REPORT

Tonkin+Taylor

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Auckland Regional Landfill

Assessment of Aquatic and Terrestrial Ecological Values and Effects

Prepared for
Waste Management NZ Ltd
Prepared by
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Abbreviations

AUP	Auckland Unitary Plan Operative in Part
AC	Auckland Council
BEA	Bin Exchange Area
DBH	Diameter at breast height
DOC	Department of Conservation
EcIAG	Ecological Impact Assessment Guidelines
ECR	Environmental Compensation Ratio
EIANZ	Environment Institute of Australia and New Zealand
FRP	Fish Relocation Protocols
ITA	Industrial and Trade Activity
LIDAR	Light Detection and Ranging
MCI	Macroinvertebrate Community Index
NSMA	Natural Stream Management Area (as defined in the AUP)
NZTA	New Zealand Transport Authority
OLFPL	Overland Flowpath Layer (from Auckland Council GeoMaps)
ONF	Outstanding Natural Feature (as defined in the AUP)
SEA	Significant Ecological Area (as defined in the AUP)
SEV	Stream Ecological Valuation (in accordance with Auckland Council Technical Reports 2011/009 and 2016/023)
WMA	Wetland Management Area
WMNZ	Waste Management NZ Ltd

Glossary

Specific terms	
Waiwhiu Tributary Block	Area of pine forestry east of Wilson Road ridge and west of Waiwhiu Stream.
WA Stream	Main stream within the northern half of the Western Block
WB Stream	Main stream within the southern half of the Western Block.
WV Stream	Main stream tributary within the Waiteraire Tributary Block.
V1 Stream	Main stream within Valley 1 of the Eastern Block.
S Stream	Main stream within Southern Block.
General terms	
Auckland Regional Landfill	Project name, encompassing the landfill itself as well as all ancillary activities.
Waste Management NZ Limited or WMNZ	Company name of applicant.
Wayby Valley	The site is located in the Wayby Valley catchment.
WMNZ landholdings	The entire landholdings secured by WMNZ.
Project footprint	Areas where works are anticipated associated with the project. Important to make distinction between WMNZ landholdings, landfill footprint and project footprint.
Landfill footprint	The area directly impacted by the landfill itself within Valley 1.

Executive Summary

Introduction

Waste Management NZ Ltd (WMNZ) is seeking to obtain resource consents for the construction and operation of a new regional landfill facility on WMNZ landholdings within the Wayby Valley area, between Warkworth and Wellsford.

This Assessment of Aquatic and Terrestrial Ecological Values and Effects Report has been prepared to accompany resource consent applications for the construction and operation of the landfill and its supporting activities.

This report provides an assessment of the ecological values of the WMNZ landholdings and assesses the effects of construction and operation of the Project on these values, before and after recommended measures are implemented. Specifically, the report:

- Describes terrestrial and freshwater values within the project footprint and surrounding landscape based on a desktop review and field investigations from June 2018 to February 2019.
- Provides an assessment of effects on ecological values in general accordance with Ecological Institute of New Zealand (EIANZ) guidelines.
- Proposes measures to avoid, remedy, mitigate or compensate for potential adverse effects in general accordance with biodiversity offsetting principles.

The WMNZ landholdings (1020 ha) consists of three distinct land use types. The Eastern Block and Waiteraire Tributary Block comprises predominantly exotic radiata pine plantation forestry; the Western Block is currently an operational farm and has pockets of high ecological value vegetation and habitat; and the Southern Block consists of wattle plantation and regenerating native vegetation. There are significant ecological areas (SEA) and natural stream management areas (NSMA) across the landholdings, however these are not located within the project footprint.

Freshwater values and effects

Stream classifications were undertaken through site assessments or modelling where access was limited. Stream ecological valuations (SEV) were undertaken at 20 sites, macroinvertebrates were collected at the same SEV sites and a further five baseline monitoring sites. Six sites were surveyed for fish.

Freshwater systems across the WMNZ landholdings are typically of high ecological value, particularly those within the Eastern and Southern Blocks. Macroinvertebrate community index (MCI) ranged from ‘Poor’ in the farmed areas to ‘Excellent’ in forested catchment sites. Six native fish and the crustacean kōura were recorded during fish surveys. The fish Index of Biotic Integrity (IBI) ranged from ‘No Natives’ to ‘Very Good’, with some barriers to fish passage limiting fish numbers at survey sites. SEV values were highest in the forested catchments, ranging from 0.71 to 0.89, while streams within the farmed areas had SEV values as low as 0.35.

The NSMA within the Southern Block had the highest SEV value, a function of its relatively intact native riparian margins and natural stream channel. Despite the presence of exotic forestry, streams within the Eastern Block had high ecological value as demonstrated by biotic indices. It is expected that during forestry activities these ecological values would decreased for a period of time until the stream systems recover. While the Western Block has been modified and subject to degradation through agricultural land use, the biodiversity values within these streams are still moderate and in some places high where native vegetation remains intact.

The potential effects of the Project on the freshwater environment includes short term effects relating to the construction phase and then longer term effects relating to the operation of the landfill. Potential short term effects relate to the effects within the construction phase which could include fish injury and/or mortality, and water quality effects resulting from sedimentation and cut vegetation storage. Potential long term effects anticipated to occur from the project include reduced fish passage, water quality effects and changes to hydrology and loss of stream ecological function and habitat area.

The potential effects during the construction period can be minimised and mitigated through the implementation of good practice erosion and sediment controls, fish salvage and relocation, vegetation clearance and monitoring through the construction period.

Many of the longer term effects of the project can also be minimised or mitigated, by ensuring fish passage where possible and implementation of good practice sediment and stormwater controls in respect of water quality and/or quantity.

The most substantial effects on freshwater ecology will occur from the permanent reclamation of 15.4 km stream length across the WMNZ landholdings (which has an estimated total stream length of 135 km), mainly within the landfill footprint. These effects cannot be mitigated, however an offset and compensation package has been prepared which goes some way to addressing these effects. This includes close to 15 km of stream enhancement within the WMNZ landholdings and a commitment to undertake enhancement on a further 30 km of stream over the lifetime of the landfill.

Marine values and effects

A desktop assessment was undertaken to review available information and data pertaining to the marine receiving environment.

The WMNZ landholdings is located approximately 35 km, 'as the river flows', from the marine receiving environment, which is the tidal reach of the Hōteo River mouth in the central, south-east of the Kaipara Harbour. The Hōteo River mouth is an SEA and the estuarine reaches provide spawning habitat for juvenile migrating fish. The Kaipara Harbour is a key snapper breeding ground and high ecological, cultural and social values.

Potential effects of the project on the marine environment include potential sedimentation from earthworks during construction and longer term water quality effects resulting from project activities.

These potential effects can be minimised and mitigated through the implementation of good practice erosion and sediment controls and stormwater treatment practices with the project footprint. Given the distance between the impact site and the marine receiving environment, there is unlikely to be a measurable effect in the marine environment.

Terrestrial and wetland values and effects

A desktop assessment and field surveys were undertaken to map all vegetation types and assess the habitat suitability, presence and importance of the site for native terrestrial species with a focus on species that are classified as nationally 'Threatened' or 'At Risk'.

The site is broadly dominated by exotic forest and pasture and native habitat types. Native habitat types include several areas of mature and regenerating forest, as well as several wetland types. In descending order, the project footprint will result in the direct loss of approximately 86.9 ha of pine forest, 17.3 ha of pasture, 9.11 ha of wattle forest, 4.62 ha of native regenerating forest, 0.87 ha of native mature forest, 0.86 ha of indigenous wetlands and 0.48 ha of exotic wetland.

The native vegetation are generally of high ecological value and provide habitat for a number of nationally 'Threatened' or 'At Risk' species, some of which are present within the project footprint. These include long-tailed bats, North Island fernbird, spotless crake, Hochstetter's frog, several lizard species, rhytid snails, peripatus, mānuka and kānuka. A number of indirect effects on habitats and associated species are also likely, including edge effects and potentially noise, light or dust disturbance. Potential effects on these ecological values and others will be addressed through:

- Avoidance through optioneering and refinement of the project footprint.
- Minimisation of effects using a range of protection measures for high value forest and wetland habitats, including avoidance of wetland and mature forest vegetation clearance during peak bird breeding season, tree-felling management plans for long-tailed bats and salvage/relocation of lizards, Hochstetter's frogs and invertebrates into suitable nearby habitats that have been enhanced to facilitate survival and recovery of the relocated fauna.

For residual adverse effects (with a moderate or higher level of effect) that cannot be avoided or minimised, to protect and improve the ecological integrity of remaining forests and wetlands, the following offset and compensation measures are proposed:

- Undertake wetland and terrestrial revegetation across all available sites within WMNZ holdings. This includes approximately 9.9 ha of terrestrial revegetation, 4.63 ha of infill wetland planting, 15.18 ha of wetland buffer planting.
- Undertake long-term pest control (for the term of the consents) across appropriate areas within the WMNZ holdings and Sunnybrook Reserve (subject to agreed access), which will provide ecological benefits across up to 220.4 ha of forest and 25.59 ha of wetlands.
- Long-term protection of native forest and wetlands on WMNZ landholdings via a covenant.

Conclusion

The project is expected to have effects on a range of ecological values. Measures to avoid, remedy or minimise effects have been identified and incorporated into the project design throughout the project development phase. Residual effects have been addressed through a comprehensive package of mitigation, offset and compensation measures which will result in the majority of effects across the site being addressed to an overall 'low' level of ecological effect.

1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by Waste Management NZ Ltd (WMNZ) to prepare a technical assessment of the aquatic and terrestrial ecological values and effects associated with a proposed Auckland Regional Landfill.

This report provides an assessment of the ecological values of the WMNZ landholdings and assesses the effects of construction and operation of the project on these values, before and after recommended measures are implemented. In particular it:

- Describes the existing marine and freshwater environment and ecology;
- Describe the existing terrestrial and wetland environment and ecology;
- Describes the actual and potential ecological effects expected to result from the construction and operation of the project;
- Recommends on-site measures to avoid, remedy, mitigate, offset or compensate potential effects on ecology, as appropriate; and
- Presents an overall conclusion on the level of actual and potential ecological effects of the Project after the recommended measures are implemented.

This report is to inform the Assessment of Effects on the Environment report (AEE) which has been prepared to accompany the resource consent applications.

1.1 Document structure

This report describes the ecological values of the WMNZ landholdings and the actual and potential ecological effects resulting from the Project.

The report has been broken into three key sections as follows.

- Freshwater ecology values and effects (Section 4);
- Marine ecology values and effects (Section 5); and
- Terrestrial and wetland ecology values and effects (Section 6).

Each of these three sections is broken into three main parts as follows:

- Desktop and field survey methods;
  - A description of the methods for each of the ecological attributes being assessed.
- Characterisation of the existing ecological values;
  - An overall characterisation of the ecological values of the project footprint, the WMNZ landholdings and the wider catchment or ecological district (ED) context.
- Assessment of the ecological effects;
  - An assessment of the actual and potential ecological effects of the proposed activity and is described at the scale of the project footprint and in the context of the WMNZ landholdings.
  - Measures to mitigate, offset or compensate these effects.
  - An assessment of the actual and potential ecological effects of the activity once the recommended mitigation package is implemented.

The method applied to the assessment of ecological effects is provided in Section 3 and applies to all environment types. A summary of all mitigation, offset and compensation measures proposed across the WMNZ landholdings are identified in Section 7.

2 Summary site description and project outline

This section provides a high level description of the ecological features of the WMNZ landholdings and an outline of WMNZ's proposed activities in the context of these. A detailed project description is provided in the AEE. The general project footprint is shown on drawings within the AEE. The ecological features referred to in this section are shown on Figures in Appendix B and are discussed in further detail throughout this report.

The WMNZ landholdings are located near the Wayby Valley, adjacent to State Highway 1 (SH1) 13 km northwest of Warkworth, within the Rodney Ecological District in the northern part of the Auckland region. For ease of description, the WMNZ landholdings has been delineated into four areas based on current land use, catchment boundaries and activities proposed by WMNZ. These are Eastern Block, Southern Block, Western Block and the Waiteraire Tributary Block as shown on Figure 1, Appendix B and described in the Glossary.

Much of the WMNZ landholdings have been subject to historic modification through forestry and farming activities. The Eastern Block is currently covered by exotic plantation forestry which is in its third harvest cycle and is 13 -16 years old. There is evidence of sediment deposition, slash and denuded understory across the Eastern Block as a result of the cyclic effects of forestry harvest.

However, the WMNZ landholdings do retain patches of regenerating native forest and a large wetland complex that includes low stature wetland vegetation as well as swamp forest habitat. Two large wetlands are identified as significant ecological areas being Wayby Wetland South (SEA_T_629) and Wayby Wetland North (SEA_T_6456). To the south, the WMNZ landholdings are bound by native forest in the Sunnybrook Scenic Reserve, which is identified as a Significant Ecological Area (SEA) in the Auckland Unitary Plan (AUP). None of the SEA's are proposed to be impacted by the works.

The main channel of the Hōteo River is adjacent to and immediately downstream of the WMNZ landholdings and is identified in the AUP as an SEA and a Natural Stream Management Area (NSMA). The incised meanders of the Hōteo are identified as being an Outstanding Natural Feature (ONF). The Hōteo River mouth at the Kaipara Harbour is a marine SEA.

There are also a diversity of streams across the WMNZ landholdings, all of which are tributaries of the Hōteo River, which discharges to the Kaipara Harbour. For the purposes of this report, the main stem within the Eastern Block is referred to as V1 Stream within Valley 1. Two main catchments are located within the Western Block, identified in this report as WA Stream to the north and WB Stream to the south. The Waiteraire Stream confluences with the Hōteo River to the south of the WMNZ landholdings, and a tributary of the Waiteraire Stream is located in the Southern Block, named S Stream. The headwaters of a second tributary within the Waiteraire Tributary Block of the Waiteraire Stream is also described within this report.

The landfill will be located within Valley 1 of the Eastern Block. It will fill the majority of the valley and the main stem and all tributaries of V1 Stream will be reclaimed.

Two stormwater treatment ponds will be located at the downstream extent of the landfill online of the V1 Stream within Valley 1. An offline wetland will be located adjacent to the V1 Stream at the confluence with a tributary from the east.

The primary landfill entrance and Access Road will be located off State Highway 1 (SH1) adjacent to a SEA. A bin exchange area (BEA) will be located approximately 160 m from SH1, within the Southern Block. The Access Road will traverse the Southern Block parallel to a natural stream management area (NSMA) and will cross 24 tributaries of the S Stream. The Access Road will cross the main stem of the S Main Stream upstream of the NSMA and will then continue into the upper catchment of WA Stream. The Access Road will then traverse downslope into the Eastern Block.

Three stockpiles are required to facilitate the development.

- Soil stockpile 1 is located in the headwaters of WB Stream within the Western Block;
- Soil stockpile 2 is located in the headwaters of WV Stream, within existing pine forest and upstream of the Sunnybrook Reserve; and
- Topsoil stockpile is located in the headwaters of WA Stream, within existing wattle and low stature regenerating native forest and upstream of Wayby Wetland (South).

A clay borrow pit will be constructed within the Western Block impacting degraded wetlands and tributaries of the WB Stream. Several smaller access roads and ancillary activities (such as office buildings) will be located across the site.

Erosion and sediment controls will be implemented across the project footprint and will comprise temporary and permanent treatment devices. Permanent sediment ponds will be constructed downstream of Stockpiles 1 and 2. Stockpile 1 Pond will be constructed offline of WB Stream on a degraded wetland. Stockpile 2 Pond will be located online of a tributary of WV Stream.

The above project activities are expected to have a range of effects on the ecological features of the WMNZ landholdings, which are discussed throughout this report.

A detailed description of the current ecological values and the anticipated ecological effects on each of these areas are described in the following sections.

3 Assessment of effects methodology

The method applied to this assessment of ecological effects broadly follows the Ecological Impact Assessment Guidelines (EcIAG) (Roper-Lindsay *et al*., 2018), with some adaptation for different fauna and ecosystem types. Using a standard framework and matrix approach such as this provides a consistent and transparent assessment of effects and is considered to be good practice.

The framework for assessment provides structure but needs to incorporate sound ecological judgement to be meaningful. Deviations or adaptions from the methodology are identified within each of the following sections as appropriate.

Outlined in the following sections, the guidelines have been used to ascertain the following:

- The level of ecological value of the environment (Step 1);
- The magnitude of ecological effect from the proposed activity on the environment (Step 2); and
- The overall level of effect to determine if mitigation is required (Step 3).

3.1 Step one: Assigning ecological value

Ecological values are assigned on a scale of 'Low' to 'Very High' based on species, communities, and habitats, using criteria in the EcIAG (see Table 3.1). These criteria can be readily applied to terrestrial environments.

There is no unifying set of attributes used to assign value to freshwater systems as there is for terrestrial ecosystems. There are however numerous metrics and measures that are used in the assessment of freshwater systems.

Matters that may be considered when assigning ecological value to freshwater systems include representativeness, rarity/distinctiveness, diversity and ecological context. The relative importance of these matters is often driven by availability of empirical information (measured attributes such as Macroinvertebrate community index (MCI) or water quality data).

In this assessment, stream ecological valuation (SEV) scores have been used as a relatively empirical measure of ecological value, although there are some subjective elements and it is a reach based assessment limiting its use as a catchment scale assessment tool. The concept of ecological integrity can be applied to freshwater systems and can use the SEV as a measure of 'deviation from pristine'.

In keeping with the guidance, professional judgement is applied throughout this assessment in relation to assigning value to species, habitats and environments, with specific reference to the empirical measures described above and the following:

- Nativeness: the degree to which an ecosystems structural composition is dominated by the indigenous biota characteristic of the region;
- Pristineness: relates to a wide array of structural, functional and physico-chemical elements (including connectivity), but is not necessarily dependent on indigenous biota constituting structural and functional elements;
- Diversity: richness (the number of taxa) and evenness (the distribution of individuals amongst taxa); link to a possible reference condition; and
- Resilience (or adaptability): quantifying to the probability of maintaining an ecosystem's structural and functional characteristics under varying degrees of human pressure.

Table 3.1: Ecological values assigned to species and habitats (adapted from Roper-Lindsay *et al.*, 2018).

Value	Species values	Habitat values
Very high	Nationally Threatened - Endangered, Critical or Vulnerable.	Supporting more than one national priority type. Nationally Threatened species found or likely to occur there, either permanently or occasionally.
High	Nationally At Risk – Declining.	Supporting one national priority type or naturally uncommon ecosystem and/or a designated significant ecological area in a regional or district Plan. At Risk - Declining species found or likely to occur there, either permanently or occasionally.
Moderate-high	Nationally At Risk - Recovering, Relict or Naturally Uncommon.	A site that meets ecological significance criteria as set out in the relevant regional or district policies and plans.
Moderate	Not Nationally Threatened or At Risk, but locally uncommon or rare	A site that does not meet ecological significance criteria but that contributes to local ecosystem services (e.g. water quality or erosion control).
Low	Not Threatened Nationally, common locally	Nationally or locally common with a low or negligible contribution to local ecosystem services.

3.2 Step two: Assess magnitude of effect

Magnitude of effect is a measure of the extent or scale of the effect of an activity and the degree of change that it will cause. The magnitude of an effect is scored on a scale of 'Negligible' to 'Very High' (Table 3.2) and is assessed in terms of:

- Level of confidence in understanding the expected effect;
- Spatial scale of the effect;
- Duration and timescale of the effect (Table 3.3);
- The relative permanence of the effect; and
- Timing of the effect in respect of key ecological factors.

The spatial scale for effects are considered in the context of the local and landscape scale effects as appropriate.

Table 3.2: Criteria for describing magnitude of effect (Roper-Lindsay *et al.*, 2018).

Magnitude	Description
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline[1] conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR

Magnitude	Description
	Loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

[1]Baseline conditions are defined as 'the conditions that would pertain in the absence of a proposed action' (Roper-Lindsay *et al*., 2018).

Table 3.3: Timescale for duration of effects (Roper-Lindsay *et al*., 2018).

Timescale	Description
Permanent	Effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years)
Long-term	Where there is likely to be substantial improvement after a 25 year period (e.g. the replacement of mature trees by young trees that need > 25 years to reach maturity, or restoration of ground after removal of a development) the effect can be termed 'long term'
Temporary[1]	Long term (15-25 years or longer – see above) Medium term (5-15 years) Short term (up to 5 years) Construction phase (days or months)

[1]Note that in the context of some planning documents, 'temporary' can have a defined timeframe.

3.3 Step three: Assessment of the level of effects

An overall level of effects is identified for each activity or habitat/fauna type using a matrix approach that combines the ecological values (described in Section 3.1) with the magnitude of effects (Section 3.2) resulting from the activity (Table 3.4).

The matrix describes an overall level of effect on a scale of 'Negligible' to 'Very High'. Positive effects are also accounted for within the matrix.

The level of effect is then used to guide the extent and nature of the ecological management response required, which may include remediation, mitigation, offsetting or compensation.

The overall level of effects on each value (habitat or species) is assessed before and after recommendations to avoid, remedy or mitigate effects. As such, the need for and extent to which recommendations to reduce effects, if implemented, is clearly understood.

Table 3.4: Criteria for describing overall levels of ecological effects (Roper-Lindsay *et al.*, 2018).

Ecological value (Table 3.1) / Magnitude (Table 3.2)	Very high	High	Moderate	Low	Negligible
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

3.4 Step four: Assigning a RMA interpretation to level of effect

Step 4 of the EcIAG process provides for the overall level of ecological effects to be translated to an 'RMA effect'. The level of 'RMA effect' is assessed by planners in consultation with ecologists and is therefore set out in the AEE report, rather than in an ecology report. This approach provides for consistency between the descriptions of ecological effects and other types of effects that may arise from a proposed activity which are considered elsewhere in the application documents.

4 Freshwater ecology values and effects

4.1 Freshwater ecology methods

A desktop assessment was undertaken to review available information and data relating to the freshwater ecology of the WMNZ landholdings and surrounding area, including reference to the New Zealand freshwater fish database (NZFFD, NIWA, 2018).

The following Auckland Council GIS layers were reviewed:

- Natural stream management areas (NSMA);
- Wetland management areas (WMA);
- Outstanding natural feature (ONF); and
- Overland flow path layer (including the predicted stream layer).

Site walkovers were undertaken to classify streams in accordance with the definitions in the Auckland Unitary Plan (AUP).

Site walkovers were undertaken from March until August 2018 to:

- Assess the extent of and classify the streams across the WMNZ landholdings;
- Determine the stream habitat types and condition across the WMNZ landholdings and within the proposed project footprint; and,
- Undertake Stream Ecological Valuations (SEVs) and baseline macroinvertebrate and fish surveys.

Aquatic ecology survey work was undertaken at stream sites that held water at the time of the survey and using methods appropriate to the particular habitat at each site. Data was collected in ArcCollector and photos were taken for each data point collected. General habitat descriptions were collected at each site/reach surveyed. The following sections describe the methods applied in more detail.

4.1.1 Stream classifications

4.1.1.1 Definitions

Watercourses in the Auckland Region are classified as permanent, intermittent, ephemeral or artificial, in accordance with the definitions listed within the AUP and as shown in Table 4.1. In keeping with the definition of 'river' in the Resource Management Act (RMA) 1991, the AUP looks to protect stream and river reaches that are permanent and intermittent.

While not explicitly identified within the AUP definitions itself, Auckland Council recommends that stream classification is undertaken between the months of July to October, when stream flows are at their peak (Neale, *et al.* 2016). This means that the overlying definition ('intermittently or permanently flowing') can be more easily identified. For this assessment stream classifications were undertaken in late June through to early August.

If the stream was flowing at time of assessment, it was considered to be a 'river or stream' and therefore was defined as either permanent, intermittent or artificial.

If the stream was observed to be highly modified, consideration was given as to whether the stream was artificial. For the most part this applied to streams within the Western Block where agricultural land use has resulted in the modification of stream and wetland systems. Consideration was given to the 'naturalness' of the channel, wider catchment topography, length, extent of modification and source of flows. Where a 'natural' portion of stream was present either upstream of, or fed into, an

otherwise artificial reach, the reach was classified as modified natural from the most upstream natural portion to the most downstream point. Where a natural portion of stream was present downstream of an otherwise artificial reach, the reach was classified as artificial to the transition point with the natural reach. These classifications were then checked against available historic aerial photography.

If at the time of assessment, the stream was not flowing, then the criteria listed under the 'intermittent' classification were applied. Where three of the criteria were present and could be assessed with confidence[1], a classification of intermittent was applied.

A classification of ephemeral was applied to reaches that could be assessed with confidence as having less than three intermittent stream criteria.

Wetlands were also identified across the site and these are discussed in the Section 6 of this report.

Table 4.1: AUP definitions of watercourses.

Classification	AUP OIP definition
River or stream	*A continually or intermittently flowing body of fresh water, excluding ephemeral streams, and includes a stream or modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal except where it is a modified element of a natural drainage system).*
Permanent river or stream	*The continually flowing reaches of any river or stream.*
Intermittent stream	*Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria:* *it has natural pools;* *it has a well-defined channel, such that the bed and banks can be distinguished;* *it contains surface water more than 48 hours after a rain event which results in stream flow;* *rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;* *organic debris resulting from flood can be seen on the floodplain; or* *there is evidence of substrate sorting process, including scour and deposition.*
Ephemeral stream	*Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.*
Artificial watercourse	*Constructed watercourses that contain no natural portions from their confluence with a river or stream to their head waters.* *Includes:* *canals that supply water to electricity power generation plants;* *farm drainage canals;* *irrigation canals; and* *water supply races.*

[1] For clarity, 'assessed with confidence' refers to the reliability of the individual criteria in the context of the site. For example, the criterion 'it has a well-defined channel, such that the bed and banks can be distinguished' could not be assessed with confidence where stock access had resulted in degradation to the channel. Similarly, if there was no upstream vegetation or source of flood debris, 'organic debris resulting from flood can be seen on the floodplain' could not be assessed with confidence.

Classification	AUP OIP definition
	Excludes: *naturally occurring watercourses.*

4.1.1.2 Approach to stream classification

Based on initial review of overland flow paths and a site walkover to inform an opportunities and constraints assessment, it was determined that walking every length of stream across the site was going to take a significant amount of time. This was because of access constraints within forestry areas where fallen trees, steep terrain and forestry slash caused a health and safety risk.

At the time of the field assessments, access to the Eastern and Southern Blocks was restricted due to dense vegetation and forestry slash. As such, a two-step approach to stream classification was applied within these Blocks. There were no restrictions to access within the Western Block and all streams were walked and classified based on the definitions provided in the AUP.

In the first step, stream length and type was estimated based on Auckland Council's Overland Flow Path Layer (OLFPL). The OLFPL models flow paths based on catchment sizes and from this the extent of permanent, intermittent and ephemeral streams can be inferred[2].

Using the estimated extent of stream across the site, 'spot checks' of headwater reaches within the Eastern and Southern Blocks were undertaken to ground-truth stream classifications. At each 'spot check' location, the AUP stream definitions were assigned and streams were classified accordingly (as described in Section 4.1.1.1).

Within the Southern Block, the most upstream extent of sections of streams anticipated to be affected were identified and classifications made accordingly. The headwaters of all streams anticipated to be impacted within the Southern Block could be accessed and assessed.

Within the Eastern Block the OLFPL model was modified based on the ground-truthing of stream classifications. The principles and concepts from Lowe (2016) and Storey and Wadhwa (2009) were applied and geology was identified from the GNS website (GNS Science, 2018).

