclidium	stream sides	inverts.	Y	Wardle 2001	

Table 4a Plant selection and information. * Known Maori applications / value

Plant authorities / references

Davies-Colley, R.J. & Payne G.W. 2023 Cooling streams with riparian trees: Thermal regime depends on total solar radiation penetrating the canopy. *Austral Ecology*, 48:1064–1073.
url: <https://onlinelibrary.wiley.com/doi/10.1111/aec.13345>

Pole, M. 2022 A vanished ecosystem: *Sophora microphylla* (Kōwhai) dominated forest recorded in mid-late Holocene rock shelters in Central Otago, New Zealand. *Palaeontologia Electronica*, 25(1):a1.
DOI: <https://doi.org/10.26879/1169> and <https://www.palaeo-electronica.org/content/2022/3503-vanished-ecosystem>

Wardle, P. 2001 Distribution of native forest in the upper Clutha district, Otago, New Zealand, *New Zealand Journal of Botany*, 39:3, 435-446.
DOI: <https://doi.org/10.1080/0028825X.2001.9512747>

Grove P.B, Mark, A.F., Dickinson, K.J.M. 2002 Vegetation monitoring of recently protected tussock grasslands in the southern South Island, New Zealand. DOI: <https://doi.org/10.1080/03014223.2002.9517700>

Email me if a paper is difficult to obtain as I have pdfs of all

Plant authorities / references

Walker et 2014 Effects of secondary shrublands on bird, lizard and invertebrate faunas in a dryland landscape. *J NZ Ecol. Soc*
url: <https://newzealandecology.org/system/files/articles/3123.pdf>
- Has a useful Bendigo lizards study.

ED - Ecological District classification system

A number of studies note how impoverished native species are in the Bendigo area. Researchers including Pole have proved the existence of a number of species no longer growing here but that have grown at least to the North and South of site in the last two to five thousand years

Plants and wildlife values

All non-monocots ('grasses' rushes, sedges, tussocks and trrue grasses) Produce nectar and / or pollen, and produce seeds.

Every non-monocot is in a system that includes either invertebrates, birds or lizards, and sometime all three are attracted. Above instances are known and documented examples



Carex comans
Highly variable in form and colour



Carex coriacea
Perennial sedge - dies partly back in winter



Carmichaelia compacta
Cromwell broom, develops wide low clumps



Chionochloa macra
Slim snow tussock



Chionochloa rigida
Narrow-leaved snow tussock



Chionochloa rubra
Red tussock



Coprosma propinqua, mingimingi *
Especially of value to lizards



Discaria toumatou matagouri
An invertebrate essential



Halocarpus bidwillii
Wet tolerant, and when established dry too



Hebe odora
Garden example, in nature form more loose



Hebe salicifolia, koromiko *
* Plants with known use by Maori



Kunzea ericoides kanuka
Useful in removing excess nutrients, useful in seepage areas and gullies



Olearia avicenniifolia
Mountain akeake
Native tree daisy to 2-3 metres



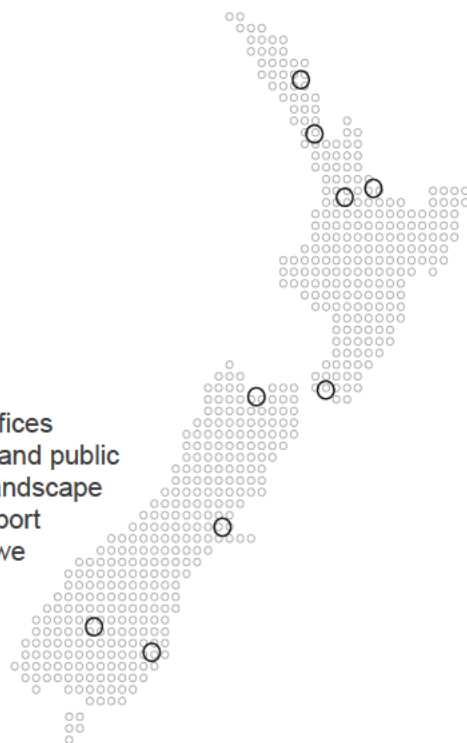
Sophora microphylla, kowhai *
Highly variable form, several natural shrub and tree forms exist in Otago



Teucrium parvifolium
Deciduous shrub, attracts invertebrates

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