

M2 Water Quality Monitoring Plan (WQMP)

Aim and Objective																													
<p>The purpose of M-2 Water Quality Monitoring Plan (WQMP) is to implement a regular monitoring program to assess surface water quality, groundwater and wastewater discharges during construction of the Project.</p> <p>The WQMP will provide HEC and THL with a tool to evaluate construction performance and is based on the requirements and standards of the ESIA (2017), the EIS (2019), and IFC Environmental Health and Safety Guidelines (2007).</p> <p>The WQMP will be implemented in parallel with M-1 Suspended Sediment Monitoring Plan (SSMP).</p>																													
Summary of Impacts and Risks																													
<p>Water quality of the Tina River and downstream Ngalimbiu River is a central issue for local villages. Project support and acceptance by the local villages depends on the capability of the Project to maintain high water quality downstream.</p> <p>Project-related activities during construction that may impact water quality (chemistry) of surface and groundwater includes but is not limited to: cement and concrete use; wastewater generation; the generation and storage of hazardous and non-hazardous waste; and the accidental spillage of chemicals. Procedures for managing spills are covered in P-14 Spill Prevention and Emergency Response Plan (SPERP). Other relevant plans are P-2 Biodiversity Management Plan, M-3 Fish, Algae and Macro-invertebrate Monitoring Plan and M-5 Flora and Fauna Monitoring Plan. Monitoring of total suspended solids (TSS) and turbidity is further detailed in the M-1 Suspended Sediment Monitoring Plan.</p>																													
Mitigation and Management Actions																													
#	Issue or Risk	Action	Timing / Frequency	Responsibility																									
M-2-1.	Discharge of sediment and contaminants from construction activities	Implementation of management actions specified in the other ESMPs, particularly 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 E&S Manager																									
Monitoring Requirements																													
#	Title	Description	Target / Performance Indicator	Timing / Frequency	Responsibility																								
M-2-A.	Surface water quality monitoring	<ul style="list-style-type: none"> Surface water monitoring will be undertaken at six sampling stations (A-E) along Tina River plus one site on the Toni River (F) as shown in Annex M-2-I. A single sample from a representative location in or near the middle of the river will be collected, at a depth of 10-20 cm from the water surface. Once per month, the following parameters shall be collected for analysis at an accredited laboratory: <ul style="list-style-type: none"> Total suspended solids (TSS) (mg/L) Ammoniacal nitrogen (NH₄-N) (mg/L) Nitrate nitrogen (NO₃-N) (mg/L) Total phosphorus (P_{tot}) (mg/L) <i>E. coli</i> (MPN) Total coliforms (MPN) Oil and grease (mg/L) Once per week, the following parameters shall be monitored <i>in situ</i> using a handheld probe: <ul style="list-style-type: none"> Temperature (°C) pH (pH units) Turbidity (NTU) Conductivity (µS/cm) Dissolved oxygen (mg/L) More frequent (daily) <i>in situ</i> monitoring will be conducted following spill events, exceedances or complaints, in order to investigate the event and inform remedial actions to be taken Further detail on sampling methods is provided in Annex M-2-II. 	<p>Water quality trigger values are set in the EIS 2019 except for TSS.</p> <table border="1"> <tr><td>Temperature</td><td><35°C and ±3°C Δ</td></tr> <tr><td>pH</td><td>6.5-8.5</td></tr> <tr><td>Conductivity</td><td>20-250 µS/cm</td></tr> <tr><td>DO</td><td>6.0 mg/L</td></tr> <tr><td>Turbidity</td><td>15.0 NTU**</td></tr> <tr><td>TSS</td><td>300**</td></tr> <tr><td>NH₄-N</td><td>0.006 mg/L</td></tr> <tr><td>NO₃-N</td><td>10 mg/L</td></tr> <tr><td>P_{tot}</td><td>0.01 mg/L</td></tr> <tr><td><i>E. coli</i></td><td>0 MPN*</td></tr> <tr><td>Total coliforms</td><td>10 MPN*</td></tr> <tr><td>Oil and grease</td><td>0 mg/L</td></tr> </table> <p>*Trigger may be lower than background. If so, new trigger to be developed from existing data. **Refer ESMP M-1 for further detail.</p>	Temperature	<35°C and ±3°C Δ	pH	6.5-8.5	Conductivity	20-250 µS/cm	DO	6.0 mg/L	Turbidity	15.0 NTU**	TSS	300**	NH ₄ -N	0.006 mg/L	NO ₃ -N	10 mg/L	P _{tot}	0.01 mg/L	<i>E. coli</i>	0 MPN*	Total coliforms	10 MPN*	Oil and grease	0 mg/L	<p>Weekly (NTU field)</p> <p>Monthly (TSS lab)</p> <p>Daily sampling to be conducted following spill events or complaints, until water quality has returned to background levels.</p> <p>Reported in the quarterly E&S monitoring report including photos.</p>	HEC E&S Supervisor
Temperature	<35°C and ±3°C Δ																												
pH	6.5-8.5																												
Conductivity	20-250 µS/cm																												
DO	6.0 mg/L																												
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NO ₃ -N	10 mg/L																												
P _{tot}	0.01 mg/L																												
<i>E. coli</i>	0 MPN*																												
Total coliforms	10 MPN*																												
Oil and grease	0 mg/L																												
M-2-B.	Groundwater monitoring	<ul style="list-style-type: none"> Groundwater quality monitoring will be carried out at five locations: BH1, BH2 and BH6 at the Workers Accommodation Camp; BP60 at the Site Office; and the Powerhouse borehole once established (refer Annex M-2-I). Groundwater quality will not be monitored at BP120 as this will be used for construction activities only (concrete production). At each site, the following parameters shall be monitored <i>in situ</i> using a handheld probe: <ul style="list-style-type: none"> Groundwater level (m) pH (pH units) Turbidity (NTU) At each site, the following parameters shall be collected for analysis at an accredited laboratory: <ul style="list-style-type: none"> Total dissolved solids (TDS) (mg/L) Nitrate nitrogen (NO₃-N) (mg/L) Sulphate (SO₄²⁻) (mg/L) <i>E. coli</i> (MPN) Total coliforms (MPN) Further detail on sampling methods is provided in Annex M-2-II. 	<p>Groundwater quality trigger values have been developed for the project based on WHO, ANZECC and ADWG guidelines.</p> <table border="1"> <tr><td>G/W level</td><td>N/A</td></tr> <tr><td>pH</td><td>6.5-8.5</td></tr> <tr><td>Turbidity</td><td>< 5.0 NTU</td></tr> <tr><td>TDS</td><td>< 600 mg/L</td></tr> <tr><td>NO₃-N</td><td>< 10 mg/L</td></tr> <tr><td>SO₄²⁻</td><td>< 250 mg/L</td></tr> <tr><td><i>E. coli</i></td><td>0 MPN</td></tr> <tr><td>Total coliforms</td><td><10 MPN</td></tr> </table>	G/W level	N/A	pH	6.5-8.5	Turbidity	< 5.0 NTU	TDS	< 600 mg/L	NO ₃ -N	< 10 mg/L	SO ₄ ²⁻	< 250 mg/L	<i>E. coli</i>	0 MPN	Total coliforms	<10 MPN	<p>Monthly</p> <p>Monitoring at BH1 and BH6 can cease once bores are filled, capped and decommissioned.</p> <p>Reported in the quarterly E&S monitoring report including photos.</p>	HEC E&S Supervisor								
G/W level	N/A																												
pH	6.5-8.5																												
Turbidity	< 5.0 NTU																												
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<i>E. coli</i>	0 MPN																												
Total coliforms	<10 MPN																												