Actual observations of the headwaters of intermittent streams within the Eastern Block were used to estimate average threshold catchment sizes to produce intermittent flows. Catchment slope can produce variability in contributing area thresholds (Storey & Wadhwa, 2009). Due to the variability of catchment slopes the Eastern Block valley was divided into six sub-areas: northwest (NW), north (N), northeast (NE), southwest (SW), south (S), and southeast (SE) (refer polygons within Figure 4.1), so that the slope within each of these sub-areas was assessed as being broadly uniform. This provided a more accurate threshold catchment size for each sub-area, rather than one threshold for the whole valley.

The sub-catchment contributing surface flow to each intermittent stream headwater observation was then drawn as a polygon in GIS using 5 m contour lines as a guide. The area of each sub-catchment polygon (shown as green polygons in Figure 4.1) was extracted from GIS, entered into a spreadsheet and the average area for each sub-area calculated (shown in Table 4.2). Table 4.2 shows the average sub-catchment size within each of the delineated catchments and then an average sub-catchment size for the northern and southern areas. This identifies that there are differences in the sub-catchment size contributing to intermittent stream flow across Valley 1.

Based on the sub-catchment sizes obtained, the OLFPL was edited within Valley 1 to account for the estimated contributing sub-catchment size. This was applied across the entire Valley, so that sub-

[2] Based on work by Storey and Wadhwa (2009).

catchments of < X ha were classified as ephemeral (where 'X' is shown in Table 4.2). Anything else was determined to be either intermittent or permanent.

Figure 4.1: Catchment delineation within Valley 1 to determine approximate contributing catchment size to result in intermittent stream flow. Red lines determine the

Table 4.2: Sub-catchment area calculations.

Sub-Areas	Northern (total)	N	NE	NW	Southern (total)	S	SE	SW	Overall
Average of Area (ha)	**0.42**	0.43	0.52	0.31	**0.62**	0.37	0.8	0.86	**0.5**
Count of Area ID	**21**	6	8	7	**13**	6	3	4	**34**

Where stream reaches were actually walked, the modelled stream classification was changed to be consistent with what was observed on site. These stream reaches are documented as 'ground-truthed' in the results. Streams that could not be accessed or were not classified on site were assigned a classification of either intermittent or permanent and are documented as 'modelled' in the results.

Stream length that was not walked or subject to modelling as described above, is referred to as 'predicted' and is based on the predictions from Auckland Council data (Lowe (2016) and Storey and Wadhwa (2009)). These 'predicted' streams are those outside of the project footprint and provide context regarding the streams present across the wider WMNZ landholdings.

Data presented is therefore a combination of 'walked' streams' (W), 'modelled' streams which include 'modelled' (M) and ground-truthed (GT) classifications, and 'predicted' (P) which are based on OLFP data. We consider that this has provided a comprehensive understanding of the distribution of stream length and classification across the project footprint and within the wider WMNZ landholdings.

4.1.2 Physico-chemical water quality

Basic water quality parameters were collected using a calibrated YSI multi meter at the same time as baseline macroinvertebrate sampling.

Monthly surface water quality monitoring has been undertaken on ten occasions at four sites as follows (for further details see Technical Report F, Volume 2):

- SW1 - A site at the base of the Access Road to monitor effects within the Southern Block;
- SW2 - A site upstream of the proposed Access Road (to provide a control site within the Southern Block);
- SW3 - A site downstream of the landfill discharge point and the control site. This will enable comparison between the control site and the landfill discharge; and
- SW4 - A control site located within a similar size catchment with similar contributing catchment (e.g. plantation forestry) to the proposed landfill site, located upstream from the landfill discharge location (landfill control site).

Samples were analysed for a suite of parameters (Table 4.3) to inform the existing water quality and provide a baseline against which changes in water quality can be assessed.

Summary results are presented within this report in the context of ecological matters. Results are reported in full in the Baseline Monitoring Report (see Technical Report F, Volume 2) and justification for these parameters is outlined in the Stormwater and Industrial and Trade Activity Report (see Technical Report P, Volume 2).

Table 4.3: Monthly surface water quality monitoring parameters

Turbidity	Electrical Conductivity (EC)	Total Manganese
Total Suspended Solids	Total Alkalinity	Total Potassium
Temperature and pH	Heavy metals, totals, As, Cd, Cr, Cu, Ni, Pb, Zn	Total Sodium
Nitrate-N	Total Hardness	Chloride
Oil and Grease	Total Aluminium	Total Ammoniacal-N
Chemical Oxygen Demand (COD)	Total Calcium	Sulphate
Total Phenols	Total Iron	Total Phosphorus
Volatile Organic Compounds	Total Magnesium	Carbonaceous Biochemical Oxygen Demand (cBOD5)

4.1.3 Aquatic macroinvertebrates

Aquatic macroinvertebrate community structure, abundance and diversity are standard indicators of the long-term health of streams. Different taxa show varying tolerance of pollutants, so their presence or absence gives an indication of stream condition.

Macroinvertebrate data was collected at a total of 25 sites for two purposes as follows:

- To inform baseline water quality across the project footprint:
  - Macroinvertebrate data were collected on 26 and 30 July 2018 to inform baseline water quality and stream health across the project footprint. Three replicate samples were collected at each of six sites (Sites MC1 to MC6 shown on Figure 2, Appendix B).
  - Sites were selected to complement baseline water quality sampling sites (MC1, MC3 and MC4 with SW1, SW3 and SW4 respectively); to monitor effects of activities on the NSMA (MC2) and to monitor effects in the Western Block (MC5 and MC6).

  - Sampling was undertaken at least 10 days after a rainfall event that elevated stream flow more than five times the preceding base flows. Stream flow data was obtained from the Waiteitei River at Sandersons site, which is approximately 7 km from the site[3].
  - Three replicates were collected from each site which means that statistically significant differences in average macroinvertebrate index values can be detected when the difference is equal to or greater than 6.25 MCI units (Stark *et al.*, 1998). This allows statistically significant differences in MCI values between sites to be determined, as well as between sampling events at the same site.
  - Basic water physicochemical measures were recorded at each site at the time of macroinvertebrate sampling using calibrated handheld instruments.
- To inform the invertebrate fauna intact (IFI) function within the Stream Ecological Valuation (SEV) methodology:
  - A single macroinvertebrate sample was taken at each SEV site.
  - 19 samples were collected at SEV sites (Figure 2, Appendix B).
  - Baseline sample MC 2 was taken at the same site as SEV12, and so the data from the three replicates was combined for inclusion in the SEV calculator.
  - All macroinvertebrate data was entered into the relevant SEV calculator.

Sites were classified as hard-bottom or soft-bottom based on the predominant substrate type present in the sampling reach. For sites where both soft-bottom and hard-bottom substrates were present, the sampling protocol was selected based on the habitat type most representative of the reach, as advised in Stark *et al.* (2001).

Macroinvertebrate samples were collected using a kick net (D-shape, 0.5 mm mesh size). Sampling followed the semi-quantitative method for hard-bottom and soft-bottom streams (protocols C1 and C2 respectively, of Stark *et al.*, 2001). Stable habitat features such as bank margins, woody debris and macrophyte were sampled in soft-bottom streams according to their occurrence in the reach. Riffle habitat was sampled in all hard-bottom streams[4].

Macroinvertebrate samples were preserved in ethanol prior to being sent to Stark Environmental Limited for taxonomic identification and processing. Samples were processed in accordance with Protocol P2 (200 fixed count and scan for rare taxa, Stark *et al.*, 2001).

The results reported include:

- Taxonomic richness. This is a measure of the number of different types of macroinvertebrate present in each sample and is a reflection on the diversity of the sample;
- Ephemeroptera, Plecoptera and Trichoptera (EPT) richness. This index measures the number of pollution-sensitive macroinvertebrates (mayfly, stonefly and caddisfly (excluding *Oxyethira* and *Paroxyethira* taxa because these are tolerant of degraded conditions) within a sample. Percent EPT richness represents the number of EPT taxa as a proportion of the total number of taxa within the sample;
- Macroinvertebrate Community Index (MCI). The MCI is an index for assessing the quality class of a stream using presence or absence of macroinvertebrates. MCI is used for hard-bottom streams, while MCI-sb is for soft bottom streams; and

[3] Flow data accessed from Auckland Council GeoMaps, https://geomapspublic.aucklandcouncil.govt.nz/viewer/index.html.
[4] The exception to this was baseline site MC3, which was characterised by bedrock cascades and deep run habitat, with minimal riffle or suitable soft-bottom habitat to allow three replicates to be taken for either protocol. Protocol C1 was therefore modified so that bedrock cascades covered with moss were sampled instead of riffle habitat.

- Quantitative Macroinvertebrate Community Index (QMCI). QMCI is another index based tool, based on the relative abundance of taxa within a community, rather than just presence or absence. QMCI is used for hard-bottom streams, while QMCI-sb is for soft bottom streams.

The MCI and QMCI reflect the sensitivity of the macroinvertebrate community to changes in water quality and habitat, where higher scores indicate better stream condition. Macroinvertebrate index values are then translated to quality classes which describe the ecological health of the stream (Table 4.4).

Table 4.4: Interpretation of macroinvertebrate biotic indices (Stark & Maxted, 2007)

Stark & Maxted (2004, 2007) quality class	MCI or MCI-sb	SQMCI & QMCI, SQMCI-sb & QMCI-sb
Excellent	>119	> 5.99
Good	100 - 119	5.00 – 5.90
Fair	80 - 99	4.00 – 4.90
Poor	<80	< 4.00

4.1.4 Freshwater fauna

NIWA administers the NZ Freshwater Fish Database (NZFFD) which stores data on the location of freshwater fish species across the country. The NZFFD was used to determine what freshwater fauna may be present on site prior to freshwater surveys commencing. NZFFD data are available for streams in the immediate catchment surrounding the WMNZ landholdings (and presented in Table 4.11).

Fish surveys were undertaken in August 2018 at seven sites (Table 4.5 and Figure 3, Appendix B).

Table 4.5: Fish survey sites and relative location in each Block

Block	Southern block		Eastern block		Western block		
Location	Downstream	Upstream	Downstream	Mid-reach	Upstream	Downstream	Upstream
Site name	F1	F2	F3	F4	F5	F6	F7

The fish survey method employed was in general accordance with the New Zealand Freshwater Fish Sampling Protocols for Wadeable Rivers and Streams (Joy *et al.*, 2013).

A combination of fyke nets and gee minnow traps were baited with cheese and left overnight and cleared the next morning at each site. Nets and traps were evenly distributed over a 100 m survey reach unless access was restricted due to large slash, thick riparian vegetation, and/or deep water. Fish were identified, measured and then released into the same stream in which they were caught.

The following variables were observed and recorded during fish assessments:

- Species and size;
- Condition (such as disease visually present); and
- GPS location, weather conditions and stream characteristics.

Fish survey results were used to calculate the Index of Biotic Integrity (IBI) (Table 4.6) (Joy, 2004). The fish IBI compares the community of fish present, with what might be expected considering the

altitude of the site and distance from the coast. It does not take into consideration presence of artificial or natural barriers to fish passage.

Table 4.6: Fish IBI classes for the Auckland region (Joy, 2004)

Total IBI score	Integrity class	Attributes
50 – 60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 97th percentile of Auckland sites.
42 – 49	Very good	Site is above the 90th percentile of all Auckland sites, species richness is slightly less than best for the region.
36 – 42	Good	Site is above the 70th percentile of Auckland sites but species richness and habitat or migratory access reduced, some signs of stress.
28 – 35	Fair	Score is just above average but species richness is significantly reduced. Habitat and or access impaired.
18 – 27	Poor	Site is less than average for Auckland region IBI scores, less than the 50th percentile thus species richness and or habitat are severely impacted.
6 – 17	Very poor	Site is impacted or migratory access almost non-existent.
0	No fish	Site is grossly impacted or migratory access non-existent.

Fish IBI data were used to inform the Fish Fauna Intact (FFI) function within the SEV. Fishing was not undertaken at all SEV sites due to access constraints and so a representative IBI was assigned to SEV reaches based on proximity or representativeness of the fish survey site.

Barriers to fish passage were identified during site walkovers and are reported in the context of the fish survey results. Where a barrier was known to be downstream of a fishing site, this has been used to provide context to the fish caught during surveys.

4.1.5 Stream ecological valuations (SEV)

The SEV method was used to assess the aquatic ecological function of 20 representative sites across the subject site using the methods described in Storey *et al*. (2011), Neale *et al*. (2011) and Neale *et al*. (2016).

Fourteen variables are assessed and values assigned to four key ecological functions as follows:

- Hydraulic – assesses the flow regime, floodplain effectiveness and connectivity of the stream reach;
- Biogeochemical – associated with the processing of pollutants, in-stream water chemistry and input and retention of organic matter;
- Habitat provision – incorporates instream habitat for aquatic fauna and for fish spawning; and
- Biodiversity provision – the level of intactness of fish fauna, invertebrate fauna and riparian vegetation.

SEV results are reported on a scale of 0 to 1, where 1 is a pristine stream (i.e. native forest, non-modified) and values below this are a departure from these reference conditions. Each function is measured and compared to what would be expected in 'reference conditions' and the final score is an aggregation of weighted attributes that identifies how far from 'pristine' the stream reach is.

Representative SEV sites were selected in Valley 1 (n=7), Southern Block (n=6), Western Block (n=6) and Waiteraire Tributary Block (n=1). A range of intermittent and permanent streams, and hard and

soft- bottom streams were selected. Sites were chosen as being either within an expected impact area, or as potential mitigation or offset sites. A summary of SEV sites and their location is provided in Table 4.7 and their locations are shown on Figure 4, Appendix B.

SEV were undertaken in July and early August 2018, consistent with the guidance for intermittent streams (Neale *et al.*, 2016). Field data were entered into the Intermittent Stream SEV calculator and Permanent Stream SEV calculator for intermittent and permanent streams respectively.

Macroinvertebrate and fish data collected as outlined in Section 4.1.2 and 4.1.4 and was added into SEV calculators. These calculators include reference data for fish and invertebrates from native intermittent and permanent reference sites.

The intermittent SEV macroinvertebrate reference data include only soft-bottom stream types. Of the 20 SEV sites, only three were truly hard-bottom. As such, no additional reference data were selected for these three sites, rather the soft-bottom intermittent stream invertebrate data have been relied on.

Table 4.7: Summary of SEV sites sampled

Date	SEV ID	Block ID	Description	Stream type	Stream classification	Within works footprint
13/07/2018	SEV3	Eastern block	Tributary south side within Valley 1	HB	Permanent	Y
17/07/2018	SEV4	Eastern block	Main channel downstream within Valley 1	SB/HB (bedrock) mix	Permanent	Y
17/07/2018	SEV5	Eastern block	Main channel mid-reach within Valley 1	SB with a few riffles	Permanent	Y
18/07/2018	SEV6	Eastern block	Main stem upstream within Valley 1	SB/HB mix	Permanent	Y
18/07/2018	SEV7	Eastern block	Tributary north east within Valley 1	SB	Intermittent	Y
24/07/2018	SEV13	Eastern block	Tributary south west side within Valley 1	SB	Intermittent	Y
25/07/2018	SEV16	Eastern block	Tributary north side within Valley 1	SB	Permanent	Y
12/07/2018	SEV1	Southern block	Side tributary impacted by Access Road	SB	Permanent	Y
12/07/2018	SEV2	Southern block	Main channel upstream of Access Road culvert	HB	Permanent	N
24/07/2018	SEV11	Southern block	Tributary impacted by Access Road	SB	Intermittent	Y
24/07/2018	SEV12	Southern block	Main channel within NSMA	HB	Permanent	Y
25/07/2018	SEV14	Southern block	Tributary impacted by Access Road	SB	Intermittent	Y
25/07/2018	SEV15	Southern block	Tributary impacted by Access Road	SB	Permanent	Y
18/07/2018	SEV8	Western block	Tributary within Stockpile 1 footprint	SB	Intermittent	Y
18/07/2018	SEV9	Western block	Tributary within Stockpile 1 footprint	SB	Permanent	Y
18/07/2018	SEV10	Western block	Access road to Valley 1 and Stockpile 1	SB	Intermittent	Y
7/08/2018	SEV17	Western block	Main channel, downstream of Stockpile 1	SB	Permanent	N
7/08/2018	SEV18	Western block	Middle of farm, east of woolshed	SB	Permanent	N
7/08/2018	SEV19	Western block	Main channel, downstream of site impacts	SB	Permanent	N
23/08/2018	SEV20	Waiteraire Tributary Block	Headwater tributary impacted by Stockpile 2	SB/HB mix	Intermittent	Y

4.2 Freshwater ecology results

4.2.1 Catchment overview

The proposed Auckland Regional Landfill site will be located on WMNZ landholdings in the mid to upper Hōteo Catchment, approximately 35 km from the Kaipara Harbour. The Hōteo is Auckland's largest catchment, draining nearly 8 % of the land area of the Auckland region. At its confluence with the Kaipara Harbour, the Hōteo has a catchment area of 405 km^2.

WMNZ landholdings are bound by the Hōteo River to the west and Wilson Road to the east. It is steep to the east adjacent to Wilson Road and the topography shallows out to gently rolling hills and then river flats closer to the Hōteo River. The total WMNZ landholdings represents approximately 2.6 % of the Hōteo catchment area (with the landfill footprint representing 0.2 % of the catchment area). Aquatic systems across the WMNZ landholdings vary as a result of historic land use and are described in four main areas (shown on Figure 1, Appendix B).

4.2.1.1 Eastern Block

The proposed landfill will be located in Valley 1 of the Eastern Block. The Eastern Block is characterised by steep gully systems and exotic pine forest. The pine forestry is currently 13 to 16 years into the harvest cycle and some native understory is present (Figure 4.2). The Eastern Block has a catchment area of approximately 4.5 km^2 including 1.09 km^2 located in Valley 1. The main stem within Valley 1 (V1 Stream) is a permanent stream and is identified on Auckland Council GeoMaps as River Number 457405.

Native vegetation is present along some stream margins with the balance largely plantation pine. The overall vegetation cover contributes to high shading of the stream systems (Figure 4.3). Streams were soft and hard-bottom with a variety of substrate types present throughout the reaches. Cobbles were the dominant substrate in the main stem, however sediment deposition was evident and is anticipated to be a result of forestry activity increasing sediment run-off. Many of the tributaries were bedrock based, resulting in waterfalls and cascades, with areas of sediment deposition evident particularly downstream of these features.

Figure 4.2: View over Valley 1 from north-eastern side. Pine canopy with native understory.

Figure 4.3: Downstream extent of Valley 1 Stream main channel.

4.2.1.2 Western Block

The Western Block comprises gently rolling hills and river flats adjacent to the Hōteo River. The Hōteo River is recognised as an NSMA and ONF in this location. Currently an operational sheep farm, this part of the site is generally devoid of native vegetation within the flats. Steeper hill country borders the Western Block on the northern, eastern and southern sides. Some areas of mature native vegetation are present in these areas, several classified as SEA.

Streams within the flatter land of the Western Block are highly modified, devoid of riparian margins and unfenced (Figure 4.5). Many of the streams on the steeper slopes were narrow, had bedrock base and were unfenced (for example, headwaters of WB Stream, AC River Numbers 457387). Pockets of native and exotic vegetation on the slopes protected the streams in some locations. To the south-west of Wayby Wetland South, an extensive area of wattle, pine and native forest protects the headwaters of the WA Stream (Auckland Council GeoMaps River Number 457385). The WA Stream had a high loading of sediment, due to the nature of the geology in the catchment (Figure 4.4).

Figure 4.4: Downstream WB catchment, upstream of Wayby Wetland South.

Figure 4.5: Modified stream channels through lower gradient land across farm.

4.2.1.3 Southern Block

The Southern Block is the most intact of the stream catchments surveyed and comprises a steep gully system of approximately 0.75 km^2 catchment area. The S Stream (AC River Number 457361) is a tributary of the Waiteraire Stream and is identified as a NSMA in the lower reaches. Fish passage to the upper part of the Southern Block has been impacted by a perched culvert under an old access track. The vegetation within the catchment is regenerating native and exotic wattle and is contiguous with the Sunnybrook Reserve (SEA-Terrestrial, SEA_T_6634).

Figure 4.6: Indicative stream channel in Southern Block.

Figure 4.7: Waterfall cascade and pool in Southern Block.

4.2.1.4 Waiteraire Tributary Block

The WV Stream (AC River Number 457368) is located to the southeast of the landfill footprint. Currently in exotic pine plantation, it falls steeply to the south and the stream discharges into the Sunnybrook Reserve and a NSMA. Streams within the WV gully system are similar to those in Valley 1, with hard-bottom substrates and pine forestry the dominant land use (Figure 4.8, Figure 4.9).

Figure 4.8: Bedrock cascade in Waiteraire Tributary Block stream site.

Figure 4.9: Example of riparian margins in Waiteraire Tributary Block stream site.

4.2.2 Stream classifications

We estimate that there is in the order of 135 km of ephemeral, intermittent and permanent stream within the WMNZ landholdings. This has been determined from walked, modelled and predicted stream length data (as described in Section 4.1.1). We estimate that there is 43 km of permanent stream, 22 km of intermittent stream and 21 km of ephemeral stream across the WMNZ landholdings (Figure 1 Appendix B, Appendix C Table 1).

There is estimated to be a further 49.4 km of 'unclassified' stream within the WMNZ landholdings. This includes overland flow path length which has been modelled (by Auckland Council) to have insufficient catchment size to create ephemeral or intermittent flows. Based on our observations in Valley 1 of the Eastern Block, where we modified stream classifications following ground-truthing, we consider that the 49.4 km of 'unclassified' stream is likely to have ephemeral or intermittent flows.

As such, we consider that the combined length of ephemeral, intermittent and permanent stream length within the WMNZ landholdings is 135 km. Refer to Appendix C for more detail.

4.2.3 Physico-chemical water quality

Basic water quality parameters were tested at the time of macroinvertebrate sampling (Table 4.8). All sites were within normal range for all parameters. Temperatures were particularly low due to winter conditions. These results are not representative of summer conditions when it is expected that conditions will be less favourable in un-vegetated stream channels within the farm.

Table 4.8: Basic water quality parameters from macroinvertebrate sampling.

Site	Date	Time	DO %	DO mg/L	Temp	pH	Electrical conductivity (uS/cm)	Temperature on probe
MC5	27/08/2018	10:00	87.8	9.74	10.8	7.48	125	10.1
MC6	27/08/2018	12:00	84.4	9.55	10	7.11	145	9.5
MC3	27/08/2018	14:00	104.6	11.2	12.3	7.56	218	12
MC4	27/08/2018	15:30	103.8	11.06	12.5	7.45	215	12.1
MC1	30/07/2018	10:00	87.5	9.77	10.5	7.3	192	10.2
MC2	30/07/2018	12:00	103.9	11.29	11.4	7.46	193	11.2

Full results from the monthly water quality monitoring are provided within the Baseline Monitoring Report (see Technical Report F, Volume 2) and discussed in the context of the proposed works within the Stormwater and Industrial and Trade Activity Report (see Technical Report P, Volume 2).

To date ten rounds of monitoring have been undertaken. Due to the limited monitoring data, the results have been compared to Auckland Council monitoring data for the Mahurangi Redwoods Catchment. The monitoring results are within similar ranges to the Redwoods site and are generally indicative of excellent water quality. This is expected due to the relatively small upstream catchments, and limited other sources of contaminants in the area.

4.2.4 Aquatic macroinvertebrates

Baseline macroinvertebrate data and SEV data are reported separately within this section. Full macroinvertebrate results are included in Appendix C.

4.2.4.1 Baseline macroinvertebrate monitoring

The average and standard error for MCI, QMCI and percent EPT richness at each site have been calculated across the three replicates (Table 4.9). The proportion of taxa within different taxonomic groups relative to the total number of taxa at a site provides an indication of the community structure[5] (Figure 4.10).

The highest average MCI and QMCI scores were found at sites MC2, MC4 and MC3 (Table 4.9) corresponding to 'Excellent' or 'Good' water quality classes. These three sites also had the highest percent EPT richness among the six baseline sites (Figure 4.10).

The MCI value at site MC2 was higher than that of Auckland's State of the Environment (SOE) macroinvertebrate monitoring sites in native forest (124.9 MCI units, Neale *et al.*, 2017). MC2 percent EPT richness was also above the average for native forest SOE sites (48.2% EPT richness, Neale *et al.*, 2017).

Despite being located within an exotic forestry catchment, MCI values and proportion of pollution-sensitive EPT taxa recorded at Sites MC3 and MC4 was high. This is because these sites have experienced minimal catchment disturbance in recent years and are well shaded. The average MCI for sites MC3 and MC4 is comparable to Auckland SOE monitoring sites in exotic forestry catchments (average MCI 118.5, Neale *et al.*, 2017). EPT richness at MC3 and MC4 was close to the maximum EPT richness recorded among SOE forestry sites (61.8% EPT richness, Neale *et al.*, 2017).

The lowest average macroinvertebrate indices were recorded at sites MC5 and MC6 which flow through pasture grazed by sheep. The average percent EPT richness at these sites is also the lowest

[5] Eight dominant taxonomic groups have been displayed individually while all remaining taxonomic groups are shown as 'Other' taxa, including Platyhelminthes (flatworms) and Microvelia (water bugs).

across the six baseline sites. The 'Poor' quality class and prevalence of pollution-tolerant taxa at these sites is expected to be a result of nutrient runoff, minimal shading, elevated deposits of fine sediments and dominance of one habitat type (macrophytes). Average MCI values for these sites were below those recorded at Auckland's SOE macroinvertebrate sites in high intensity rural areas (85.8 MCI units between 2011 and 2013), however EPT richness was above the average for SOE rural high intensity sites (22.9% EPT richness, Neale *et al.*, 2017).

Results from MC1 corresponded to 'Fair' (MCI) and 'Poor' (QMCI) quality classes. On average one third of the taxa at MC1 were pollution-sensitive EPT taxa. Although this site is located on the same reach as the high-scoring MC2 site, it flows through a raupō wetland with minimal shading along the true left bank of the stream. Dissolved oxygen at MC1 was comparable to readings at sites MC5 and MC6. Elevated fine sediment loads and a lack of woody debris to provide stable habitat for macroinvertebrates were observed at this site. These factors may explain the lower macroinvertebrate index values and corresponding quality classes at this site compared to the MC2 site upstream.

Table 4.9: Macroinvertebrate Indices across three replicates at each baseline monitoring site

		MC1	MC2	MC3	MC4	MC5	MC6
MCI/ MCI-sb[1]	Average	99	132	118	124	74	75
	Std. error	1.25	4.18	1.20	1.94	1.10	3.84
QMCI/ QMCI-sb[1]	Average	3.91	8.03	6.27	6.96	3.07	2.75
	Std. error	0.62	0.06	0.11	0.28	0.19	0.12
EPT richness (%)	Average	32.49	52.38	61.62	57.01	12.22	13.89
	Std. error	4.10	3.26	2.53	0.80	0.58	3.17

Notes:

1. Grey shading indicates that soft-bottom indices (MCI-sb, QMCI-sb) were used, according to the substrate type and corresponding macroinvertebrate sampling methodology.

