Ecology supplementary report – Freshwater Ecology

February 2018

River Lake Ltd

NZ TRANSPORT AGENCY WAKA KOTAHI | Mt Messenger Bypass

New Zealand Government

Quality Assurance Statement			
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Revision schedule		
Rev. Number	**Date**	**Description**
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Contents

Glossary

Term	Meaning
AEE	Assessment of Effects on the Environment Report
District Council	New Plymouth District Council
DOC	Department of Conservation
EcIA guidelines	Ecological Impact Assessment guidelines
ECR	Environmental compensation ratio
ELMP	Ecology and Landscape Management Plan
MCI	Macroinvertebrate community index
Project	The Mt Messenger Bypass project
EPT	Ephemeroptera-Plecoptera-Trichoptera taxa
QMCI	Quantitative Macroinvertebrate Community Index
RMA	Resource Management Act 1991
SH3	State Highway 3
Transport Agency	New Zealand Transport Agency

1 Introduction

The NZ Transport Agency (Transport Agency) is proposing to construct and operate a new section of State Highway 3 (SH3), generally between Uruti and Ahititi to the north of New Plymouth. The Transport Agency lodged applications for resource consents and a Notice of Requirement on 15 December 2017 to alter the existing SH3 designation, to enable the Mt Messenger Bypass project (the Project) to proceed.

This application included assessments of ecological effects attached as Technical Reports 7a – 7h, in Volume 3 of the Assessment of Effects on the Environment (AEE) report. The Freshwater Ecology Assessment, dated December 2017, was completed as part of this package (Technical Report 7b, Hamill 2017). This report assessed potential adverse effects of the Project on freshwater ecology, and informed the assessment of effects in the AEE and the proposed mitigation and offset package for the Project.

The ecology technical reports noted the conservative and precautionary approach taken in assessing potential adverse ecological effects from the Project, and that more information would be available following summer field investigations.

These field investigations, which have now concluded, have informed this supplementary report. The purpose of this report is to describe those investigations and their results as they relate to freshwater ecology, and to update the original Freshwater Ecology Assessment as appropriate.

2 Further ecological investigations

2.1 Introduction

The Freshwater Ecology Assessment, dated December 2017, included assessments of ecological values and potential adverse effects based on the information available at the time the assessment was completed. Subsequent investigations have provided additional information on fish, macroinvertebrates and stream habitat to support and strengthen these ecological effects assessments.

2.2 Methodology

2.2.1 Field assessment methods

The additional field work focused on the following areas:

- Completing site visits and morphological measurements of all affected streams, including those sites that were unable to be accessed in mid-2017 when the data for the December 2017 assessment report were collected. These sites were primarily in the northern Mangapepeke Stream, but also included site Ea23a (a fill site in the Mimi River catchment). These visits included identifying the location where some of the smaller streams become ephemeral, and identifying where the Mimi River tributary from the tunnel enters the kahikatea swamp forest.
- Additional fish surveys at both new sites and some previously visited sites. This provides multi-season survey data and makes the effects assessment more robust.
- Additional Stream Ecological Valuation (SEV) surveys, including two sites with potential for stream restoration (sites ETL5 and N1TL).
- Longitudinal survey of stream bed profile and water depth downstream of proposed water take locations.

The additional work was undertaken from 30 October 2017 to 1 November 2017. The weather at the time of the survey was stable. There had been 8.2mm of rain in the previous seven days but no rain in the previous two days. The average minimum and maximum air temperature during the week before the survey (26 Oct-1 Nov) was 12.4 ^{o}C and 18.9 ^{o}C respectively.

2.2.2 Location of sites

The locations of sites surveyed along the proposed route are shown in Figure 2.1a to 2.1b and described in Table 2.1. These maps have been revised in this supplementary report and now include sites Ea30 and Ea31, and the accurate location of streams near site Ea3 and downstream of site E6.

Table 2.1 – Location of waterways potentially affected by the Project (culverts, swales, stream diversion) and stream surveys. Highlighted cells indicate sites visited or revisited as part of the supplementary survey. This replaces Table 2.1 in Hamill (2017).

Site	Catchment	latitude	longitude	catchment area (ha)	ID culvert / diverson	Chainage	Length of culvert / diversion	survey method
Ea1	Mangapepeke trib	-38.869671	174.598523	3.82	1	250	24	v
Ea2	Mangapepeke trib	-38.870796	174.598444	1.80	2	300	26	v
E1	Mangapepeke	-38.873345	174.599765	328				H, F
Ea3	Mangapepeke trib	-38.872707	174.600242	6.3	3	570	67	v
Ea3a	Mangapepeke trib	-38.873304	174.600246	6.3	3	570	67	v
Ea4	Mangapepeke trib	-38.874061	174.600811	1.8	4	750	81	v
Ea5	Mangapepeke trib	-38.875142	174.601345	4.2	5	870	87	v
E2	Mangapepeke	-38.876197	174.600613	306				SEV, H
Ea6	Mangapepeke trib	-38.876297	174.601484	4.4	SD2 swale	1050	90	H
Ea7	Mangapepeke trib	-38.878920	174.602306	6.8	6	1300	27	SEV, H, F
E2a	Mangapepeke	-38.879580	174.602552	248				H
Ea8	Mangapepeke trib	-38.880407	174.603903	5.8	7	1500	36	v
Ea9	Mangapepeke trib	-38.881602	174.604886	7.9	8	1700	35	v
Ea10a	Mangapepeke trib	-38.883153	174.605548	67	9	1850	56	F
Ea10b	Mangapepeke	-38.883153	174.605548	149	SD5	1850-1950		SEV, H, F
E3	Mangapepeke	-38.885127	174.603628	133				SEV, H
Ea11	Mangapepeke trib	-38.886086	174.603931	2	10	2220	37	v
Ea12	Mangapepeke trib	-38.886820	174.603485	1.6	11	2300	25	F
Ea13	Mangapepeke trib	-38.887543	174.602936	9.8	12	2400	74	SEV, H, F
E4	Mangapepeke	-38.888551	174.601769	116				SEV, H, F
Ea14	Mangapepeke trib	-38.890273	174.602344	1.7	13	2700	15	F
E5	Mangapepeke	-38.892081	174.602827	64	SD6	2800-2900		SEV, H, F
Ea15	Mangapepeke trib	-38.892053	174.603057	5	14	2900	117	H, F
Ea16	Mangapepeke trib	-38.893312	174.603602	36	15	2960	210	v
Ea17	Mangapepeke trib	-38.893624	174.603009	17	SD7	3000-3350	300	v

Table 2.1 continued

Site	Catchment	latitude	longitude	catchment area (ha)	ID culvert / diverson	Chainage	Length of culvert / diversion	survey method
Ea18	Mimi trib	-38.897816	174.597454	6	SD8	3650-3930	250	v
Ea19	Mimi trib	-38.897950	174.597026	10	16	3800	115	v
E6	Mimi trib	-38.899262	174.596944	21				SEV, H, F
Ea20	Mimi trib	-38.901392	174.594367	15	Bridge			v
Ea21	Mimi trib	-38.902276	174.592733	3	17	4440	22	H, F
Ea22	Mimi trib	-38.902848	174.590586	1.5	swale			H
Ea23	Mimi trib	-38.903208	174.588603	25	18/19	4750	29/43	H
Ea23a	Mimi trib	-38.902294	174.588693	25				SEV, H, F
E7	Mimi	-38.903693	174.587532	919				SEV, H, F
Ea24	Mimi trib	-38.904961	174.584971	13	20	5150	40	v
Ea29	Mimi trib	-38.906730	174.579537	12	21	5650	34	v
Ea30	Mimi trib	-38.902671	174.578163	2.9				v
Ea31	Mimi trib	-38.905831	174.583556	4.1	SD	5225-5300		v
Ea25	Mimi trib	-38.903034	174.594584	208				F
Ea26	Mimi trib	-38.903309	174.591411	221	restoration			SEV, H
Ea27	Mimi	-38.905400	174.591865	630	restoration			SEV, H
Ea28	Mimi trib	-38.905169	174.590710	25	restoration			SEV, H
E TL1	Mangapepeke trib	-38.872089	174.597347	1.3				v
E TL2	Mangapepeke trib	-38.874071	174.599807	1.9				v
E TL3	Mangapepeke trib	-38.876573	174.600008	2.1	SD3	1050	900	v
E TL4	Mangapepeke trib	-38.876884	174.599855	6.6	SD4	1100	200	H
E TL5	Mangapepeke trib	-38.879318	174.601197	32				SEV, H, F
E TL6	Mangapepeke trib	-38.880764	174.602792	3.1				v

Stream survey: SEV = SEV + macroinvertebrate samples, H = habitat assessment, F = fish survey, v = site visit only.

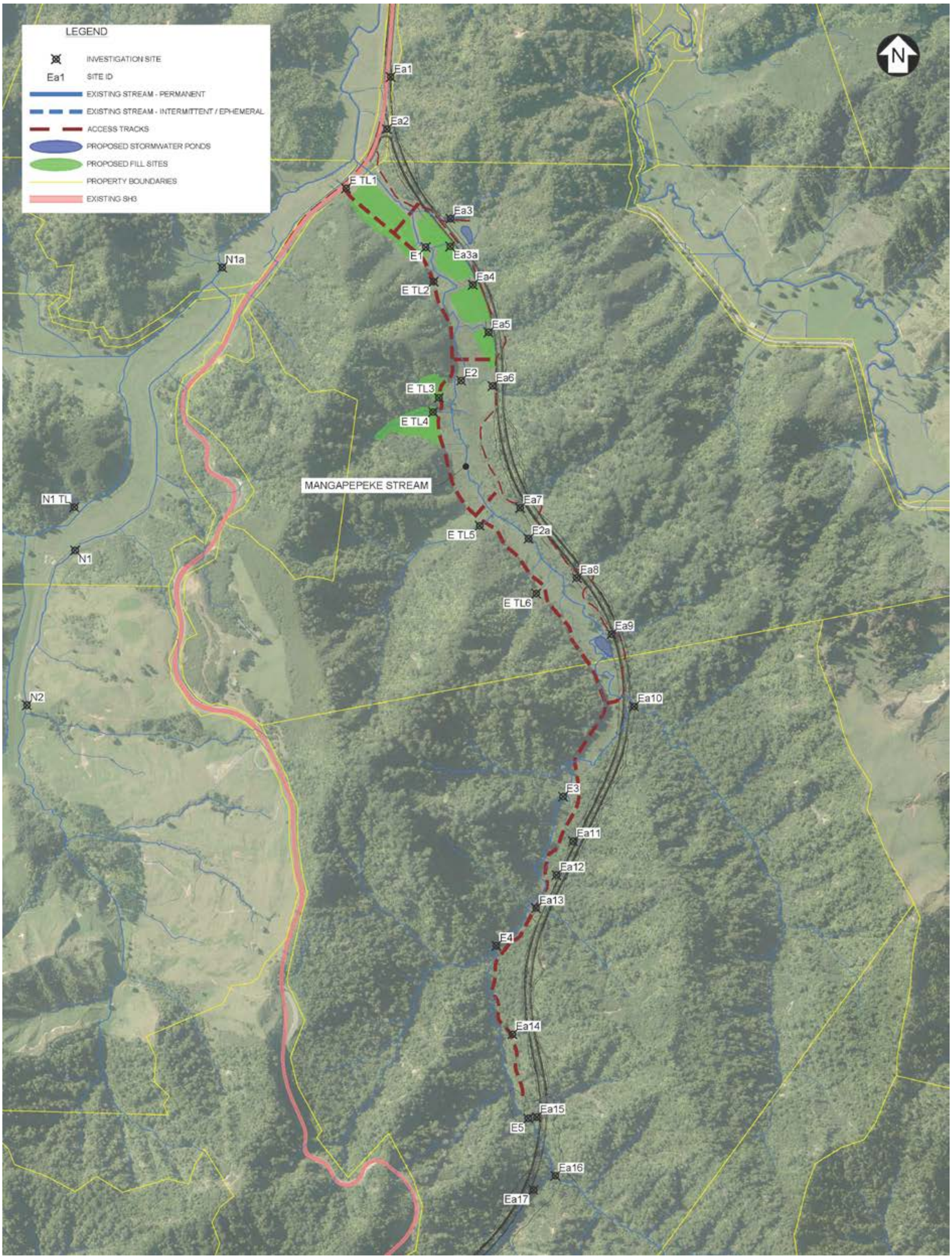


Figure 2.1a – Location of waterways potentially affected by the Project and stream surveys in Mangapepeke Stream catchment.