		<ul style="list-style-type: none"> More frequent (daily) <i>in situ</i> monitoring will be conducted following spill events, exceedances or complaints, in order to investigate the event and inform remedial actions to be taken 			
M-2-C.	Erosion and sediment control and water treatment devices monitoring	<ul style="list-style-type: none"> Monitoring for <i>in situ</i> chemical parameters will be undertaken at four erosion and sediment control devices along the access road: at the outlet of three sediment ponds (ST1-3) and at one location downstream of spoil disposal sites 2, 3, and 5 (ST4) (refer Annex M-1-I). Monitoring for <i>in situ</i> chemical parameters will be undertaken at the discharge location for other water treatment devices on site, as applicable e.g. wheel wash bay, concrete batching plant, aggregate crusher/washing plant, dam, powerhouse, tunnel treatment plant. At each site, the following parameters shall be monitored <i>in situ</i> using a handheld probe: <ul style="list-style-type: none"> Temperature (°C) pH (pH units) Turbidity (NTU) Conductivity (µS/cm) Dissolved oxygen (mg/L) Oil and grease (none visible) More frequent (daily) <i>in situ</i> monitoring will be conducted following spill events, exceedances or complaints, in order to investigate the event and inform remedial actions to be taken 	Water quality trigger values are set in the EIS 2019 except for turbidity. pH 6.5-8.5 Turbidity 15.0 NTU Oil and grease No oil sheen Other monitored parameters are to be recorded and used as an indicator of change (not a trigger) unless discharging direct into a watercourse.	Monthly throughout construction Reported in quarterly E&S monitoring report	HEC E&S Supervisor
M-2-D.	Treated wastewater quality monitoring	<ul style="list-style-type: none"> Monitoring of the treated effluent from the wastewater treatment plant at the Workers Accommodation Camp will be conducted. The following parameters shall be collected for analysis at an accredited laboratory: <ul style="list-style-type: none"> pH (pH units) Biochemical Oxygen Demand (BOD₅) (mg/L) Chemical Oxygen Demand (BOD) (mg/L) Total Suspended Solids (TSS) (mg/L) Total Nitrogen (TN) (mg/L) Total phosphorus (P_{tot}) (mg/L) <i>E. coli</i> (MPN) Total coliforms (MPN) Oil and grease (mg/L) Further detail on sampling methods is provided in Annex M-2-II. More frequent (daily) <i>in situ</i> monitoring will be conducted following spill events, exceedances or complaints, in order to investigate the event and inform remedial actions to be taken 	IFC EHS guidelines for treated sanitary sewage: pH 6.0-9.0 BOD ₅ 30 mg/L COD 125 mg/L TSS 50 mg/L TN 10 mg/L P _{tot} 2 mg/L <i>E. coli</i> 0 MPN Total coliforms 10 MPN Oil and grease 10 mg/L	Monthly Reported in quarterly E&S monitoring report	HEC E&S Supervisor
M-2-E.	Community water supply monitoring	<ul style="list-style-type: none"> The Project will supply selected affected communities with water during construction as per C-7 Water Supply Replacement Plan (WSRP). Monthly water quality monitoring will be conducted of all replacement water supplies used for drinking. More frequent (daily) <i>in situ</i> monitoring will be conducted following contamination events, exceedances or complaints, in order to investigate the event and inform remedial actions to be taken 	Drinking water supplies to meet WHO guidelines. If trigger values exceeded, corrective actions are taken	Monthly monitoring Reported in HEC Monthly Project and Quarterly E&S Reports	HEC HSE Manager
M-2-F.	Metals and pesticides	<ul style="list-style-type: none"> One-off analysis of pesticides and heavy metals from the groundwater bores is required to confirm if these contaminants are already present in the aquifer. Samples shall be taken from all three bores at the Workers Accommodation Camp (BH1, BH2, BH6). Details of parameters to be tested are included in Annex M-2-II. Pre-construction monitoring for the presence of heavy metals and pesticides in Tina River was completed in 2021 and 2022. Ongoing monitoring is not required as these contaminants are not expected to be generated by the project. 	Monitoring completed and reported. Any sources to be used for drinking to meet WHO guidelines.	Once at beginning of project to provide evidence of existing contamination. Reported in the quarterly E&S monitoring report	HEC E&S Supervisor
Supporting Documents					
Annex	Name	Description			
M-2-I.	Water quality monitoring locations	Locations of monitoring locations			
M-2-II.	Water sampling methods	Methods and equipment required for sampling surface water, treated sewage effluent and groundwater			