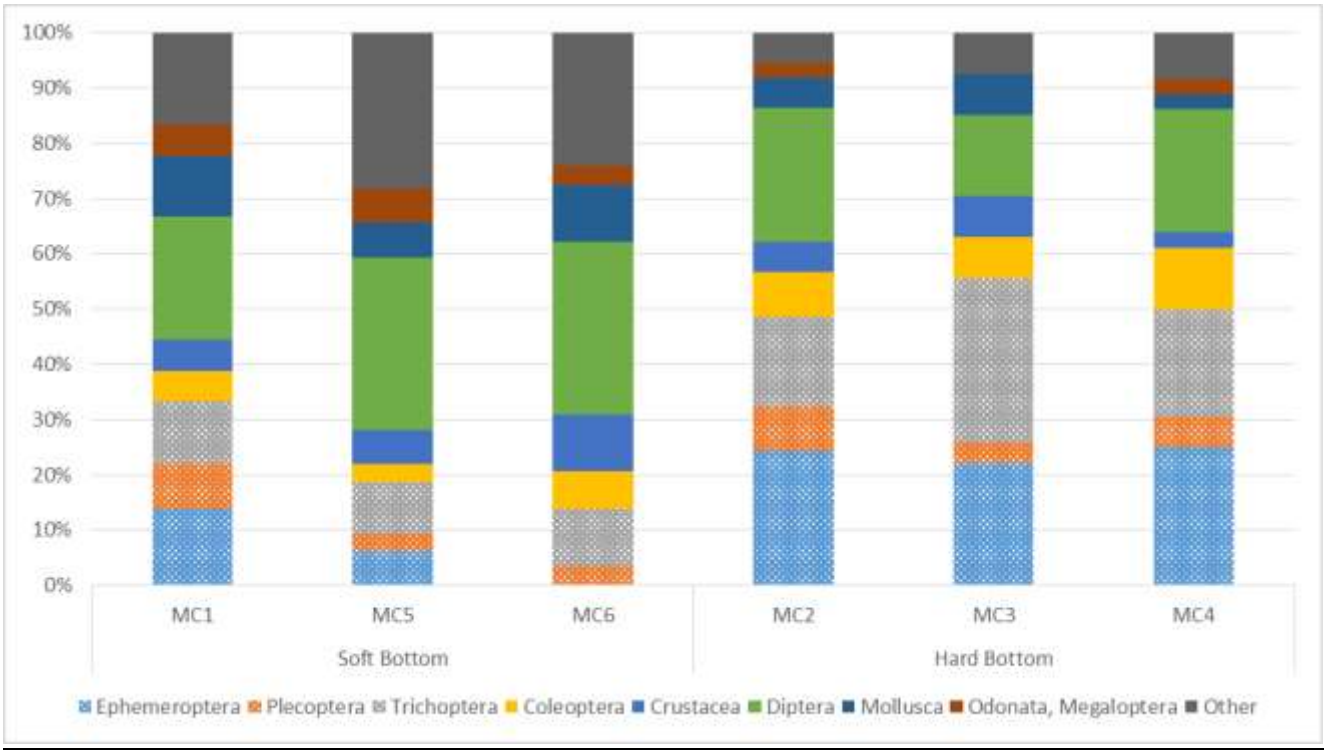

Figure 4.10: Baseline macroinvertebrate taxa richness. Cross-hatched areas are pollution-sensitive EPT taxa

4.2.4.2 SEV macroinvertebrate data

The MCI, QMCI, taxa richness and percent EPT richness have been calculated for each of the SEV sites (Table 4.10). The proportion of taxa within different taxonomic groups relative to the total number of taxa at a site provides an indication of the community structure[6] (Figure 4.11).

Macroinvertebrate data from sites within the Western Block were typically representative of 'Poor' or 'Fair' MCI and QMCI values. These sites also had the lowest % EPT richness, with one site having no EPT taxa at all. SEV 10 was the only hard-bottom site within the Western Block and was the exception with a MCI of 113, indicative of 'good' stream health. SEV 8 had a QMCI indicative of 'good' stream health and a % EPT richness of 25%, the highest of the scores within the Western Block.

All but one SEV site within Valley 1 of the Eastern Block had soft-bottom streams and had MCI scores indicative of either 'good' or 'excellent' stream health. Five of the seven sites had QMCI indicative of excellent stream health and four had % EPT richness of > 40 %. SEV 3 was the only hard-bottomed SEV site within the Eastern Block had had the highest of all MCI recorded (133). Four of the SEV macroinvertebrate scores were higher than the average scores for Auckland SOE monitoring sites in exotic forestry catchments (average MCI 118.5) and three of these were higher than reference native forest sites (average MCI 124.9) (Neale *et al.*, 2017).

Streams within the Southern Block had similarly high MCI scores to the Eastern Block. All but one site had an MCI value indicative of 'excellent' stream health. Two sites had %EPT richness of greater than 40 %. The MCI scores obtained within the Southern Block are comparable to Auckland SOE monitoring sites in reference native forest sites (average MCI 124.9) (Neale *et al.*, 2017).

[6] Eight dominant taxonomic groups have been displayed individually while all remaining taxonomic groups are shown as 'Other' taxa, including Platyhelminthes (flatworms) and Microvelia (water bugs).

A single SEV was undertaken at the proposed location of Stockpile 2 and revealed an MCI and QMCI score indicative of 'good' stream health. This score is comparable to the average score for Auckland SOE monitoring sites in exotic forestry catchments (average MCI 118.5, Neale *et al.*, 2017).

Table 4.10: Summary statistics for macroinvertebrate samples collected at SEV sites

Area block	SEV ID	Stream classification	MCI/MCI-sb[1]	QMCI/QMCI-sb[1]	Taxa richness	EPT richness (%)
Western block	SEV 8	Intermittent	89	5.08	16	25
	SEV 9	Permanent	80	2.63	21	14
	SEV 10	Intermittent	113	4.04	15	20
	SEV 17	Permanent	72	2.92	22	14
	SEV 18	Permanent	67	2.04	22	0
	SEV 19	Permanent	73	1.93	20	10
Eastern block	SEV 3	Permanent	133	6.68	20	45
	SEV 4	Permanent	110	6.78	25	40
	SEV 5	Permanent	126	7.77	24	54
	SEV 6	Permanent	118	7.36	18	44
	SEV 7	Intermittent	129	5.70	25	12
	SEV 13	Intermittent	117	5.83	13	15
	SEV 16	Permanent	121	6.87	10	30
Southern block	SEV 1	Permanent	124	6.79	12	17
	SEV 2	Permanent	122	6.86	24	42
	SEV 11	Intermittent	116	7.60	20	20
	SEV 12[2]	Permanent	130	8.03	37	49
	SEV 14	Intermittent	122	5.70	18	17
	SEV 15	Permanent	122	4.29	12	17
Waiteraire Tributary Block	SEV 20	Intermittent	118	5.31	17	18

Notes:

1 Grey shading indicates that soft-bottom indices (MCI-sb, QMCI-sb) were used, according to the substrate type and corresponding macroinvertebrate sampling methodology.

2 SEV12 values were obtained from combining three replicates from MC2 baseline sampling. As such, the number of taxa is markedly higher than other sites which is expected to be a result of the sample volume being three times that collected for other samples.

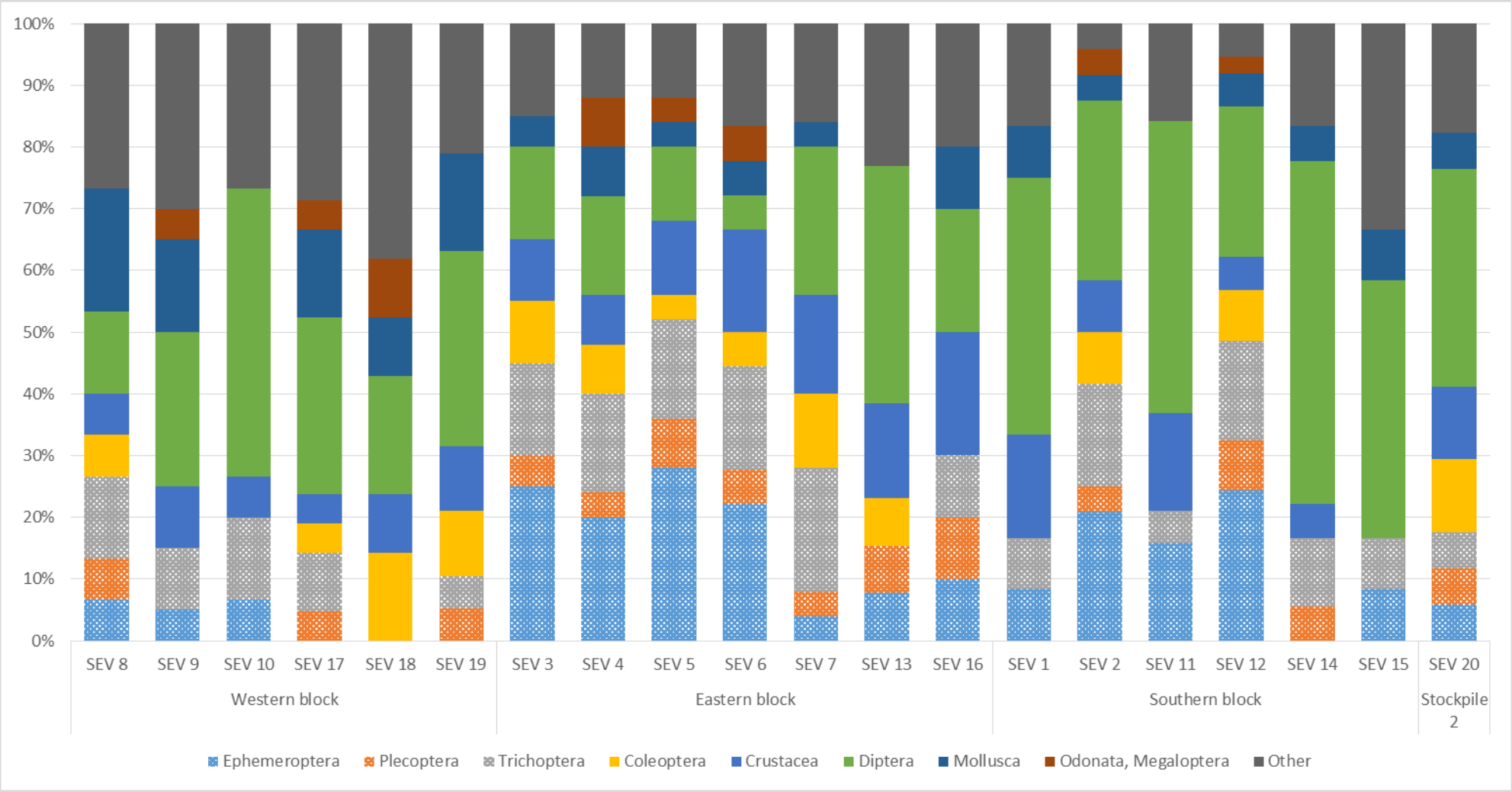

Figure 4.11: SEV macroinvertebrate data taxa richness. Cross-hatched areas are pollution-sensitive EPT taxa

4.2.5 Freshwater fauna

Prior to this survey, there were no records of fish within the WMNZ landholdings. NZFFD data for streams immediately surrounding the WMNZ landholdings were collated and presented in Table 4.11 and Figure 3, Appendix B. Two species recorded in the NZFFD are identified as 'at risk declining'.

Fish captured during the survey were similar species to those recorded in the NZFFD. Crans bully have previously been recorded in nearby catchments, including the reach downstream of the F3 site, but were not recorded at any of the project fishing sites. With the exception of Crans bully, the fish species present in the Eastern Block were similar to those at forestry sites in the Waiteraire Stream catchment.

No bullies (*Gobiomorphus* sp.)were recorded in the mid- and upstream extent of the Eastern Block sites (sites F4 and F5), even though they have been recorded at upstream sites in the Waiteraire Stream catchment. A series of 3 to 4 m high waterfalls are present through the main stem in the Eastern Block, which may present a partial barrier to some fish.

Freshwater mussels have been found within forestry sites in the Waiteraire Stream catchment. They were not observed at any of the project fishing sites, although they were not searched for specifically.

Fish IBI scores are presented in Table 4.13. The fish IBI scores were 'very good' at all sites within the Eastern Block indicating that the species diversity is high given the location in the catchment. Site F1 within the Southern Block also had a 'very good' fish IBI, however the presence of a perched culvert partway up the stream reach may have influenced the IBI at site F2 ('no fish').

Sites F6 and F7 within the Western Block had 'fair' fish IBI scores, which may be the result of velocity barriers present within the site. A perched culvert is also located within the Western Block F7 reach, and traps set above this culvert did not retrieve any fish.

An exhaustive survey of fish passage barriers was not undertaken but some artificial barriers were identified during the site walkovers:

- A perched culvert (1) is located at the downstream extent of Waiteraire Stream (just upstream of the confluence with S Stream). While this appears to be a perch, there are populations of fish upstream of this and so fish may pass this barrier during high flow events;
- A perched culvert (2) is located in the upstream extent of the NSMA in the Southern Block;
- A slightly perched culvert (3), forming a velocity barrier was located at the downstream extent of WB Stream;
- A fish pass has been constructed at the upstream extent of Wayby Wetland North, however has undercut and become perched (4);
- A perched culvert (5) is located in the headwaters of the WB Stream; and
- A road culvert (6) downstream of Wayby Wetland South is a partial barrier to passage.

Identifying numbers are shown in brackets above and on Figure 3, Appendix B.

Table 4.11: Freshwater fish database results (retrieved 30 August 2018)

Common name	Scientific name	Threat status (Dunn *et al.* 2018, Grainger *et al.* 2013)
Shortfin eel	*Anguilla australis*	Not threatened
Longfin eel	*Anguilla dieffenbachii*	At risk - declining
Inanga	*Galaxias maculatus*	At risk - declining
Banded kōkopu	*Galaxias fasciatus*	Not threatened
Crans bully	*Gobiomorphus basalis*	Not threatened
Redfin bully	*Gobiomorphus huttonii*	Not threatened
Common bully	*Gobiomorphus cotidianus*	Not threatened
Unidentified bully	*Gobiomorphus* spp.	N/A
Freshwater mussel (Kākahi)	*Echyridella menziesi*	At risk - declining
Kōura	*Paranephrops* spp.	Not threatened
Freshwater shrimp	*Paratya curvirostris*	Not threatened

Table 4.12: Presence/absence fish data from winter 2018 fish sampling efforts.

	Southern block		Eastern block			Western block	
Site	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Longfin eel			●	●	●	●	
Shortfin eel						●	●
Banded kōkopu	●			●	●		●
Inanga	●						
Unidentified galaxiid				●			
Redfin bully	●		●				
Common bully	●		●			●	
Unidentified bully							●
Gambusia						●	
Unidentified fish							●
Kōura		●	●	●	●		
Freshwater shrimp	●					●	

Table 4.13: Fish survey IBI scores

Site name	F1	F2	F3	F4	F5	F6	F7
IBI Score	46	0	44	48	48	28	32
Rating	Very good	No natives	Very good	Very good	Very good	Fair	Fair

4.2.6 Stream Ecological Valuations (SEV)

Photos of the cross section of each SEV site are included in Appendix E. Summary SEV analysis sheets are included in Appendix F and shown in Table 4.14 below.

SEV scores within the Western Block ranged from 0.35 to 0.89. SEV10 scored the highest at 0.89 and was located in the upper reaches of a forested reach, upstream of Wayby Wetland South. All other SEV sites scored less than 0.52 which is a reflection of the poor riparian vegetation, channel modification and low biodiversity values. Excluding SEV10, the SEV scores within the Western Block were the lowest of all recorded across the WMNZ landholdings.

The highest SEV scores across the site were obtained from within the Southern Block and ranged from 0.79 to 0.93. SEV2 was located in the NSMA and was the highest scoring of all SEV within the project area. Natural channel and intact riparian margins contributed to very high hydraulic and biogeochemical functions. Biodiversity functions in the upper reaches were reduced due to a barrier to fish passage. Overall, the Southern Block SEV scores are consistent with native forest stream scores (Neale *et al.* 2016, Storey *et al.* 2011) indicating the streams within the Southern Block are of high ecological value.

The SEV scores recorded within the Eastern Block ranged between 0.71 and 0.83. Biogeochemical functions scored the highest across the SEV sites, a result of a variety of substrates and intact (albeit exotic) riparian margins. SEV scores within the Eastern Block were typical of those recorded in exotic forestry in Neale *et al.* (2016) and Storey *et al.* (2011).

SEV20 within the proposed Stockpile 2 area had a SEV score (0.85) which was slightly higher than those obtained in the Eastern Block.

Table 4.14: Summary SEV results by Block (intermittent stream sites are *italicised*).

Location	SEV site	Hydraulic	Biogeochemical	Habitat provision	Biodiversity	SEV Score (all functions incl)
Southern Block	SEV1	0.93	0.91	0.61	0.44	0.77
	SEV2	0.91	0.92	0.73	0.48	0.79
	SEV11	0.84	0.98	0.65	0.83	0.86
	SEV12	0.97	0.96	0.93	0.83	0.93
	SEV14	0.83	0.97	0.64	0.74	0.83
	SEV15	0.9	0.86	0.53	0.68	0.79
Western Block	*SEV8*	0.65	0.49	0.36	0.49	0.52
	SEV9	0.68	0.46	0.41	0.42	0.51
	SEV10	0.97	0.99	0.76	0.71	0.89
	SEV17	0.55	0.24	0.27	0.41	0.37
	SEV18	0.58	0.27	0.22	0.28	0.35
	SEV19	0.64	0.22	0.26	0.32	0.37
Eastern Block	SEV3	0.7	0.78	0.64	0.67	0.71
	SEV4	0.87	0.87	0.81	0.73	0.83
	SEV5	0.82	0.91	0.84	0.71	0.83
	SEV6	0.7	0.8	0.76	0.66	0.73
	SEV7	0.71	0.83	0.59	0.82	0.76
	SEV13	0.74	0.93	0.75	0.73	0.81
	SEV16	0.84	0.88	0.75	0.73	0.82
Stockpile 2	*SEV20*	0.84	0.92	0.82	0.78	0.85

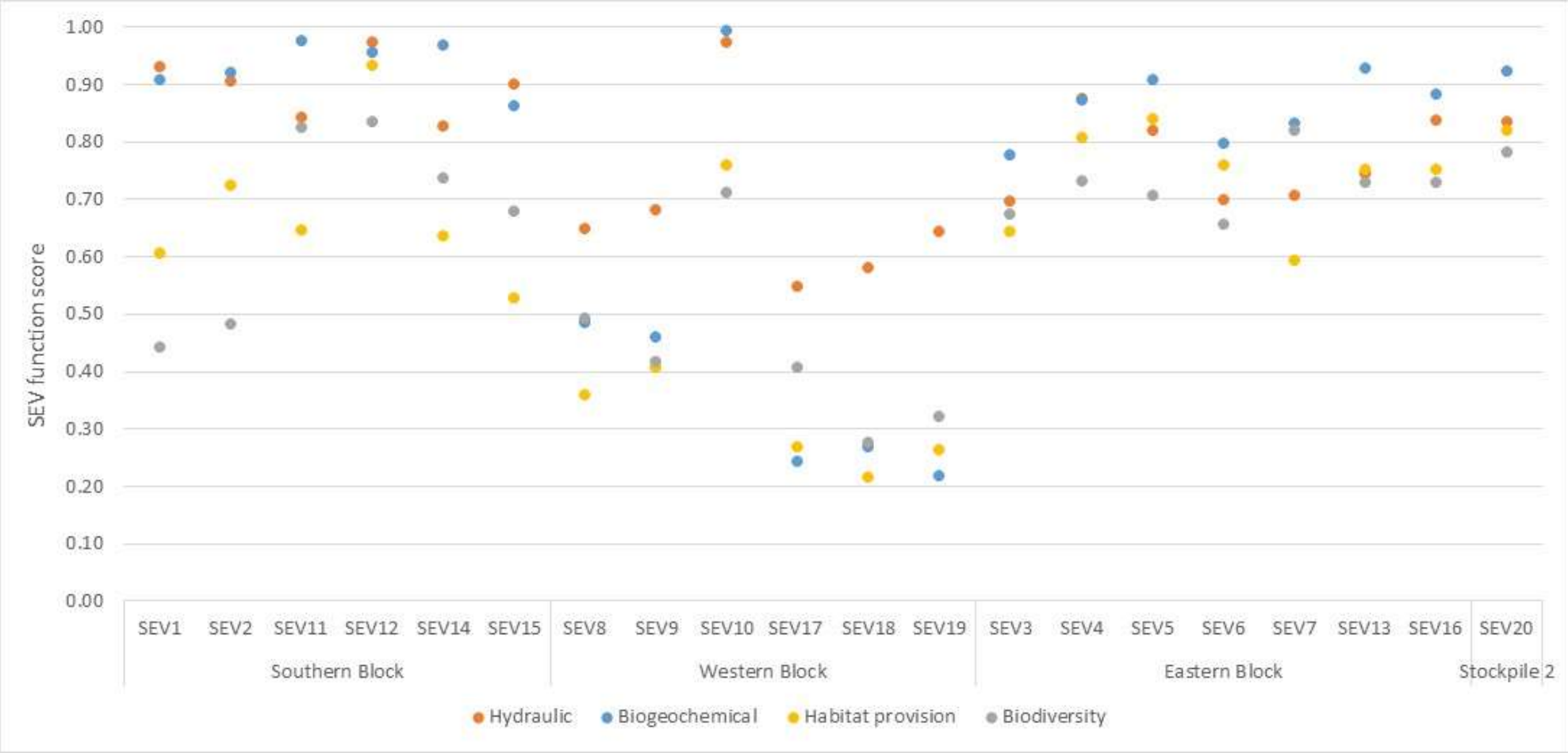

Figure 4.12: SEV functions at each site broken into each block of the site.

4.2.7 Summary of freshwater ecology values

Freshwater systems across the WMNZ landholdings are of high ecological value, particularly those within the Eastern and Southern Blocks. The NSMA within the Southern Block has the highest SEV value, a function of its relatively intact native riparian margins and natural stream channel.

Despite the presence of exotic forestry, streams within the Eastern Block have high ecological value as demonstrated by biotic indices. It is expected that during forestry activities these ecological values would decrease for a period of time until the stream systems recover.

While the Western Block has been modified and subject to degradation through agricultural land use, the biodiversity values within these streams are still moderate and the headwaters in particular have high potential for enhancement.

4.3 Assessment of effects on freshwater ecology

The assessment of effects has been undertaken in general accordance with the EcIAG produced by EIANZ (Roper-Lindsay *et al.,* 2018), described in Section 3, to determine the overall 'level of effect' of the project on freshwater ecological values.

Freshwater systems across the site range from having 'High' to 'Very High' value as determined using EcIAG (2018).

Hard-bottom streams are relatively rare in the Auckland region and are common on site. Across the site, SEV scores, presence of native fish and water and habitat quality are high. As a result, the streams across the site scored reasonably high for ecological value. The relative ecological value of each Block are summarised as follows:

- All streams within the Southern Block were assessed as having 'Very high' ecological values because these streams are either designated as 'natural stream management area', or are connected to them and have high SEV scores and biotic indices;
- Streams within the Eastern Block were assessed as having 'Very high' ecological values due to the presence of threatened native fish, high macroinvertebrate indices and the presence of high habitat heterogeneity and hard substrates;
- Streams within the Stockpile 2 area were assessed as having 'Very high' ecological values due to the onsite values and because they are upstream of a SEA and NSMA; and
- Streams within the Western Block were assessed as having 'Very high' and 'High' ecological values. The upper catchment of WA Stream was identified as having 'Very high' value due to its high SEV score and macroinvertebrate fauna. The WB catchment was of lower value, however in the upper catchment has relatively intact stream systems, with an absence of riparian margins contributing to a slightly lower value.

Typically the potential value (rather than just the current value) of freshwater systems is considered when assessing freshwater ecological values and effects. In the case of many of the streams across the site, the current ecological values are already high or very high and the potential value is unlikely to change markedly (as measured by SEV and macroinvertebrate indices). As such, the current values are considered sufficient to address 'potential' when assessing effects across most of the site. The exception to this is the un-vegetated stream channels in the Western Block, which have high potential for enhancement. For these streams the potential value has been considered in the above.

4.3.1 Overview of effects

This section provides an overview of the assessment in Sections 4.3.2 and 4.3.3. The potential effects on freshwater ecology resulting from the project have been assessed in terms of short and long term effects.

Short term effects relate to the effects within the construction phase which could include fish injury and/or mortality, and water quality effects resulting from sedimentation and cut vegetation storage. Potential long term effects anticipated to occur from the project include reduced fish passage, water quality effects and changes to hydrology and loss of stream ecological function and habitat area.

The magnitude of effect from different activity types is summarised in Table 4.15 using the approach described in Section 3 above. The level of effect (which combines ecological value and magnitude of effect) was used to guide the extent and nature of the ecological management response recommended, which may include remediation, mitigation, offsetting or compensation.

Native freshwater fauna are present across the project footprint and include 'At risk – Declining' species. There is high potential for injury or mortality of native freshwater fauna during dewatering of streams and construction of the landfill and ancillary activities in the absence of any controls. Implementation of fish salvage and relocation protocols will reduce the magnitude of effect to 'Low'.

The residual risk of sedimentation from earthworks was assessed for short term construction effects and was determined to be 'Low' after mitigation measures are implemented. Standard erosion and sediment controls (ESC's) and management plans will be implemented across the project footprint.

The overall potential effect from runoff of wood leachate resulting from storage of felled vegetation will be similar to that of sedimentation. However, risk of residual adverse effects is more a feature of practice and less dependent on weather conditions. Application of best practice in accordance with relevant guideline documents discussed below will result in the magnitude of effects being 'Low'.

Culverts have the potential to restrict fish passage to upstream habitats if constructed poorly. Where practicable culverts will be constructed to be 'fish-friendly'. Within the Western Block, fish passage will be provided for all culverts constructed and so will have a Low overall effect. Within the Southern Block, fish passage will be provided for one culvert, while two are unlikely to provide fish passage. The limited amount and quality of upstream habitat means the magnitude of effect is 'Low'.

Stormwater runoff can impact water quality and erosion potential of streams. Stormwater controls will be implemented across the site which address both quality and quantity and are consistent with best practice methods. The magnitude of effect will be 'Low' and the overall effect ranges from 'Low' to 'Moderate' depending on different activities and associated controls.

The most substantial effects on freshwater ecology will occur from the permanent reclamation of 15.4 km stream length across the site. These effects cannot be mitigated and the overall level of effect from habitat loss is 'Very High' for all areas, confirming the need for an offset and compensation package as outlined in the EcIA guidelines (Roper-Lindsay *et al*., 2018).

Potential effects from the project on freshwater ecology are discussed in more detail in the sections below.

Table 4.15: Magnitude of impact for activities before and after mitigation

Effect/activity	Magnitude with no mitigation	Reason for impact without mitigation (spatial extent, duration, time scale)	Key mitigation measures	Magnitude with mitigation
Short term				
Sedimentation from earthworks	Very high	Increase in sediment load over construction period. Potential for smothering of stream substrates. Impacts on banded kokopu and potentially kākahi.	Sediment and erosion controls (GD05)	Low
Fish injury and mortality	High	Direct impact to 6.9 km of permanent habitat and 8.5 km intermittent habitat. Short term, but extensive habitat loss.	Fish recovery protocols	Low
Vegetation clearance water quality effects	High	Potential for sediment movement (low in areas where retained vegetation can filter), risk of high BOD leachate, woodchip or mulch entering stream. Deoxygenates water.	Vegetation clearance protocols, sensible placement of cleared vegetation, management of placement to reduce risk.	Low
Long term				
Loss of fish passage to upper catchments	Moderate	Fish passage lost to Waiteraire Stream catchment, and upper NSMA catchment, and various parts of Western Block.	Culverts designed for fish passage.	Negligible to Low
Loss of stream habitat	Very high	Stream reclamation resulting in permanent and irreversible loss of habitat at the impact reach within the project footprint. 15.4 km permanent and intermittent stream loss equating to 11% of total stream length within WMNZ landholdings. 100 % of Valley 1 sub-catchment lost.	Cannot be mitigated. Offset required.	Very high
Water quality - access road and BEA	Very high	New contaminants entering environment (NSMA). Industrial and Trade (ITA) activity area. Sensitive aquatic species.	Filter strips, proprietary devices	Low
Water quality - landfill	Very high	New contaminants entering environment. Stormwater and leachate. Sensitive aquatic species.	Leachate captured and treated. Two ponds, polishing wetland.	Low
Increased flows resulting in erosion	High	Potential for erosion effects in streams.	Ponds, wetlands, filter strips, retention of 95th percentile flows	Low
Sedimentation from stockpiles	Very high	Increase in long term sediment discharge. Potential for smothering of stream substrates. Impacts on banded kokopu. Long and short term impact in different areas.	Permanent sediment ponds.	Low

4.3.2 Short term construction effects

4.3.2.1 Impacts on freshwater fauna

The magnitude of potential effect on native freshwater fauna (fish, kōura, kākahi) is driven by the nature of the activity, the area of stream disturbance, density of fish present in a given area, the ability of fish to escape disturbance and the controls applied. The conservation status of fish species is also relevant when assessing the potential level of effect.

