M3 Fish, Algae, and Macroinvertebrate Monitoring Plan

Aim and Objective

The purpose of **M-3 Fish, Algae, and Macroinvertebrate Monitoring Plan** (FAMMP) is to provide a mechanism to monitor aquatic biodiversity (including fish, macroinvertebrates, macrophytes and algae) over time, and to detect any potential changes as a result of the Project. Monitoring can also be used to inform the strategy, objectives and criteria for adaptive management, if required.

Summary of Impacts and Risks

Project-related activities during construction that may impact aquatic ecology include but are not limited to: vegetation clearance; excavation and blasting of roads, the dam site or other project infrastructure; road gravelling, sealing and maintenance; aggregate extraction; spoil stockpiling; inadequate erosion and sediment control; cement and concrete use; wastewater generation; the generation and storage of hazardous and non-hazardous waste; and the accidental spillage of chemicals. There is also the risk of fishing, poaching, use and degradation of the river by workers or project followers. Non-project impacts that may also impact the ecology of the Tina River include: timber harvesting in the middle and upper catchment; domestic activities by local villages; algal blooms; and downstream activities such as agriculture, palm oil, and gravel extraction.

The mitigation and management of these impacts is largely dependent upon the effective implementation of **P-1 CESMP** and related subplans. The purpose of this plan to monitor the receiving environment to confirm that the proposed environmental and social safeguards are effective and that the river is not being adversely impacted. .

Mitigation and Management Actions

#	Issue or Risk	Action	Timing / Frequency	Responsibility
M-3-1.	Reduction in aquatic habitat and species due to discharge of sediment and contaminants from construction activities	• Implementation of management actions specified in the other ESMPs, particularly **P-2 Biodiversity Management Plan**, **P-9 Workers Code of Conduct, P-12 Waste Management and Point Source Pollution Plan**, **P-13 Hazardous Materials Management Plan**; **P-14 Spill Prevention and Emergency Response Plan**; **C-8 Watercourse Crossing Management Plan**; **C-9 Spoil and Topsoil Management Plan**; and **C-10 Drainage, Erosion and Sediment Control Plan.**	Throughout construction	HEC Construction Manager HEC EHS Manager

Monitoring Requirements

#	Title	Description	Target / Performance Indicator	Timing / Frequency	Responsibility
M-3-A.	6-monthly aquatic ecology monitoring	Aquatic sampling will be undertaken at 12 established monitoring sites along the Tina/Ngalimbiu River and Sutakama River, as shown in **Annex M-3-I.** Monitoring will comprise the following parameters as described in **Annex M-3-II**: • Aquatic habitat assessment with photopoint monitoring • Macroinvertebrate sampling • Electric fishing (except for netting at Site 12*) • Environmental DNA • Recording of any invasive plant and animal species A standalone report shall be prepared summarising results and comparing spatial and temporal trends. * Site 12 at the river mouth will not be sampled by electric fishing due to high salinity, however netting by locals will continue.	No statistically significant temporal change in diversity and abundance of aquatic species/communities over time. No new aquatic invasive plant or animal species recorded within Core Land.	Every 6 months, during the wet and dry seasons Report shall be appended to the quarterly E&S report	HEC EHS Manager Ecologist / Aquatic Scientist
M-3-B.	Fish trap and haul	Monitoring of the operation of the upstream trap and haul system, including release of fish upstream of the dam: • Dates, times and flow conditions when the trap is (a) lowered and (b) raised, including personnel involved • Photograph of trap when it is raised each week, including any fish caught • Number, size and (if possible) species of fish caught • Operations and maintenance of the system, any other issues • Analysis of data to track temporal and seasonal trends in fish abundance and migration patterns The trap shall be submerged the day prior to the transfer for up to 24 hours, thereafter the trap shall be raised to prevent fish mortality	Weekly transfers completed Traps not to be lowered for more than 24 hours at a time	Weekly Reported in quarterly E&S monitoring report	HEC EHS Manager
M-3-C.	Juvenile fish trap and transfer	Manual netting / trapping of juvenile fish from downstream during the migration season, with release of fish upstream of the dam: • Trapping and/or netting of fish, targeting migrating juveniles moving upstream • Record the date and time, flow conditions, number of fish caught and genus/species (if possible) • Analysis of data to track temporal and seasonal trends in fish abundance and migration patterns	8 x trapping events occur per migration season	Weekly 8 x during upstream migration (or once per month, 8 x per year until the migration season is better known)	HEC EHS Manager Ecologist / Aquatic Scientist