ANNEX M-2-I WATER QUALITY MONITORING LOCATIONS

M-2 Water Quality Monitoring Locations

Tina River and Toni River Monitoring Sites

Site	ID	Location	GPS Coordinates
A	A2	Within reservoir / Upstream of dam and all construction activity (M)	9°33'33.48"S, 160° 3'23.13"E
B	B2	100m downstream toe of dam (M)	9°33'28.53"S, 160° 3'38.63"E
C*	C2*	Upstream of the powerhouse (M)	9°32'44.83"S, 160° 5'4.88"E
C	C2	Immediately downstream of the powerhouse (M)	9°32'33.30"S, 160° 5'1.00"E
D	D2	At Vuramali, approximately 10 km downstream of the dam (M)	9°30'22.21"S, 160° 7'17.31"E
E	E2	At Ngalmibiu bridge, approximately 20km downstream of the dam (M)	9°27'17.90"S, 160° 8'43.10"E
F	F	Toni River upstream of confluence with Tina River. Same as M-3 site 8.	9°31'25.14"S, 160° 7'26.94"E

Should landowners prevent access to Site E this monitoring site can be moved downstream to M-3 site 10.

Erosion and Sediment Control Monitoring Sites

Site	Location	GPS Coordinates
ST1	Sediment trap located adjacent to Lot 2-3	9°33'22.98"S, 160° 3'30.65"E
ST2	Sediment trap located adjacent to Lot 2-2	9°33'13.38"S, 160° 4'10.14"E
ST3	Sediment trap located adjacent to Lot 3-2	9°32'45.00"S, 160° 4'10.74"E
ST4	Confluence below Spoil Disposal Sites 2,3 and 5	9°31'18.84"S, 160° 4'37.45"E

Wastewater Treatment Plant

Site	Location	GPS Coordinates
WWTP	Workers Accommodation Camp wastewater treatment plant outlet	9°28'11.68"S, 160° 6'14.78"E