In the absence of fish salvage, activities such as culvert placement and stream in-filling (stockpiles and landfill) can cause stranding, injury or mortality to fish. Fish are anticipated to be present within all catchments and stream types, although ephemeral and intermittent streams only provide temporary habitats during peak flows.

The direct effects of stream works on freshwater fauna can be minimised and mitigated by implementing Fish Recovery Protocols (FRP) prior to dewatering or excavating streams.

A combination of fish recovery methods (electric fishing, nets/traps, slow dewatering and sorting through dewatered materials) will be applied in different habitats as appropriate. Each of these methods has inherent risks and the FRP should be developed to minimise potential additional effects on fish during recovery and to provide for the most effective recovery approach.

For ease of access to the streams within forestry areas (i.e. Stockpile 2 and Valley 1), FRP should be implemented prior to harvesting. This is expected to result in a higher success rate for fish salvage compared to post-harvest when slash restricts access and stream habitats may be damaged. It will be important to install barriers to passage at the downstream extent of the sites to prevent fish re-accessing these streams.

Ephemeral and intermittent streams are expected to provide less habitat for native fish, and fauna are expected to migrate downstream to areas of continual flow (during summer months). Undertaking stream dewatering and construction during summer months when these streams are dry is a way of reducing potential effects on fish.

It is proposed that appropriate FRP will be applied across the site, with intensity of effort in any given area dictated by the likelihood of ‘at risk species or type of habitat present. The FRP will include procedures and locations for:

- Recovery of fauna (including fish, kōura, kākahi) prior to instream works (or forestry harvesting as outlined below);
- Measures to prevent fish returning to cleared areas;
- Rescue of fauna from spoil or dewatered materials;
- Relocation of fish; and
- Reporting.

Following the successful implementation of a comprehensive FRP the magnitude of effect on freshwater fauna will reduce to ‘Low’, meaning an overall ‘Low’ ecological effect.

4.3.2.2 Potential sedimentation from earthworks and construction

In the absence of controls, there is potential for an uncontrolled discharge of sediment laden water to be discharged into the receiving environment during construction works for the landfill, road and during the stockpile operation.

The effect of excess in-stream sedimentation is recognised as a major impact of changing land use on river and stream health (Clapcott *et al.*, 2011). Sediment entering stream systems can impact

water clarity. However, many native fish species are tolerant of high levels of suspended sediment in the water column. Sedimentation has more noticeable effects on physical habitats of streams. Excess sediment can clog the small spaces (interstitial) between hard stream substrates which impacts aquatic macroinvertebrates, alters food sources (i.e. macroinvertebrates for predation by fish) and removes egg laying sites for fauna.

As such, the potential magnitude of sedimentation effects without mitigation can be 'Very High'. The implementation of a Construction Erosion and Sediment Management Plan (CESMP), with activity specific Erosion and Sediment Controls will reduce the potential magnitude of effect of construction sedimentation effects. A range of ESC's will be utilised across the site, depending on the sensitivity of the receiving environment, the available space for controls, the duration of works and the local topography. The proposed approach to erosion and sediment control is described in more detail in the CESMP.

Following the implementation of mitigation measures, the magnitude of effect will be 'Low', and the overall effect when accounting for ecological values will be 'Moderate' in most catchments, and 'Low' in Western Block WB catchment (Table 4.16).

Table 4.16: Overall effect of short term sedimentation effects (after mitigation)

Site area	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect	Reason for magnitude	Step 3: Overall effect
Southern Block	Very high	Discharging to NSMA, high SEV values, hard bottom substrates expected frog habitat, banded kokopu present (sensitive to sediment), high MCI, Waiteraire Stream catchment.	Low	Erosion and sediment controls implemented in accordance with GD05.	Moderate
Eastern Block	Very high	Existing sedimentation issues, forestry catchment, hard bottom substrates (bedrock and cobbles), fauna (banded kokopu) sensitive to changes in sediment.	Low	Erosion and sediment controls implemented in accordance with GD05.	Moderate
Western Block - WB catchment	High	Headwater stream systems, hard bottom substrates, moderate SEV values, banded kokopu (sensitive to sediment).	Low	Erosion and sediment controls implemented in accordance with GD05.	Low
Western Block - WA catchment	Very high	Forested headwaters (combined exotic and native), high SEV values, upstream of SEA and WMA wetland banded kokopu (sensitive to sediment).	Low	Erosion and sediment controls implemented in accordance with GD05.	Moderate
Waiteraire Tributary Block	Very high	High SEV values, upstream of DOC reserve, hard bottom substrates, fauna sensitive to changes in substrate. Upstream of DOC reserve - SEA and NSMA, known frog habitat, banded kokopu (sensitive to sediment).	Low	Erosion and sediment controls implemented in accordance with GD05.	Moderate

4.3.2.3 Potential water quality effects from vegetation clearance

Vegetation clearance can have a potential impacts on stream systems in two main ways. Removal of vegetation can expose soil making it more prone to erosion, resulting in increased sedimentation in streams. Secondly, the storage of vegetation as chip or mulch can result in 'wood waste leachate' which has a high biochemical oxygen demand (BOD) and dissolved organic matter. This assessment is limited to the potential effects resulting from the storage of cut vegetation resulting from vegetation clearance associated with the landfill activities[7] and the potential water quality effects.

Cut vegetation will be stockpiled away from streams within pine forestry areas of the site in accordance with the permitted activity standards in the National Environmental Standard for Plantation Forestry. Vegetation Clearance Protocol (VCP) is proposed as a condition of consent. It will include procedures for minimising the area and duration of soil exposure from vegetation clearance, minimising the volume of vegetation to be mulched, locating wood residue piles with an appropriate separation distance from streams and minimising potential wood waste leachate from these piles.

Following the implementation of vegetation clearance protocols, the overall effect is considered to be 'Low' (Table 4.17).

Table 4.17: Overall effect from storage of cut vegetation on water quality (after mitigation)

Site area	Step 1: Ecological Value	Reason for value	Step 2: Magnitude of effect	Reason for magnitude	Step 3: Overall effect
Southern Block	High	Discharging to NSMA, Waiteraire Stream catchment, intermittent tributaries nearby, but location of vegetation away from stream channels	Low	Vegetation will be in upper catchment away from streams. Controls in place to reduce risk.	Low
Eastern Block	High	Hard bottom substrates (bedrock and cobbles), fauna sensitive to changes in water quality. Intermittent tributaries nearby, but location of vegetation away from stream channels. Immediate environment to be reclaimed.	Low	Vegetation will be placed in upper catchment away from stream margins.	Low

4.3.3 Long term effects

4.3.3.1 Fish passage

Maintaining fish passage is important as many native fish are diadromous, which means they migrate to and from the sea as part of their lifecycle. Further, whilst kōura are not diadromous, maintaining fish passage is nevertheless important to avoid isolating and fragmenting populations.

[7] Vegetation clearance activities included within this assessment are limited to those activities undertaken by WMNZ and do not include the clearance of pine forest within Valley 1 which is being undertaken by others.

Waterfalls and cascades are present in the Southern, Eastern and Waiteraire Tributary Blocks, which form natural barriers to non-climbing fish such as inanga.

Artificial structures and poor culvert design can restrict fish migration. Often this occurs as a result of culverts being perched, too steep or long, subsequent increases in water flow or a resultant laminar flow with insufficient roughness to allow effective fish movement. The resultant decrease in fish mobility can result in fragmented populations, a reduction in population size, and limiting overall available habitat for freshwater fauna.

The project involves installing a number of culverts in the Southern Block and Western Block.

An existing perched culvert at the upstream extent of the NSMA will be removed and replaced with a 105 m long culvert. The culvert will be located upstream of a series of natural barriers (waterfalls and cascades) and so will be designed (as much as practicable) to target climbing fish species. This culvert will be at a grade of approximately 10 % and will have a bend in the middle of it. Baffles will be embedded into the base of the culvert to provide rest areas for fish.

For the most part there will be no habitat upstream of culverts along the Access Road as cut-faces on the southern side of the road will remove most upstream habitat. Therefore, the majority of culverts will not require fish passage.

Two Access Road culverts will be located on streams where upstream habitat is retained. One of these has only intermittent stream upstream and the other has approximately 200 m of permanent and intermittent habitat upstream. Due to the steepness of the grade, effective fish passage is unlikely to be provided to these stream reaches. It may be appropriate to install baffles or spat ropes to provide a level of fish passage however given the size of these catchments, and the limited upstream habitat it is not considered necessary.

The Access Road will cross the Waiteraire Stream upstream of the confluence with S Stream in the Southern Block. This crossing will be a bridge and so will be located out of the stream bed and effects on fish passage will be avoided.

Several culverts are required to enable the stockpile and borrow area access road within the Western Block and can be constructed in accordance with the NZ Fish Passage Guidelines. There will be no effect on fish passage through the Western Block.

There are at least six barriers to fish passage in proximity to the project footprint and within the WMNZ landholdings, which can be remediated to contribute to mitigating effects of the project on fish passage (refer to Section 4.2.5).

An existing perched culvert immediately upstream of the S Stream on the Waiteraire Stream is proposed to be removed. This perched culvert appears to be passable during flood flows as fish are present upstream, however it is restricting passage to approximately 20 km of relatively intact stream catchment.

Some culverts within the Western Block are perched and could be removed to improve access to the farm channels, but note that without habitat enhancement for all stream reaches retained, the ecological benefit is minimal for fish fauna.

On the whole the provision of fish passage where possible, and the remediation of existing artificial fish passage barriers will result in the overall level of effects ranging from ‘Low’ to ‘Negligible’ in different catchments.

4.3.3.2 Potential effects of operational stormwater runoff

4.3.3.2.1 Quantity

Increases in impervious surface change the velocity and volume of stormwater runoff within a catchment, which can result in erosion and habitat modification in streams. Streams are particularly susceptible to erosion during the first flows following rainfall down a catchment and can be managed by detention and slow release of flows.

The streams within the project footprint are generally 'hard bottom', comprising boulders, cobbles and bedrock. Sediment accumulation is however present in deep pools, below waterfalls and in lower gradient reaches. The stream banks are formed of silty sands, with evidence of stream bank erosion and incision present across the areas surveyed (Figure 4.4).

Streams within the project footprint are considered to be susceptible to stream bank erosion which can modify instream habitat and result in sediment deposition in downstream environments. Measures to mitigate increased flows resulting from the project are required to reduce the erosion potential.

A full description of the stormwater quantity approach is provided in the Stormwater and Industrial and Trade Activity Report (SITAR) (see Technical Report P, Volume 2). In brief, attenuation of the 95th percentile volume will be provided for runoff from the main landfill and stockpile locations. A ponding area will be provided for the bin exchange area and channels adjacent to the access road will be designed to discharge to land in the first instance via filter strips and spreader bars.

The proposed quantity mitigation measures are consistent with best practice from Auckland Council Guideline Document GD01 and/or the New Zealand Transport Agency 'Stormwater Treatment Standard for State Highway Infrastructure', May 2010. Further, changes to the contributing catchment size downstream of the landfill (i.e. the removal of Valley 1) are expected to reduce erosion potential within the main stem of the Eastern Block.

The proposed mitigation measures are expected to reduce the magnitude of erosion effects from 'High' to 'Low'. When considering ecological value, this results in an overall 'Moderate' ecological effect (Table 4.18).

Table 4.18: Overall long term water quantity effects after mitigation.

Site area	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect	Reason for magnitude	Step 3: Overall effect
Southern Block	Very High	High SEV values, NSMA, banded kokopu present (sensitive to sediment), sediment sensitive EPT taxa present.	Low	95th percentile flows collected and discharged to land via spreader bars. Ponding areas for BEA to attenuate flows.	Moderate
Eastern Block	Very High	High SEV values, banded kokopu present (sensitive to sediment), sediment sensitive EPT taxa present.	Low	Attenuation of 95th percentile flows. Additional attenuation anticipated through wetland.	Moderate
Western Block	Moderate	Existing sediment issues resulting from agricultural land use. Banded kokopu present.	Low	Attenuation of 95th percentile flows.	Low
Waiteraire Tributary Block	Very High	High SEV values, upstream of DOC reserve and NSMA, banded kokopu present, sediment sensitive EPT taxa present.	Low	Attenuation of 95th percentile flows.	Moderate

4.3.3.2.2 Quality

Contaminants entrained in stormwater runoff have the potential to impact fauna and ecosystem health within the freshwater environment. There are a variety of potential contaminants associated with different activities across the site. These are described in full in the Stormwater and Industrial and Trade Activity Report (SITAR) (see Technical Report P, Volume 2).

The potential water quality effects of the project vary depending on the area of the site, the activities and the management measures implemented.

A surface water management approach has been developed based on the specific requirements for each project activity. This has been undertaken using a risk-based approach which considers the sensitivity of the receiving environment both immediate and further downstream and the activities undertaken in each catchment.

The purpose of the strategy is to assist in the identification of areas of the site and activities which may have a high risk of adverse effects if not effectively managed. This assists in identifying the level of controls required, and increased confidence that the proposed controls will be effective. The approach is discussed in full in Section 9.3.1 of the SITAR.

Stormwater contaminants

Site controls across the project footprint will reduce the potential for contaminants to be entrained in stormwater, which will also include an Environmental Management System and a Landfill Management Plan.

Within the landfill catchment, any surface water that comes into contact with refuse will be treated as leachate, and kept separate from 'clean' surface water. All surface water (except leachate) will pass through two stormwater treatment ponds and a polishing treatment wetland prior to discharge to the Eastern Block streams.

Contaminants associated with road runoff, such as metals and hydrocarbons are expected along the Access Road. Stormwater from the Access Road will be discharged either into the landfill catchment or into filter strips, which will then discharge to land (in native vegetation) which will provide further treatment prior to flows entering the NSMA.

Stormwater runoff from the BEA will be treated via a raingarden prior to entering the S Stream via outlets with erosion protection.

Specific controls are identified within the SITAR and are designed in accordance with best practice Auckland Council GD01 and NZTA stormwater management standard.

Permanent sediment controls

In the long term, there are permanent erosion and sediment controls to reduce the amount of sediment being mobilised from the site and then to contain any mobilised sediment within the site.

Three soil stockpiles are proposed across the site all of which are upstream of sensitive receiving environments.

- Stockpile 1 is proposed to be located at the head of the WB Stream within the Western Block and is located upstream of a permanent stream and SEA wetland (Wayby Wetland North);
- Stockpile 2 is located in the forested headwaters of the Waiteraire Tributary Block, upstream of Sunnybrook Reserve which is both an NSMA and SEA; and

- The Topsoil Stockpile is located in the headwaters of the Wayby Wetland South. Stockpiles and clay borrow area will have permanent sediment control ponds, sized to 3% of the catchment.

Without mitigation the sediment load anticipated within the landfill catchment could be in the order of four to five times existing loads (SITAR). With mitigation (treatment ponds), it is anticipated that there would be no less than 91% removal of sediment, resulting in lower sediment loads than calculated current baseline sediment loads.

Streams within the Southern Block, the WA catchment of the Western Block and the Eastern Block have high or very high ecological value and are therefore most sensitive to changes in water quality. The WB stream catchment of the Western Block is of lower ecological value due to agricultural land use.

A Surface Water Monitoring Plan (SWMP) will be prepared which will set out the approach to developing trigger levels based on long term (up to four years) of baseline water quality monitoring data. This will enable trigger levels to be developed in the context deviation from baseline conditions and the sensitivity receiving environment. Long term monitoring will be undertaken to monitor discharges into and from the treatment systems on site and will include device and receiving environment monitoring.

Without the mitigation measures identified above and in the SITAR, the potential magnitude of effect on the freshwater ecosystems would be 'Very High'. The implementation of these measures reduces the magnitude from 'Very High' to 'Low', resulting in an overall ecological effect of 'Low' to 'Moderate'.

Table 4.19: Overall long term water quality effects after mitigation.

Site area	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect	Reason for magnitude	Step 3: Overall effect
Southern Block	Very high	High SEV values, NSMA, native fauna (at risk declining), pollution sensitive EPT taxa present.	Low	Stormwater quality treatment proposed, consistent with GD01. Access road and BEA treated by filter strips and raingarden respectively. Monitoring in the receiving environment will be undertaken.	Moderate
Eastern Block	Very high	High SEV values, native fauna (at risk declining), pollution sensitive EPT taxa present.	Low	Key contaminants, sediment, copper, zinc. Stormwater treated via two stormwater ponds and a polishing wetland. Leachate diverted back into landfill, no discharge to environment. Monitoring in the receiving environment will be undertaken.	Moderate
Western Block	High	Presence of SEA, WMA. Macroinvertebrates indicate low to moderate ecological health. Discharging to the Hōteo River.	Low	Permanent sediment ponds for stockpile and clay borrow area. Monitoring in the receiving environment will be undertaken.	Low
Waiteraire Tributary Block	Very high	High SEV values, upstream of DOC reserve, native fauna (at risk declining) and pollution sensitive EPT taxa present.	Low	Permanent sediment pond. Road runoff not treated but discharged to land. Monitoring in the receiving environment will be undertaken.	Moderate

4.3.3.3 Permanent loss of stream habitat

The proposed landfill and associated ancillary activities will result in the infilling of approximately 21.5 km of soft and hard-bottom stream, which equates to approximately 16% of the total stream length within the WMNZ landholdings[8]. Of this, 6.1 km is ephemeral stream which is not protected by specific rules under the AUP.

A total of 15.4 km of intermittent and permanent stream will be impacted, which equates to 11% of the total stream length expected to be present within the WMNZ landholdings. The quantum of intermittent and permanent stream loss expected from each of the key project activities is summarised below and in Table 4.20, and compared to the total stream length within each block (as shown in Appendix C Table 1).

The majority of stream loss will occur in Valley 1 of the Eastern Block as a result of the construction of the landfill base grade and lining system and provision of stormwater Ponds 1 and 2. The entire Valley 1 sub catchment will be reclaimed, comprising 9.5 km of intermittent and permanent stream habitat and 21% of the total stream length within the Eastern Block.

Approximately 0.8 km of intermittent and 0.5 km of permanent stream will be reclaimed for Stockpile 1 within the Western Block, which equates to approximately 3.4% of the total stream length within the Western Block.

Within the headwaters of the Waiteraire Tributary Block, a 0.8 km intermittent and 0.6 km permanent stream will be reclaimed for Stockpile 2.

Construction of the Access Road requires several stream crossings and a cut face upslope of the road. The slope required for the cut face will result in almost complete loss of stream channels upstream of the Access Road. Of the 2.1 km of stream impacted by the Access Road, 1.9 km will be reclaimed and approximately 0.2 km will be culverted. The 2.1 km of intermittent and permanent stream impact, comprises approximately 22% of the total stream length within the Southern Block.

In addition to the main project activities discussed above, just over 1 km of stream will be impacted by a top soil stockpile, clay borrow pit and ancillary activities. This comprises 0.4 km of intermittent stream and 0.7 km of permanent stream.

Table 4.20: Summary estimate of stream impact across the subject site (metres).

Landfill activity	Ephemeral	Intermittent	Permanent	Total
Valley 1 Landfill (incl Pond 1 and Pond 2)	4862	5479	4070	14411
Access Road	337	1026	1104	2467
Stockpile 1	115	801	456	1372
Stockpile 2	327	792	573	1693
Topsoil Stockpile	0	161	227	388
Clay Borrow and Stockpile	0	128	0	128
Combined ancillary stream length*	432	129	439	1000
Total length (m)	**6073**	**8516**	**6869**	**21459**

*Combined ancillary length includes forestry access roads, ancillary building footprints etc. resulting from the project.

Stream loss has been minimised to the extent possible, however with a project of this nature, it is not possible to avoid stream loss completely (refer Assessment of Alternatives in AEE for discussion).

[8] This includes total stream length predicted to be present (Appendix C Table 1), and known to be impacted (Table 5.21). Note that only intermittent and permanent streams are protected under the AUP.

Applying the EcIAG, the magnitude of effect of stream loss, without offset or compensation, is assessed as being 'Very High' due to the length and ecological value of stream being lost and the irreversible nature of the effect (Table 4.21).

It is not possible to remediate or mitigate stream reclamation at the point of impact. To 'mitigate' means to alleviate, or moderate the severity of something (Maseyk *et al.* 2018) which is not possible in relation to stream reclamation as there is a complete and permanent loss of habitat.

While stream reclamation cannot be mitigated, it can be offset or compensated. Offsetting is 'a measurable conservation outcome resulting from actions designed to compensate for residual adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied' (Maseyk *et al.* 2018). To be considered an offset, the conservation outcomes resulting should be consistent with a set of offsetting principles, including the goal of 'no net loss' (Maseyk *et al.* 2018).

Compensation is designed to compensate for losses but is more subjective than offsetting and does not require that no net loss is achieved. Compensation is the last tier in the mitigation hierarchy and it is not a form of offsetting. The discussion following will outline how the proposed stream habitat loss will be either offset (through a quantified process) or compensated.

The environmental compensation ratio (ECR) is a tool identified within the AUP to quantify the amount of streambed area that is required to be restored, depending on the extent and type of enhancement works proposed, relative to the amount lost to achieve a 'no-net-loss' in ecological function as a result of the activities. The ECR quantifies the likely loss in values and functions at an impact site and the increase in stream ecological values and functions at a compensation or mitigation site.

At this stage of the project, some habitat enhancement and protection options have been identified which will contribute to offsetting or compensating effects (Table 5.23). Some of these have measurable ecological benefits which should be considered when reviewing this offset and compensation package as a whole. The following provides a summary of the ECR calculations undertaken and the ecological effects being offset at several enhancement sites within WMNZ landholdings. Detail regarding the numbers used in the ECR calculations is provided in Appendix F.

The reclamation of 1,365 m stream length (627.9 m^2 of streambed area) within the footprint of Stockpile 2 can be offset with enhancement of 763.5 m stream length (1,947 m^2 of streambed area) at the site identified as 2b in Table 5.23 below. An ECR of 3.101 was calculated to account for the ecological function lost which can be achieved at site 2b. However, a key component of the SEV and ECR methodology is that the length of stream being enhanced must be equal or greater than that being lost. Due to the width of the stream at site 2b being much wider than at the impact site, there is a shortfall of 601.5 m length which has not been accounted for at this site.

The access road culvert will result in the modification of 105 m (71 m^2) permanent stream within the Southern Block. The effects of this can be offset by enhancing 68 m (173.21 m^2 streambed area) within the area identified as 2b in Table 5.23 below. An ECR of 2.44 was calculated to account for the ecological function lost which can be achieved at site 2b. Due to the width of the stream at site 2b being much wider than at the impact site, there is a shortfall of 37 m length which has not been accounted for at this site.

Table 4.21: Magnitude of effect from stream loss/reclamation (without offset or compensation).

Site area	Step 1: Ecological value	Reason for value (refer to Section 4.2 for more detail)	Step 2: Magnitude of effect	Reason for magnitude	Step 3: Overall effect
Eastern Block	High	Full catchment in forestry, hard-bottom streams, intermittent and permanent. Existing high value SEV, MCI, at 'risk-declining' fish present.	Very high	Magnitude at point of impact is permanent and irreversible stream loss. Reclamation of 9,549 m intermittent and permanent stream, comprising one sub catchment (21%) of the Eastern Block.	Very high
Southern Block	Very high	Predominantly intermittent stream tributaries connect to NSMA, high SEV values, hard-bottom substrates expected frog habitat, likely to be At Risk Declining fish present, high MCI, Waiteraire Stream catchment.	Very high	Magnitude at point of impact is permanent and irreversible stream loss. Reclamation or culverting of 13 headwater tributaries comprising 2,130 m stream, along southern side of S Stream. Only two tributaries (out of 13) remaining with upstream habitat.	Very high *Stream length lost is offset as described above.*
Western Block - WB catchment	High	'High' due to potential for enhancement, as in headwater catchment and hard bottom substrate. Currently degraded due to stock access and absence of riparian vegetation, moderate SEV values, absence of fish (due to existing perched culvert).	Very high	Magnitude at point of impact is permanent and irreversible stream loss. Reclamation of headwater section comprising 1,384 m of intermittent and permanent stream.	Very high
Western Block - WA catchment	Very high	Forested headwaters (combined exotic and native), high SEV values, upstream of SEA and WMA wetland.	Very high	Magnitude at point of impact is permanent and irreversible stream loss. Reclamation of 388 m permanent and intermittent streams in headwater section.	Very high
Waiteraire Tributary Block	Very high	High SEV values, upstream of DOC reserve, hard bottom substrates expected frog habitat, likely to be 'at risk declining fish' present, high MCI	Very high	Magnitude at point of impact is permanent and irreversible stream loss. Reclamation of entire headwater section of stream comprising 1,365 m of intermittent and permanent stream.	Very high *Stream length lost is offset as described above.*

A total length of 2,025 m stream length (estimated to be 607.5 m^2 stream bed area) will be reclaimed within the Southern Block. Three different sites have been identified for enhancement to be undertaken to offset these effects as follows:

- Site 2b – at an ECR of 3.064 and available enhancement area of 812 m^2 streambed area this site can address 44 % of the impact area;
- Site 2d – at an ECR of 3.056 and available enhancement area of 720 m^2 stream bed area, this site can address 69 % of the remaining impact area; and
- Site 2a – at an ECR of 3.677 and available enhancement area of 840 m^2 stream bed area, and only 392 m^2 required, this site can address the remaining impact area.

The combined length of Site 2b, 2d and 2a required to be enhanced is approximately 1,610 m, leaving a shortfall of 414 m not accounted for by the quantum calculated above. Approximately 320 m of Site 2a is available for enhancement, however still leaves a residual shortfall of 95 m to address the length lost within the Southern Block.

Based on ECR calculations, the effects of stream bed area being lost within the Southern Block and Waiteraire Tributary Block can be offset in full using the streams available within the Western Block as identified above. However, while the total stream bed area as calculated is offset, there is a shortfall in total length being enhanced.

A total of 3,495 lineal metres of intermittent and permanent stream is being impacted within these two areas, however only 2,441 m has been calculated as being required (when measured using stream bed area). A further 1,053 lineal metres must be enhanced to balance out the length being lost.

The additional length required to meet the overall objective of no-net-loss of ecological function can be provided within the remaining length of enhancement area identified across the site. For the purposes of specifying an area a length of 1,053 m within the Matariki forestry area, downstream of the landfill footprint (identified as item 2g in Table 4.22 below), is earmarked to provide this additional length.

Given the scale of impact, WMNZ are not seeking to achieve a no-net-loss of ecological function due to the difficulty of finding suitable sites with sufficient stream length available for enhancement. As such, the ECR has not been applied across the site to calculate the length of offset that would be required to achieve no net loss of ecological function. The two areas identified above, are considered to be those with the highest current ecological value and were prioritised for offset calculations. The offset and compensation package identified in Table 4.22 below summarises all currently available opportunities for enhancement within the WMNZ landholdings. This provides for a close to 1:1 ratio loss to enhancement and will be supplemented within a further ~ 30 km of offset and compensation works over the lifetime of the project to take the total enhancement to no less than 46.2 km.