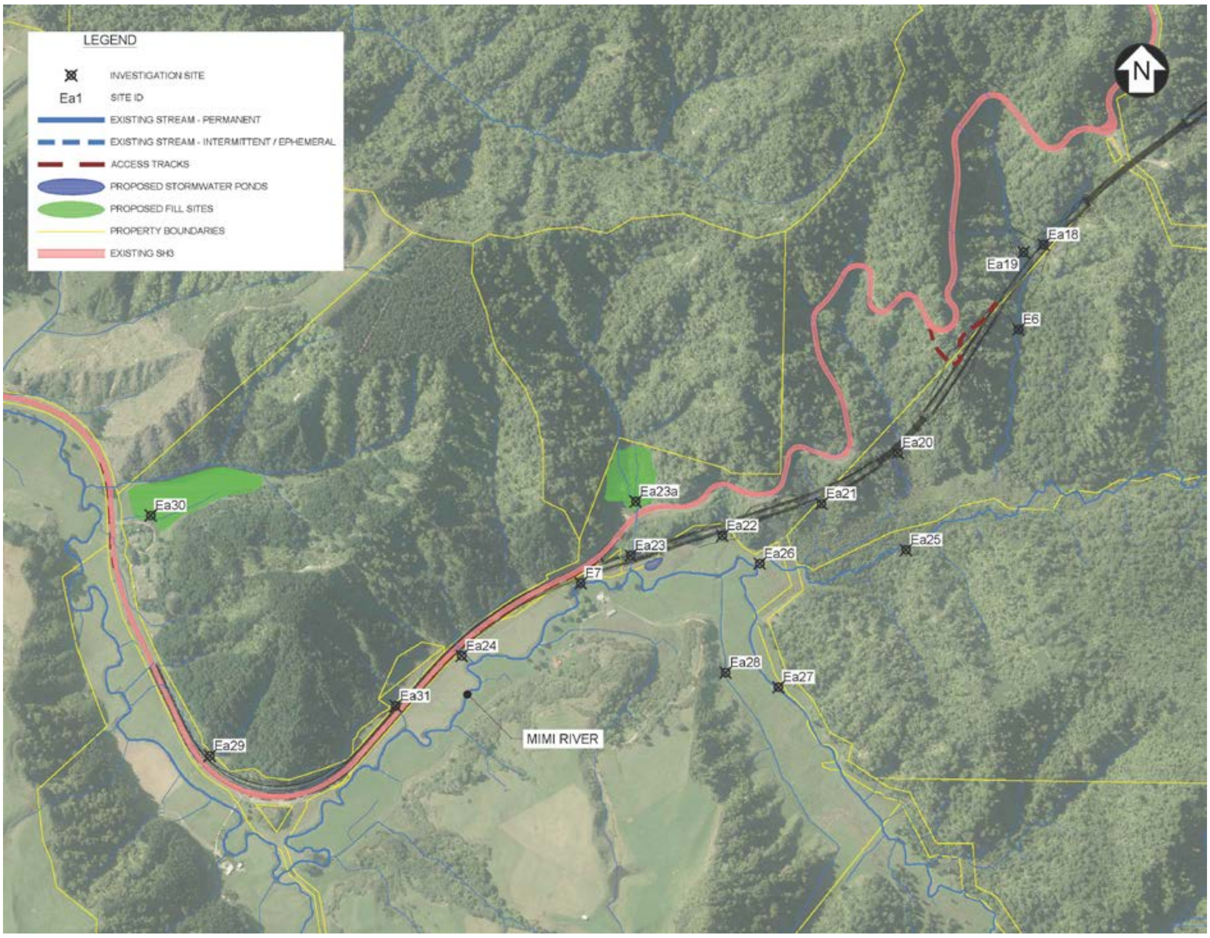


Figure 2.1b – Location of waterways potentially affected by the Project and stream surveys in Mimi River catchment.

2.2.1 Stream surveys

The focus of the stream survey was to take measurements from sites not previously visited. These were sites Ea3, Ea4, Ea5, Ea6, Ea7, Ea8, Ea9, ETL1, ETL2, ETL3, ETL4, ETL5, ETL6, NTL1, and Ea23a (fill site above the road).

At all sites, photos were taken and measurements were made of stream width, water depth (mid-channel), macrophyte cover and riparian vegetation type (indicated as 'v' in Table 2.1). The habitat was assessed and scored using the national rapid habitat assessment protocol (Clapcott 2015). Other habitat variables were assessed as part of the SEV method.

Stream widths used in the SEV calculations were the average width of run habitat as measured during site visits during winter and late spring. The width of run habitat was typically wider than riffles and narrower than pools.

2.2.2 Fish surveys

Fish surveys were repeated at sites E4 and E5 (spotlight method) and site E6 (electro fished). New fish surveys were undertaken at sites ETL5, Ea7, Ea10, Ea12, Ea13, Ea14, Ea15, Ea21 and Ea23a.

The fish surveys followed the methods described in Hamill (2017) and were consistent with protocols in Joy et al. (2013). The electrofishing method was used at most sites (i.e. E6, ETL5, Ea7, Ea12, Ea13, Ea14, Ea15, Ea21 and Ea23a). In addition, fine mesh fyke nets were used at site Ea10 and the spotlighting method was used at sites Ea10/Ea10a (mainstem and tributary of the Mangapepeke Stream), and the reach between E4 and E5. In total about 725m of the Mangapepeke Stream was surveyed by spotlight.

The fish survey sites included all waterways where very steep culverts are proposed, i.e. sites Ea12, Ea14, Ea15 and Ea21.

2.2.3 Stream Ecological Valuation (SEV) and macroinvertebrates

The Stream Ecological Valuation (SEV) method was used to assess the ecological value of streams at an extra four sites (sites Ea7, Ea23a, ETL5, and N1TL). Two of these sites (ETL5, and NTL1) are possible restoration sites, while the other two sites (Ea7 and Ea23a) are representative of sites being affected by the Project.

The SEV method was the same as that described in Hamill (2017).

2.2.4 Longitudinal survey at water take sites

A morphology survey was undertaken downstream of the proposed water take sites in the Mangapepeke Stream and the Mimi River. These are downstream of SH3 on the Mangapepeke Stream and downstream of site Ea24 on the Mimi River.

The survey was done on 1 November 2017 in conditions likely to represent spring baseflow conditions. There is no monitoring data to use for comparison of baseflow conditions. As part of the survey, the Mangapepeke River was gauged downstream of the confluence of the east and west branch; the measured flow was 76.6 L/s.

The longitudinal bed profile was measured along the reach by measuring the water depth at the deepest point across the stream width (i.e. depth of the stream thalweg). The measurements were used to characterise the extent of pools in the stream. The survey in the Mangapepeke Stream started just downstream of the SH3 culvert and covered a 460m reach with measurements every 4m. The survey in the Mimi River started at site Ea24 and covered a 520m reach with measurements every 5m.

2.3 Results from further investigations

2.3.1 Stream surveys

The stream survey information was primarily used to check assumptions that had previously been made about stream morphology and condition. The tables previously provided in the Freshwater Ecology Assessment (Hamill 2017) have been updated below to incorporate the new information (Table 2.2 to Table 2.4).

Overall the new streams surveyed were similar to what was expected based on nearby reaches and aerial photos. However, the location of three streams was different than previously expected. The stream layer in Figure 2.1 above has been revised to reflect ground conditions. The changes are:

- Site Ea3: The stream previously thought to be draining to this site actually flows along the true right of the valley. The waterway at site Ea3a is a recently dug drain which collects a small amount of flow from cut-off drains along the base of the hill.
- Site Ea4 does not exist as a waterway, instead there is a cut-off drain flowing along the base of the hill to site Ea3.
- The tributary to the Mimi River draining the tunnel and downstream of site E6 dissipates within the wetland and does not have a defined channel through the wetland. This improves the effectiveness of the raupo wetland to act as a buffer between the stream and the kahikatea swamp forest. It gives confidence that the raupo wetland will provide a high level of protection to the kahikatea swamp forest from sedimentation.

Sediment traps and sediment plates have been established in the raupo wetland near the end of the stream. These can be used to check the extent of any sediment deposition in the raupo wetland extending from the stream to the kahikatea wetland.

Table 2.2 – Habitat scores for streams affected by the Project (Clapcott 2015). High scores indicate better habitat quality. Sites surveyed on 31 October and 1 November 2017 are highlighted. This expands and replaces Table 3.1 in Hamill (2017).

	Mangapepeke catchment													Mimi catchment							
Habitat parameter	**E1**	**E2**	**E2a**	**E3**	**E4**	**E5**	**Ea6**	**Ea7**	**Ea10**	**Ea13**	**Ea15**	**ETL4**	**ETL5**	**E6**	**E7**	**Ea21**	**Ea22**	**Ea23**	**Ea26**	**Ea27**	**Ea28**
Deposited sediment	1	1	1	1	5	5	1	2	4	5	3	2	1	6	1	3	1	3	3	1	1
Invertebrate habitat diversity	4	3	7	4	7	7	5	5	8	8	9	4	4	9	8	8	1	8	7	5	1
Invertebrate habitat abundance	4	4	2	5	5	8	3	4	6	7	8	3	4	7	3	6	5	6	5	3	2
Fish cover diversity	4.5	5.5	6	4	7	7	5	6	9	8	7	4	6	9	7.5	8	3	8	7	5	2
Fish cover abundance	6	4	7	7	4	8	4	5	9	5	8	3	6	6	6	4	7	8	9	8	3
Hydraulic heterogeneity	4	8	7	7	7	8	5	5	10	6	7	4	7	8	7	6	1	8	7	8	4
Bank erosion	3	6	4	7	5	7	7	7	3	7	8	5	4	8	6	7	5	7	3	4	4
Bank vegetation	2	8	7	4	3	8	4	7	5	8	9	4	3	10	2	8	3	9	5	2	2
Riparian width	1	1	1	1	8	10	5	5.5	6	10	10	2	1	10	1	10	1	7	4.5	1	1.5
Riparian shade	4	4	5.5	1	4	8	8	8	6	9	9	6	4	9.5	3	9	1	9	3	1.5	1
Total score (out of 100)	**33.5**	**44.5**	**47.5**	**41**	**55**	**76**	**47**	**54.5**	**66**	**73**	**78**	**37**	**40**	**82.5**	**44.5**	**69**	**28**	**73**	**53.5**	**38.5**	**21.5**

Each habitat parameter scored on a scale of 1 to 10

Sites surveyed on 31 Oct and 1 Nov 2017 were: Ea6, Ea7, ETL4, ETL5, Ea15, Ea23.