Groundwater Monitoring Sites

Site	Location	GPS Coordinates
BH1	HEC Camp Garivera 1 Borehole (existing shallow bore)	9°28'12.10"S, 160° 6'14.62"E
BH2	HEC Camp Production Borehole (new deep bore)	9°28'13.02"S, 160° 6'11.96"E
BH6	HEC Camp Clean Water for Life Borehole (existing shallow bore)	9°28'12.40"S, 160° 6'11.91"E
BP60	Office, Batching Plant and Crusher Plant Production Borehole (new)	9°32'34.68"S, 160° 4'35.88"E
TBC	Powerhouse Borehole (proposed)	TBC
Additional boreholes not to be routinely monitored (unless to be used for drinking):		
BP120	Batching Plant Production Borehole (proposed)	9°33'28.67"S, 160°03'28.00"E

ANNEX M-2-II WATER SAMPLING METHODS

WATER QUALITY SAMPLING METHODOLOGY

Extracted from draft Water Quality Monitoring Plan prepared by HEC and dated 03 December 2021 as reviewed by the Owners Engineer.

SAMPLE COLLECTION

For the six sampling locations along rivers, water samples will be collected in or near the centre of the river, and below the surface, at a depth of c.10-20 cm from the surface.

Sample bottles are dipped into stream flow either by hand or at the end of a sampling pole. During flood events or at sites where it is difficult or not hygienic to collect samples by hand, reusable 1 L bailers will be used to collect water samples. Bailers will be thrown into the sampling location with a rope attached at one end, will sink to the bottom. The collected sample volume will be retrieved, assessed and stored. Sample bottles are sealed, labelled, and placed into a cooler. Where required by the analytical laboratory, samples will be kept in the dark and at a stable cold temperature with ice.

For the collection of treated sewage effluent water sample, sample bottle is hold by hand at the final discharge point. Where it is difficult to collect samples by hand, reusable 1-L bailers will be used to collect water samples. The collected sample volume will be retrieved, assessed and stored. Sample bottles are sealed, labelled, and placed into a cooler. Where required by the analytical laboratory, samples will be kept in the dark and at a stable cold temperature with ice.

Groundwater sample(s) will be collected using reusable 1-L bailers. The collected sample volume will be retrieved, assessed and stored. Sample bottles are sealed, labelled, and placed into a cooler. Where required by the analytical laboratory, samples will be kept in the dark and at a stable cold temperature with ice.

The following parameters shall be measured *in-situ* or on the spot at each sampling position across the river and at each sampling location for river water, treated sewage effluent and groundwater sampling: Turbidity, Temperature, pH, Electrical conductivity (EC), and Dissolved oxygen (DO). In addition to laboratory determination, water colour shall also be assessed *in-situ* through photography. The following parameters shall be determined in the laboratory: Colour, Odour, Oil & Grease, Nutrients (Ammonia-N, Nitrate-N, Phosphate-N), Total Nitrogen, Total Phosphorus, Sulphate, BOD, COD, Total coliform and E. coli.

Water samples for Oil & Grease shall be collected separately in 1L Amber glass bottles, while water samples for Turbidity, Nutrients, Sulphate, Total Phosphorus, Colour and Odour shall be collected in 500 mL plastic (PE) bottles. The same water sample in which suspended solids will be measured will also be used to measure the turbidity *in-situ* or on site. Water samples for faecal contamination (*E. coli* and Total Coliform) shall be collected in sterilized 100 mL bottles impregnated with sodium thiosulphate to minimise microbial growth during transport and storage. Water samples for BOD analysis shall be collected in clean 1 L glass bottles, stored in the dark and kept in coolers with ice packs during transportation and storage (maximum holding time of 24 hours when refrigerated at < 4°C). For water samples for COD analysis, they are to be collected in clean 100 mL glass bottles. To preserve samples for later analysis, adjust the sample

pH to less than 2 with concentrated sulfuric acid (approximately 2 mL per liter) and store in the dark and in coolers with ice packs (2-6 °C) during transportation to the laboratory and storage (maximum of 28 days). Water samples for Total Nitrogen shall be collected in 250mL plastic (PE) bottle. If Titanium Trichloride Reduction Method (Method 10021) is used and if the sample contains chlorine, add one drop of 0.1 N sodium thiosulfate to 1 litre of sample to remove each 0.3 mg/L of chlorine. For all testing methods, adjust the sample pH to less than 2 with concentrated hydrochloric acid (for Titanium Trichloride Reduction Method)/sulfuric acid (Persulfate Digestion Method) (approximately 2 mL per liter) to preserve samples for later analysis and keep the preserved samples in coolers with ice packs (at or below 6°C) during transportation to the laboratory and storage (maximum of 28 days).

In-situ the samples for turbidity will be collected and measured first before other parameters. This is to prevent disturbance of riverbed and contamination of the results of TSS in the laboratory and *in-situ* turbidity results. If this does happen, then allow sufficient time and flow to pass for stream to clear itself before collecting a sample.