In considering the offset and compensation package below, we acknowledge that the principle of 'no net loss' of ecological function is not being achieved. While not meeting the principle of 'no net loss' for all impact areas, there are other biodiversity offsetting principles that should be considered when determining the value of this package of works.

In respect of proximity, the offset and compensation package identified is in the immediate vicinity of the impact sites and is within WMNZ landholdings. Some of the enhancement opportunities are immediately downstream of impact areas and all are within the Hōteo catchment.

All enhancement works proposed are additional to any other enhancement that may be otherwise required. There are no covenants or consent conditions that require any of these activities to be

undertaken, with the exception of the Overseas Investment Office (OIO) conditions, which specify enhancement activities be undertaken as determined through the Resource Consenting process.

The concept of 'like for like' requires that consideration be made in respect of the type of streams being impacted, location in catchment and what the offset or compensatory activity includes. The majority of the offset and compensation package includes streams which are permanent in nature, rather than intermittent. Further, the majority of the streams being impacted are narrow, while the offset and compensation sites are wider, including streams which are greater than 3 m in width. While not strictly like for like across all impact areas, a range of streams along the continuum will be impacted and a range will be enhanced for offset or compensation. The SEV and ECR calculations presented above have been used to identify whole areas that could be offset, rather than for instance, the permanent watercourse within Valley 1, which we expect could be partially offset. On the whole, the enhancement identified above offsets 23% of the total stream length being lost.

The package as outlined in Table 4.22 provides for a close to 1:1 length offset and compensation package. WMNZ has committed to undertake similar activities over an additional c. 30 km of stream over the life of the project. This will result in no less than three times the stream length lost, being offset or compensated and can be adjusted closer to time of impact if the impact length changes as a result of detailed design.

The package has not been developed to achieve 'no-net-loss' of ecological function overall, however it does work towards some of the other principles of biodiversity offsetting, in particular proximity and additionality. The offset and compensation package has been developed to optimise opportunities available on site and goes some way to address the effects of the landfill activity.

The effects on the Southern Block and Waiteraire Tributary Block as quantified by the ECR can be entirely offset by the enhancement of some of the streams within the Western Block. This is a positive effect of the development and does not contribute to a reduction in the level of effect overall.

Notwithstanding the effort made in developing the offset and compensation package above, in applying the EcIAG, the overall effect of the project in relation to stream habitat loss across the project footprint is considered to be 'Very High' and is not sufficiently mitigated, offset or compensated to achieve no net loss of ecological function (Table 4.21). This is because of the high ecological values of the streams, the length of stream impacted and the impact being irreversible.

Table 4.22: Proposed offset and compensation package to address stream reclamation effects. *Italicised* items are those included in the offset package quantified above.

Enhancement activity	Map reference (Figure 13)	Approximate stream length (m)
Stream length within Springhill to be planted and enhanced:		
• *One side of the stream parallel to airstrip*	2a	600 m
• *On stream between southern SEA wetland and Hōteo River and toward airstrip*	2b	1150 m
• Degraded streams to the west of the clay borrow area	2c	950 m
• *Between clay borrow pit and Stockpile 1*	2d	1,000 m
• One side of the Waiteraire Stream, adjacent to SH1 and downstream of Access Road. Some of this is existing NSMA	2e	700 m
Protection in perpetuity of the main channel through the NSMA in the Southern Block (and the headwaters of this catchment)	2f	1,600 m (main channel)
Retirement and protection of the 10 m margins of waterways within the Matariki Forestry areas (of permanent streams, greater than 3 m wide)	2g	2,000 m (downstream of landfill footprint)
Protection of the western margin of the Waiwhiu Stream within WMNZ land (~3 km).	2h	3,000 m
Hōteo River margins are required to be planted and protected in the OIO conditions. We anticipate that this will involve approximately 3 km of protection and planting along one side of the Hōteo River. Whilst this will provide some additional protection to the Hōteo River, as the existing riparian margins are ~ 15 to 30 m in width, the ecological benefit of protecting the existing margins and providing infill planting will be limited, compared to new planting along un-vegetated riparian margins.	2i	3,000 m
Total length		**14,000 m**

4.3.4 Summary of effects on freshwater ecology

In summary, the project is anticipated to have effects on a range of freshwater ecology values. A range of mitigation measures are proposed throughout the life of the project.

Within the sections above, some measures are identified which relate to best practice site management approaches which will mitigate some of the freshwater and marine ecology effects anticipated from the project.

The following measures are recommended to minimise and mitigate effects on aquatic ecology within the impact footprint and in the receiving environment. These measures are required to address overall effects as discussed in Section 4.3.

- Fish Recovery Protocols to salvage and relocate fish from within works footprints;
- Erosion and sediment controls to be implemented in accordance with Auckland Council GD05 and to be identified in a Construction and Environmental Management Plan;
- Vegetation Clearance Protocols to manage the potential effects of run off from cleared vegetation;
- Stormwater management approach to include filter strips, rain gardens, ponds, wetlands and consistent with Auckland Council GD01 for hard stand areas (roads, BEA, landfill);
- Long term sediment ponds at stockpile locations, GD05 but long term; and
- Construction methodologies to be consistent with GD05. Sensitive areas during construction are catchments with WMA/SEA/NSMA.

The above management protocols are required to be implemented in order for the magnitude of effects as discussed in the sections above to be reduced to the extent predicted.

If the above measures are implemented, we conclude that the short and long term effects on freshwater ecology values from the construction and operation of the project will be as follows:

- Effects on freshwater fauna will be ‘Low’;
- Sedimentation during construction will have ‘Moderate’ to ‘Low’ effects;
- Storage of cut vegetation will result in ‘Low’ effects;
- Effects on fish passage will range from ‘Negligible’ to ‘Low’;
- Long term changes to stormwater quantity will be ‘Moderate’;
- Long term water quality effects will be ‘Low’ to ‘Moderate’; and
- Effects of stream habitat loss will be ‘Very high’.

5 Marine ecology values and effects

5.1 Marine ecology method

A desktop assessment was undertaken to review available information and data pertaining to the marine receiving environment. Site investigations were not undertaken given the distance between the WMNZ landholdings and the Kaipara Harbour (approximately 35 km) and the relative size of the contributing catchment compared to the total Hōteo River catchment.

5.2 Marine ecology results

The WMNZ landholdings is located approximately 35 km, 'as the river flows', from the marine receiving environment, which is the tidal Hōteo River mouth in the central, south-east of the Kaipara Harbour (Figure 5.1). The Kaipara Harbour is one of the largest harbours in the world and is important for its ecological, social and cultural values.

Figure 5.1: Site location (shown by red star) in the context of the Hōteo River and the Kaipara Harbour receiving environments.

For the purposes of this report, the marine receiving environment is restricted to the tidal reaches of the Hōteo River mouth and the immediate Kaipara as the area of potential influence from the project.

The Hōteo River mouth is identified as a SEA-Marine (SEA-M2 5b) under the AUP, as it provides mangrove-saltmarsh habitat for banded rail (*Gallirallus philippensis*).

Spawning grounds for juvenile migrating fish e.g. whitebait species are present within the estuarine and lower reaches of the Hōteo River, and as a result these reaches have important ecological and recreational value for whitebait fisheries within the Auckland region.

The Kaipara Harbour is a key snapper breeding ground with high ecological, cultural and social value (Hart and Scott, 2014). This is primarily due to the presence of sea grass habitat near the Hōteo River mouth on the Kakarai flats. Cockles (*Austrovenus stutchburyi*) are present on the sandy intertidal

flats further offshore. Cockles provide an important recreational and cultural food source and are functionally important in the marine ecosystem.

Seagrass and cockles are both sensitive to excessive suspended sediment and are impacted by runoff containing sediment from the predominantly agricultural land use within the Hōteo catchment (Green & Daigneault, 2018).

5.3 Assessment of effects on marine ecology

It is considered that there are two project activities which have the potential to impact the marine environment which are described in the section following. Note that the EcIAG are not designed for use in marine environments, however for the reasons described below, are considered appropriate to provide some high level context in this instance.

5.3.1 Potential sedimentation from earthworks

Green and Daigneault (2018) identified that while the sediment deposited on the intertidal flats at the mouth of the Hōteo River primarily originates from the Hōteo River catchment, some also originates from the Wairoa and Tauhoa River catchments.

The Hōteo catchment is primarily under agricultural landuse, with forestry in the upper catchment. These high sediment yielding activities comprise approximately 58% and 20% of the total catchment area respectively (Green & Daigneault, 2018).

As described in Section 4.3.2.2, the proposed erosion and sediment controls will mitigate the potential effects of sediment in the freshwater receiving environment. As such, and in consideration of the wider catchment influences, the potential sediment contribution anticipated from the project is unlikely to result in a measurable change from the baseline condition in the marine environment and the overall effects is expected to be 'Negligible'.

5.3.2 Long term water quality

Auckland Council monitors water quality at the Hōteo River mouth as part of the State of the Environment (SOE) monitoring. The water quality index (WQI) reported by Auckland Council at this site has declined in the period 2014 to 2016, from 'fair' to 'poor' (Vaughan, 2017).

As described in the Stormwater, Sediment and Industrial and Trade Activity Report (see Technical Report P, Volume 2) and Section 4.3.3.2.2 above, the mitigation measures proposed on site to treat stormwater runoff will result in 'Moderate' to 'Low' ecological effect in the freshwater environment on the site. Moderate effects are only anticipated in catchments with sensitive EPT taxa and threatened native fauna.

It is expected that water quality effects within the marine environment will be 'Negligible' given the controls in place on site, the distance (and subsequent dilution effects) between the discharge and the marine environment and the additional catchment influences present within the Hōteo River catchment.

5.4 Summary

Given the distance between the impact site and the marine receiving environment, there is unlikely to be a measurable effect in the marine environment and therefore the effects are considered to be negligible after mitigation measures are imposed on site. This includes, but is not limited to, sediment and erosion controls in accordance with GD05; stormwater controls including specific targeted sediment control and a three-way treatment approach for landfill stormwater; leachate management; regular monitoring of water quality downstream of the site.

6 Terrestrial ecology values and effects

6.1 Terrestrial ecology methods

To determine terrestrial ecology characteristics and values, a combination of desktop assessments, literature reviews, habitat assessments and site surveys have been undertaken.

6.1.1 Desktop review

A literature review of all available literature and data was undertaken. Key documents reviewed included:

- Auckland Unitary Plan geographic information system (GIS) layers:
  - Significant ecological areas (SEA);
  - Wetland management areas (WMA);
  - Outstanding natural feature (ONF);
  - Overland flow path layers (OLFPL); and
  - Biodiversity layers
- Aerial imagery of the project area to assess habitat suitability for terrestrial fauna;
- Natural Areas of Rodney Ecological District (Goldwater et al., 2012);
- Indigenous Terrestrial and Wetland Ecosystems of Auckland guide (Singers *et al.*, 2017);
- Auckland Council Herpetofauna Database;
- NZ Herpetofauna Atlas Webmap;
- Historical records of bat presence from the New Zealand bat distribution database (DOC);
- New Zealand Plant Conservation Network Database (NZPCND); and
- eBird database (https://ebird.org).

6.1.2 Forest and wetland vegetation

During six days in July and August 2018, a Phantom 4 Pro UAV drone was used to provide high-resolution aerial imagery of vegetation across the entire site, excluding areas of pine forestry. The drone also enabled measurements of tree height using a LIDAR heat map, which allows for a canopy height map to be established and specimen trees pulled out from this data. An indicative canopy height model was developed for parts of the site where the drone was flown. The model was created from the 2018 UAV derived surface model and removed the 2006 AC LiDAR DTM to establish indicative canopy height. Canopy heights of greater than 5 m were mapped in 5 m height classes (5-10 m, and so on up to 30-40 m).

The UAV surveys took place from high points around the site with a clear view across the habitats to be surveyed, between the hours of 10 am and 2 pm to ensure good lighting for photogrammetry capture and to minimise shadowing.

These images were then used to identify, characterise and delineate broad terrestrial and wetland[9] habitat types, including:

[9] Wetlands are defined within the Resource Management Act (RMA, 1991) as being: *"Permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions".* A wetland dominated by exotic plants and animals associated with wetland habitats still meets the RMA definition of a wetland [1] [2].

- Exotic pine forest;
- Exotic wattle forest;
- Mature native forest (SEA and non-SEA forest);
- Regenerating native forest;
- Indigenous dominated wetlands (SEA and non-SEA wetlands);
- Exotic dominated wetlands; and
- Degraded pasture wetland.

Drone imagery was also used to determine the height and location of all 'High Value' trees. 'High Value' trees included:

- Large mature trees including:
  - All native species above 15m in height;
  - All exotic trees above 20 m in height as older larger trees are more likely to include cavities that provide suitable habitat for bat roosting; and
  - Nationally 'Threatened' or 'At Risk' trees or shrubs (e.g. *Syzygium maire* [swamp maire]).

Field-based vegetation assessments were undertaken between March and November 2018 within most of the vegetation habitat types[10] on the property to:

- Ground-truth the drone-based delineation and identification of habitat types and 'High Value' trees. Wetlands were ground-truthed and delineated digitally in the field using ArcCollector. Areas were checked against UAV aerial imagery to determine the final extent of wetland habitat;
- Describe the overall condition of habitat types based on plant species composition and relative abundance, and the level of degradation associated with potential impacts such as browsing pressure;
- Make observations of nationally 'Threatened' or 'At Risk' plants during site walk overs, particularly low-stature or sub-canopy species that were less likely to be detected through drone imagery analyses;
- Measure the diameter at breast height (DBH) of all 'High Value' trees to determine the basal area of high value trees that may be impacted; and
- Assess the likely presence of nationally 'Threatened', 'At Risk' or legally protected indigenous fauna based on habitat suitability.

6.1.3 Long-tailed bats

6.1.3.1 Overview

The project area offers potential suitable habitat for long-tailed bats (*Chalinolobus tuberculatus*), which are classified as nationally 'Threatened' (Nationally Critical) and are protected under the Wildlife Act 1953. Given their high threat status, areas that provide habitat to long-tailed bats are considered to be significant habitats under s 6(c) RMA 1991.

Long-tailed bats roost in cavities, splits and loose bark in both native and exotic trees (including standing dead trees), as well as large hollow tree stumps and hollow tree ferns. They typically use linear landscape features such as bush edges, gullies, watercourses and roads to travel between

[10] The SEA sites in the northern extent of the project area (outside of the project footprint) were not included in the scope of the vegetation assessments.

roosting and feeding sites. They also tend to forage in open areas, including clearings, along forest edges around wetlands, open water and along rivers and roadways (Borkin & Parsons 2009; Griffiths, 1996).

From aerial imagery and site walkovers, it was established that the project area may offer potential bat habitat and accordingly, acoustic long-tailed bat surveys were undertaken.

The objectives of the long-tailed bat survey were to:

- Determine presence/absence of long-tailed bats within the WMNZ landholdings;
- Determine key habitat features for long-tailed bats within the WMNZ landholdings; and
- Establish how long-tailed bats are utilising the site (e.g. foraging, commuting) to understand the importance of the WMNZ landholdings for the local bat population and how this is potentially affected by the Project.

Short-tailed bats (*Mystacina tuberculata*), New Zealand's other bat species, are associated with extensive areas of old-growth native forest (Lloyd 2001). Because of the absence of this habitat in the WMNZ landholdings and there are no short-tailed bat records within 20 km of the project area, we consider this species is unlikely to be present.

6.1.3.2 Bat survey methodology

An acoustic bat survey was undertaken using Acoustic Bat Monitors (ABMs). ABMs passively record both long-tailed bat (40 kHz) and lesser short-tailed bat (28 kHz) echolocation calls. They operate remotely by recording and storing echolocation calls (bat passes), along with the time and date of occurrence.

The most recent generation of ABM was used for the survey; the AR4 acoustic bat recorder developed by the Department of Conservation (DOC). The survey methodology followed best practice guided by the DOC's inventory and monitoring tool box for bats (Sedgeley *et al*. 2012)

It should be noted that the ABMs record bat *calls*, which provide an index of activity rather than bat abundance, as the number of bat calls does not necessarily correlate with the number of individual bats encountered.

6.1.3.2.1 ABM deployment

Fifteen ABMs were deployed in the Western Block, Southern Block and forested areas of the Eastern Block in areas targeting potential bat habitat features and foraging areas including forest edges, isolated trees in pasture areas, potential flyways (commuting routes), watercourses and wetlands (Figure 8, Appendix B). ABM sites were chosen to ensure maximum coverage both directly within the project footprint and in areas immediately adjacent. ABMs were located at least 50 m apart to minimise double-counting. ABMs were suspended in vegetation, between 2 and 5 m from the ground with minimal surrounding foliage or obstructions, in open edge habitats or within forest interiors with clear flyways.

The ABMs were deployed from 23 October 2018 to 15 November 2018, totalling 23 survey nights. The ABMs were programmed to record from one hour before sunset to one hour after sunrise each night. Sunset and sunrise times were retrieved from the closest available location (Warkworth, 17838) from the NIWA CliFlo website (www.cliflo.niwa.nz).

6.1.3.2.2 Data analysis

Long-tailed bat activity is influenced by overnight temperatures and rainfall (O'Donnell, 2000b), as well as moon phase and amount of moonlight (Griffiths, 1996). As such, weather data from the survey period was reviewed to ensure conditions were suitable for long-tailed bats to be active.

Suitable weather conditions are referred to as 'fine weather nights' and for the purpose of this report are defined as:

- Minimum overnight temperature >7°C; and
- Less than 2mm of rainfall overnight.

Weather data (temperature and rainfall) was retrieved from the NIWA CliFlo website. Data from the nearest weather station at Warkworth was used which is located approximately 15 km from the WMNZ landholdings.

Moon phase and amount of moon light has also been found to influence long-tailed bat activity (Griffiths, 1996). It is now considered best practice to exclude monitoring data from the night of the full moon and one night either side. A full moon occurred on 25 October 2018, therefore data collected on the nights of the 24, 25 and 26 October 2018 were excluded from analysis.

Acoustic data recorded by the ABMs were analysed using the latest version of bat call analysis software developed by DOC (BatSearch version 3.12). Bat echolocation passes were distinguished from other noise files (e.g. insect noise, wind and rain), along with the time and date of each recording and any activity indicative of feeding or foraging. The timing of any bat activity recorded relative to sunrise and sunset was also analysed to provide an indication of whether any bats may be roosting within or near the project area.

Data extracted from the bat call analysis were analysed and summarised to provide the following information:

- Presence/absence of long-tailed bats within the project footprint and WMNZ landholdings;
- Distribution of long-tailed bat activity within the project footprint and WMNZ landholdings;
- Levels of long-tailed bat activity at each monitoring site (if detected);
- Mean long-tailed bat activity/night; and,
- Any activity indicative of feeding or roosting.

6.1.4 Birds

Suitable bird habitats on site include areas of wetland, mature and regenerating native forest, exotic wattle forest, exotic pine forest and pasture.

Presence of grassland and forest birds was determined through incidental visual and call observations whilst on site and likely presence was determined based on habitat suitability and known species ranges.

Targeted wetland bird surveys were undertaken within suitable onsite wetland habitats to determine wetland bird composition and relative abundance (Figure 9, Appendix B). Cryptic wetland birds targeted included spotless crake (*Porzana tabuensis*), marsh crake (*Porzana pusilla*), Australasian bittern (*Botaurus poiciloptilus*) and fernbird (*Bowdleria punctata*). To survey for these species calls, playback surveys were undertaken (involving the playing of pre-recorded calls of wetland birds and waiting for a response) coupled with the standard 5-minute point count method (5MBC; Hartley and Green, 2012).

Play-back calls were used during the peak of the breeding season from mid-September to mid-October, during peak evening calling periods (30 minutes before sunset and 1 hour after sunset) and also around sunrise, in calm, fine weather conditions. These surveys were undertaken at 40 locations, approximately between 50 and 100 m apart (depending on suitable habitat) along the edge of suitable wetland habitats. At each location the following method was applied:

- Taped calls of spotless crake, marsh crake and fernbird played separately for five minutes at a maximum amplitude of 90 decibels, before listening for return calls for one minute;
- Played recordings on calm mornings and evenings (around sunset and sunrise);
- During the 5MBC for each cryptic species, any other birds calling or seen were noted;
- Any wetland bird footprints seen during counts or walkovers were recorded; and
- GPS location, time of day and weather conditions were recorded.

Bio-acoustic techniques were applied to supplement on site field observations and to provide greater site survey coverage (Steer, 2010). One monitor was located in the degraded wetland at the proposed Stockpile 1 location and three monitors were placed in the large Wayby Wetland (South) (Figure 9 Appendix B). The monitors were deployed for a period of two weeks from 23 October to 6 November 2018. Over 800 hours of data were analysed using Raven Lite 2.0 software, which is an interactive sound analysis tool for animal bioacoustics.

6.1.5 Lizards

A qualitative assessment of habitat values for native lizards (skinks and geckos) was undertaking during numerous site walkovers in September and October 2018. Several nationally 'At Risk' skinks and geckos are likely to be present. The habitat assessment focused on identifying suitable groundcover habitat such as rotting logs, leaf litter, scrub vegetation and artificial debris that may offer suitable refugia.

Lizard surveys were undertaken between 31 October and 13 November 2018 and consisted of:

- Manual searches and visual encounter surveys (VES) along forest margins and in rank grassland areas which provide suitable habitat for skinks. Approximately 42 hours of manual searching for lizards was undertaken during fine, sunny weather conditions and included:
  - Turning over or pulling apart cover objects (e.g. coarse wood debris);
  - Raking of leaf litter or groundcover, (e.g. pampas or tradescantia); and
  - Habitat searches (e.g. epiphytes).
- Nocturnal spotlight searches along forest and shrubland margins with a focus on areas of kānuka or mānuka, which provide suitable habitat for geckos. Spotlighting was undertaken by walking along the edge of suitable habitat (largely native bush margins) and shining high powered spotlights (Led Lenser MT14 model) into branches and trunks of trees. Approximately 22 hours of spotlight searching was undertaken during fine and dry weather conditions.

6.1.6 Frogs

The WMNZ landholdings has potential habitat values for Hochstetter's frog (*Leiopelma hochstetteri*) which is classified as nationally 'At Risk' (Declining) and is protected under the Wildlife Act 1953. The objective of the frog surveys was to determine the spatial distribution and relative abundance of frogs within the project footprint and the WMNZ landholdings. Frog surveys were undertaken within representative hard-bottomed shaded streams across the project footprint with a focus on stream cascade complexes. Stream cascade complexes provide suitable habitat for frogs because they included small crevices and rock clusters that are free of sediment. All other stream habitat types were considered poor to marginal habitat due the extent of sedimentation. Surveys were undertaken on 1, 8 and 9 February 2019 and included 80 person-hours of searching. All potential habitat type was searched at each cascade complex until at least one frog was found (so as not to disturb more habitat than was needed to confirm the presence of frogs). The location of each frog was recorded, as was its length (from Snout to Urostyle), before the frog was placed back in its original habitat.

6.1.7 Invertebrates

Several invertebrates of high ecological value may be present onsite, including a species of kauri snail (*Paryphanta busbyi)*, rhytid snail *(Amborhytida dunniae),* and peripatus (*Peripatoides sympatrica*). The kauri and rhytid snail are both classified as 'At Risk' declining and peripatus is classified as Non Threatened, however, like the kauri and rhytid snail, this species is legally protected under the Wildlife Act 1953.

All three species may be present in the project area based on the known presence of these species in nearby areas and the habitat suitability of both native and exotic vegetation within the wide project area. Kauri snails are classified as nationally 'At Risk' (Declining) and are protected by the Wildlife Act 1953. The objective of invertebrate surveys was to determine the spatial distribution and relative abundance of these species and potentially other ecologically significant invertebrates (e.g. peripatus and the snails across the site). To this end, surveys were undertaken in all vegetated habitats across the site, with a focus on the areas potentially affected by the project. Surveys were undertaken on 30 and 31 January and 4 and 5 of February 2019, and included 40 person-hours of searching.

6.2 Terrestrial ecology results

This section describes the terrestrial (forest and wetland) characteristics and values within the WMNZ landholdings and immediate surrounds to provide ecological context when describing project effects on ecological values. It is important to note that while the potential exists for the project to have indirect effects on some ecological values outside the project areas, a number of ecological values within the WMNZ landholdings and surrounds will not be affected. Specific details on the terrestrial and wetland values that are affected directly or indirectly by the project are described in Section 7.3.

The WMNZ landholdings is located within the Rodney Ecological District (ED) which was originally forested prior to human settlement. The ED has since been extensively modified for farming, predominantly semi-intensive sheep and cattle grazing (Goldwater *et al*. 2012). Exotic pine forest, exotic wattle forest and grazed pasture are the dominant land-uses on site with land use dominance varying across the site as follows:

- The Western Block is approximately 304 ha and is currently an operational farm, with much of the flat land devoid of native vegetation;
- The Eastern Block is approximately 355 ha. This block is located within a wider area of 13-16 year old forestry at a similar stage of the harvest cycle. Although the valley is dominated by pine forest, the upper catchment is characterised by relatively dense, predominantly native, understory vegetation. At the lower end of the catchment, near the confluence with the adjacent valley to the north, understory vegetation is sparse;
- The Southern Block is 82 ha and is densely vegetated in native and exotic vegetation. Native vegetation is limited to early to mid-successional native forest towards the top of the catchment and on the northern side of the gully. Exotic wattle plantation dominates the remainder of the gully. None of the vegetation within the main Southern Block is identified as an SEA; however, a terrestrial SEA is located adjacent to State Highway. The Southern Block is bound to the south by the Sunnybrook Reserve, which is a SEA and DOC reserve; and
- The Waiteraire Tributary Block is 336 ha and is currently in pine forest upstream of the Sunnybrook Reserve and includes a tributary of the Waiteraire Stream.

6.2.1 Vegetation types and values

The site is broadly dominated by exotic forest, pasture and native habitat types. Native habitats include 11 habitat types including 5 mature native forest habitat types, 3 regenerating native forest habitat types and 3 wetland habitat types (Table 6.1). The native vegetation on site is in general of high ecological value, with eight of the 11 native habitat types classified as 'Threatened' under IUCN threat status classifications (Singers *et al.*, 2017).

The remaining three habitat types are classified as 'Not Threatened' based on current IUCN threat status classifications. However, several dominant plant species within these 'Not Threatened' habitat types have been recently classified as nationally 'Threatened' (i.e., kānuka and mānuka) and this will likely change IUCN threat classifications. Moreover, several native habitats across the site are classified as SEA under the AUP (Table 6.2).

Many of these native habitat types and sites described in this section occur outside the project footprint and will not be adversely affected by the project. Specific details on those sites and habitat types that are affected are provided in Section 6.3.

6.2.2 Areas of significance

Native forest and wetland sites are common, albeit patchily distributed across the site. Several of these sites are of particularly high ecological value and are designated as Significant Ecological Areas (SEA)[11], have Wetland Management Areas (WMA)[12] and/or are recognised as a Natural Stream Management Area (NSMA[13]) (Table 6.2 and Figure 5, Appendix B)

Across the project area, these SEAs, WMAs and NSMAs, and a number of other forest and wetland sites provide habitat for native fauna, including bats, birds, lizards, frogs and invertebrates. Many of these species are legally protected under the Wildlife Act 1953 and/or classified as Nationally Threatened or At Risk under the Department of Conservation (DOC) National Threat Classification System (NZTCS). SEAs and WMAs located within the WMNZ landholdings have deliberately been avoided in the project design and as such there are no SEAs or WMAs within the project footprint.

[11] SEAs are identified by Auckland Council and are defined as "*identified areas of significant indigenous vegetation or significant habitats of indigenous fauna located either on land or in freshwater environments*".