Table 2.3 – Percentage of substrate on the stream bed of different size and type. Measured using the SEV method, ie 100 points assessed in stream reach with organic material recorded separately as either overlying inorganic or wood material. Highlighted cells show the dominant inorganic substrate (ie the substrate covering >50% of the stream bed). This expands and replaces Table 3.2 in Hamill (2017).

Site	Inorganic material									Wood			Organic material		
	Si/Sa	SG	SMG	MLG	LG	SC	LC	B	BR	small	medum	large	Leaf litter	Periphyton, roots, macrophytes	Roots
E2	97										1	2		44	10
E3	95									2	3		1	47	4
E4	17	8	14	19	23	6	3			3	3	4	2		3
E5	16	2	9	11	9	11	23	7	4	2	3	3	3		
Ea6	26	13	22	37	11	2				4	1		15		3
Ea7	55	11	6	6	9	4.5					8.5		9		2
Ea10	57	1	10	12	9		1			5		5	11		17
Ea13	35	6	13	20	17	7	2						4		6
ETL5	90	3.5		2	1	3.5							7		13
E6	12	9	15	11	21	18	5	1	2	3	3		12	2	2
E7	66	2	1	2	5	2	4	1	8	6	1	2		24	7
Ea23a	35	10	7	11	19	15	1			1	1		20		4
Ea26	97									2	1		3	3	39
Ea27	48		12	16			1		3	2	9	9	4	22	6
Ea28	98									2				38	1
N1TL	92	8													38

Si = silt, Sa=sand, SG=small gravel, SMG=small medium gravel, MLG = medium large gravel, LG=large gravel, SC=small cobble, LC=large cobble, B=boulder, BR=bedrock

Table 2.4 – Characteristics of waterways potentially affected by the Project. This expands on Table 3.3 in Hamill (2017). TL=true left.

Site	Catchment	catchment area (ha)	Riparian cover	Morphology	width (m)	depth run	depth pool (m)	Stream description
Ea1	Mangapepeke trib	3.82	indigenous forest	Ephemeral, steep	0.2	0.03	0.05	No fish passage through existing culvert. Wet mud but no flow.
Ea2	Mangapepeke trib	1.80	road side, scrub	Ephemeral cut-off drain	0.2			Ephemeral road cutoff drain. No water on alignment
E1	Mangapepeke	328	pasture	meander	1.4	0.4	0.8	Meandering pastural stream
Ea3	Mangapepeke trib	6.3	pasture, grazed wetland	run	0.35	0.02	0.2	Channelised drain adjacent to bush edge. Channel w 0.9m, h 0.3m to 1m. More natural within bush section
Ea3	Mangapepeke trib	6.3		run	0.35			
Ea3a	Mangapepeke trib	6.3	pasture, grazed wetland	drain	0.3	0.02	0.2	Drain recently deepened and widened for cut-off drains (e.g. Ea4)
Ea4	Mangapepeke trib	1.8	pasture, grazed wetland	Ephemeral drain	0.2	0		No water or channel at alignment. Cutoff drain to north, dug out.
Ea5	Mangapepeke trib	4.2	pasture, grazed wetland	intermittent, riffle-run	0.35	0.01		dribble of water disappears to wetland. High erosion. Incised channel to 0.7m
E2	Mangapepeke	306	pasture, grazed wetland	meander	1.4	0.4	0.8	Drains recently excavated. Cattle access to stream
Ea6	Mangapepeke trib	4.4	pasture, forest	step-pool, intermittent	0.35	0.05	0.2	incised channel w 0.6m, h 0.6m. Isolated pools with koura. Partial fish barrier where incised. Dry in places.
Ea7	Mangapepeke trib	6.8	pasture, grazed wetland	step-pool	0.4	0.02	0.5	incised channel w 1.1m, h 2m. Deep pools below drops.
Ea7	Mangapepeke trib	6.8			0.4			
E2a	Mangapepeke	248	pasture, degraded wetland	meander	1.3	0.4	0.5	Single row of manuka along stream edge near this reach.
Ea8	Mangapepeke trib	5.8	pasture, grazed wetland	step-pool	0.4	0.02	0.4	Incised channel w 0.7m, h 0.5m to 1m. Deep pools where log jams.
Ea9	Mangapepeke trib	7.9	pasture, grazed wetland	meander	0.5	0.05	0.15	Incised channel w 1.5m, h 1.4m. Meander along bush edge
Ea10a	Mangapepeke trib	67	Pasture/swamp forest	meander	1	0.3	1.5	Pools >1.2m with 0.8m drops in confined sections
Ea10b	Mangapepeke	149	Pasture/swamp forest	meander	1.2	0.3	1.5	Main stem through Kahikatea remnant. Drops of about 0.8m from root mass forming deep pools. Bank height 0.6 to 1.2m (typically 0.7m)
E3	Mangapepeke	133	pasture, grazed wetland	meander	1.25	0.35	0.45	Cattle causing pugging.
Ea11	Mangapepeke trib	2	indigenous forest	Ephemeral, steep	0.2	0.01	0.2	Ephemeral. disappears in wet ground. No flow on alignment. Too shallow to fish
Ea12	Mangapepeke trib	1.6	indigenous forest	Ephemeral, steep	0.2	0.01	0.1	Ephemeral. No flow on alignment centre. Small koura
Ea13	Mangapepeke trib	9.8	indigenous forest & pasture	step-pool	0.6	0.1	0.3	Narrower through pasture (0.65m wide and 0.1m deep). Longfin, banded, koura (d/s alignment). Pools remain us road.
E4	Mangapepeke	116	indigenous forest, grazed wetland	riffle-run	1.8	0.25	0.4	Cattle access causing pugging and erosion. Vegetation in poor condition and open.
Ea14	Mangapepeke trib	1.7	indigenous forest	Ephemeral. Steep	0.2	0.05	0.08	waterfall below the alignment. Ephemeral to intermittent through alignment. Small pools (fished d/s waterfall). Koura
E5	Mangapepeke	64	indigenous forest	riffle-run	2.5	0.25	1.5	Waterfall at upstream extent of reach.
Ea15	Mangapepeke trib	5	indigenous forest	Ephemeral. step-pool, waterfall	0.4	0.08	0.2	Large waterfall ds alignment. Ephemeral u/s alignment. Banded, koura
Ea16	Mangapepeke trib	36	indigenous forest	step-pool, waterfall	1.2	0.35		TR branch confined gorge. width 0.8-2m. Important to maintain long term fish passage for climbers.
Ea17	Mangapepeke trib	17	indigenous forest	step-pool, waterfall	1	0.15	0.5	TL branch confined gorge. width 0.8-1.3m

Table 2.4 continued

Site	Catchment	catchment area (ha)	Riparian cover	Morphology	width (m)	depth run	depth pool (m)	Stream description
Ea18	Mimi trib	6	indigenous forest	step-pool	0.5	0.08		TL = smaller. W 0.4-0.7m. Small stream cobbles.
Ea19	Mimi trib	10	indigenous forest	step-pool	0.9			TR channel 2.1m wide.
E6	Mimi trib	21	indigenous forest	riffle-run	1.2	0.15	0.55	Near u/s end width =1m and drops of about 1.6m. 2 L/s on 1 Nov 2017
Ea20	Mimi trib	15	Swamp forest	meander	0.9	0.1	0.5	Swamp forest. SMG/SG. *Tradescantia* present.
Ea21	Mimi trib	3	indigenous forest	Intermittent, step-pool	0.4	0.02	0.35	Small step-pool forest stream. Intermittent. Flow on 31/10/2017 = 0.064 L/s at upstream culverts combined. Koura
Ea22	Mimi trib	1.5	pasture	Intermittent, drain	0.35	0.05		Widens to a degraded wetland with heavy stock pugging
Ea23	Mimi trib	25	Swamp forest to pasture	riffle-run	0.6	0.2	0.45	Kahikatea forest d/s SH3. Incised channel height 0.5m narrow to 0.5m wide through kahekatea. Pools widen to about 0.9m. Banded, koura bully.
Ea23a	Mimi trib	25	forest	riffle-run	0.7	0.1	0.45	Forest u/s SH3.
E7	Mimi	919	pasture	meander	2.1	0.46	0.8	Cattle access to stream.
Ea24	Mimi trib	13	pasture	Drain	0.6	0.1		road cutoff drain and farm drain.
Ea29	Mimi trib	12	pasture	Drain, ephemeral	0.5			Wet but no flow. Watercress in drain. Additional stream length created to convey water to chainage 5450.
Ea30	Mimi trib	2.9		Drain	0.3			Farm cutoff drain affected by fill site. Drain dugout for logging. Very low values
Ea31	Mimi trib	4.1		Drain, ephemeral	0.3			Cut off drain. No water during spring site visit.
Ea25	Mimi trib	208	Swamp forest	meander	1	1		Kahikatea forest.
Ea26	Mimi trib	221	pasture, forest	meander	1.1	0.4		Raupo TL, wood in stream
Ea27	Mimi	630	pasture	meander	1.5	0.55		Main flow of Mimi Stm. Top end about 1.2 to 1.7m wide, moderate velocity.
Ea28	Mimi trib	25	pasture	Drain	0.9	0.17	0.4	Farm drain. Tributary enters at Ea28 from hill. Heavy pugging and sedimentation. Width 0.4m at top and 1.2m at lower end. Pools to 0.3m.
E TL1	Mangapepeke trib	1.3	pasture, scrub	Roadside drain	0.25	0.02		Roadside drain perched. Raupo in drain.
E TL2	Mangapepeke trib	1.9	pasture, scrub	Intermittent drain	0.2	0.02		Very shallow and degraded
E TL3	Mangapepeke trib	2.1	pasture, grazed wetland	Ephemeral drain	0.2	0.02		Heavy pugging, degraded stream, tiny flow.
E TL4	Mangapepeke trib	6.6	pasture, grazed wetland	riffle-run, drain	0.3	0.02		Very incised (1.3m bank hieght)
E TL5	Mangapepeke trib	32	pasture, grazed wetland	riffle-run, wetland	0.5	0.13	0.4	Riffle-run form, channel width about 1m, bank height 0.5m. Drain dug in upper valley. Banded, inanga, longfin, shortfin, koura.
E TL6	Mangapepeke trib	3.1	pasture, grazed wetland	Intermittent	0.3	0.01	0.05	Currently no fish passage

2.3.2 Fish surveys

The fish surveys from 30 October to 1 November 2017 found longfin eel, shortfin eel, inanga, giant kōkopu, banded kōkopu, redfin bully, kōura and Paratya shrimp (Table 2.5). The overall species list was very similar to that of previous sampling in the vicinity during February, June and July 2017. The only species not found during the October/November survey was common bully, previously found at site E1 in June 2017.