At each location, sample bottles (except for sampling bottles with preservative, such as samples for faecal contamination) shall be rinsed twice with the sample water before being filled with the sample water. Care will be given to not touch the insides of the sample bottles, especially for faecal contamination analyses. All sample bottles shall be sealed and labelled accordingly to the sampling location ID where the alphabet represents the sampling locations and 1-3 indicates the sampling positions or replicates across the river at each location. The filled sample bottles will be placed inside zip lock bags before storing them in coolers containing ice packs for transportation to the laboratory for analyses. A Chain of Custody (COC) form will be completed for each sample and weather conditions should be noted during sampling.

Sampling personnel are to wear disposable gloves, preferably nitrile (if nitrile gloves are unavailable, sterile gloves from a commercially packaged box will be acceptable). The use of disposable gloves will reduce the risk of cross-contamination of samples.

A blank sample will be taken to assess laboratory accuracy.

Hand-held instruments will be used to take *In-Situ* measurements such as Temperature, pH, Conductivity, Dissolved oxygen, and Turbidity. Measurements will be recorded once levels have stabilised. Field sampling equipment shall be regularly calibrated and maintained as per manufacturers specifications.

Assurance and Quality Control (QA/QC)

Field logs shall be maintained for all survey work, noting the date of the survey, equipment used, and a record of all activities and observations. Field logs shall be retained for the duration of the survey.

Measured data shall be digitally recorded from the instruments and converted into Microsoft Excel format, or manually noted. Both disc copy and hard copy shall be retained for the file records. Any deviation from the standard procedure shall be noted in the log and the reason for the deviation recorded. In addition, field logs shall contain notes of events or activities in the vicinity of the monitoring location which might give rise to anomalous data being recorded.

All *in-situ* monitoring instruments shall be checked, calibrated, and certified and subsequently re-calibrated throughout all stages of the monitoring, as required by the manufacture's specification. Representatives from THL and HEC Environment and Social team will witness the sampling of water and *in-situ* monitoring of water samples to ensure compliance of Quality.

QA/QC procedures to be implemented for water quality analyses typically includes:




- Laboratory Blanks – Water used in the blank samples will be routinely tested ensuring no contamination is present (ie. Pure MilliQ water). Any reported concentrations of inorganic or organic contaminants in blanks should be investigated immediately and this would indicate that potentially the contamination is from the container, equipment, field, transport or the laboratory itself.


Transport of Samples

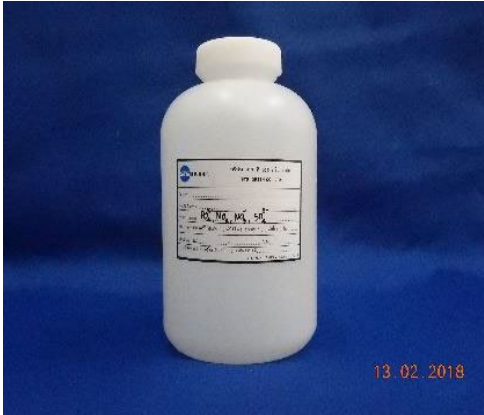

BOD samples shall be delivered immediately to the laboratory, otherwise refrigerated or chilled with ice and delivered within 24 hours.



All samples transferred to the laboratory should be accompanied by COC forms (Annex B). The number of samples, the parameters to be tested and the time of delivery will be clearly stated on the COC forms to ensure that samples are analysed for the correct parameters and suitable time is provided to the analytical laboratory for provision of resources required to meet sample holding times. This is particularly relevant for coliforms.

Analytical methods and Sampling methodology of Surface Water monitoring.

Parameter	Width (cm)	Height (cm)	Campaign Requirements
<p>Temperature</p> <p>pH</p> <p>Electrical conductivity</p> <p>Dissolved oxygen</p> <p>Turbidity</p>	<p>N/A</p>	<p>N/A</p>	<p>Hand-held water probe for multi parameter measurement</p> <p>Example:</p>   

Parameter	Width (cm)	Height (cm)	Campaign Requirements
			<p>Methodology: As per operational manual, the measurement will be taken by placing the sensor directly into the river or by inserting the sensor into a collected water sample. The 'one-off' reading will be recorded in the daily survey log and electronically.</p> <p>Water probes will be appropriately calibrated prior to surveys and calibration records maintained (Annex C).</p>
Oil and grease	23	10	<p>Amber Glass Bottle, 1,000 mL</p> <p>Rinse bottles twice with sampling water, fill bottle with sampling water without slop (bottleneck is fine), Preserved by Conc. H₂SO₄ 2 mL. and shake, tightly close the bottle and put in a zip lock bag and seal tightly.</p>  <p>Methodology: Liquid-Liquid, Partition Gravimetric Method</p>
Total Phosphorus and NO₃-N	18	10	<p>Plastic (PE) Bottle 500 mL.</p> <p>Rinse bottles twice with sampling water, fill bottle with sampling water without slop (bottleneck is fine), tightly close the bottle and put in a zip lock bag and seal tightly.</p>