Supporting Documents

Annex	Name	Description
M-3-I.	Sampling sites	Locations of the 12 sampling stations along Tina/Ngalimbiu River and Sutakama River
M-3-II.	Monitoring methodology	Methodology for data collection and analysis
M-3-III.	Habitat Assessment Field Sheet	River Bioassessment Program Habitat Assessment Field Sheet from the Queensland AUSRIVAS Sampling and Processing Manual
M-3-IV.	Macroinvertebrate Field Sheet	River Bioassessment Program Macroinvertebrate Field Sheet from the Queensland AUSRIVAS Sampling and Processing Manual
M-3-V.	SIGNAL and PET metrics	Queensland biological assessment – species richness, SIGNAL and PET calculations
M-3-VI.	SIGNAL 2 Grades for Macroinvertebrates	Chessman, B.C. 2003. New Sensitivity Grades for Australian River Macroinvertebrates. *Marine and Freshwater Research*. Vol 54: 95-103.

ANNEX M-3-I SAMPLING SITES

AQUATIC ECOLOGY SAMPLING SITES

Sampling will be undertaken at a total of 12 established sites (with pre-existing baseline data) along the Tina/Ngalimbiu River (9 sites) and Sutakama River (3 sites), listed below.

Site Number	Name*	Description	Latitude (S)	Longitude (E)
Site 1	Becho/Voraha	Tina River Upstream - upstream of the proposed reservoir (tributary)	9°35'42.78"	160°1'40.56"
Site 3	Gauging Station	Tina River upstream - upstream of the proposed reservoir (main river)	9°35'41.88"	160°2'2.16"
Site 4	Reservoir	Tina River within the proposed reservoir	9°33'44.92"	160°3'14.63"
Site 5	Koropa	Tina River Downstream of Reservoir - downstream of proposed dam wall and within the dewatered section of river	9°33'11.04"	160°4'52.08"
Site 6	Powerhouse	Tina River adjacent to Powerhouse site - downstream of the dewatered section. At or near M-1/M-2 water quality Site C.	9°32'31.64"	160°5'2.16"
Site 7	Nalitata	Tina River upstream of Toni River confluence - in the vicinity of Tina Village	9°31'16.07"	160°6'48.92"
Site 8	Toni River	Toni River - upstream of Tina/Ngalimbiu River confluence	9°31'25.14"	160°7'26.94"
Site 10	Ngalimbiu	Lower Ngalimbiu River - downstream of Ngalimbiu bridge. Downstream of project and below palm plantations on Ngalimbiu River (estuarine)	9°26'41.83"	160°8'57.40"
Site 12	River mouth	Ngalimbiu River mouth - assessing estuarine / marine species that utilize the Ngalimbiu River and the commercial fishing area	9°24'32.58"	160°8'52.86"
Site A	Sutakama U/S	Upper catchment of Sutakama River - located 1.7 km southeast of Nanala Village downstream of confluence with a minor tributary. Reference site to align with upstream of Tina River HPP (Site 3).	9°40'32.40"	160° 8'27.50"
Site B	Sutakama Mid	Mid-catchment of Sutakama River - located 4 km northeast of Rerere Village. Reference site to align with Tina River HPP impact sites (Sites 4/5).	9°37'3.02"	160°12'33.56"
Site C	Sutakama D/S	Downstream catchment of Sutakama River - located 550 m northwest of Tetupa Village. Reference site to align with downstream of Tina River HPP (Site 7).	9°31'45.20"S	160°14'42.00"E

*Site names for 1-12 adapted from the 2020 study conducted by David Boseto. Stations 6 and 10 have been moved slightly downstream since 2020 (to align with powerhouse site and due to restrictions in land access, respectively) but are consistent with monitoring in 2021 and 2022.