The spotlight survey along the Mangapepeke Stream near sites Ea10, E4 and E5 found more species than previously caught in this reach of river (i.e. longfin eel, inanga, giant kōkopu, banded kōkopu, redfin bully, kōura and Paratya shrimp). However, it does not change any conclusions or SEV calculations in the Freshwater Ecology Assessment (Hamill 2017), because the new species caught in this section of river (i.e. banded kōkopu, giant kōkopu) were already assumed to be present based on nearby records.

It is interesting to note that site E6, the tributary to the Mimi River draining the proposed tunnel, had low abundance of banded kōkopu in both the June and November surveys (four and two individuals respectively). This may be related to the stream channel petering out downstream within the raupo wetland, which could cause a partial fish barrier.

The Freshwater Ecology Assessment (Hamill 2017) recognised that sampling during winter was not ideal and can find lower fish abundance. The additional sampling undertaken in October/November 2017 therefore provides additional confidence to the previous conclusions. It has used a range of different fishing methods to assess additional sites and to re-sample some previously sampled sites.

2.3.2.1 Fish habitat upstream of steep culverts

Four culverts are designed with a steep grade (i.e. >12%): culverts 11, 13, 14 and 17 (sites Ea12, Ea14, Ea15 and Ea21). Achieving fish passage on steep culverts can be challenging, so the November 2017 survey included fish surveys of these streams. The survey found:

- Site Ea12: The stream was ephemeral (i.e. no water present at time of October survey) at the alignment centre. Where there was water downstream of the alignment, only kōura were found.
- Site Ea14: The stream was ephemeral upstream of the alignment and intermittent on the alignment itself. There was a large waterfall just downstream of the alignment. Fishing the section downstream of this waterfall found only kōura.
- Site Ea15: The stream was ephemeral about 20m upstream of the Project footprint and the last pool of greater than 5cm deep was within the section being culverted. There was a large waterfall downstream of the alignment but kōura and banded kōkopu were found in pools (about 0.2m deep) just upstream of this waterfall.
- Site Ea21: This is a small stream with a flow of about 0.07 L/s on 31 October 2017. Electric fishing only found kōura at this site with lower abundance further upstream as the stream branched and became shallower. There is a fish passage barrier (perched culvert) at the current road crossing.

The results indicate that the proposed approach to fish passage in these locations is adequate because of the limited upstream fish habitat upstream of the alignment. Kōura are present upstream of some sites, but as they are very good at climbing, koura passage can be maintained using baffles and/or spat rope.

Table 2.5 – Fish and invertebrates caught along the proposed route. This data is in addition to Table 3.5 in Hamill (2017). Size Class Categories from Joy et al. (2013).

ETL5. Electrofish (320m above and below wetland), 31 Oct 2017

Species		0+	Small	Med	Large	Total
Longfin eel	*Anguilla diefenbachii*		2			2
Shortfin eel	*Anguilla australis*		1			1
Eel Unidentified	*Anguilla sp.*	1	1			2
Inanga	*Galaxias maculatus*		3	5		8
Kōura	*Paranephrops planifrons*	15	19			34
Banded Kōkopu	*Galaxias fasciatus*		1	1		2

Ea7, Electrofish (170m), 31 Oct 2017

Species		0+	Small	Med	Large	Total
Unidentified	-					1
Kōura	*Paranephrops planifrons*	13	3	4		20
Banded Kōkopu	*Galaxias fasciatus*			1		1

Ea10 side tributary. Spotlighting Survey (60m), 31 Oct 2017

Species		0+	Small	Med	Large	Total
Longfin eel	*Anguilla diefenbachii*		4	1		5
Redfin Bully	*Gobiomorphus huttoni*		2	9	5	16
Kōura	*Paranephrops planifrons*	1	6	5		12
Banded Kōkopu	*Galaxias fasciatus*	11	9	8		28

Ea10 main stem. Spotlighting Survey (220m), 31 Oct 2017

Species		0+	Small	Med	Large	Total
Longfin eel	*Anguilla diefenbachii*				4	4
Inanga	*Galaxias maculatus*		4	2		6
Redfin Bully	*Gobiomorphus huttoni*			7	1	8
Kōura	*Paranephrops planifrons*			1		1
Banded Kōkopu	*Galaxias fasciatus*		10	9		19
Giant Kōkopu	*Galaxias argenteus*			1		1

Ea10. 6 fyke nets, 31 Oct 2017

Species		0+	Small	Med	Large	Total
Longfin eel	*Anguilla diefenbachii*				5	5
Inanga	*Galaxias maculatus*	1	3	10	2	16
Banded Kōkopu	*Galaxias fasciatus*	2	3	3		8
Giant Kōkopu	*Galaxias argenteus*			2		2
Redfin Bully	*Gobiomorphus huttoni*	17	30	7	5	59
Kōura	*Paranephrops planifrons*			1		1
Paratya shrimp						118

E4 to E5. Spotlight (445m) 31 Oct 2017

Species		0+	Small	Med	Large	Total
Longfin eel	*Anguilla diefenbachii*		4	2	1	7
unid eel			2	1	2	5
Banded Kōkopu	*Galaxias fasciatus*	3	10	8		21
Giant Kōkopu	*Galaxias argenteus*		1	2	2	5
unid Galaxiid		16	1	1		18
Redfin Bully	*Gobiomorphus huttoni*	9	8	11	7	35
Kōura	*Paranephrops planifrons*		2	4	2	8

Table 2.5 continued

Ea12. Electofish (60m), 30 Oct 2017.

Species		0+	Small	Med	Large	Total
koura	*Paranephrops planifrons*		2			2

Ea13. Electofish (120m), 30 Oct 2017. Most caught downstream alignment.

Species		0+	Small	Med	Large	Total
longfin	*Anguilla diefenbachii*			1		1
banded	*Galaxias fasciatus*	1	6	1		8
koura	*Paranephrops planifrons*		4	1		5

Ea14. Electrofish downstream waterfall (30m), 30 Oct 2017

Species		0+	Small	Med	Large	Total
Kōura	*Paranephrops planifrons*		3			3
Frog unidentified						1

Ea15. Electrofish upstream waterfall (60m), 30 Oct 2017,

Species		0+	Small	Med	Large	Total
Banded kōkopu	*Galaxias fasciatus*		1	3		4
koura	*Paranephrops planifrons*			1	1	2

E6 DoC Track. Electrofishing (220m), 1 Nov 2017

Species		0+	Small	Med	Large	Total
Longfin eel	*Anguilla diefenbachii*				1	1
Banded Kōkopu	*Galaxias fasciatus*		1	1		2
Kōura	*Paranephrops planifrons*		12	4		16
Unidentified	-					1

Ea21. Electofish (110m), 31 Oct 2017. Flow 0.064 L/s at SH3 (fewer caught upstream)

Species		0+	Small	Med	Large	Total
koura	*Paranephrops planifrons*		1	5		6

Ea23a (fill site) below 30m Culvet. Electrofishing (100m), 1 Nov 2017

Species		0+	Small	Med	Large	Total
Bully unidentified	*Gobiomorphus sp.*		1			1
Banded Kōkopu	*Galaxias fasciatus*		2	3		5

Ea23a (fill site) above 30m culvet. Electrofishing (100m), 1 Nov 2017

Species		0+	Small	Med	Large	Total
Unidentified	-					3
Banded Kōkopu	*Galaxias fasciatus*		3	1		4
Kōura	*Paranephrops planifrons*	4				4

2.3.3 Macroinvertebrate surveys

The Freshwater Ecology Assessment (Hamill 2017) recognised that sampling of aquatic macroinvertebrates soon after large flood events (as occurred in early August) is not ideal as macroinvertebrate abundance and richness can be depleted. But macroinvertebrate sampling results were considered fit for purpose because they were consistent with previous summer monitoring in the western branch of the Mangapepeke Stream, and they were primarily used to establish species presence and richness.

Nevertheless, additional macroinvertebrate samples were collected as part of the SEV surveys at sites ETL5, Ea7, Ea23 and N1TL (on the western branch of the Mangapepeke Stream). The results show generally higher taxa richness and high MCI scores at sites with bush catchments (e.g. Ea13, Ea23) compared to the lowland stream sites with little shading (e.g. N1TL) (Tables 2.6 and 2.7).

These additional macroinvertebrate surveys primarily support the additional SEV assessments but also improve our understanding of the current state of these streams. They provide additional confidence to the discussion and conclusions of the Freshwater Ecology Assessment (Hamill 2017).

Table 2.6 – Aquatic macroinvertebrate metric for streams along the proposed route. This expands and replaces Table 3.6 in Hamill (2017). Sites ETL5, Ea7, Ea23 and N1TL (western branch of the Mangapepeke Stream) were sampled in November 2017.

	Mangapepeke Stream									Mimi River					
Metric	**E2**	**E3**	**ETL5**	**Ea7**	**Ea10**	**Ea13**	**E4**	**E5**	**N1 TL**	**E6**	**E7**	**Ea23**	**Ea26**	**Ea27**	**Ea28**
Number of taxa	23	31	32	16	23	23	22	16	32	29	27	32	28	15	28
Number of EPT taxa	11	15	9	6	13	12	12	9	11	15	19	13	15	12	3
% EPT taxa	48	48	28	38	57	52	55	56	34	52	70	41	54	80	11
MCI score	90	107	94	128	127	130	126	130	93	133	121	114	126	125	76
SQMCI score	5.2	5.1	3.9	7.2	6.6	7.4	6.9	5.6	3.6	6.3	5.8	6.3	6.4	7.3	3.2

EPT metrics exclude *Oxythera* sp.

Table 2.7 – Aquatic macroinvertebrate results for additional sampling sites, Mt Messenger, 30 October to 1 November 2017.