Parameter	Width (cm)	Height (cm)	Campaign Requirements
			 <p data-bbox="685 768 867 800">Nutrients NO₃-N</p> <p data-bbox="685 837 1156 869">Methodology: Cadmium Reduction Method</p> <p data-bbox="685 905 878 936">Total Phosphorus</p> <p data-bbox="685 972 1247 1003">Methodology: Acid Digestion/Ascorbic Acid Method</p>
<p data-bbox="183 1058 358 1121">E Coli and Total Coliform</p>			<p data-bbox="685 1058 1187 1089">Sterile Sample bottle (300 mL)- single use only</p>  <p data-bbox="685 1606 1377 1743">Carefully open the sampling bottle by keeping hands away from inside of the cap or the bottle rim. Fill in the sample, label it and put it in plastic bag. Preserve the sample in ice pack until it reaches the laboratory.</p> <p data-bbox="685 1780 956 1812">Methodology: Colilert 18</p>

Parameter	Width (cm)	Height (cm)	Campaign Requirements
BOD			<p data-bbox="691 342 1027 373">Glass Sample bottle (1,000 mL)</p>  <p data-bbox="691 934 1377 1033">After sample collection, store samples in the dark and keep in coolers with ice packs during transportation and storage. The maximum holding time when refrigerated at < 4°C is 24 hours.</p> <p data-bbox="691 1071 914 1102">Methodology: BOD5</p>
COD			<p data-bbox="691 1157 1008 1188">Glass Sample bottle (100 mL)</p>  <p data-bbox="691 1610 1377 1709">Samples to be acidified with sulphuric acid (H₂SO₄) to pH 1 – 2, stored in the dark and kept in coolers with ice packs during transportation and storage.</p> <p data-bbox="691 1747 1377 1885">Methodology: Mercury-Free Reactor Digestion, TNTplus 825, Method 10236/ Manganese III Reactor Digestion Method 10067 (with Chlorine Removal)/ Manganese III Reactor Digestion Method 10067 (without Chlorine Removal)/ Reactor Digestion</p>

Parameter	Width (cm)	Height (cm)	Campaign Requirements
			Method 8000/ Reactor Digestion Method 8000, TNTplus/ Reactor Digestion ULR TNT Method 10211/ UHR Reactor Digestion Method 10212
Sulphate	18	10	<p>Plastic (PE) Bottle 500mL.</p> <p>Rinse bottles twice with sampling water, fill bottle with sampling water without slop (bottleneck is fine), tightly close the bottle and put in a zip lock bag and seal tightly. Keep in coolers with ice packs during transportation and storage.</p>  <p>Methodology: SulfaVer4 Method 8051/ Turbidmetric, TNTplus 864, Method 10227 / Turbidmetric, TNTplus 865, Method 10227</p>
Total Nitrogen	18	10	<p>Plastic (PE) Bottle 250mL.</p> <p>Rinse bottles twice with sampling water, fill bottle with sampling water without slop (bottleneck is fine), tightly close the bottle and put in a zip lock bag and seal tightly. Keep in coolers with ice packs during transportation and storage.</p>

Parameter	Width (cm)	Height (cm)	Campaign Requirements
			<div data-bbox="911 321 1159 758" data-label="Image"> </div> <p data-bbox="691 800 846 827">Methodology:</p> <p data-bbox="691 865 1377 926">Total inorganic nitrogen: Titanium Trichloride Reduction Method 10021</p> <p data-bbox="691 968 1377 1100">Total nitrogen: Persulfate Digestion HR Method 10208/ Persulfate Digestion HR Method 10072/ Persulfate Digestion LR Method (10071)/ Persulfate Digestion LR TNT Method 10208/ Persulfate Digestion UHR TNT Method 10208</p>

EVALUATION OF MONITORING CAMPAIGN

The purpose of water quality monitoring is to evaluate the current performance of the control measures in place in the construction sites. In the event that the water quality degrades for causes not attributable to natural causes, e.g. spillage of construction material in the river, HEC is responsible to improve the current technologies used or elaborate new strategies to limit degradation of the receiving environment.

The results of the analysis will be compared and benchmarked to:

- Pre-construction conditions.
- ANZECC Water Quality Guidelines for freshwater, for parameters that can affect aquatic life (Upland and lowland rivers in Tropical Australia (for physico-chemical stressors) and default guideline values for toxicity of metals; 95th percentile for species protection) (ANZWQG 2018).
- Australian Government, Australian Drinking Water Guidelines (ADWG) 2011 (updated March 2021).
- World Health Organization (WHO) drinking water guidelines (Fourth edition, 2022) for parameters that can affect domestic use.