Site 12
Site 10
Site 8
Site 7
Site 6
Site 5
Site 4
Site 3
Site 1
Site C
Site B
Site A

ANNEX M-3-II MONITORING METHODOLOGY

AQUATIC ECOLOGY METHODOLOGY

Sampling will be undertaken at 12 established sites along the Tina/Ngalimbiu River and Sutakama Rivers following the methodology below:

Parameter	Description
Aquatic habitat	**Photographs** of aquatic habitat will be taken at fixed photopoints to establish a record of current condition (with GPS location recorded). Photographs shall be taken looking upstream, downstream, and of both banks. A **Habitat Assessment** shall be completed using the Habitat Assessment Field Sheet (**Annex M-3-III**). This method provides a numerical index of aquatic habitat condition based on 9 criteria. The sum of the scores for each criterion gives the overall habitat score, which is used to allocate sites to one of four defined categories as described in the Queensland AUSRIVAS Sampling and Processing Manual: • excellent habitat condition (overall score >110); • good habitat condition (overall score 75 to 110); • moderate habitat condition (overall score 39 to 74), and • poor habitat condition (overall score ≤38).
Macroinvertebrates	A single macroinvertebrate sample will be collected by disturbing a representative 10 m long section of composite habitat at each site with a dip net (250 µm mesh size). The following procedures are recommended for dislodging macroinvertebrates from the habitats and substrates: • Riffle: vigorously disturb the substrate starting at the downstream end moving upstream using a kick sampling technique, collecting suspended material in the net. • Edge and pool: Use two types of sweeping motion, the first type is sequential, short movements at right angles to the bank, dislodging macroinvertebrates from substrates, with the second movement to sweep suspended material into the net. • Macrophytes: submerged, floating and emergent plants sampled using the same edge sampling technique. Macroinvertebrate samples will be preserved using 95% ethanol, and transported to a suitably qualified laboratory for sorting, enumeration and identification. A Macroinvertebrate Field Sheet (**Annex M-3-IV**) will be completed to record in-stream conditions and habitat sampled. Macroinvertebrate taxa will be sorted and identified to genus or morphospecies (where possible) in the laboratory, by a suitably qualified aquatic scientist. The following metrics will be recorded and investigated: • Diversity and abundance: Number of macroinvertebrate taxa and individuals; • PET richness: Number of stonefly, mayfly and caddisfly (Plecoptera / Ephemeroptera / Trichoptera) taxa. • SIGNAL 2: Stream Invertebrate Grade Number – Average Level scores (referr **Annex M-3-V** and **Annex M-3-VII**). • Discussion and analysis of any differences in community structure between sites
Fish	Fish will be surveyed as follows: • **Backpack electrofishing** will be undertaken with a minimum of 500 seconds of electrofishing conducted across all available habitat types (e.g. pool, riffle, run, shallow and deep) at each site (consisting of a 100 m stretch the river). • In habitats with potential estuarine influence (Site 12), fish survey will be conducted using **seine netting**, which will be conducted by experienced local fishermen under the supervision of a suitably qualified aquatic scientist consultant. Where river conditions pose a health and safety risk to electric fishing and/or netting, fish shall solely be surveyed via eDNA sampling. Where possible, all fish species will be photographed underwater or in a small field tank for identification to species level. All individuals will be counted and the length of up to 50 individuals of each species at each site will be measured.