		Mt Messenger			
TAXON	MCI score	Ea7	N1 TL	Ea 23a	ETL5
ACARINA	5	3		3	10
COLEOPTERA					
Elmidae	6	2			
Hydrophilidae	5		1	3	
Liodessus species	5				1
Ptilodactylidae	8	1		3	
COLLEMBOLA	6			12	1
CRUSTACEA					
Copepoda	5		180		
Isopoda	5			12	
Ostracoda	3		20		10
Paracalliope fluviatilis	5		1520	3	390
Paraleptamphopus species	5	2			
DIPTERA					
Austrosimulium species	3		640		190
Ceratopogonidae	3			3	
Chironomus species	1		220		
Corynoneura scutellata	2		20		1
Culicidae	3		1		
Empididae	3			6	
Eriopterini	9	1			1
Forcipomyiinae	3				1
Hexatomini	5			3	
Orthocladiinae	2	4	1240	6	130
Paradixa species	4	1	1	81	40
Paralimnophila skusei	6	1	20	1	10
Polypedilum species	3		40	3	1
Tanypodinae	5		20	18	
Tanytarsini	3	1	20		20
Zelandotipula species	6				1
EPHEMEROPTERA					
Acanthophlebia species	7			3	
Arachnocolus species	8			24	10
Austroclima species	9		60		
Austronella species	7		1	54	
Deleatidium species	8	43	40	9	10
Ichthybotus species	8			3	
Neozephlebia scita	7		1	75	1
Nesameletus species	9		1	15	
Zephlebia species	7	95	1	321	1
HEMIPTERA					
Microvelia macgregori	5	2	1		40
MOLLUSCA					
Lymnaeidae	3		1		
Potamopyrgus antipodarum	4		1560	30	1860
Sphaeriidae	3		1		1
NEMATODA	3				10
ODONATA					
Anisoptera	5			3	
Xanthocnemis zealandica	5		1	6	1
OLIGOCHAETA	1		60	12	10
PLATYHELMINTHES	3				1
PLECOPTERA					
Acroperla species	5		100	1	40
Stenoperla species	10			3	
Zelandobius species	5				10
TRICHOPTERA					
Hudsonema species	6				1
Hudsonema amabile	6		1		
Hydrobiosella species	9	1			
Hydrobiosis umbripennis group	5		1		1
Orthopsyche species	9	2		1	
Oxyethira albiceps	2		260	1	10
Polyplectropus species	8	1		33	
Psilochorema species	8	1	20	6	10
Triplectides species	5		40		
Number of taxa		16	32	32	32
Number of EPT taxa		6	11	13	9
% EPT taxa		38	34	41	28
MCI score		128	93	114	94
SQMCI score		7.2	3.6	6.3	3.9

2.3.4 Stream Ecological Valuations and offset calculations

2.3.4.1 Stream Ecological Valuations

The additional SEV assessments were used to improve our understanding of the condition of sites affected by the Project, and to give a fuller picture of the condition of potential restoration sites (NTL1 and ETL5). SEV scores for all sites are summarised in Table 2.8. Full SEV results from the November 2017 surveys are shown in Table 2.9.

The estimated improvement in SEV scores at potential offset sites was recalculated to include the additional SEV results (site ETL5 and Ea7). There was no significant change. The average estimated improvement in SEV scores at potential offset sites was still 0.23 and the area-weighted average improvement remained 0.24 (Table 3.8 in Hamill 2017).

Table 2.8 – Summary of SEV scores for sites surveyed along the Project route. This expands and replaces Table 3.7 in Hamill (2017). Shaded cells are potential restoration sites

	Mangapepeke Stream (east branch)								Mimi River					
Function	**ETL5**	**E2**	**Ea7**	**Ea10**	**Ea13**	**E3**	**E4**	**E5**	**E6**	**Ea23a**	**Ea26**	**Ea27**	**Ea28**	**E7**
Hydraulic	0.56	0.68	0.73	0.85	0.98	0.79	0.87	0.99	1	0.87	0.73	0.66	0.52	0.6
Biogeochemical	0.39	0.48	0.76	0.69	0.87	0.51	0.67	0.87	0.94	0.78	0.57	0.42	0.28	0.41
Habitat provision	0.41	0.55	0.66	0.64	0.68	0.43	0.57	0.94	0.94	0.69	0.42	0.55	0.22	0.51
Biodiversity	0.58	0.57	0.71	0.72	0.81	0.54	0.69	0.87	0.88	0.71	0.68	0.59	0.32	0.61
Overall mean SEV score (maximum value 1)	**0.48**	**0.57**	**0.73**	**0.73**	**0.86**	**0.58**	**0.72**	**0.92**	**0.94**	**0.78**	**0.62**	**0.54**	**0.35**	**0.52**

Table 2.9 – SEV calculations for additional survey sites along the Project footprint

30 Oct 2017 to 1 Nov 2017			Test sites			
			Site name/number			
Function category	Function	Variable (code)	ETL5	Ea23a	Ea7	N1TL
		Vchann	0.22	0.68	0.80	0.10
		Vlining	0.84	0.98	1.00	0.80
		Vpipe	1.00	1.00	1.00	1.00
Hydraulic	**NFR**	**=**	**0.43**	**0.78**	**0.87**	**0.33**
		Vbank	0.92	0.88	0.20	1.00
		Vrough	0.18	0.90	0.60	0.20
Hydraulic	**FLE**	**=**	**0.17**	**0.79**	**0.12**	**0.20**
		Vbarr	1.00	1.00	1.00	1.00
Hydraulic	**CSM**	**=**	**1.00**	**1.00**	**1.00**	**1.00**
		Vchanshape	0.32	0.72	0.84	0.20
		Vlining	0.84	0.98	1.00	0.80
Hydraulic	**CGW**	**=**	**0.67**	**0.89**	**0.95**	**0.60**
	Hydraulic function mean score		**0.56**	**0.87**	**0.73**	**0.53**
		Vshade	0.28	0.68	0.70	0.20
biogeochemical	**WTC**	**=**	**0.28**	**0.68**	**0.70**	**0.20**
		Vdod	0.60	1.00	1.00	0.40
biogeochemical	**DOM**	**=**	**0.60**	**1.00**	**1.00**	**0.40**
		Vripar	0.30	0.80	0.60	0.10
		Vdecid	1.00	1.00	1.00	1.00
biogeochemical	**OMI**	**=**	**0.30**	**0.80**	**0.60**	**0.10**
		Vmacro	0.77	0.94	1.00	0.54
		Vretain	0.38	0.74	0.92	0.20
biogeochemical	**IPR**	**=**	**0.38**	**0.74**	**0.92**	**0.20**
		Vsurf	0.38	0.60	0.40	0.40
		Vripfilt	0.38	0.80	0.80	0.40
biogeochemical	**DOP**	**=**	**0.38**	**0.70**	**0.60**	**0.40**
	Biogeochemical function mean score		**0.39**	**0.78**	**0.76**	**0.26**
		Vgalspwn	1.00	1.00	0.33	0.85
		Vgalqual	0.25	0.75	0.25	0.00
		Vgobspwn	0.10	0.10	0.80	0.10
habitat provision	**FSH**	**=**	**0.18**	**0.43**	**0.44**	**0.05**
		Vphyshab	0.60	1.00	0.82	0.41
		Vwatqual	0.38	0.84	0.85	0.24
		Vimperv	1.00	1.00	1.00	1.00
habitat provision	**HAF**	**=**	**0.65**	**0.96**	**0.87**	**0.52**
	Habitat provision function mean score		**0.41**	**0.69**	**0.66**	**0.28**
		Vfish	0.83	0.73	0.60	0.83
Biodiversity	**FFI**	**=**	**0.83**	**0.73**	**0.60**	**0.83**
		Vmci	0.67	0.95	1.00	0.64
		Vept	1.00	1.00	1.00	1.00
		Vinvert	0.58	0.82	0.47	0.70
Biodiversity	**IFI**	**=**	**0.75**	**0.92**	**0.82**	**0.78**
		Vripcond	0.17	0.68	0.70	0.10
		Vripconn	1.00	0.70	1.00	1.00
Biodiversity	**RVI**	**=**	**0.17**	**0.48**	**0.70**	**0.10**
	Biodiversity function mean score		**0.58**	**0.71**	**0.71**	**0.57**
Overall mean SEV score (maximum value 1)			**0.48**	**0.78**	**0.73**	**0.41**

2.3.4.2 Offset

The length of stream affected by the Project and the length/area of stream restoration required as offset was recalculated to incorporate the additional survey information. The revised estimate of total stream loss is a length of 3822 m and a stream area of 3361 m^2 (Table 2.10 and Table 2.11).

The SEV approach calculated that to offset this loss in stream values will require a compensation package that includes restoration of 8157m^2 of stream (wetted width) (Table 2.10). The updated offset calculations show more stream length being affected (3822m compared to 3470m), but less offset required (8157m^2 compared to 8724m^2) compared to that reported in the original assessment (Hamill 2017). The difference was primarily because the updated calculations account for a stream diversion around the fill site at Ea23 instead of a culvert, less impact on stream Ea3 because it already flows where the diversion is planned, and now include the potential diversion for wetland W2 (near culvert 8).

As discussed in Hamill (2017), it is possible that the design may evolve further as the detailed designs are developed. Offsets should be recalculated if there are substantive changes to designs that affect streams. The amount of offset required to achieve 'no net loss' of stream habitat may change with modifications in the designs and better understanding of what can be achieved with stream diversions. For example, wetland W2 near culvert 8 requires a diversion of the main Mangapepeke Stream. The amount of stream impacted by the diversion shown in the design (and allowed for in calculations) could be substantially reduced with a small design change from about 200m to 110m.

An update of the detailed site-by-site calculation of offset compensation required to address effects of the Project footprint is shown in Table 2.12.

The hypothetical scenarios used to inform the assigning of potential SEV scores for sites after impact and after potential restoration are shown in Appendix B. These were used only as a guide. In most cases, the 'potential SEV' used in the calculation was the actual SEV of a similar site. In practice the SEV score used for 'potential' state has only a small influence on the final environmental compensation ratio (ECR). This is because we have assumed that for streams of similar habitat and SEV values, the SEV value assumed after restoration efforts (SEVm-P) was the same as the potential SEV (SEVi-P) used in the calculation.

Table 2.10 – Extent of stream affected by the Project and the area of offset required to achieve 'no net loss'. This table updates and replaces Table 3.9 in Hamill (2017).

	Impact		Offset	
Catchment	**Length (m)**	**area (m^2)**	**Length (m)**	**area (m^2)**
Mangapepeke	2799	2678	6110	6234
Mimi	1023	683	2517	1923
Total	3822	3361	8627	8157

Table 2.11 – Amount of stream affected by the Project footprint differentiated according to catchment and current SEV value (SEV scores >0.9 represent pristine habitat). This table updates and replaces Table 4.5 in Hamill (2017).

	Current SEV score				
Catchment	>0.9	0.7 - 0.9	0.5 -0.7	<0.5	**Total**
Mangapepeke length (m)	887	815	672	425	2799
Mimi length (m)	505	298	0	220	1023
Total length (m)	1392	1113	672	645	3822
Total area (m^2)	1871	724	580	185	3361
% length permanent	100%	76%	91%	42%	82%
% area permanent	100%	90%	97%	47%	94%

Table 2.12 – Calculations for the amount of stream biodiversity offset required to address the impact on streams from the Project. This table replaces Tables C2 and C3 in Hamill (2017).