International standards for water quality (as per ESIA 2019 and aforementioned guidelines).

Parameter	Trigger values (or range of acceptable values)	Reference
pH	6.5 – 7.9	ADWG and ANZECC
Conductivity	20 – 250 μ S/cm	ANZECC
Turbidity	2 – 15 NTU	ANZECC
Dissolved Oxygen	> 6 ppm	ANZECC
Oil and grease	Any detection is a sign of spills	N/A
Sulphate	< 250 mg/L	ADWG
Nutrients NH ₄ -N	< 0.006 mg/L	ANZECC
Nutrients NO ₃ -N	< 10 mg/L	WHO
Nutrient P _{tot}	< 0.01 mg/L	ANZECC
Faecal contamination – <i>E. coli</i>	0 MPN	WHO
Faecal contamination: total coliforms	<10 MPN	WHO

Parameter	Trigger values (or range of acceptable values)	Reference
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Note: Two sets of standards have been considered in line with the ESIA 2017. The river waters are used for bathing, washing (ANZECC) and drinking (WHO) hence these two sets of guidelines must be referenced. WHO guideline for example has no specific guideline values for Ammonia, Odour, etc., hence the ANZECC values are used in these parameters. The Two set of references are adopted, similar to ESIA 2017 to maintain uniformity.

Indicative values for treated sanitary sewage discharges (as per Wastewater and Ambient Water Quality provided in IFC General EHS Guidelines 2007).

Parameter	Guideline Value
pH	6 – 9
BOD	30 mg/L
COD	125 mg/L
Total Nitrogen	10 mg/L
Total Phosphorus	2 mg/L
Oil and Grease	10 mg/L
Total Suspended Solids	50 mg/L
Total coliform bacteria	400 MPN ^a /100 mL
Faecal contamination – <i>E. coli</i>	0 MPN
Faecal contamination: total coliforms	<10 MPN

^aMPN = Most Probable Number

International standards for groundwater quality (as per aforementioned guidelines).

Parameter	Trigger values (or range of acceptable values)	Reference
Total Dissolved Solids (TDS)	>300 mg/L	ANZECC/ADWG
Turbidity	<5.0 NTU	ANZECC/ADWG
pH	6.5 - 8.5	ANZECC/ADWG
Nitrate	< 10 mg/L	ANZECC/ADWG
Sulphate	< 250 mg/L	ANZECC/ADWG
Odour Test (Average 5 sniffers)	Acceptable	ANZECC/ADWG
<i>E. coli</i>	0 (MPN/100mL)	WHO
Total Coliform	< 10 (MPN/100mL)	WHO

PESTICIDES AND HEAVY METALS

Potential contamination of the Tina/Ngalimbiu River from sources non-related to the Project could consist of palm oil cultivation, Gold Ridge Mine and very limited sand and gravel extraction along the Ngalimbiu river conducted by local landowners. As per the ESIA 2019 requirements, a single monitoring event is to be carried out for pesticide chemical and metals related to mining activities to create a reference of water quality prior to construction commencement (refer below). HEC has since carried out the single monitoring event in December 2021. Further monitoring was completed in August 2022.

The aim of the single monitoring event is to create a reference of water quality for the parameters that are not likely to be affected from the construction activities. Results will be evaluated against the detection limits listed below.

Item	Campaign Requirements
Stations	Samples will be taken at two stations: <ol style="list-style-type: none"> 1) At Vuramali, approximately 10km downstream of the dam; 2) At Ngalimbiu bridge, approximately 20 km downstream of the dam.
Time of the Year	Before commencement of construction activities.
Effort per Monitoring Event	Sampling results to be recorded and appropriately stored within 24h from laboratory analysis completion.
Frequency	Single event.
Analysis	Pesticides in water such as Glyphosate CT, Basta, 2-4-D Amine, Ally (Metsulfuron Methyl), Kamba 500 Selective herbicide (present as the dimethylamine salt), Gramoxone Tropical (Paraquat). Metals in water such as, Nickel, Aluminium, Copper, Arsenic, Cadmium, Lead, Cobalt, Mercury, Silver, Zinc, and non-metal inorganics such as Cyanide. Bioaccumulated metals in fish flesh related to mining activities for the following metals: Silver, Arsenic, Cadmium, Cobalt, Copper, Mercury, Lead and Zinc.
Sampling Method	Sampling methodology for pesticides and metals is described in Section 3.4. Pesticides and heavy metal samples will to be sent over to ALS laboratory in Brisbane for Testing. HEC is currently liaising with ALS regarding available tests.
Data collation and reporting	Data to be presented in tabular and graphical form in the three monitoring E&S Monitoring Report

Detection limits of pesticides.