[12] Wetland Management Areas are protected under the AUP and are listed in Schedule 1 Wetland Management Areas Schedule

[13] Auckland Council Natural Stream Management Area Overlay identifies river and stream reaches with high natural character and high ecological values

Table 6.1: Vegetation types within the WMNZ landholdings[14]

Vegetation type	Area and location	Habitat description	Vegetation values
Mature Indigenous Forest			
WF7: Pūriri forest	0.9 ha fragment borders the Hōteo river and borders the overall site boundary. This is outside of the project.	Dominant canopy: Pūriri, tītoki.	IUCN threat status: Threatened (Critically endangered) Includes SEA_T_5541. High value trees >20 m present.
WF8: Kahikatea, pukatea forest	17.2 ha in total - small fragments are present within the swamp mosaic in the middle of Western Block. Approximately 0.6 ha of this habitat type will be affected by the project. Large fragments are present at the northern extents of the site and to the east of Stockpile 1.	Dominant canopy: Kahikatea, pukatea, swamp maire, matai, kauri and taraire present. Understory of areas outside swamp mosaic degraded by stock access. However, swamp maire, swamp māhoe, kaikomako, marble leaf and tree ferns are abundant. Black maire present in low abundance. Stock access in kahikatea, pukatea fragments outside of the swamp mosaic.	IUCN threat status: Threatened (Critically endangered) Threatened species present: Swamp maire, white rātā (*Metrosideros perforata*), mānuka, and kauri. Regionally rare species: kaikomako (sparse), black maire (regionally critical) Includes SEA_T_909 and SEA_T_909c. High value trees >20 m present.
WF9: Taraire, tawa, podocarp forest	11.1 ha in total. Most significant remnant is present to the south and west of the wetland mosaic. Smaller fragments of this forest type form riparian strips to the Hōteo river. Approximately 0.3 ha of this habitat type will be affected by the project.	Dominant canopy: Taraire, tōtara, rewarewa. Stock have access to some areas of this forest, resulting in low understory diversity. Tradescantia dominates the groundcover in some sections of this forest.	IUCN threat status: Threatened (Endangered) Threatened species: *Metrosideros diffusa*, kānuka. Includes SEA_T_683. High value trees >20 m present.
WF11: Kauri, podocarp, broadleaved forest	Approximately 2 ha of this forest type is present on site. A 0.06 ha remnant fragment is connected to the large swamp mosaic, there is a 1 ha fragment of this forest type at the centre of the farm, and approximately 0.4 ha is present within a pine block at the north-	Dominant canopy: Kauri, rimu, tōtara. Contains mature and juvenile kawaka. Signs of pig disturbance, however understory mostly intact in centre fragment. Fenced from stock access.	IUCN threat status: Threatened (Endangered) Threatened species present: Kauri, kānuka, *Metrosideros perforata*, *Metrosideros fulgens* and *Metrosideros diffusa*, kānuka. Regionally rare species: kawaka (sparse). Includes SEA_T_629 (0.06 ha fragment).

[14] Many of these sites and habitat types are not adversely affected by the project. Specific details on those sites and habitat types that are affected are provided in Section 6.3.

Vegetation type	Area and location	Habitat description	Vegetation values
	eastern corner of the farm. This vegetation type is located outside the project.		High value trees >20m DBH present.
WF12: Kauri, podocarp, broadleaves, beech forest	4.3 ha of this forest type is present to the east of the wetland mosaic, intermingled with pine forest. This is outside the project.	Dominant canopy: Kauri, hard beech, tanekaha, tōtara. Limited stock access to this forest. Understory mostly intact, dominated by tree ferns, hangehange and canopy seedlings. Pixie cap orchids and green-hooded orchids present.	IUCN threat status: Threatened (Endangered) Threatened species present: Kauri, Metrosideros perforata, Metrosideros fulgens, Metrosideros diffusa. High value trees >20 m present.
Regenerating native forest			
VS2: Kānuka scrub/forest	31 ha in total. Substantial kānuka forest south of Western Block is contiguous with the Southern Block. It contains reasonably mature kānuka scrub; emergent trees are beginning to overtop the kānuka canopy. Approximately 4.4 ha of this habitat type is affected by the project.	Dominant canopy: Kānuka, rewarewa, tōtara, tanekaha, towai, pigeonwood. Numerous kawaka seedlings are scattered in close vicinity to a single mature individual in the Southern Block. Good understory regeneration. Green-hooded and pixie cap orchids abundant in some sections. Tradescantia, African clubmoss present in groundcover.	IUCN threat status: Least Concern Threatened species present: Kānuka, mānuka, Metrosideros perforata. Regionally rare species: kawaka (sparse).
Farm forest fragments/treelands	2.3 ha in total – several forest fragments, across the farm that have not been fenced from stock. Numerous small stands remain. Approximately 0.2 ha of this habitat type is affected by the project.	Dominant canopy: Tōtara, kānuka, kahikatea. No or very little understory present as impacted by stock access.	Threatened species present: Kānuka, mānuka.
Exotic forest			
Pine & wattle forest	728.92 ha in total. 49.42 ha wattle forest / 679.4 ha pine forest. Large forestry block located in the Eastern Block and in the Western Block. Sporadic pine trees located within regenerating native areas in the Southern Block. Approximately 9.11 ha of wattle and	Monoculture plantation forestry approximately 25 years old.	Regionally rare species: Kaikomako (sparse) seedlings present at the edges of the Southern Block bordering wattle forest.

Vegetation type	Area and location	Habitat description	Vegetation values
	86.41 ha of pine forest will be affected by the project.		
Indigenous wetlands			
WL 12: Mānuka, tangle fern scrub/fernland*	4.4 ha in total. Medium sized wetland located adjacent to Stockpile 1 and adjacent to wattle forest and regenerating native forest within the Southern Block. Approximately 0.1 ha of this habitat type will be affected by the project. The affected area is not scheduled as an SEA.	Scrub of abundant mānuka, sub-canopy plants include tangle fern, sphagnum, swamp coprosma and Carex spp.	IUCN threat status: Threatened (Critically endangered). Includes SEA_T_629. Threatened species: Swamp maire. Regionally rare species: swamp coprosma (data deficient)
WL 18: Flaxland*	0.6 ha in total scattered amongst mānuka, tangle fern scrub/fernland.	Abundant harakeke, kiokio, species of Carex and occasional mānuka.	IUCN threat status: Threatened (Critically endangered). Includes SEA_T_629.
WL 19: Raupō reedland*	7.1 ha in total across the site. The majority of this ecosystem type is located alongside mānuka, tangle fern scrub/fernland (WL12) and flaxland (WL18). Approximately 1 ha is present on the northern side of the site, downstream of a large open pond, which has been fenced from stock access. Two fragments of approximately 0.5 ha and 0.3 ha are present at the north eastern corner of the site. The former is surrounded by pine forestry and the latter is downstream of degraded WF8 forest. Approximately 0.03 ha of this habitat type will be affected by the project. The affected area is not scheduled as an SEA.	Dominated by raupō, occasional lake clubrush, jointed twig rush, toetoe and harakeke. Mānuka occasionally present. Stock access to some areas. Approximately 0.15 ha of invasive crack willow is present in the wetland mosaic, and is contiguous with WL19 and WL18 wetland extents.	IUCN threat status: Threatened (Endangered) Includes SEA_T_629, SEA_T_6456, SEA_T_6850. Threatened species: Swamp maire, mānuka. Regionally rare species: swamp coprosma (data deficient).

Vegetation type	Area and location	Habitat description	Vegetation values
Exotic wetlands			
Exotic wetland	4.4 ha in total located in middle of the Western Block, within the Stockpile 1 footprint, and scattered throughout the farm. Approximately 0.47 ha of this habitat type will be affected by the project (Stockpile 1).	Dominated by exotic Juncus sp (mostly Juncus effesus.	

Vegetation type from (Singers *et al.*, 2017).

Table 6.2: Areas of significance and classification type within the WMNZ landholdings (all outside of the project footprint)

Site ID	Habitat	Reasons for classification
Significant Ecological Area (SEA) – Wetland		
SEA_T_629 / 15.5ha	Swamp mosaic of raupō reedland, mānuka, tangle fern scrub/fernland, kahikatea, pukatea forest, flaxland and exotic wetland predominantly surrounded by pasture swamp mosaic of raupō reedland, mānuka, tangle fern scrub/fernland, kahikatea, pukatea forest, flaxland and exotic wetland predominantly surrounded by pasture	Representativeness, threat status and rarity, and diversity. Swamp maire (Threatened – nationally critical) distributed throughout the wetland. This wetland is mostly intact, however only some sections are fenced allowing stock access in many areas, affecting the understory composition. The eastern end of the wetland has been invaded by pampas.
SEA_T_6456 / 2.1ha	Dominated by raupō, wheki ponga, cabbage trees and pampas present, with mānuka and tōtara bordering the edge.	Threat status, rarity, and diversity. Wetland is generally in good condition, stock access has resulted in some degradation. Watercourse is present along the southern boundary, fed primarily by a 0.3ha lake to the east of the wetland and south of an adjoining pine forest block.
SEA_T_6850 / 3.2ha	Dominated by wiwi (*Juncus edgariae*) and individual kahikatea trees.	Species diversity and importance as a stepping-stone, migration pathway and buffer. Headwaters consist of kahikatea forest. Wetland has been degraded by stock access and pampas is present in low abundance.
Significant Ecological Area (SEA) - Forest		
SEA_T_909	Kahikatea and pukatea forest. Remnant forest wetland surrounded by pasture with sheep stock access. Vegetation mosaic of black maire, matai, swamp coprosma, swamp maire,	"Critically endangered" regional IUCN threat status. This type of forest has been greatly reduced through drainage and agriculture land development. Representativeness, threat status and rarity, and diversity. Presence of swamp maire (Threatened – nationally critical) throughout the remnant.

Site ID	Habitat	Reasons for classification
	pukatea, kahikatea, tōtara, cabbage tree, kaikomako, and wheki.	Intact remnant fragment, retention of associating swamp forest species even with stock pressure. Headwater tributaries within the remnant contribute to intact hydrology and water table. This remaining forest fragment offers important stepping stones providing connectivity to other patches surrounding a SEA wetland.
SEA_T_909c	Kahikatea and pukatea forest. Remnant forest wetland surrounded by pasture with sheep stock access. Vegetation mosaic of black maire, titoki, matai, *Melicytus micranthus*, *Melicope simplex*, swamp coprosma, kaikomako, swamp maire, pukatea, kahikatea, and supplejack.	"Critically endangered" regional IUCN threat status. This type of forest has been greatly reduced through drainage and agriculture land development. Representativeness, threat status and rarity, and diversity. Presence of swamp maire (threatened – nationally critical) throughout the remnant. Intact remnant fragment, retention of associating swamp forest species even with stock pressure. Headwater tributaries within the remnant contribute to intact hydrology and water table. The species composition in this remnant is not common in the Auckland region.
SEA_T_6634	Mosaic of dominant mature wattle and native taraire and tōtara with tradescantia understorey along the vegetation margins surrounding an exotic dominate wetland.	Identified as a kānuka scrub/forest (VS2) ecosystem. The remnant mature species consists of species that are not indicative of a kānuka scrub/forest, with a lack of diagnostic species such as kānuka, mingimingi, prickly mingimingi, lancewood, kowhai, and putaputaweta.
SEA_T_683	Tararie, tawa, podocarp forest (WF9). Mosaic of mature podocarp forest with a mix of understorey species include titoki, tōtara, nīkau, and karaka.	"Endangered" regional IUCN threat status. This forest fragment meets the representativeness, threat status and rarity, and diversity characteristics. This remnant forest fragment is mature, intact and relatively large and Waiteraire Stream runs through the southern portion of the fragment.
Wetland Management Areas (WMA)		
Wayby Wetland 159	Wayby Wetland 159 has been identified as the wider SEA_T_6456. This WMA is characterised by Raupo reedland (WL19).	Threat status, rarity, and diversity. Wetland is generally in good condition, stock access has resulted in some degradation. Watercourse is present along the southern, fed primarily by a 0.3ha lake to the east of the wetland and south of an adjoining pine forest block.
Wayby Wetland 164	Wayby Wetland 164 has been identified as the wider SEA_T_629. This WMA is characterised by Raupo reedland (WL19), mānuka, tangle fern scrub/fernland (WL12), flaxland (WL18), and small pockets of kahikatea and pukatea forests (WF8) and exotic wetland consisting of *Salix* (EW) along the wetland margin.	Representativeness, threat status and rarity, and diversity. Swamp maire (Threatened – nationally critical) distributed throughout the wetland. This wetland is mostly intact, however only some sections are fenced allowing stock access in many areas, affecting the understory composition. The eastern end of the wetland has been invaded by pampas and some northern margins are encroached by *Salix* spp.

Site ID	Habitat	Reasons for classification
Natural Stream Management Areas (NSMA)		
Along River Number 457361 (Auckland Council GeoMaps)	Stream reach is of high natural character, ecological values, and water quality. High in-stream values include an intact canopy cover of regenerating native forest and old exotic wattle planation. Mature kawaka (At Risk – Naturally Uncommon) was observed, as well as kauri saplings and pockets of kānuka grove, both of which are Threatened – Nationally Vulnerable. Stream edge margins are sheltered by parataniwha and native fern.	Representativeness, threat status and rarity, and diversity. This reach of stream consists of high quality value that provide diverse and abundant habitat and food source for native aquatic fauna and macroinvertebrates. The in-stream value is characterised by cool temperatures, high hydrological heterogeneity, and diversity of substrates and stream characteristics such as deep pools and waterfalls.

6.2.3 Threatened plants

Eight nationally 'Threatened' or 'At Risk' plant species have been identified across the site and are outlined below in Table 6.3. In addition, kawaka (*Libocedrus plumosa*) and kaikomako (*Pennantia corymbosa*) have been identified on site and are rare across the Auckland region (Sawyer and Forbes, 2013). A list of all plant species recorded on site can be found in Appendix H.

Most of the habitat types or sites supporting nationally 'Threatened' or 'At Risk' plant species are located outside the project footprint.

Table 6.3: Threatened plant species observed within WMNZ landholdings[15]

Common name	Scientific name	Threat status	Vegetation type and Location
Kānuka	*Kunzea robusta*	Threatened – nationally vulnerable	Throughout site, including Southern Block, Eastern Block and Western Block. Approximately 1.29 ha of manuka and kanuka habitat are affected by the project as well as an unknown number of isolated trees.
Mānuka	*Leptospermum scoparium*	At Risk - declining	Throughout site, including Southern Block, Eastern Block and Western Block. Approximately 1.29 ha of manuka and kanuka habitat are affected by the project as well as an unknown number of isolated trees.
Kauri	*Agathis australis*	Threatened – nationally vulnerable	Kauri, podocarp, broadleaved, beech forest, and a small fragment within the wetland mosaic. No kauri will be affected by the project.
White rātā	*Metrosideros perforata*	Threatened – nationally vulnerable	Throughout site, including Southern Block, Eastern Block and Western Block. Possible that this species will be affected by the project in some areas.
Akatawhiwhi	*Metrosideros fulgens*	Threatened – nationally vulnerable	Within the kauri, podocarp, broadleaved, beech forest. No Akatawhiwhi will be affected by the project.
White rātā	*Metrosideros diffusa*	Threatened – nationally vulnerable	Within the kauri, podocarp, broadleaved, beech forest. Possible that this species will be affected by the project in some areas.

[15] Most of the habitat types or sites supporting nationally 'Threatened' or 'At Risk' plant species are located outside the project activity areas. Specific details on nationally 'Threatened' or 'At Risk' plants located within the project activity areas are set out in section 7.3.

Common name	Scientific name	Threat status	Vegetation type and Location
Swamp maire	*Syzigium maire*	Threatened – nationally critical	Within kahikatea and pukatea forests throughout site. Within swamp mosaic. No swamp maire will be affected by the project.
Pōhutukawa (planted)	*Metrosideros excelsa*	Threatened – nationally vulnerable	Western Block, near the farmhouse. No pohutakawa will be affected by the project.
Kawaka	*Libocedrus plumosa*	Not threatened – but locally rare.	Indigenous broadleaf forest to the centre of the Southern Block. Single mature tree identified with multiple seedlings throughout this area. No kawaka will be affected by the project.
Kaikomako	*Pennantia corymbosa*	Not threatened – but locally rare.	Within kahikatea and pukatea forests throughout site. Within swamp mosaic. Possible that some kaikaomako will be affected by the project in some areas.

6.2.4 Bats

A total of 558 long-tailed bat passes were recorded at all 15 ABM locations over 17 fine weather nights during the survey period. Bats were recorded along the Forest Road access track, pine forest in the Eastern Block, wetland areas and along edges of native forest. Long-tailed bat activity recorded at the 15 monitoring sites is summarised in Table 6.4 below. Figure 8 in Appendix B shows long-tailed bat activity and distribution across the WMNZ landholdings.

Bat activity levels recorded across the 15 sites were low to moderate and ranged from 0.2 to 5.7 mean bat passes/night (Table 6.4). Activity levels were highest at Sites 1, 6, 7 and 9 (where mean bat activity was >3 passes/night, (Table 6.4, Figure 8, Appendix B). Three of these monitoring sites were located within the project footprint in direct impact sites on the proposed access road, within mature native forest and on the edge of the Eastern Block pine plantation (Sites 1, 6 and 7). The fourth site (Site 9), was located on the northern edge of the regenerating native forest within the Southern Block (Figure 5, Appendix B).

Bat activity was recorded on over 50 % of the 17 fine weather nights, on ten out of 15 ABMs deployed (Table 6.4). These results confirm that bats are present.

Table 6.4: Summary of long-tailed bat activity recorded during period 23 October to 15 November 2018

Site ID	Fine weather nights	No. of nights with bat passes	Total no. of bat passes	Mean no. of bat passes per night	Total no. of feeding buzzes
1	17	10	69	4.1	3
2	17	12	40	2.4	0
3	17	4	5	0.3	0
4	17	11	33	1.9	3

Site ID	Fine weather nights	No. of nights with bat passes	Total no. of bat passes	Mean no. of bat passes per night	Total no. of feeding buzzes
5	17	11	60	3.5	0
6	17	16	97	5.7	9
7	17	7	61	3.6	7
8	17	8	23	1.4	1
9	17	11	64	3.8	2
10	17	14	40	2.4	0
11	17	5	9	0.5	0
12	17	11	38	2.2	0
13	17	6	12	0.7	0
14	17	3	3	0.2	0
15	17	2	4	0.2	0

6.2.4.1 Bat foraging activity

"Feeding buzzes" occur when bats increase the frequency of their echolocation as they home in on prey. Occurrence of feeding buzzes from the bat call analysis can provide an indication of foraging behaviour and the importance of the site as a foraging ground.

While the overall level of bat activity recorded was low to moderate, some of the bat activity recorded within the WMNZ landholdings is indicative of feeding/foraging behaviour. 25 independent feeding buzzes were recorded at six of the 15 ABM sites. These occurred at sites 1, 6, 7, 9 (same as the higher mean activity sites), as well as at sites 4 and 8 (located in the regenerating native forest in the Southern Block and on the edge of the mature native forest block directly above stockpile 1; see Table 6.4 and Figure 8, Appendix B).

6.2.4.2 Bat roosting activity

It is possible to infer bat roosting activity in the vicinity of a monitoring site from the timing of bat activity as long-tailed bats generally emerge from their roosts approximately 30 minutes after sunset (Griffiths, 2007). However, minimal bat activity was recorded on all ABMs within 2 hours of sunset (see Figure 8, Appendix B), indicating that it is unlikely bats were roosting in proximity to the 15 ABMs during the survey period. Attaining complete site coverage is not possible using 15 ABMs, therefore we cannot rule out the presence of active bat roosts on site. Furthermore, as long-tailed bats are highly mobile and change roosts regularly, roosting activity may still occur on site but this wasn't captured during the 3 week survey period.

6.2.4.3 Bat habitat assessment

One particularly distinctive potential bat roost tree, an individual exotic pine tree (>20 m high and >15cm DBH) was identified within the project footprint (Figure 8, Appendix B) and contained typical bat roost tree characteristics such as cavities, hollow limbs, flaky and loose bark. A further 10 individual stands of mature pine are located in direct impact areas within the project footprint.

At least 55 potential bat roost trees were identified within the WMNZ landholdings, but outside of the project footprint. These trees are located outside of the eastern pine block, amongst the native regenerating forest in the Southern Block (Figure 6, Appendix B). The wattle (acacia) forest areas in the Southern Block (Figure 6, Appendix B) also provide potential bat roost habitat, particularly those with broken branches and hollow limbs.

Long-tailed bats tend to use linear habitat features such as roads, forest edges and water courses when commuting between roosts and foraging sites (O'Donnell 2000), all of which are present within the project area and some of which will be directly impacted by the project by varying degrees. While most of the potential roost trees are located in areas that will be maintained, approximately and appropriate best-practice tree removal protocols will need to be used when these are to be removed. Within the wider landscape beyond the project footprint, there are several areas of mature native vegetation and mature pine blocks which may offer potential roosting areas for bats. SEA blocks, all of which are outside the project areas, contain a large abundance of mature native trees which likely provide suitable conditions for long-tailed bat roosts.

6.2.5 Birds

Twenty six avifauna species (comprised of 21 native and five exotic species) were observed during site walkovers. Table 6.5 lists bird species observed, habitat and threat status (Robertson *et al.*2013), as well as those expected to be present based on suitable habitat on site.

The bird assemblage in the project area is dominated by native and introduced species that are ubiquitous in agricultural landscapes or forestry landscapes (Table 6.5).

However, wetlands and forest habitats also support nationally 'Threatened' or 'At Risk' species such as the nationally 'Threatened' (Nationally Critical) Australasian bittern and six nationally 'At Risk' species were also recorded, including black shag (Naturally Uncommon), long-tailed cuckoo (Naturally Uncommon), NZ pipit (Declining), whitehead (Declining), fernbird (Declining) and spotless crake (Declining). Also, a further three 'At Risk' species, kaka (Recovering), kākāriki (Relict) and pied stilt (Declining), while not detected, may be present on site. Of particular note, a relatively high number of fernbird and spotless crake were recorded in wetland habitats within the WMNZ landholdings (Table 7.6, Figure 9). Almost all of the wetland and forest habitat that support these species is located outside the project footprint (Section 7.3).

Table 6.5: Forest bird species observed or expected to occur on the WMNZ landholdings and their national threat status[16].

Common name	Scientific name	Observed on WMNZ landholdings?	Habitat	Threat status
Bellbird	*Anthornis melanura*	Yes	Indigenous forest	N/A
Black shag	*Phalacrocorax carbo*	Yes	Streams within forest	At Risk – Naturally uncommon
Chaffinch*	*Fringilla coelebs*	Yes	Farmland	N/A
Eastern rosella*	*Platycercus eximius*	Yes	Farmland	N/A
European goldfinch*	*Carduelis*	Yes	Farmland	N/A
Grey warbler	*Gerygone igata*	Yes	Indigenous and exotic forest	N/A
House sparrow*	*Passer domesticus*	Yes	Farmland	N/A

[16] Almost all of the wetland and forest habitat that support terrestrial and wetland bird species is located outside the project activity areas (Section 6.3).

Common name	Scientific name	Observed on WMNZ landholdings?	Habitat	Threat status
Kaka	*Nestor meridionalis*	No	Indigenous and exotic forest	At Risk - recovering
Kākāriki	*Cyanoramphus novaezelandiae*	No	Indigenous forest	At Risk - relict
Kererū	*Hemiphaga novaeseelandiae*	Yes	Indigenous forest	N/A
Long-tailed cuckoo	*Eudynamys taitensis*	Yes	Indigenous and exotic forest	At Risk - Naturally uncommon
Morepork	*Ninox novaeseelandiae*	Yes	Indigenous and exotic forest, farmland	N/A
NZ fantail	*Rhipidura fuliginosa*	Yes	Indigenous forest	N/A
NZ pipit	*Anthus novaeseelandiae*	Yes	Farmland	At Risk - declining
Paradise shelduck	*Tadorna variegate*	Yes	Wetland and farmland	N/A
Pūkeko	*Porphyrio melanotus*	Yes	Wetland and farmland	N/A
Sacred kingfisher	*Todiramphus sanctus*	Yes	Indigenous and exotic forest, wetland, farmland	N/A
Shining cuckoo	*Chrysococcyx lucidus*	Yes	Indigenous forest	N/A
Silvereye	*Zosterops lateralis*	Yes	Indigenous forest, farmland	N/A
Song thrush*	*Turdus philomelos*	Yes	Farmland	N/A
Spur-winged plover	*Vanellus miles*	Yes	Farmland	N/A
Swamp harrier	*Circus approximans*	Yes	Wetland, farmland, pine	N/A
Tomtit	*Petroica macrocephala*	Yes	Indigenous and exotic forest	N/A
Tūī	*Prosthemadera novaeseelandiae*	Yes	Indigenous forest	N/A
Welcome swallow	*Hirundo neoxena*	Yes	Farmland	N/A
Whitehead	*Mohoua albicilla*	Yes	Indigenous forest	At Risk - declining

* = exotic species, all other species are native.

Table 6.6: Wetland bird species known to be present or likely to be present within WMNZ landholdings.

Common name	Scientific name	Threat status	Detected in field surveys	Observations during field surveys			
				Location	Visual	Aural	Acoustic recordings
Fernbird	*Bowdleria punctata*	At Risk – declining	Yes	SEA wetland	2	9	✓
				Degraded wetland (stockpile 1)	4	3	✓
Spotless crake	*Porzana tabuensis*	At Risk – declining	Yes	SEA wetland	1	8	✓
				Wattle forest near access road		3	
				Degraded wetland (stockpile 1)			
Australasian bittern**	*Botaurus poiciloptilus*	Threatened – nationally critical	Yes	SEA wetland			✓
Marsh crake	*Porzana pusilla*	At Risk – declining	No	N/A			
Pied Stilt		At Risk – declining	No	N/A			

** Likely Australasian bittern booms were recorded via Acoustic recordings. Recordings are difficult to confirm, however, is assumed to be present on site within the SEA wetland.

6.2.6 Lizards

Twenty three skinks, including four native copper skinks and 19 exotic plague species were recorded during 42 person hours of manual searching and VES (Figure 10). No geckos were found during 22 person hours of spotlighting surveys (Table 6.7). The native copper skink is classified as 'Not Threatened' but it is protected under the Wildlife Act 1953. The introduced plague skink is not threatened and is not protected under the Wildlife Act.

Up to four native lizard species (Pacific gecko, Auckland green gecko, forest gecko and ornate skink, Table 6.7) are expected to be present within the WMNZ landholdings based on habitat suitability and known presence in the general area. All these species are nationally 'At Risk' and protected under the Wildlife Act 1953.

Most of the wetland and forest habitat that support these species is located outside the project footprint (Section 6.3).

Table 6.7: Herpetofauna found during surveys and expected to be present in the WMNZ landholdings, including the project footprint[17].

Species detected on WMNZ landholdings during field surveys				
Common name	**Scientific name**	**Threat status**	**No. of observations found in field surveys**	**Location/s & habitat of observations**
Copper skink	*Oligosoma aeneum*	Not threatened	4	Native kānuka/mānuka forest edges, basking on fence posts & forestry Road track under rockpiles. Two individuals found within project footprint.
Rainbow plague skink	*Lampropholis delicata*	Introduced	20	Native kānuka/mānuka forest edges, wattle forest & Forestry Road track under rockpiles. Two individuals found within project footprint.
Species likely to be present on WMNZ landholdings				
Common name	**Scientific name**	**Threat status**	**No. of records within 15 km of WMNZ landholdings**	**Potential location/s & habitat within WMNZ landholdings**
Pacific gecko	*Dactylocnemis pacificus*	At Risk – relict	2	Areas of mānuka, kānuka, tōtara and in native bush. The flaking bark of wattle may provide habitat for this species.
Forest gecko	*Mokopirirakau granulatus*	At Risk-declining	3	Areas of mānuka, kānuka, tōtara and in native bush. The flaking bark of wattle may provide habitat for this species.
Auckland green (elegant) gecko	*Naultinus elegans*	At Risk - declining	10	Areas of mānuka, kānuka, tōtara and in native bush. The flaking bark of wattle may provide habitat for this species.
Ornate skink	*Oligosoma ornatum*	At Risk - declining	14	Beneath native leaf litter.
Copper skink	*Oligosoma aeneum*	N/A	8	Beneath leaf litter or coarse woody debris in native forest or forest fragments on the farm.