Site	width (m)	Project impact	Effect type	SEVi-C	SEVi-P	SEVi-I	SEVm-P - SEVm-C	ECR	Length of impact (m)	Area of impact (m^2)	Area to restore (m^2)
Ea1	0.2	Widen existing culvert	P	0.75	0.75	0.23	0.24	3.3	15	3	10
Ea2	0.2	Widen existing culvert	P	0.5	0.65	0.23	0.24	2.6	15	3	8
E1	1.4							n.a.	0	0	
Ea3	0.35	The consent shows this as a new stream diversion but it is the existing channel. = small diversion and culvert	P	0.57	0.77	0.23	0.24	3.4	72	25.2	85
Ea3	0.35	Diversion section	D	0.57		0.57		0.5	45	15.75	8
Ea3a	0.3	Drain replaced with new swale	P	0.35	0.65	0.23	0.24	2.6	65	19.5	51
Ea4	0.2	Shift cut-off drain upslope. Existing drain replaced by similar length of grassed swales. No waterway exists where culvert is shown.	P	0.35	0.65	0.4		0.5	80	16	8
Ea5	0.35	Culvert 5	P	0.57	0.77	0.23	0.24	3.4	45	15.75	53
E2	1.4	Access track crossing main step about 3 times	Sa	**0.57**	0.77	0.58		0.5	45	63	32
Ea6	0.35	Stream cut-off at the top of the cut and directed to stormwater. No fish passage provided unless allowed via stormwater pond. No culvert at present.	P	0.73	0.77	0.35	0.24	2.6	70	24.5	64
Ea7	0.4	Culvert 6 + stream diversion. Road drainage runs to treatment pond.	P	**0.73**	0.77	0.23	0.24	3.4	40	16	54
Ea7	0.4	stream diversion section + access track.	D	**0.73**	0.77	0.73		0.5	60	24	12
E2a	1.3			0.58	0.77			n.a.	0	0	
Ea8	0.4	Culvert 7 + stream diversion.	P	0.57	0.77	0.23	0.24	3.4	40	16	54
Ea8	0.5	stream diversion section + access track.	D	0.57		0.57		0.5	40	20	10
Ea9	0.5	Culvert 8	P	0.57	0.77	0.23	0.24	3.4	40	20	68
Ea9	0.5	stream diversion section + access track.	D	0.57		0.57		0.5	15	7.5	4
Ea10a	1	tributary section	P	**0.73**	0.86	0.23	0.24	7.9	20	20	158
Ea10b	1.2	total of 190m of stream lost in this area. More stream lost than culvert length because diversion is shorter.	P	**0.73**	0.86	0.23	0.24	7.9	45	54	425
Ea10b	1.2	110m diversion section of the total of 190m of stream lost in this area.	D	**0.73**	0.86	0.75	0.24	2.0	110	132	264
Ea10b	1.2	works area, dirty water drain, access track crossing	S a	**0.73**	0.86	0.75	0.24	2.0	15	18	36
E3	1.25	Stream diversion for wetland W2 near culvert 8. Design change could reduce impact length from 200m to 110m. Added 100m to account for shortened stream length	D	**0.58**	0.77	0.58		0.5	300	375	188
E3	1.25	Access track crossing + dirty water	S a	**0.58**	0.77	0.58		0.5	15	18.75	9
Ea11	0.2	Culvert 10. Stream to man hole, conveyed back to existing stream.	P	0.86	0.86	0.23	0.24	3.9	40	8	32
Ea11	0.2		S a	0.86	0.86	0.75	0.24	0.7	15	3	2
Ea12	0.2	Culvert 11	P	0.86	0.86	0.23	0.24	3.9	35	7	28
Ea12	0.2		S a	0.86	0.86	0.75	0.24	0.7	20	4	3
Ea13	0.6	Culvert 12	P	**0.86**	0.86	0.23	0.24	3.9	85	51	201
Ea13	0.75	clean water diversion works	S a	**0.86**	0.86	0.75	0.24	0.7	20	15	10
E4	1.8	inside temporary footprint	S a	**0.72**	0.85	0.75	0.24	0.6	50	90	56
Ea14	0.2	Culvert 13	P	0.86	0.86	0.23	0.24	3.9	20	4	16
Ea14	0.3		S a	0.86	0.86	0.75	0.24	0.7	15	4.5	3
E5	2.5	250m of stream lost d/s Ea16. 80m to stream diversion.	D	**0.92**	0.92	0.55	0.24	2.3	80	200	463
E5b	2.5	250m of stream lost d/s Ea16. 80m to stream diversion.	P	**0.92**	0.92	0.23	0.24	4.3	180	450	1941
E5	2.5	access track + dirty water drain	S a	**0.92**	0.92	0.75	0.24	1.1	100	250	266
Ea15	0.4	Culvert 15 length = longer than stream length lost.	P	0.86	0.86	0.23	0.24	3.9	95	38	150
Ea15	0.4	Access tracks expected	S a	0.86	0.86	0.75	0.24	0.7	45	18	12
Ea16	1.2	Section lost to Culvert 15.	P	0.92	0.92	0.23	0.24	4.3	77	92.4	398
Ea16	1.2	Sediment ponds	S a	0.92	0.92	0.75	0.24	1.1	50	60	64
Ea17	1	Clean water diversion made into stream diversion.	D	0.92	0.92	0.55	0.24	2.3	400	400	925

Table 2.12 continued

Site	width (m)	Project impact	Effect type	SEVi-C	SEVi-P	SEVi-I	SEVm-P - SEVm-C	ECR	Length of impact (m)	Area of impact (m^2)	Area to restore (m^2)
Ea18	0.5		D	0.94	0.94	0.55	0.24	2.4	250	125	305
Ea19	0.9	Culvert 16	P	0.94	0.94	0.23	0.24	4.4	40	36	160
E6	1.2	Culvert 16	P	**0.94**	0.94	0.23	0.24	4.4	165	198	879
E6	1.2	E&S ponds	S a	**0.94**	0.94	0.75	0.24	1.2	50	60	71
Ea20	0.9	Bridge		0.86	0.86			n.a.	0	0	
Ea21	0.4	Culvert 17	P	0.86	0.86	0.23	0.24	3.9	33	13.2	52
Ea22	0.35	Collected by grass swales to stormwater treatment pond.	P	0.35	0.77	0.4	0.24	2.3	50	17.5	40
Ea23	0.6	Culvert 18/19	P	**0.78**	0.78	0.23	0.24	3.4	85	51	175
Ea23a	0.7	Fill upstream of SH3 with diversion around the disposal site (C19)	D	**0.78**	0.78	0.55	0.24	1.4	180	126	181
E7	2.1		D	**0.52**		0.52			na		
Ea24	0.6	Extend/replace existing culvert. Exit to farm drain.	P	0.35	0.77	0.23	0.24	3.4	10	6	20
Ea29	0.5	Replace existing culvert with Culvert 21	P	0.35	0.77	0.23	0.24	3.4	10	5	17
Ea30	0.3	Main stream avoided. Cut-off drain replaced.	D a	0.35		0.4		0.5	150	45	23
Ea31	0.3	Cut-off drain shifted, main tributary avoided.	D	0.35		0.4			0	0	
Ea25	1	No direct disturbance but downstream of Project.	R					n.a.	0	0	
Ea26	1.1	Potential restoration site	R	**0.62**	0.86			n.a.	0	0	
Ea27	1.5	Potential restoration site	R	**0.54**	0.77			n.a.	0	0	
Ea28	0.9	Potential restoration site	R	**0.35**	0.77			n.a.	0	0	
E TL1	0.25	Access track culvert extension	P a	0.48	0.77	0.23	0.24	3.4	5	1.25	4
E TL2	0.2	Access track culvert extension	P a	0.48	0.86	0.23	0.24	3.9	5	1	4
E TL3	0.2	Fill - diversion section.	D a	0.48		0.55		0.5	75	15	8
E TL4	0.3	Fill - diversion section.	D a	0.48		0.55		0.5	175	52.5	26
E TL5	0.5	Access track. Potential restoration site	R, P a	**0.48**	0.86	0.23	0.24	3.9	5	2.5	10
E TL6	0.3	Access track culvert extension	P a	0.48	0.86	0.23	0.24	3.9	5	1.5	6

Effect type: P = permanent loss, D = stream diversion, S = short term, R = possible restoration site, a = access or fill site

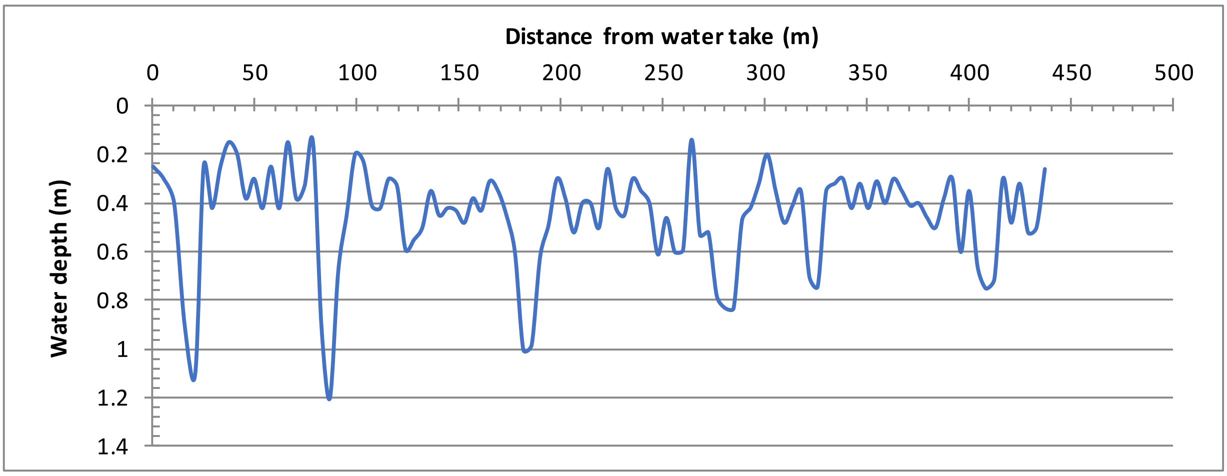
2.3.5 Longitudinal survey at water take locations

2.3.5.1 Mangapepeke Stream

The Mangapepeke Stream downstream of the confluence of the proposed water take is about 1.7m wide and about 0.4m deep in runs. The stream typically has a U-shaped cross-sectional profile, is incised and has frequent slumping and erosion of the stream banks. This provides occasional undercut banks. The longitudinal profile shows the stream bed to undulate with wide, deep scour pools on meander bends (about 0.8 to 1.2m deep) (Figure 2.2 and Figure 2.3).

The western branch of the Mangapepeke Stream enters about 20 metres downstream of the current SH3 culvert (start of survey) and is associated with the first meander and deep hole. A constructed boulder weir about 76m downstream appears to have raised the stream bed, and the stream is generally deeper downstream of this structure (Figure 2.2).

The riparian vegetation is predominantly grassed pasture and there is very little shading or over-hanging vegetative cover. Occasionally wood in the stream provides cover. There was little macrophyte cover (*Glyceria fluitans* and *Chara* sp.) at the time of the survey.



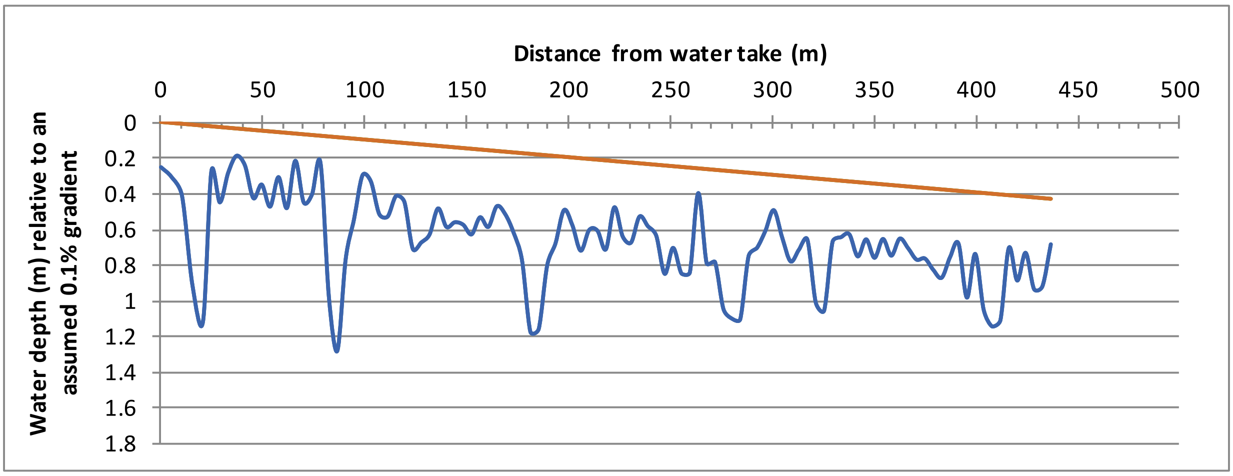


Figure 2.2 – Water depth longitudinally down the Mangapepeke Stream, downstream of the proposed water take (1 November 2017). The top graph is relative to water level, the bottom graph has an assumed gradient of 0.1%.