	All pest species will be ethically euthanised and disposed of by a suitably qualified aquatic scientist. Fish data from the survey will be collated with any additional identification completed in the laboratory by a suitably qualified aquatic scientist, if required. The following metrics will be recorded: • Species diversity and distribution. • Species abundance. • Size of individuals. • eDNA results (refer below). • Differences in community structure discriminating between sites.
Environmental DNA	Metabarcoding will be used to test for aquatic biodiversity, with eDNA to be sampled in water at each site using kits provided by a suitably qualified laboratory as follows. • three replicate filter samples will be collected from each site using kits provided by a suitably qualified laboratory. • A total of 1 litre of water shall be filtered for each sample, or until the filter is clogged, whichever comes first. The volume of water filtered shall be recorded. • For any unknown fish species, the fish shall be swabbed using the specialized swab kits provided by a suitably qualified laboratory for analysis. • Preserve the samples using the preservative provided (DNA/RNA Shield or similar). A suitably qualified laboratory will complete the analysis of eDNA, noting the accuracy of results are dependent on available sequencing data to detect species. Wilderlab New Zealand is a recommended laboratory service provider. The results of eDNA testing will augment the data collected via conventional sampling.
Invasive Species	During field surveys, the presence of any invasive aquatic plant or animal species will be recorded. Data from eDNA will also be used to detect the presence of terrestrial and aquatic pests.

ANNEX M-3-III HABITAT ASSESSMENT FIELD SHEET

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** _____

Date: ____/____/_____ **Time (24 hrs): [| | |]** **GPS:** _____ **Project Name:** _____

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (LM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score

○ ○ ○ ○

ANNEX M-3-IV MACROINVERTIBRATE FIELD SHEET

River Bioassessment Program

MACROINVERTEBRATE SAMPLING FIELD SHEET

NATURAL RESOURCES Queensland Government

SITE NUMBER: [| | | | | |] **SITE NAME:** _____

Project Name: _____ **Date:** ___/___/___ **Time (24 hrs):** [| | |] **GPS:** _____

EDGE/BACKWATER: Y [ ] N [ ] Collected by: [| |] Picked By: [| |] No. vials: [ ]

Velocity (m/sec): max [| • | |] min [| • | |]

Mean Depth: [| • | |] m

Mean Channel Width: [| | | • |] m

Method: 10 m sweep [ ]
60 min random pick [ ]
Other _____ [ ]

Canopy Cover: [| |] %

Width of Riparian Zone: LB [| |] m RB [| |] m

Composition of Riparian Zone:
Native [| |] % Exotic [| |] %

***Riparian Vegetation:**
Grass [| |] % Trees <10 m high [| |] %
Shrubs [| |] % Trees >10 m high [| |] %

Substrate Description:

Bedrock	[| |] %	Gravel (4 - 16 mm)	[| |] %
Boulder (> 256 mm)	[| |] %	Sand (1 - 4 mm)	[| |] %
Cobble (64 - 256 mm)	[| |] %	Silt/Clay (< 1mm)	[| |] %
Pebble (16 - 64 mm)	[| |] %		

Substrate Cover:

Periphyton	0	1	2	3	4
Moss	0	1	2	3	4
Filamentous algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Detritus	0	1	2	3	4

0 = <10% 1 = 10-35% 2 = 35-65% 3 = 65-90% 4 = >90%

Bank Overhang Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

Trailing Bank Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

BED: Y [ ] N [ ] Collected by: [| |] Picked By: [| |] No. vials: [ ]
TYPE: Riffle [ ] Rocky/Gravel Bed [ ] Sandy/Silty [ ]

Velocity (m/sec): max [| • | |] min [| • | |]

Mean Depth: [| • | |] m

Mean Channel Width: [| | | • |] m

Method: 10 m kick only [ ]
10 m kick & gleaning rocks of different sizes (5) [ ]
60 min random pick [ ]
Other _____ [ ]

Canopy Cover: [| |] %

Width of Riparian Zone: LB [| |] m RB [| |] m

Composition of Riparian Zone:
Native [| |] % Exotic [| |] %

***Riparian Vegetation:**
Grass [| |] % Trees <10 m high [| |] %
Shrubs [| |] % Trees >10 m high [| |] %

Substrate Description:

Bedrock	[| |] %	Gravel (4 - 16 mm)	[| |] %
Boulder (> 256 mm)	[| |] %	Sand (1 - 4 mm)	[| |] %
Cobble (64 - 256 mm)	[| |] %	Silt/Clay (< 1mm)	[| |] %
Pebble (16 - 64 mm)	[| |] %		

Substrate Cover:

Periphyton	0	1	2	3	4
Moss	0	1	2	3	4
Filamentous algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Detritus	0	1	2	3	4

0 = <10% 1 = 10-35% 2 = 35-65% 3 = 65-90% 4 = >90%

Bank Overhang Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

Trailing Bank Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

* Can add to > 100%

Adjacent Landuse:

Upstream Landuse:

****Percent of habitat types in 100 m reach:**

Riffle [| |] % Run [| |] % Macrophytes [| |] %
Pool (rocky) [| |] % Pool (sandy) [| |] % Dry [| |] % Edge [| |] %

** Riffle + Run + Pool + Macrophyte + Dry = 100%; Edge is % of habitat available to sample from L and R banks

TOTAL NO. VIALS: **OTHERS:**

DU502676RSC.P65 (LM3883) 20/8/98

1. LONGITUDINAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate
1. Biological sampling sites for each habitat type and % of reach.
2. Water quality measurement and water sample collection sites.
3. Location from where photograph(s) taken.
4. Location of cross-sectional profile sketch.

2. CROSS-SECTIONAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate
1. Approx. bank height/bank width (overflow), stream width and depth.
2. Approx. riparian vegetation height.

3. COMMENTS

(Office use only) **Entered into Hydsys on** ____/____/____ **By** _____

Checked on ____/____/____ **By** _____

ANNEX M-3-V SIGNAL AND PET METRICS

Calculation of SIGNAL and PET Metrics

7.7 Calculation of richness, SIGNAL, PET taxa richness, per cent sensitive taxa and per cent tolerant taxa

7.7.1 Richness (taxa) index

Count the number of different taxa at the relevant level of taxonomic resolution (as outlined in the aquatic macroinvertebrate laboratory identification sheet – Appendix 4).

7.7.2 Average SIGNAL index calculation

1. Allocate a SIGNAL grade number to each taxon in the sample. SIGNAL grade numbers for version 2.4 are available from the SIGNAL manual (Chessman 2003) which can be found at http://www.environment.gov.au/resource/signal-2iv-scoring-system-macroinvertebrates-water-bugs-australian-rivers.
2. The SIGNAL Index is calculated for each sample by averaging the SIGNAL grade numbers of all of the aquatic macroinvertebrate taxa collected in a sample.
3. Taxa that do not have a SIGNAL grade number, for example Copepoda, Cladocera and Ostracoda, are not used in the calculation of the SIGNAL Index.

7.7.3 PET taxa richness

PET taxa richness is the count of families (or genera/species) that belong to the following three orders of aquatic macroinvertebrates: Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies).

7.7.4 Calculating the % sensitive taxa index using presence/absence data

1. Count the number of taxa in a sample that have SIGNAL grade numbers.
2. Count the number of taxa that are sensitive (SIGNAL grade ≥8).
3. Calculate the per cent sensitive taxa using the formula below:

$$\%\ \text{Sensitive Taxa Index} = \frac{\text{Number of taxa with SIGNAL grade numbers} \geq 8}{\text{Total number of taxa in sample with SIGNAL grade numbers}} \times 100$$

7.7.5 Calculating the % tolerant taxa index using presence/absence data

1. Count the total number of taxa in a sample that have SIGNAL grade numbers.
2. Count the number of taxa that are sensitive (SIGNAL grade ≤3).
3. Calculate the per cent sensitive taxa using the formula below:

$$\%\ \text{Tolerant Taxa Index} = \frac{\text{Number of taxa with SIGNAL grade numbers} \leq 3}{\text{Total number of taxa in sample that have SIGNAL grade numbers}} \times 100$$

ANNEX M-3-VI SIGNAL 2 GRADES FOR MACROINVERTEBRATES