6.2.7 Hochstetter's frog

Hochstetter's frogs were common within hard-bottom stream cascade complexes across most of the project footprint and wider WMNZ landholdings with a total of 22 frogs found within or immediately adjacent to the footprint during 63.5 person hours of searching (Figure 11, Appendix B). Moreover, a number of juveniles were detected, indicating a breeding population. We estimate suitable cascade complexes to constitute around 2 to 5 % of the 15.4 km of intermittent and permanent stream

[17] Most of the habitat that support these species is located outside the project activity areas (Section 7.3).

length that will be affected by the footprint of the Project components (approximately 300 to 770 m). We expect very few frogs to be present in other stream habitat types, which are all impacted by sediment and/or lack refugia. Sediment is attributed to historical land use activities associated with the clear felling of original native bush and subsequent forestry rotations.

Hochstetter's frogs have also been found within indigenous and pine forest vegetation surrounding the WMNZ landholdings (Thelma Wilson, Department of Conservation Senior Ranger, *pers. Com*. 31 Jan 2019) and is therefore likely to be common in the wider landscape (i.e. beyond the WMNZ landholdings).

6.2.8 Invertebrates

Twenty-four rhytid snails and three peripatus were detected during 53.5 person hours searching in representative suitable habitat across the WMNZ landholdings and within the project footprint (Figure 12). These species are expected to be common and widespread across native and exotic forest habitats within the WMNZ landholdings.

Kauri snail were not detected during surveys despite their known presence within 5 km from the WMNZ landholdings in the nearby Dome Valley and within 10 km near the Woodcocks Road area, near Warkworth (Spencer et al, 2006). Based on the level of searching effort we cannot rule out their presence but if present, the population is likely to be localised and or small.

6.2.9 Introduced mammals

Introduced mammal surveys were not undertaken, however a number of introduced mammals and/or introduced mammal activities were observed during field visits to the WMNZ landholdings. Observations includes possums (*Trichosurus vulpecula*) and possum scat, substantial pig (*Sus scrofa*) rooting and scat, and sign of goat (*Capra hircus*) browse, bark damage and scat. Other likely mammalian predators on the WMNZ landholdings include feral cats (*Felis catus*), rats (*Rattus norvegicus*) and mustelids as would be expected in mainland New Zealand forested habitats not subject to pest control.

6.2.10 Terrestrial ecology values summary

The key ecological features within the WMNZ landholdings are described and summarised in Table 6.8 below, with many of these values located in areas outside the project footprint. Of particular note, the WMNZ landholdings includes:

- Several forest and wetland SEAs (these areas have been deliberately avoided with selecting the locations for the project activities);
- Three species classified as nationally Threatened (Nationally Critical), the highest threat status in New Zealand, namely swamp maire and long-tailed bat and the Australian bittern (which are likely to be present but have not yet been detected); and
- Sizeable populations of three 'At Risk' species, namely fernbird, spotless crake and Hochstetter's frog.

Table 6.8: Summary of key ecological values within the WMNZ landholdings[18]

Key Ecological Features	IUCN threat status for habitats and DOC Threat classification system for species
Habitat/vegetation type	
Indigenous mature forest (0.86 ha of non-SEA mature forest affected)	Endangered or Critically Endangered and supports native bats, lizards, birds, invertebrates
Indigenous regenerating forest (4.62 ha affected)	Least Concern but provides habitat for native bats, lizards, birds, invertebrates
Exotic wattle forest (9.11 ha affected)	Not threatened but provides habitat for native bats, lizards, birds, invertebrates
Exotic pine forest (86.41 ha affected)	Not Threatened but provides habitat for native bats, birds, invertebrates
Indigenous wetland (0.85 ha of non-SEA wetland affected)	Critically Endangered and provides habitat for native bats, lizards, birds, invertebrates
Exotic wetland (0.478 ha affected)	Not Threatened but provides habitat for native birds, invertebrates
Threatened and/or high value flora	
Large individual native trees (affected)	Various threat statuses but provide habitat for native bats, lizards, birds
Large exotic trees (affected)	Not Threatened but potential bat roosting habitat
Swamp maire (not affected)	'Threatened – Nationally Critical'
Kauri (not affected)	'Threatened – Nationally Vulnerable'
Kawaka (not affected)	Locally uncommon
Kānuka (affected)	'Threatened – Nationally Vulnerable'[1]
Mānuka (affected)	'At Risk – Declining'*
Akatawhiwhi (potentially affected)	Threatened – Nationally Vulnerable
Kaikomako (potentially affected)	Not threatened – but locally rare
Pohutakawa (planted)(not affected)	Threatened – Nationally Vulnerable
White rata (potentially affected)	'Threatened – Nationally Vulnerable'*
Threatened and/or high value fauna (all fauna are expected or likely to be affected to varying degrees)	
Long-tailed bat	'Threatened - Nationally Critical'
Australasian bittern	'Threatened - Nationally Critical'
Black shag	'At risk – Naturally Uncommon'
Long-tailed cuckoo	'At risk – Naturally Uncommon'
North Island kaka	'At Risk - Recovering'
North Island fernbird	'At Risk - Declining'
Spotless crake	'At Risk - Declining'
Pied stilt	'At Risk - Declining'
NZ pipit	'At Risk - Declining'
Whitehead	'At Risk - Declining'
Auckland green gecko	'At Risk - Declining'
Forest gecko	'At Risk - Declining'
Pacific gecko	'At Risk – Relict'
Ornate skink	'At Risk - Declining'

[18] Many of these values are located outside the project activity areas. Details on ecological values that are affected by the project are set out in section 7.3.

Key Ecological Features	IUCN threat status for habitats and DOC Threat classification system for species
Threatened and/or high value fauna (all fauna are expected or likely to be affected to varying degrees)	
Copper skink	Not Threatened but protected under the Wildlife Act
Hochstetter's frog	'At Risk - Declining'
Kauri snail	'At Risk - Declining'
Rhytida snails	'At Risk' Gradual Decline
Peripatus	Not Threatened but protected under the Wildlife Act

Notes:

[1] Level of threat status is primarily associated with a precautionary approach due to disease risk.

6.3 Assessment of effects on terrestrial and wetland ecology

The previous section described the ecological values present within the WMNZ landholdings and immediate surrounds to provide context.

This section focuses on assessing project-related effects on terrestrial and wetland ecological values that are directly (within the project footprint) or indirectly affected. The assessment is based on the EcIAG produced by EIANZ (Roper-Lindsay *et al.,* 2018) and adapted based on expert opinion as described in Section 3 to determine the overall 'level of effect' of the project on terrestrial and wetland ecological values.

6.3.1 Overview of effects

This section provides an overview of the level of effects assigned to each habitat or species value with and without mitigation or compensation.

The site is broadly dominated by exotic forest (729 ha), pasture (213 ha) and native species dominated habitat types (135 ha). The native vegetation types are generally of high or very high ecological value and include a number of nationally 'Threatened' or 'At Risk' species, some of which are present within the proposed project footprint.

Vegetation clearance within the project footprint will primarily comprise pine forest (86.88 ha) and pasture (17.3 ha). Additional vegetation clearance includes, in descending order of size approximately 9.11 ha of wattle forest, 4.62 ha of native regenerating forest (non-SEA), 0.86 ha of native mature forest (non-SEA), 0.85 ha of native wetlands (non-SEA) and 0.48 ha of exotic dominated wetlands. None of the habitat lost is scheduled as an SEA, although a number of nationally 'Threatened' or 'At Risk' species are present within these affected habitats including long-tailed bats, North Island fernbird, spotless crake, Hochstetter's frog, several lizard species, rhytid snails, peripatus, manuka and kanuka. Indirect effects on habitats and associated species are also likely to occur including edge effects and potentially noise, light or dust disturbance.

Potential effects on these ecological values and others has been addressed through:

- Avoidance through optioneering and refinement of the location and extent of the project footprint as described in the Assessment of Effects report); and
- Development and implementation of management plans that are focused on avoidance or minimisation of effects (e.g. a tree-felling management plan for birds and bats and salvage and relocation plans for lizards, Hochstetter's frogs, and invertebrates).

For residual adverse effects (with moderate or higher level of effect) that cannot be avoided or minimised, to protect and improve the ecological integrity of remaining forests and wetlands, the following offset and compensation measures are proposed:

- Undertake wetland and terrestrial revegetation across all available sites within the WMNZ landholdings. This includes approximately 9.9 ha of terrestrial revegetation, 4.63 ha of infill wetland planting and 15.17 ha of wetland buffer planting.
- Undertake long-term pest control (for the term of the consents) across:
  - the WMNZ landholdings (subject to access agreements), which will provide ecological benefits across 63.72 ha of mature native forest, 44.01 ha of regenerating native forest and 26.92 ha of wetlands; and
  - Sunnybrook Reserve (subject to access agreements), the extent of which is to be confirmed with DOC, WMNZ and following development of a robust offset accounting proposal.
- Long-term protection of native terrestrial habitats and wetlands within WMNZ landholdings via a covenant.

Following sections provide further details in accordance with the steps outlined in Section 4.

Proposed mitigation and compensation measures to address the potential effects on terrestrial and wetland ecological values within the project footprint are outlined in Table 6.9 below.

Table 6.9: Measures to address potential effects on terrestrial and wetland ecological values.

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
Indigenous mature forest	High	Direct and indirect effects associated with the loss of 0.87 ha, including one kahikatea > 20m height	Terrestrial revegetation, Long-term mammalian pest control and covenanting of no less than 40ha indigenous forest on WMNZ landholdings.	Low
Indigenous regen forest	High	Direct and indirect effects associated with the loss of 4.62 ha (which includes the loss of 1.29 ha of threatened kanuka and manuka)		Low
Exotic wattle forest	Moderate	Direct and indirect effects associated with the loss of 9.11 ha of habitat for ecologically significant species (see below)	See proposed mitigation and compensation for effects on bats, Hochstetter's frog and snails	Low
Exotic pine forest	Moderate	Direct and indirect effects associated with the loss of 86.88 ha of habitat for ecologically significant species (see species rows below)	See proposed mitigation and compensation for effects on bats, Hochstetter's frog and snails	Low
Pasture	Low	Direct and indirect effects associated with the loss of 17.3 ha of pasture	None	Low
Indigenous wetland (non-SEA)	High	Direct and indirect effects associated with the loss of 0.85 ha of habitat. Potential	Ecological enhancement of degraded pasture wetlands. Control of introduced	Low

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
		indirect effects associated with effects in water quality	predatory mammals on all remaining wetlands on WMNZ landholdings. Wetland margin buffer planting around existing indigenous dominated wetlands.	
Exotic wetland	High	Direct and indirect effects associated with the loss of 0.48 ha of habitat. Potential indirect effects associated with effects in water quality		Low
Swamp maire	Moderate	Potential indirect effects associated with effects on water quality (including sedimentation)	Moderate	Low
Kanuka	High	Direct and indirect effects associated with the loss of 1.29 ha of kanuka and manuka dominated regenerating forest (included in the 4.86 ha of regenerating forest as above)	Terrestrial revegetation and wetland and riparian margin buffer plantings (which will include a high proportion of kanuka and mitigation plantings).	Low
Manuka	High			Low
Kauri	Low	Kauri not present within project footprint.	None required	Low
White rata	Low	Individual white rata vine known to occur in within the project footprint. Note: white rata vine not visible from drone imagery, potentially present in project footprint.	Not required	Low
Long tailed bat (Threatened)	High	Effects associated with the loss of 102.81 ha of variably suitable habitat (all vegetated habitats except pasture)	Application of tree felling protocol to avoid or minimise potential effects on roosting bats. Terrestrial, wetland and riparian revegetation across the WMNZ landholdings to provide foraging and roosting habitats (long term). Pest control across the WMNZ landholdings mature indigenous forest (mostly SEA)	Low
Australasian bittern (Threatened)	Moderate	Direct and indirect effects associated with the loss of up to 1.33 ha of wetlands. Potential indirect effects associated with effects in water quality	Avoidance of effects on wetlands during peak bittern breeding season (August to January inclusive) Ecological enhancement of degraded pasture wetlands. Control of introduced predatory mammals on all remaining wetlands on WMNZ	Low

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
			landholdings. Wetland margin buffer planting around existing indigenous dominated wetlands.	
North Island kaka (Threatened)	Low	Direct and indirect effects associated with the loss of exotic and native forest	None required	Low
North island fernbird (At Risk)	High	Effects associated with the loss of up to 1.33 ha of fernbird habitat (all wetland classified as non-pasture wetland).	Avoidance of wetland loss during peak fernbird breeding season (Aug-Jan inclusive) Enhancement of pasture wetlands. Control of mammalian on remaining wetlands on WMNZ landholdings. Wetland margin buffer planting around existing indigenous dominated wetlands.	Low
Spotless crake (At Risk)	Moderate	Effects associated with the loss of up to 1.33 ha of habitat (all wetland classified as non-pasture wetland). Potential indirect effects associated with effects in water quality	Avoidance of effects on wetlands during peak spotless crake breeding season (Aug-Jan inclusive). Enhancement of pasture wetlands. Control of mammalian pests on remaining wetlands on WMNZ landholdings. Wetland margin buffer planting around existing indigenous dominated wetlands.	Low
NZ pipit (At Risk)	Low	Direct and indirect effects associated with the loss of up to 17 ha of pasture/grassland foraging habitat.	None required	Low
Auckland green gecko (At Risk)	Moderate	Direct and indirect effects associated with the loss of 5.49 ha of indigenous regenerating and mature forest	Salvage and relocation operations and habitat enhancement of proposed relocation site. Terrestrial revegetation, Long-term mammalian pest control and covenanting of all remaining indigenous forest on WMNZ landholdings.	Low
Forest gecko (At Risk)	Moderate			Low
Pacific gecko (At Risk)	Moderate			Low
Ornate skink (At Risk)	Moderate			Low
Copper skink	Moderate	Direct and indirect effects associated with the loss of all non-wetland vegetation habitat within the footprint.	Salvage and relocation operations and habitat enhancement of proposed relocation site. Terrestrial	Low

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
			revegetation, and long-term mammalian pest control across the entire WMNZ landholdings.	
Hochstetter's frog (At Risk)	High	Effects associated with the loss of 10.5 km streams within exotic and native forest habitat.	Salvage and relocation operations and habitat enhancement of proposed relocation site within the WMNZ landholdings, which will include Long-term mammalian pest control.	TBC pending final agreement
Kauri snail (At Risk)	Moderate	Direct and indirect effects associated with the loss of forest vegetation and assuming kauri snail are present but in low numbers	Salvage and relocation operations and habitat enhancement of proposed relocation site within the WMNZ landholdings, which will include Long-term mammalian pest control.	Low
Peripatus	Moderate	Direct and indirect effects associated with the loss of exotic and native vegetation within the footprint.	Salvage and relocation of decaying and felled logs (in which peripatus reside) into existing native forest and revegetated habitat	Low

Subject to implementation of the proposed mitigation and compensation outlined above, we expect all terrestrial and wetland effects to be adequately addressed.

6.3.2 Ecological values assessment (Step 1)

All habitats, flora, and fauna present within the WMNZ landholdings, irrespective of whether they are affected by the project, have been assigned an ecological value (Table 6.10) ranging from 'Low' to 'Very High' value, following the EcIAG (2018) (Table 3.1). Those ecological values that are affected by the project will be made clear in the magnitude of effects assessment on each value as set out in the following subsection (Section 7.3.2). In general, ecological values within the WMNZ landholdings are assessed as follows:

- All mature native forest and native wetland vegetation types were assessed as having 'Very High' ecological values because these areas met at least three of the ecological value criteria (Table 3.1) namely:
  - Rarity and distinctiveness: these habitats are classified as 'Threatened' under IUCN criteria and provide habitat for nationally 'Threatened' or 'At Risk' flora and fauna (Table 6.10);
  - Representativeness: they are indigenous dominated and typical of vegetation types and species that would be expected for each of these habitat/vegetation types;
  - Diversity and pattern: these habitats have a high level of biodiversity with respect to species richness and habitat and microhabitat diversity;
  - Ecological context: some of these larger habitats or habitats that are contiguous with other native habitats (e.g. where these habitats are contiguous with other habitat types) provide ecological connectivity and buffering potential in the landscape.

- Exotic forest, regenerating forest and exotic wetland vegetation types were categorised as having 'High' ecological value because they have high values for one of the ecological criteria and moderate values for the remaining 3 ecological value criteria. Specifically:
  - Rarity and distinctiveness: while none of these habitats are classified as 'Threatened' under IUCN criteria they have high value for rarity and distinctiveness as all provide habitat for several nationally 'Threatened' or 'At Risk' flora and/or fauna (Table 6.10);
  - Representativeness: these habitats are moderately representative in that they typically have an intact indigenous dominated regenerating understory (exotic forest) and/or indigenous dominated regenerating suite of species that would be expected;
  - Diversity and pattern: these habitats have a moderate level of indigenous biodiversity, particularly regenerating forest; and
  - Ecological context and buffering; these vegetation types are generally larger fragments that have moderate value for ecological connectivity and buffering in the landscape, including the provision and maintenance of important ecosystem services (e.g. erosion and sediment control).
- Degraded pasture wetlands were assessed as having 'Low' value because a moderate value was applied with respect to one of the ecological criteria and low value for the remaining three ecological criteria. Specifically, this habitat type is of moderate value for rarity and distinctiveness because it provides foraging habitat for the pied stilt, a nationally 'At Risk' species. However, degraded pasture wetlands are considered of low value for the other three ecological value criteria;
- Pasture was assessed as having 'Negligible' ecological value on the basis that these habitats do not meet any of the four ecological value criteria, i.e. it does not constitute a representative habitat, it is not a rare or distinctive habitat, it has low native diversity and pattern and has low value in terms of ecological context (it does not provide a buffer or maintain connectivity to other habitats of ecological value); and
- All species values are prescriptively assigned a value ranging from 'Low' to 'Very High' based solely on threat status.

Table 6.10: Ecological values assessment for all habitats, flora and fauna within the WMNZ landholdings[19].

Ecological features	Ecological value category	Rationale
Habitat/vegetation type		
Indigenous mature forest (0.87 ha of non-SEA forest affected)	Very High	Rates highly for at least three of the assessment matters (representativeness, diversity and pattern, rarity and distinctiveness and ecological context)
Indigenous regenerating forest (4.62 ha affected)	High	Rates highly for one of the ecological value criteria (rarity and distinctiveness), specifically the presence or likely presence of nationally 'Threatened' or 'At Risk' species (long-tailed bats, lizards, Hochstetter's frog and Kauri snail)
Exotic wattle forest (9.11 ha)	High	Rates highly for one of the ecological value criteria (rarity and distinctiveness) specifically the presence or likely presence of nationally 'Threatened' or 'At Risk' species (long-tailed bats,

[19] Not all values set out below will be affected by the project. Details on project effects on ecological values are set out in the next subsection (Section 7.3.2).

Ecological features	Ecological value category	Rationale
		Hochstetter's frog and Kauri snail). Rates moderate for remaining criteria.
Exotic pine forest (86.88 ha affected)	High	Rates highly for one of the assessment matters (rarity and distinctiveness) specifically the presence or likely presence of nationally 'Threatened' or 'At Risk' species (long-tailed bats, Hochstetter's frog and Kauri snail). Rates moderate for remaining criteria.
Pasture (17.31 ha affected)	Negligible	Rates low for all four ecological value criteria
Indigenous wetland (0.85 ha of non-SEA wetland affected)	Very High	Rates highly for all four ecological value criteria (representativeness, diversity and pattern, rarity and distinctiveness and ecological context)
Exotic wetland (0.48 ha affected)	Moderate	Rates highly for one of the ecological value criteria (rarity and distinctiveness), specifically wetlands are a Threatened ecosystem type and can includes the presence or likely presence of nationally Threatened or 'At Risk' wetland birds
Species (See Table 4.2 for link between Ecological value and species threat status)		
Swamp maire	Very High	Nationally 'Threatened'
Kauri (not affected)	Very High	Nationally 'Threatened'
Kawaka	Moderate	Locally uncommon
Kānuka	Very High	Nationally 'Threatened'
Mānuka	Very High	Nationally 'Threatened'
White rata	Very High	Nationally 'Threatened'
Long-tailed bat	Very High	Nationally 'Threatened'
Australasian bittern	Very High	Nationally 'Threatened'
North Island kaka	High	Nationally 'At Risk'
North island fernbird	High	Nationally 'At Risk'
Spotless crake (At Risk)	High	Nationally 'At Risk'
NZ pipit	High	Nationally 'At Risk'
Auckland green gecko	High	Nationally 'At Risk'
Forest gecko	High	Nationally 'At Risk'
Pacific gecko	High	Nationally 'At Risk'
Ornate skink	High	Nationally 'At Risk'
Copper skink	Moderate	Protected under the Wildlife Act 1953
Hochstetter's frog	High	Nationally 'At Risk'
Kauri snail	High	Nationally 'At Risk'
Rhytid snail	High	Nationally 'At Risk'
Peripatus	Moderate	Protected under the Wildlife Act 1953

6.3.3 Magnitude of effects assessment (Step 2)

The magnitude of effects on ecological values is assessed based on the extent, intensity, duration and timing of effects associated with the project. Project effects on terrestrial and wetland values are set out below and in turn the magnitude of effects on each of these values are assessed. It is important to note that:

- A high magnitude of effect only corresponds to a high 'Level of effect' when the ecological value is also high. For example, the project is assessed as having a high magnitude of effect on pasture but because the ecological values of pasture are low, the overall 'Level of Effect' is 'Low';
- The 'Magnitude of Effects' are assessed prior to efforts to avoid, remedy or mitigate for potential adverse effects to determine where mitigation is most needed to adequately address overall 'Level of Effects'; and
- Proposed mitigation measures and an assessment of the Level of Effects after proposed mitigation is provided in Section 6.3.6.

6.3.3.1 Project effects on terrestrial and wetland values

Collectively the project footprint includes the landfill, stockpile sites, bin exchange area, the landfill access road and ancillary areas, all of which will have effects. The amount of vegetation loss associated with specific project activities is shown in (Table 6.11).

Table 6.11: Anticipated vegetation loss (ha) associated within the project footprint.

Habitats	Valley 1 Landfill (includes Pond 1 and Pond 2)	Access Road + Site Access Road	Stockpile 1 (includes Pond)	Stockpile 2 (includes Pond)	Topsoil Stockpile	Clay Borrow and Stockpile	Bin Exchange Area	Combined ancillary	Total area (ha)
SEA mature native	0	0	0	0	0	0	0	0	**0**
Non-SEA Mature Native	0	0.25	0.44	0	0	0	0.0006	0.1696	**0.86**
Regenerating Native	0	4.59	0.02	0	0	0	0	0.0036	**4.62**
Wattle	0	5.64	0.00	0	1.069	0	2.292	0.107	**9.11**
Pine	71.89	3.03	0.00	7.362	0.009	0	0	4.115	**86.41**
Pasture	0	1.60	9.80	0	0.302	4.209	0	1.402	**17.31**
SEA wetland	0	0	0	0	0	0	0	0	**0**
Indigenous wetland	0	0.05	0.73	0	0	0	0.069	0.0001	**0.8491**
Exotic wetland	0	0.014	0.05	0	0	0.032	0.32	0.054	**0.47**
Total	**1**	**15.2**	**11.1**	**7.4**	**1.4**	**4.2**	**2.7**	**5.7**	**119.62**

Note

Reference to vegetation 'loss' relates to areas where trees or other flora are proposed to be removed within the project footprint.

The terrestrial and wetland habitat loss has the potential to create a range of adverse effects on ecological values, both during enabling works construction (resulting from direct physical disturbance), seasonal construction, and on an ongoing basis from disposal operations (if any) that involve vegetation removal or habitat disturbance. Potential adverse effects on terrestrial and wetland values during and after construction may include:

- Vegetation and habitat loss through vegetation clearance and earthworks;
- The creation of habitat edge effects, altering the composition and health of adjacent vegetation (i.e. habitat degradation), which may affect habitat suitability for flora and fauna;
- Direct mortality or injury to species, for example all plants and most of the smaller less mobile species (e.g. lizards and invertebrates) may be harmed during vegetation clearance or earthworks activities, Likewise, roosting bats could potentially harmed during vegetation clearance activities. Outside of bird breeding season, bird mortality would be low however during breeding season vegetation removal has the potential to result in the destruction of nests, eggs and fledglings;
- Habitat fragmentation and isolation due to the loss and reduction of available habitat types and by reducing the ability for plants and animals to disperse across the landscape for food, shelter, and breeding purposes, i.e. severing or partially severing access to habitats that would otherwise be suitable;
- Construction and operations related noise and vibrations or dust effects; and
- Sediment runoff to wetlands and watercourses that may affect the quality of wetland habitat.

Potential long-term ongoing adverse effects may include:

- Ongoing habitat degradation associated with habitat loss, edge effects and fragmentation, which permanently affecting movement of some species, with possible effects on meta-population dynamics and increased vulnerability to local extinction;
- Ongoing disturbance effects, particularly on habitat margins/edges, through noise, dust and lighting associated with operational activities;
- Mortality or injury on roads through strike or road kill for some species;
- The increased presence of people and introduced species in previously less accessible areas;
- Lost opportunities for creating wildlife corridors; and
- Degradation of wetland and riparian habitat quality through:
  - altered hydrology of wetlands;
  - contaminated stormwater runoff (sediment, heavy metals and elevated temperature) from road surface to wetlands;
  - risk of spills of potential toxins (for example, oil or chemicals) from cartage vehicles; and
  - Ongoing dust issues.

6.3.3.2 Magnitude of effects on terrestrial and wetland vegetation values

In the absence of mitigation, the magnitude of effects on habitat types and associated species ranges from 'Negligible' to 'Very High' as set out in Table 6.12 below and as determined by the potential for both direct and indirect effects.