Figure 2.3 - Mangapepeke Stream facing upstream towards SH3. Photo taken from about 95m downstream of SH3 culvert.

2.3.5.2 Mimi River

The Mimi River downstream of the confluence of the proposed water take is about 2.1m wide and about 0.3 to 0.6m deep in runs. The stream typically has a U-shaped cross-sectional profile, is incised and has frequent slumping of the stream banks. The river is highly sinuous with wide, deep scour pools (about 1m to 1.8m deep) particularly apparent on meander bends. Small side drains enter the river at about 150m (from true left (TL)), 300m (from TR), and 400m (from TL) (Figure 2.4 and Figure 2.5).

The riparian vegetation is predominantly grassed pasture and there is very little shading or over-hanging vegetative cover. There was little macrophyte cover at the time of the survey.

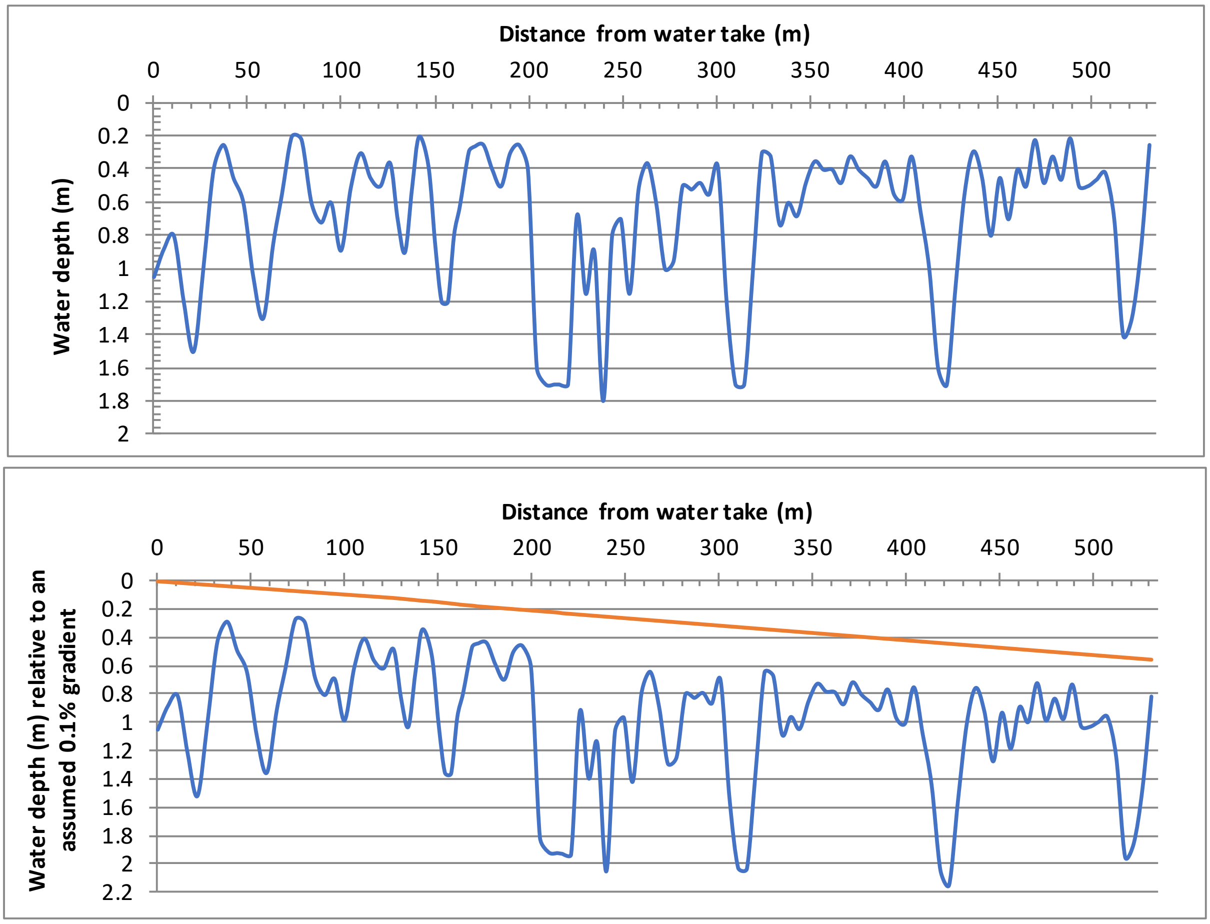


Figure 2.4 – Water depth longitudinally down the Mimi River, downstream of the proposed water take (1 November 2017). The top graph is relative to water level, the bottom graph has an assumed gradient of 0.1%.

Figure 2.5 – Mimi River near site Ea24.

2.3.5.3 Sensitivity of the streams to water takes

The longitudinal survey shows that both streams, but particularly the Mimi River, are likely to be insensitive to water takes because of the frequency of deep pools. The depth of water in the pools is largely controlled by the relative height of the crest at the downstream end. The pools provide refuge even with large drops in water levels.

Aquatic macroinvertebrate communities are often resistant to short-term flow reduction as long as some water remains (James et al 2008). In one study, a short-term reduction in the discharge of small streams caused macroinvertebrates to accumulate in the decreased available area, increasing invertebrate density (Dewson et al. 2007). Instead, habitat changes are often more apparent in fish communities.

The fish surveys of the downstream sections of the Mangapepeke River have found the fish community dominated by inanga, longfin eel and to a lesser extent redfin bully (Hamill 2017, Hamill 2017b).

Large longfin eels preferred deep (0.4m), slow-flowing water. In larger rivers they move from deep water during the day into shallower water at night (Garnooth and Brooker 2009, Appendix A). Small longfin eel prefer slow flowing water near cover on the river margins and are more commonly found in shallow areas (<0.21m) compared to large eels. However, Garnooth and Brooker (2009) found in a survey of 212 river sites that eel biomass was only weakly related to the weighted useable area and that other factors such as the amount of in-stream cover, bank cover and fishing pressure were likely to be more important than weighted useable area.

Inanga prefer water deeper than about 0.25m but exhibit little depth preference beyond that depth. They prefer low water velocity (0–0.14m/s).

The stream water depth in the Mangapepeke Stream could well be about 0.1m lower during summer low flow compared to that during the November survey. Even under these lower flow conditions, most of the river habitat would be deeper than 0.25m deep (i.e. suited to inanga) and there would be little change in the depth of the deep pools that provide refuge for large eels during the day.

Overall, the proposed water takes (of up to 300m^3/day from the Mangapepeke Stream and up to 150m^3/day from the Mimi River) are expected to have only minor effects (or less) on these rivers because of the small scale and short term nature of the takes, and the characteristics of the streams. Any effects will be less in the Mimi River than in the Mangapepeke Stream because the proposed water take is smaller, and the average flow is larger.

As discussed in Hamill (2017), the water intakes themselves will need to be appropriately designed to exclude fish, and this will be addressed in the Ecology and Landscape Management Plan.

3 Conclusions

The additional investigations described in this report have confirmed assumptions made in the Freshwater Ecology Assessment (December 2017). In particular:

- All remaining waterways affected by the Project were visited. Their width and stream condition were similar to what had previously been assumed.
- The offset for effects on streams was recalculated using the updated data. The updated offset calculations show 3822m of stream affected by the Project. To offset this loss will require restoration of 8157m^2 of stream area.
- Additional fish surveys (netting, electric fishing and spotlighting) confirmed the conclusions from previous fish surveys. Some additional species were found at some sites but the Freshwater Ecology Assessment had already assumed that these species would be present based on habitat and fish present in nearby streams. There is no change to conclusions based on these fish surveys.
- Several streams were confirmed as being ephemeral (i.e. only flows after rain) at the upstream extent of the road. These ephemeral sections were at culverts 1, 2, 4, 10, 11, 13, and 14 (associated with site Ea1, Ea2, Ea3, Ea11, Ea12, Ea14 and Ea15 respectively). The Project does not propose fish passage though culverts 2, 10 and 13 (sites Ea2, Ea11, and Ea14 respectively). The additional work has confirmed that the effect of this is negligible considering the ephemeral conditions upstream.
- Four culverts are designed with a steep grade (i.e. >12%): culverts 11, 13, 14 and 17 (sites Ea12, Ea14, Ea15 and Ea21). Achieving fish passage on steep culverts can be challenging, but the proposed approach is considered adequate because of the limited upstream fish habitat (i.e. ephemeral or restricted to kōura).
- The Mangapepeke Stream and the Mimi River have a U-shaped cross-sectional profile with large number of deep pools. The morphology makes the stream habitat relatively insensitive to water takes.

4 References

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Appendices

Appendix A: Habitat Preference curves

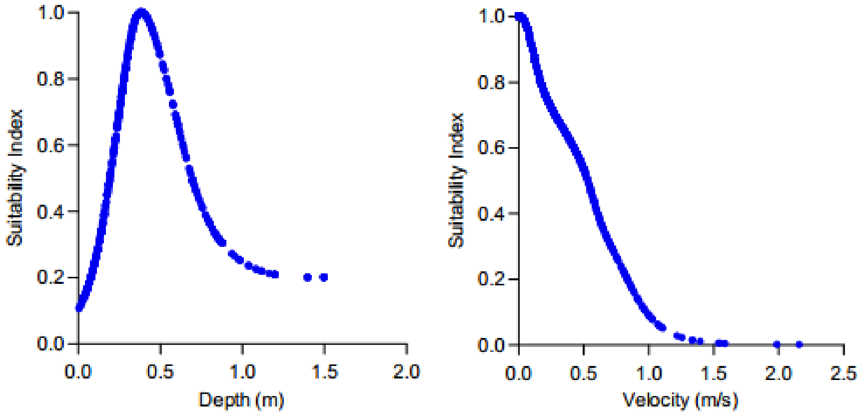

Figure A1 – Habitat preference curves for large longfin eel during the day (top graphs) and at night (bottom graphs) (Garnooth and Brooker 2009).