Pesticides	Detection Limits
Glyphosate CT	<p>The limit of determination in water is reported to be 1.2 µg/litre as in drinking water quality</p> <p>Reference: WHO WHO/SDE/WSH/03.04/97</p>
BASTA (active ingredient: glufosinate-ammonium)	<p>LD50 (mg/kg bw) / LC50 431 mg/l in oral route in mammals.</p> <p>Reference: GLUFOSINATE-AMMONIUM First draft prepared by G. Wolterink , C.M. Mahieu1 and L. DaviesCentre for Substances and Integrated Risk Assessment, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands and Australian Pesticides and Veterinary Medicines Authority, Kingston, ACT, Australia</p>
2-4-D Amine	<p>Generally, in surface waters contents should be below <0.1 µg/litre, in view of the relatively rapid biodegradation of 2,4-D in the environment.</p> <p>Reference: IPCS (1984); WHO WHO/SDE/WSH/03.04/97</p>
Ally (Metsulfuron Methyl)	<p>The detection limits for MSM are 0.40 µg L⁻¹ to be significant in the environment.</p> <p>Reference: Springer, V. H., & Lista, A. G. (2010). A simple and fast method for chloresulfuron and metsulfuron methyl determination in water samples using multiwalled carbon nanotubes (MWCNTs) and capillary electrophoresis. Talanta, 83(1), 126-129.</p>
Kamba 500 (selective herbicide, present as the dimethylamine salt)	<p>Generally, in surface waters contents should be below <0.1 µg/litre, in view of the relatively rapid biodegradation of 2,4-D in the environment</p> <p>Reference: IPCS (1984); WHO WHO/SDE/WSH/03.04/97</p>
Gramoxone Tropical (Paraquat)	<p>0.68 µg L⁻¹ Method Detection level for environment</p> <p>Hodgeson, J. W., Bashe, W. J., & Eichelberger, J. W. (1997). Method 549.2: Determination of Diquat and Paraquat in Drinking Water by Liquid-solid Extraction and High Performance Liquid Chromatography with Ultraviolet Detection. United States Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory.</p>

Detection limits of metals

Item	Detection Limits and Methodology (EPA)	Default guideline value for toxicity in freshwater (ANZWQG 2018); 95 th percentile species protection
Aluminum	3050A/6010A; U.S. EPA (1993a) Detection Limit 50 mg/L	0.055 mg/L (where pH >6.5)
Arsenic	7061; 7060A; 3050A; U.S. EPA (1993a); PSEP (1990a); EPRI (1986) Detection Limit 5.0 mg/L	0.024 mg/L (AsIII)
Cadmium	3050A; 6010A; 7131A/7130; U.S. EPA (1993a); PSEP (1990a) Detection Limit 0.3 mg/L	0.0002 mg/L
Cobalt	7201 Detection Limit 0.1 mg/L	0.0014 mg/L*
Copper	3050A/7211; 7210; 6010A; U.S. EPA (1993a); PSEP (1990a) Detection Limit 5.0 mg/L ^b	0.0014 mg/L
Lead	3050A/7421; 7420; 6010A; U.S. EPA (1993a); PSEP (1990a) Detection Limit 5.0 mg/L	0.0034 mg/L
Mercury	7471; U.S. EPA (1993a) Detection Limit 0.2 mg/L	0.0006 mg/L (inorganic)
Nickel	3050A/6010A; 7521; 7520; U.S. EPA (1993a); PSEP (1990a) Detection Limit 5.0 mg/L	0.011 mg/L
Silver	3050A/7761; 7760; U.S. EPA (1993a); PSEP (1990a) Detection Limit 0.2 mg/L ^c	0.00005 mg/L
Zinc	3050A/7951; 7950; U.S. EPA (1993a); PSEP (1990a); PSEP (1990a) Detection Limit 15 mg/L	0.008 mg/L ^d

^a Less than 1/10 of available sediment guidelines for screening concentrations or potential adverse effects, but still cost effective and feasible to attain with a range of routine analytical methods

^b No sediment screening or adverse effects guidelines are available for comparison

^c TDL may restrict use of some routine analytical methods, but reflects work group consensus

^d Figure may not protect key test species from chronic toxicity (this refers to experimental chronic figures or geometric mean for species)- check Section 8.3.7 for spread data and its significance in ANZECC 2000.

Note: United States Environmental Protection Agency (EPA), QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluation – Chemical Evaluations. April 1995.

ANZWQG 2018 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, updated 2018,

*ANZWQG 2018 default guideline value for Cobalt is not a 95th percentile default guideline value; the percentile for species protection is unknown