Table 6.12: Magnitude of effects assessment in the absence of mitigation (see Section 6.3.5 for proposed mitigation measures)

Ecological value	Direct effects within the project footprint	Indirect effects (e.g. habitat degradation)	Magnitude of effects category without mitigation (see Table 3.2)
Habitat/vegetation type	**Habitat loss (ha) in relation to the proportion of habitat loss available habitat on the WMNZ landholdings and in the surrounding landscape**		
Indigenous mature forest	Permanent loss of 0.86 ha (1.37 % of 63.52 ha available the WMNZ landholdings and < 1% in the surrounding landscape))	The quality of adjacent habitat may be subject to edge effects and potential light, noise and dust disturbance	Moderate
Indigenous regenerating forest	Permanent loss of 4.62 ha (10.4 % of 44.01 ha available on the WMNZ landholdings and <1% in the surrounding landscape)		Moderate
Exotic wattle forest	Permanent loss of 9.11 ha (18.4% of 49.52 ha available on the WMNZ landholdings) and <10% in the surrounding landscape		Moderate
Exotic pine forest	Permanent loss of 86.88 ha (12.78 %) of 679.39 ha available on the WMNZ landholdings and <10% in the surrounding landscape). Forest clear-felling will not be undertaken as part of this project. However switching from forest to landfill will result in a permanent rather than temporary loss of pine forest habitat		Moderate
Pasture	Permanent loss of 17.3 ha (8.15%) of 212.29 ha available on the WMNZ landholdings and < 1% in the surrounding landscape)		Moderate
Indigenous wetlands	Permanent loss of 0.85 ha (4.08%) of 20.82 ha available on the WMNZ landholdings with the WMNZ landholdings wetlands constituting almost all of the indigenous wetland habitat in the surrounding landscape	The quality of adjacent habitat may be subject to edge effects, degradation of water quality, and potential light, noise and dust disturbance	Moderate

Ecological value	Direct effects within the project footprint	Indirect effects (e.g. habitat degradation)	Magnitude of effects category without mitigation (see Table 3.2)
Exotic wetland	Permanent loss of 0.48 ha (7.8%) of 6.1 ha available on the WMNZ landholdings with the with the onsite wetlands constituting almost all of the exotic wetland habitat in the immediate surrounds	The quality of adjacent habitat may be subject to edge effects, degradation of water quality, and potential light, noise and dust disturbance	High
Threatened plants (habitats)	**Habitat loss/loss of individual trees**		
Swamp maire (mature forest)	No loss of swamp maire trees (0% of 36 swamp maire trees observable via drone imagery). No loss of kahikatea forest where swamp maire has been observed in the understory. Impact <1% of swamp maire forest in immediate surrounds	Adjacent trees may also be subject to edge effects, hydrological changes and dust disturbance	Low
Kānuka and mānuka (regenerating forest)	Permanent loss of 1.29 ha (9.3% of 15.2 ha available on the WMNZ landholdings) and < 1% of what is available in immediate surrounds. No loss of mānuka or kānuka trees above 20 m tall expected (0% of 128 on the WMNZ landholdings) and <1 % of what is available in immediate surrounds		Moderate
Kauri (mature forest)	No loss of kauri tree forest (0% of 0.72 ha available on the WMNZ landholdings) and < 1% of what is available in the immediate surrounds. No loss of kauri tree individuals (0% of 70 kauri trees identified via drone imagery) and <1% of what is available in immediate surrounds		Low
White rata (mature forest)	Permanent loss of an individual *Metrosideros perforata* and *M. diffusa* vine (40% of observed vines on the WMNZ landholdings) and < 1% of what is available in immediate surrounds. Note: white rata vine not visible from drone imagery, therefore potential more vines on the WMNZ landholdings.		Low

Ecological value	Direct effects within the project footprint	Indirect effects (e.g. habitat degradation)	Magnitude of effects category without mitigation (see Table 3.2)
Mature native trees	Permanent loss of 1 native tree above 20 m (0.4% of 247 available on the WMNZ landholdings) and < 1 % of what is available in immediate surrounds Permanent loss of 22 trees between 15 and 20 m (1.4% of 1541 trees available on the WMNZ landholdings) and < 1% of what is available in immediate surrounds Permanent loss of 136 canopy trees (excludes mānuka kānuka) above 15 cm DBH excluding stockpile 1. This constitutes < 1% of 15 cm DBH canopy trees available on the WMNZ landholdings and in immediate surrounds		Low
Threatened fauna (associated habitats)	**WMNZ landholdings habitat loss/population loss**		
Long-tailed bat (all non-pasture habitat types)	Permanent loss of roosting trees in mature native and exotic forest and standalone trees and foraging habitat. The magnitude of this loss is considered low relative to what is available in the immediate surrounds to be <10%. Magnitude of effect on the local population through mortality is considered low	Habitat immediately adjacent to the project footprint may also be subject to edge effects such as noise and light disturbance. Bats in the wider landscape may also be affected by severance or partial severance of flyways	Moderate
Australasian bittern (vegetated wetlands)	Permanent loss of wetland nesting and foraging habitat. Magnitude of effect on the local population through mortality is considered low	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, wetland water quality degradation, noise, light and dust disturbance	High
North Island kaka (mature forest)	Permanent loss of nesting and foraging habitat in all forest types. Magnitude of effect on local population through mortality is considered low	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, noise, light and dust disturbance	Low
North island fernbird (wetlands and associated forest)	Permanent loss of nesting and foraging habitat is high. Magnitude of effect on local population through mortality is potentially high	Habitat and populations immediately adjacent to the project footprint may also be subject to edge	High

Ecological value	Direct effects within the project footprint	Indirect effects (e.g. habitat degradation)	Magnitude of effects category without mitigation (see Table 3.2)
		effects, wetland water quality degradation, noise, light and dust disturbance	
Spotless crake	Permanent loss of nesting and foraging habitat is high. Magnitude of effect on local population through mortality is potentially high	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, wetland water quality degradation, noise, light and dust disturbance	High
NZ pipit	Permanent loss foraging habitat is low. Magnitude of effect on local population through mortality is likely to be low	Habitat and populations immediately adjacent to the project footprint may also be subject to noise, light and dust disturbance	Low
Auckland green gecko (At Risk)	Permanent loss of 5.49 ha (5.1% of 107.53 ha) Magnitude of effect on local population through mortality is likely to be moderate	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, noise, light and dust disturbance	Moderate (assuming they are present)
Forest gecko (mature and regenerating native forest)	Permanent loss of 5.49 ha (5.1% of 107.53 ha) Magnitude of effect on local population through mortality is likely to be moderate	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, noise, light and dust disturbance	Moderate (assuming they are present)
Pacific gecko (mature and regenerating native forest)	Permanent loss of 5.49 ha (5.1% of 107.53ha) Magnitude of effect on local population through mortality is likely to be moderate	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, noise, light and dust disturbance	Moderate (assuming they are present)
Ornate skink (mature and regenerating native forest)	Permanent loss of 5.49 ha (5.1% of 107.53 ha) Magnitude of effect on local population through mortality is likely to be moderate	Habitat and populations immediately adjacent to the project footprint may also be subject to noise, light and dust disturbance	Moderate (assuming they are present)
Copper skink (all forested habitats and margins)	Permanent loss of up to 272.07 ha. Magnitude of effect on local population through mortality is likely to be moderate	Habitat and populations immediately adjacent to the may also be subject to noise, light and dust disturbance	Moderate (assuming they are present)
Hochstetter's frog (all hard-bottom streams)	Permanent loss of approx. 10.5 km of hard-bottom shaded streams and surrounding forested habitat and all individuals within the project footprint. The 'Magnitude of Effect' on local population through mortality is likely to be high in the absence of mitigation	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, water quality degradation, light and dust disturbance	High

Ecological value	Direct effects within the project footprint	Indirect effects (e.g. habitat degradation)	Magnitude of effects category without mitigation (see Table 3.2)
Rhytid snail (all forested habitat types)	Permanent loss of up to 272.07 ha of predominately exotic forest habitat but expected to be common and widespread in the surrounding landscape. 'Magnitude of effect' on local population through mortality is moderate in the absence of mitigation	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, light and dust disturbance	High
Kauri snail (all forested habitat types)	Permanent loss of up to 272.07 ha of predominately exotic forest habitat but expected to be common and widespread in the surrounding landscape. 'Magnitude of effect' on local population through mortality is potentially moderate in the absence of mitigation noting that it is unclear if kauri snail are present or that the population is localised and/or small.	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, light and dust disturbance	Potentially moderate
Peripatus (all forested habitat types)	Permanent loss of up to 272.07 ha of predominately exotic forest habitat but expected to be common and widespread in the surrounding landscape. The 'Magnitude of effect' on local population through mortality is potentially moderate	Habitat and populations immediately adjacent to the project footprint may also be subject to edge effects, light and dust disturbance	Moderate

6.3.4 Levels of effect (Step 3)

Table 6.13 below sets out the potential 'Level of Effects' for habitats and species in the absence of efforts to address potential adverse effects. The 'Level of Effects' is based on the assigned 'Ecological Value' category set out in Table 3.1 and the expected 'Magnitude of Effects' set out in Table 6.12 as per Step 3 of the ECIAG (Table 3.4).

The 'Level of Effects' assigned to each ecological value in Table 6.13 below ranges from 'Low' to 'High' without mitigation. Efforts to address potential adverse effects are considered necessary for all habitats or species that have the potential for 'Moderate' 'Level of Effects' and above.

Recommendations for addressing 'Moderate' and 'High' 'Level of Effects' are provided in Section 7.3.4 and correspondingly, 'Level of Effects' for habitats and species are then reassessed on the assumption that recommended measures to address effects are undertaken. Level of effects assessment with mitigation are set out in section 6.3.4).

Table 6.13: Level of effects without mitigation

Ecological value	Ecological value category	Magnitude of effects category	Level of effects category (without mitigation)
Habitat/vegetation type			
Indigenous mature forest	Very High	Moderate	High
Indigenous regenerating forest	High	High	High
Exotic wattle forest	High	Moderate	Moderate
Exotic pine forest	High	Moderate	Moderate
Pasture	Low	Moderate	Low
Indigenous wetland	Very High	Moderate	High
Exotic wetland	High	Moderate	Moderate
Pasture wetland	Moderate	Low	Low
Species			
Swamp maire	Very High	Negligible	Low
Kānuka	Very High	Moderate	High
Mānuka	Very High	Moderate	High
Kauri	Very High	Negligible	Low
White rata	Very High	Negligible	Low
Long-tailed bat (Threatened)	Very High	Moderate	High
Australasian bittern (Threatened)	Very High	Low	Moderate
North Island kaka (Threatened)	Very High	Negligible	Low
North island fernbird (At Risk)	High	High	High
Spotless crake (At Risk)	High	High	High
NZ pipit (At Risk)	High	Low	Low
Auckland green gecko (At Risk)	High	Moderate	Moderate
Forest gecko (At Risk)	High	Moderate	Moderate
Pacific gecko (At Risk)	High	Moderate	Moderate
Ornate skink (At Risk)	High	Moderate	Moderate

Ecological value	Ecological value category	Magnitude of effects category	Level of effects category (without mitigation)
Copper skink	Moderate	Moderate	Moderate
Hochstetter's frog (At Risk)	High	High	High
Kauri snail (At Risk)	High	Potentially Moderate	Potentially High
Peripatus	Moderate	Moderate	High

6.3.5 Recommendations to address potential adverse effects on terrestrial and wetland ecology

Efforts to address potential adverse effects are considered necessary for all habitats and species that are expected to incur 'Moderate' or 'High' 'Level of Effects' as a result of the project (Table 6.13) (Roper-Lindsay *et al*., 2018). Proposed measures to avoid or minimise effects and to mitigate or compensate for residual effects that cannot be avoided or minimised are provided in section 6.3.5.1 and section 6.3.5.2 respectively. Moreover, sets out the suite of measures proposed to adequately address the level of effects on each ecological value for which level of effects have been assessed as 'Moderate' or 'High'.

6.3.5.1 Measures to avoid or minimise potential effects

Efforts to avoid or minimise the potential for adverse ecological effects have been undertaken though the optioneering and concept design phases of the project and have included refining the configuration of the project (e.g. soil stockpile sites and access roads). These measures are detailed in the Assessment of Effects (AEE) report.

Efforts to avoid effects or minimise effects based on the project footprint will include:

- Measures to avoid or minimise forest and wetland habitat loss through site management and appropriate construction methodology in ecologically significant areas. This would include avoidance of unnecessary vegetation clearance through the physical delineation of the footprint boundary or targeted efforts to avoid or minimise the potential for wetland sedimentation;
- Avoidance of large scale vegetation clearance within wetlands and native forests during peak bird breeding season (September to December inclusive);
- Adoption of bat tree-felling protocol to avoid or minimise direct harm to roosting bats, most importantly maternal bat roosts that may include several or more adult female and juvenile bats; and
- Salvage and relocation of Hochstetter's frogs, native lizards, and invertebrates into suitable habitat that has been enhanced through long term control of introduced predatory mammals.

6.3.5.2 Onsite (WMNZ landholdings) measures to mitigate or compensate for residual effects associated with the project

Notable reductions in the level of residual effects that cannot be avoided or minimised will result from the proposed wetland and forest revegetation and pest control initiatives (Appendix B Figure 14). Forest and wetland revegetation on the WMNZ landholdings will offset or compensate for habitat loss by providing habitat for forest and wetland plants and associated species that have been affected by the project. Revegetation efforts will focus on replacing plant species that have been affected by the project and optimising ecological benefits through improving ecological connectivity

between habitat types and protecting significant habitat types through buffer/margin plantings. Forest and wetland revegetation will include:

- Site preparation, including weed management and stock exclusion fencing (where necessary) and the deployment of felled logs into revegetation sites to improve biodiversity values. A minimum of 20 m of logs (> 40 cm DBH) per ha of revegetation will be deployed;
- Planting of eco-sourced native species;
- 10 years of plant maintenance, including weed management and infill planting (where necessary); and
- Covenanting to ensure long-term protection of revegetated habitats

Long term control of mammalian pests within the WMNZ landholdings and adjacent Sunnybrook Reserve will improve the ecological integrity of forest and wetland ecosystems within these areas and facilitate the recovery of a number of native plant and animal species. This includes nationally 'Threatened' or 'At Risk' fauna such as long-tailed bats, North Island fernbird, spotless crake, several lizard species, Hochstetter's frogs, and several invertebrate species that will be affected to varying degrees by the project. Long-term control of mammalian pests will include the ongoing control of mustelids (stoats, ferrets, weasels), feral cats, rats, possums, goats and pigs for the term of the consentsusing typical residual trap catch measures (e.g. < 2% Residual Trap Catch for rats and < 5% for possums) and standard practice methods.

Table 6.14: Proposed measures to address residual effects on forest and wetland habitats

Residual effect	Enhancement activity	Total area (ha)
0.87 ha of non-SEA mature forest (including high value trees), 4.62 ha of regenerating forest (including high value trees), Indirect effects on adjacent habitats and to varying degrees direct and indirect effects on forest species including long-tailed bats, forest birds, lizards, Hochstetter's frogs and invertebrates	Planting of native terrestrial vegetation within available areas on WMNZ landholdings.	9.9 ha
	Long term pest control of the entire WMNZ holdings and nearby Sunnybrook Reserve (TBC)	Up to 220.4 ha
	Protection of all native forest habitats onsite by covenant	111.9 ha
0.85 ha of indigenous non-SEA wetlands, and 0.49 ha of exotic dominated wetlands. Indirect effects on adjacent habitats and to varying degrees direct and indirect effects on wetland species most notably North Island fernbird and spotless crake	Planting of native wetland vegetation within all degraded exotic wetlands on Springhill farm that are not affected by the project	4.63 ha
	10m wetland margin plantings around SEA wetlands (9.03 ha) and 5m wetland margin plantings (TBC) around all non-SEA wetlands (6.15 ha) to improve the quality of wetlands by buffering them from the potential effects of surrounding landuses	15.18 ha
	Long term pest control of the WMNZ landholdings (subject to agreed access) and nearby Sunnybrook Reserve (TBC) that will result in pest control across all wetland habitats within the WMNZ landholdings	25.59 ha
	Protection of all native wetland habitats onsite by covenant	25.59 ha

6.3.6 Level of effects after mitigation

Notable reductions in the level of effects will result from the following revegetation, habitat enhancement and pest control initiatives. As set out in Table 6.15 below, we consider all potential adverse effects on forests and wetlands to be adequately addressed by the measures proposed.

Table 6.15: Measures to address potential effects on terrestrial and wetland ecological values

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
Indigenous mature forest (non-SEA)	High	Direct and indirect effects associated with the loss of 0.86 ha, including one kahikatea > 20m height	9.9 ha of terrestrial revegetation, Long-term mammalian pest control and covenanting of all 111.9 ha of remaining indigenous forest on WMNZ landholdings including the 9.9 ha of revegetation. Most of the indigenous forest is scheduled as SEA. Proposed pest control within the Sunnybrook Reserve (TBC).	Low
Indigenous regen forest	High	Direct and indirect effects associated with the loss of 4.62 ha (which includes the loss of 1.29 ha of threatened kanuka and manuka)		Low
Exotic wattle forest	Moderate	Direct and indirect effects associated with the loss of 9.11 ha of habitat for ecologically significant species (see below)	See proposed mitigation and compensation for effects on bats, Hochstetter's frog and snails	Low
Exotic pine forest	Moderate	Direct and indirect effects associated with the loss of 124 ha of habitat for ecologically significant species (see species rows below)	See proposed mitigation and compensation for effects on bats, Hochstetter's frog and snails	Low
Pasture	Low	Direct and indirect effects associated with the loss of 17.3 ha of habitat for ecologically significant species (see species rows below)	None	Low
Indigenous wetland (non-SEA)	High	Direct and indirect effects associated with the loss of 0.13 ha of habitat. Potential indirect effects associated with effects in water quality	Ecological enhancement of 4.63 ha of degraded pasture wetlands. Control of introduced predatory mammals on all 25.59 ha of remaining wetlands on WMNZ land. 15.18 ha of wetland margin buffer planting around existing indigenous dominated wetlands.	Low
Exotic wetland	High	Direct and indirect effects associated with the loss of 1.07 ha of habitat. Potential indirect effects associated with effects in water quality		Low
Swamp maire	Moderate	Potential indirect effects associated with effects on water quality (including sedimentation)	Moderate	Low
Kanuka	High	Direct and indirect effects associated with the loss of 1.29 ha of kanuka and manuka	9.9 ha of terrestrial revegetation and 15.18 ha of wetland margin buffer plantings (which will	Low
Manuka	High			Low

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
		dominated regenerating forest (included in the 4.86 ha of regenerating forest as above)	include a high proportion of kanuka and Manuka mitigation plantings).	
Kauri	Low	No kauri is known to occur in proximity to the project footprint	None required	Low
White rata	Low	No white rata is known to occur in proximity to the project footprint	Not required	Low
Long tailed bat (Threatened)	High	Effects associated with the loss of 157.2 ha of variably suitable habitat	Application of tree felling protocol to avoid or minimise potential effects on roosting bats. Terrestrial, wetland and riparian revegetation across the WMNZ landholdings to provide foraging and roosting habitats (long term). Pest control across the WMNZ landholdings that will include 48 ha of pest control in mature indigenous forest (mostly SEA) that will reduce levels of predation on roosting bats.	Low
Australasian bittern (Threatened)	Moderate	Direct and indirect effects associated with the loss of up to 1.2 ha of habitat (all wetland classified as non-pasture wetland). Potential indirect effects associated with effects in water quality	Avoidance of effects on wetlands during peak bittern breeding season (August to January inclusive) to avoid/minimise the potential loss of eggs/chicks. Ecological enhancement of 3.3 ha of degraded pasture wetlands. Control of introduced predatory mammals on all 25.59 ha of remaining wetlands on WMNZ land. 15.18 ha of wetland margin buffer planting around existing indigenous dominated wetlands.	Low
North Island kaka (Threatened)	Low	Direct and indirect effects associated with the loss of exotic and native forest	None required	Low
North island fernbird (At Risk)	High	Effects associated with the loss of up to 1.2 ha of habitat (all wetland classified as non-pasture wetland).	Avoidance of wetland loss during peak fernbird breeding season (Aug-Jan inclusive) to avoid the potential loss of eggs/chicks. Enhancement of 3.3 ha of pasture wetlands. Control of mammalian on	Low

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
			all 25.59 ha of remaining wetlands on WMNZ land. 15.18 ha of wetland margin buffer planting around existing indigenous dominated wetlands (which will provide habitat for fernbird).	
Spotless crake (At Risk)	Moderate	Effects associated with the loss of up to 1.2 ha of habitat (all wetland classified as non-pasture wetland). Potential indirect effects associated with effects in water quality	Avoidance of effects on wetlands during peak fernbird breeding season (Aug-Jan inclusive) to avoid potential loss of eggs/chicks. Enhancement of 3.3 ha of pasture wetlands. Control of mammalian pests on all 25.59 ha of remaining wetlands on WMNZ land. 15.18 ha of wetland margin buffer planting around existing indigenous dominated wetlands.	Low
NZ pipit (At Risk)	Low	Direct and indirect effects associated with the loss of up to 17 ha of pasture/grassland foraging habitat.	None required	Low
Auckland green gecko (At Risk)	Moderate	Direct and indirect effects associated with the loss of 5.48 ha of indigenous regenerating and mature forest	Salvage and relocation operations and habitat enhancement of proposed relocation site. 9.3 ha of terrestrial revegetation, Long-term mammalian pest control and covenanting of all remaining indigenous forest on WMNZ landholdings. Most of the 111.9 ha of indigenous forest (which includes the 9.9 ha of proposed revegetation) is scheduled as SEA	Low
Forest gecko (At Risk)	Moderate			Low
Pacific gecko (At Risk)	Moderate			Low
Ornate skink (At Risk)	Moderate			Low
Copper skink	Moderate	Direct and indirect effects associated with the loss of all non-wetland vegetation habitat within the footprint	Salvage and relocation operations and habitat enhancement of proposed relocation site. 9.9 ha of terrestrial revegetation, Long-term mammalian pest control across the entire WMNZ landholdings.	Low
Hochstetter's frog (At Risk)	High	Effects associated with the loss of 10.5km streams within exotic and native forest habitat. It is assumed the Hochstetter's frog population	Salvage and relocation operations and habitat enhancement of proposed relocation site within the Sunnybrook Reserve (TBC), which will include	TBC

Ecological value	Level of effects without mitigation	Effect summary	Proposed Mitigation and Compensation	Level of effects with mitigation or compensation
		in the footprint numbers in the late hundreds to early thousands	Long-term mammalian pest control. It is assumed that approximately 10% of frogs will be removed through salvage and relocation operations but it is not certain that relocated individuals will survive.	
Kauri snail (At Risk)	Moderate	Direct and indirect effects associated with the loss of forest vegetation and assuming kauri snail are present but in low numbers	Salvage and relocation operations and habitat enhancement of proposed relocation site within the WMNZ landholdings, which will include Long-term mammalian pest control.	Low
Peripatus	Moderate	Direct and indirect effects associated with the loss of exotic and native vegetation within the footprint.	Salvage and relocation of decaying and felled logs (in which peripatus reside) into existing native forest and revegetated habitat	Low

If all the above mitigation measures are undertaken, it is expected that all adverse terrestrial and wetland ecological effects associated with the project will be adequately addressed with the notable exception of effects on the 'At Risk' Hochstetter's frogs. For Hochstetter's frogs the success of salvage and relocation efforts are uncertain. To address this uncertainty a monitoring programme would be required to track changes in relative abundance and spatial distribution of frogs at the release site (s) would be required

Table 6.16: Summary of terrestrial and wetland ecology level of effects after mitigation and compensation

Ecological value	Ecological value category	Magnitude of effects category	Level of effects category (without mitigation)	Level of effects with mitigation and compensation
Indigenous mature forest	Very High	Moderate	High	Low
Indigenous regenerating forest	High	High	High	Low
Exotic wattle forest	High	Moderate	Moderate	Low
Exotic pine forest	High	Moderate	Moderate	Low
Indigenous wetland	Very High	Moderate	High	Low
Exotic wetland	High	Moderate	Moderate	Low
Kānuka	Very High	Moderate	High	Low
Mānuka	Very High	Moderate	High	Low
Long-tailed bat (Threatened)	Very High	Moderate	High	Low
Australasian bittern (Threatened)	Very High	Low	Moderate	Low
North island fernbird (At Risk)	High	High	High	Low
Spotless crake (At Risk)	High	High	High	Low
Auckland green gecko (At Risk)	High	Moderate	Moderate	Low
Forest gecko (At Risk)	High	Moderate	Moderate	Low
Pacific gecko (At Risk)	High	Moderate	Moderate	Low
Ornate skink (At Risk)	High	Moderate	Moderate	Low
Copper skink	Moderate	Moderate	Moderate	Low
Hochstetter's frog (At Risk)	High	High	High	TBC
Kauri snail (At Risk)	High	Moderate	Potentially High	TBC
Peripatus	Moderate	Moderate	High	Low

7 Summary of overall mitigation, offset and compensation package project

The following provides a summary of the activities proposed to be undertaken to mitigate, offset or compensate the ecological effects of the Auckland Regional Landfill project. Full details are provided in earlier sections within this report.

- Remediation of fish passage barriers within WMNZ landholdings;
- Erosion and sediment controls during construction to manage sediment runoff;
- Stormwater treatment to manage changes to surface water flows and quality;
- Ongoing surface water monitoring;
- A vegetation clearance protocol to manage potential wood waste leachate;
- Fauna management plans for salvage and relocation;
- Avoidance of large scale vegetation clearance within wetlands and native forests during peak bird breeding season;
- Adoption of bat tree-felling protocol to avoid or minimise direct harm to roosting bats.
- Enhancement and/or protection of 14 km of stream within the WMNZ landholdings, with a commitment to enhancing no less than 46.2 km total stream length over the life of the project;
- Planting of 9.9 ha of native terrestrial vegetation within WMNZ landholdings;
- Long term pest control of WMNZ landholdings and in Sunnybrook Reserve of up to 220.4 ha (subject to access agreements);
- Protection of 11.9 ha native forest areas within WMNZ landholdings by covenant;
- Planting and protection of all (4.63 ha) degraded wetlands within the Western Block that are not affected by the project;
- Planting of wetland buffers of 10 m or 5 m around SEA and non-SEA wetlands within the Western Block, approximately 15.18 ha; and
- Protection of all native wetland habitats by covenant, approximately 25.59 ha.

8 Conclusions

The proposed Auckland Regional Landfill project is to be located in the Wayby Valley, northwest of Warkworth. This landfill will be a piece of Regionally Significant Infrastructure.

As expected with a project of this scale, effects on the aquatic ecology at discrete locations within the project footprint are anticipated to occur.

The on-site management controls outlined within this report will reduce the potential ecological effects to 'moderate' or 'low' levels for the majority of the potential effects. Management plans are recommended to be prepared to detail approaches to be implemented as conditions of consent. As such, we consider that the majority of effects will be appropriately managed.

The exception to the above are the effects on freshwater habitat, specifically, the irreversible reclamation of 15.4 km of intermittent and permanent stream, comprising approximately 11% of the 135 km of total stream length within the landholdings. Approximately 15 km of stream habitat within the site is available for protection or enhancement. WMNZ has committed to providing a further 30 km of stream enhancement and protection over the lifetime of the project as a condition of consent.

The offset and compensation package has been developed to optimise opportunities available on site and goes some way to address the effects of the landfill activity, however has not been developed to achieve 'no-net-loss' of ecological function overall. The offset and compensation package is consistent with some of the other principles of biodiversity offsetting, in particular proximity and additionality. The effects on the Southern Block and Waiteraire Tributary Block as quantified by the ECR can be offset by the enhancement of some of the streams within the Western Block. Overall this will provide for enhancement and protection of no less than three times the stream length being lost which will contribute to reducing the effects of stream reclamation to a degree.

The level of ecological benefit each enhancement activity can provide varies, and overall does not provide for 'no net loss' of ecological function across the site. As such, and due to the scale of the activity, the permanence of the effect and the high ecological values being lost, the ecological effect of the stream reclamation is 'Very high'.

For terrestrial and wetland ecological effects, we consider that, provided the recommendations regarding extent of works required are undertaken, then potential effects on terrestrial and wetland ecology values can be adequately addressed. A mitigation and compensation package for effects on Hochstetter's frogs is to be developed. Further, a coarse level biodiversity offset model will be developed in accordance with national guidance to quantify the enhancement measures proposed across all terrestrial and wetland ecological values that are potentially affected by the project. This information will be provided as supplementary reports.

In all, effects have been avoided and minimised where practicable. For those effects which cannot be avoided or minimised, a comprehensive package of mitigation, offset and compensation measures has been prepared which will result in the majority of effects across the site being addressed to an overall 'low' level of ecological effect.

9 Applicability

This report has been prepared for the exclusive use of our client Waste Management NZ Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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Appendix A: References

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