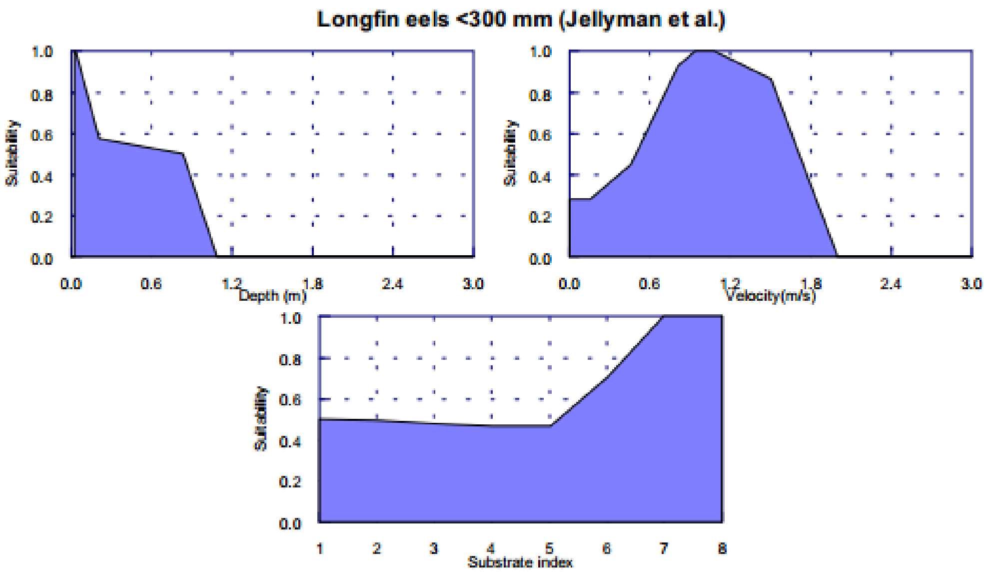

Figure A2 – Habitat preference curves for small to medium longfin eel (Jowett and Richardson 2008)

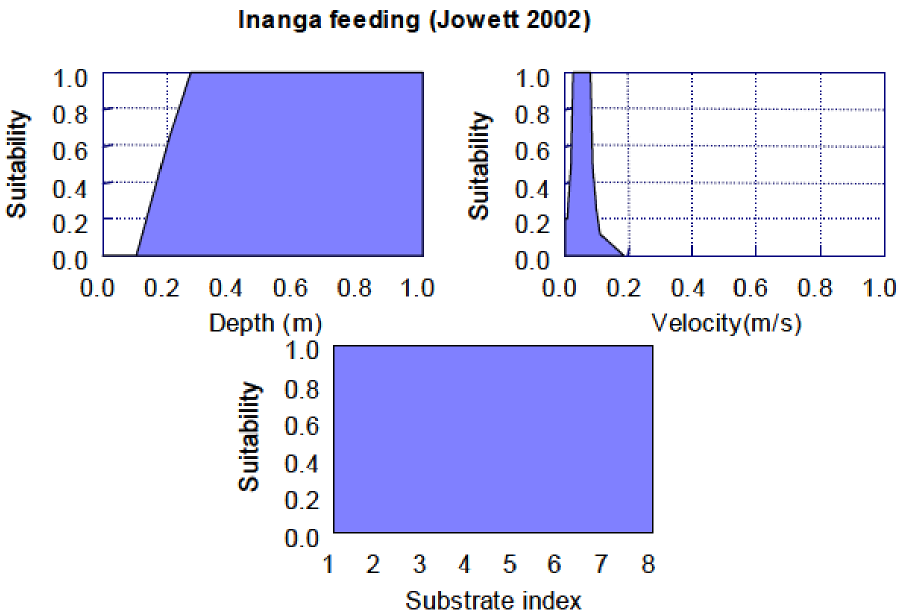

Figure A3 – Habitat preference curves for inanga (derived from Jowett 2002, in Jowett and Richardson 2008).

Appendix B: Potential SEV scores

Table B 1 – Hypothetical scenario of SEV scores for sites after impact and a potential restoration site after restoration. These helped inform the assigning of potential SEV scores. Sites N1 and N2 are on the western branch of the Mangapepeke Stream (surveyed in February 2017, Hamill 2017b)

14-Feb-17			Test sites					
			Site name/number					
Function categoi	Function	Variable (code)	N1	N2	N1 after restoration	culvert steep	E6 diversion rock	Culvert flat
		Vchann	0.38	0.59	0.65	0.10	0.42	0.10
		Vlining	0.80	0.80	0.80	0.00	0.20	0.00
		Vpipe	1.00	1.00	1.00	0.30	0.70	0.30
Hydraulic	**NFR**	**=**	**0.52**	**0.66**	**0.70**	**0.02**	**0.24**	**0.02**
		Vbank	1.00	1.00	1.00	0.00	0.28	0.00
		Vrough	0.20	0.20	0.84	0.00	0.72	0.00
Hydraulic	**FLE**	**=**	**0.20**	**0.20**	**0.84**	**0.00**	**0.20**	**0.00**
		Vbarr	1.00	1.00	1.00	0.30	0.30	1.00
Hydraulic	**CSM**	**=**	**1.00**	**1.00**	**1.00**	**0.30**	**0.30**	**1.00**
		Vchanshape	0.28	0.54	0.52	0.20	0.66	0.20
		Vlining	0.80	0.80	0.80	0.00	0.20	0.00
Hydraulic	**CGW**	**=**	**0.63**	**0.71**	**0.71**	**0.07**	**0.35**	**0.07**
Hydraulic function mean score			**0.59**	**0.64**	**0.81**	**0.10**	**0.27**	**0.27**
		Vshade	0.14	0.22	0.80	0.96	0.40	0.96
biogeochemical	**WTC**	**=**	**0.14**	**0.22**	**0.80**	**0.96**	**0.40**	**0.96**
		Vdod	0.68	1.00	1.00	1.00	1.00	0.68
biogeochemical	**DOM**	**=**	**0.68**	**1.00**	**1.00**	**1.00**	**1.00**	**0.68**
		Vripar	0.00	0.00	0.80	0.00	0.90	0.00
		Vdecid	1.00	1.00	1.00	1.00	1.00	1.00
biogeochemical	**OMI**	**=**	**0.00**	**0.00**	**0.80**	**0.00**	**0.90**	**0.00**
		Vmacro	0.85	0.98	0.96	1.00	1.00	1.00
		Vretain	0.36	0.74	0.60	0.20	0.52	0.20
biogeochemical	**IPR**	**=**	**0.36**	**0.74**	**0.60**	**0.20**	**0.52**	**0.20**
		Vsurf	0.47	0.50	0.82	0.13	0.57	0.13
		Vripfilt	0.56	0.80	0.80	0.00	0.70	0.00
biogeochemical	**DOP**	**=**	**0.52**	**0.65**	**0.81**	**0.07**	**0.64**	**0.07**
Biogeochemical function mean score			**0.34**	**0.52**	**0.80**	**0.45**	**0.69**	**0.38**
		Vgalspwn	1.00	0.63	1.00	0.00	1.00	0.00
		Vgalqual	0.00	0.75	1.00	0.00	0.75	0.00
		Vgobspwn	0.10	0.80	0.80	0.10	0.80	0.10
habitat provision	**FSH**	**=**	**0.05**	**0.63**	**0.90**	**0.05**	**0.78**	**0.05**
		Vphyshab	0.44	0.61	0.93	0.32	0.59	0.26
		Vwatqual	0.22	0.36	0.90	0.98	0.70	0.66
		Vimperv	1.00	1.00	1.00	0.90	0.90	0.90
habitat provision	**HAF**	**=**	**0.52**	**0.65**	**0.94**	**0.63**	**0.69**	**0.52**
Habitat provision function mean score			**0.29**	**0.64**	**0.92**	**0.34**	**0.73**	**0.28**
		Vfish	0.97	0.97	0.97	0.00	0.77	0.00
Biodiversity	**FFI**	**=**	**0.97**	**0.97**	**0.97**	**0.00**	**0.77**	**0.00**
		Vmci	0.77	0.79	0.77	0.28	1.00	0.41
		Vept	1.00	0.28	1.00	0.06	0.83	0.06
		Vinvert	0.82	0.55	0.82	0.16	0.77	0.22
Biodiversity	**IFI**	**=**	**0.86**	**0.54**	**0.86**	**0.17**	**0.87**	**0.23**
		Vripcond	0.18	0.20	0.36	0.00	0.51	0.00
		Vripconn	1.00	1.00	1.00	0.00	0.43	0.00
Biodiversity	**RVI**	**=**	**0.18**	**0.20**	**0.36**	**0.00**	**0.22**	**0.00**
Biodiversity function mean score			**0.67**	**0.57**	**0.73**	**0.06**	**0.62**	**0.08**
Overall mean SEV score (maximum value 1)			**0.47**	**0.58**	**0.81**	**0.25**	**0.56**	**0.27**

Appendix C: Site Photos

Figure C 1: Site Ea3, Mangapepeke Stream catchment.

Figure C 2: Site Ea3a, Mangapepeke Stream catchment.

Figure C 3: Site Ea4, Mangapepeke Stream catchment.

Figure C 4: Site Ea5, Mangapepeke Stream catchment. Dissipates into wet pasture with no formed channel.

Figure C 5: Site Ea6, Mangapepeke Stream catchment. Dry sections in places.

Figure C 6: Site Ea7, Mangapepeke Stream catchment. Deeply incised.

Figure C 6a: Site Ea7, Mangapepeke Stream catchment, shaded section.

Figure C 7: Site Ea8, Mangapepeke Stream catchment.

Figure C 8: Site Ea9, Mangapepeke Stream catchment.

Figure C 9: Site Ea10, Mangapepeke Stream. Fyke net in water.

Figure C 10: Site Ea11, Mangapepeke Stream catchment.

Figure C 11: Site Ea12, Mangapepeke Stream catchment.

Figure C 12: Site Ea13, Mangapepeke Stream catchment. Small waterfall near upstream extent of fill on Ea13 (Culvert 12).

Figure C 13: Site Ea14, Mangapepeke Stream catchment upstream of waterfall.

Figure C 14: Site Ea15, Mangapepeke Stream catchment upstream of waterfall.

Figure C 15: Site E TL1, Mangapepeke Stream catchment, facing upstream. Adjacent to SH3.

Figure C 16: Site E TL2, Mangapepeke Stream catchment, facing upstream. Cut off drain upstream draining through a 350mm culvert.

Figure C 17: Site E TL3, Mangapepeke Stream catchment. Ephemeral in upper valley.

Figure C 18: Site E TL4, Mangapepeke Stream catchment, facing upstream.

Figure C 19: Site E TL5, Mangapepeke Stream catchment facing upstream.

Figure C 20: Site E TL6, Mangapepeke Stream catchment facing upstream.

Figure C 21: Site Ea23, Mimi River catchment. Downstream of SH3.

Figure C 22: Site Ea23a, Mimi River catchment. Upstream of SH3.

Figure C 23: Site Ea24, Mimi River catchment, facing upstream towards SH3.

Figure C 24: Site Ea29, Mimi River catchment facing downstream towards Mimi River. No flow on 1 November 2017.

Figure C 25: Site Ea30, Mimi River catchment. Fill is proposed in this valley. The cut-off drain on true right of the valley has been by recent logging. The main stream is on true right of the valley is not affected by the Project.

Figure C 26: Site N1 TL, Mangapepeke Stream west branch.