Mamara New Capital City Development Phase 1

Environment Impact Statement (EIS)

Chapter 8: Freshwater Biodiversity Assessment

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1 INTRODUCTION

1.1 Background

It is obvious that the Solomon Islands Government's policy to drive decentralizing of its development, authority and presence is taking shape in the development of the Mamara New Capital City for the Solomon Islands. It is a policy that the government want to providing avenues for improving socio-economic platforms for the local-rural communities in Solomon Islands. This is also grown out of the opportunities arising from the challenges of Honiara in terms of infrastructure and township functions.

The concept and agreement to develop the New Capital City has a long history which is tied within the provision and agreement of the Mamara-Tasivarongo-Mavo Development Agreement, Law of Solomon Islands Chapter 145. This Mamara New Capital City Project is one of the national partnership projects with a developer who will develop and build the City and over a short time

The location between the Poha River and Mamara River was selected for the New Capital City Project which is 7 kilometers from Honiara. Given the significance of the area in terms of popularity and recreation a considerate planning and design of infrastructure would add value to the natural resources at the site. The Ministry of Commerce do engage local experts to conduct EIA and prepare an EIS report.

The ESIA findings are inconclusive on the project impact on fish and their habitats. Therefore, a proper research approach is recommended to devise an effective mitigation plan with proper review of past studies and publications to validate the freshwater flora and fauna.
The following areas require further analysis:

i. Collection of quantitative data on migratory populations that reflect significance of Mamara and Poha Rivers
ii. Establishing a regional approach to assess the impact on aquatic populations over a wider geographical area than the Tina River catchment.
iii. Recommend mitigation measures and explore the pros and cons of these measures.

The areas listed above needs to be explored before a mitigation plan is developed

1.2 The Scope of work

The focus of this studies would be on the freshwater biodiversity with considerations to the social and economic context of the area. The baseline studies for the freshwater fauna of Mamara and Poha Rivers includes;

- A review of any existing literature on the distribution in catchments throughout Guadalcanal and other parts of Solomon Islands. The migratory aquatic fish identified in the Mamara and Poha Rivers are then checked again these species.
- A description of a rapid survey methodology for identifying the presence of Mamara and Poha freshwater biodiversity and evaluate their habitats and presence.
- Recommendations on a monitoring program to manage these biodiversity and habitats.
- An analysis of the extent to which Mamara development will impact on the freshwater biodiversity.

1.3 Solomon Islands and the Guadalcanal

Guadalcanal is one of the largest islands (by area) in Solomon Islands and hosts the capital of Solomon Islands and most of Solomon Islands' state functioned developments. The islands is also the second by population after Malaita Island.

Guadalcanal Islands is known of its dense rain forest and has the most mountainous region in its interior that reaches to over 2000 meters above sea level (masl) creating a unique river morphology and biodiversity. This unique environment enables the island to host some of the endemic flora and fauna for Solomon Islands given it vast land features from its beautiful glossy seas, lowland rivers, and streams to the mountains. Given so many studies were conducted in marine and coastal and terrestrial ecologies very little studies were conducted for freshwater ecology especially on freshwater fish of Solomon Islands. The first recorded and published work on freshwater and brackish fish was done by Gray in the mid-70s (Gray 1974) which represents the Guadalcanal Island and the Solomon Islands as a whole.

A second study on Guadalcanal for freshwater ecology and fish was conducted as a part of an ESIA study to fulfill government's environment safeguards. The study was conducted for the major mining development that took place at Gold Ridge, Central Guadalcanal plains. Guadalcanal studies conducted for on freshwater ecology and fish were and reported and published from the Gold Ridge Projects, 1990, 1995, 2003 and 2006, Tina River System by Entura in 2010 and Tina River Hydro Development Project ESIA Report 2015).

In September 2015, a study on mountainous freshwater ecology of headwater catchments were also conducted which documents a total of nine fish species that composed of two eel fish species, six goby species and a Ryacichthys species.

In 2016 a detailed study was conducted as part of another ESIA baseline water quality and aquatic ecology downstream of the Gold Ridge Mining. A total of 36 species from 23 genus and 14 families of freshwater fish fauna was documented from Metapona River, Tinahulu River, Kwara River, Chovohio River, and Charivunga River. Other aquatic studies includes rapid aquatic survey of freshwater biotas of Solomon Islands, a baseline study on the Islands of Tetepare based on available literature, a study of, Choiseul Mt Maetambe corridor assessment documenting the flora and fauna of both freshwater and terrestrial biota.

Based on the freshwater fish fauna compiled from the review studies, a validating process was conducted to establish freshwater fish fauna of Guadalcanal as describe in a report by Boseto and Hevalao (2016). The list is hereby present.

1.3.1 Guadalcanal Fish List

Table 1 shows all reviewed and validated freshwater and brackish water fish found in Guadalcanal and Solomon Islands. This is based on update review of fish taxa and extension of fish distribution and within published documents presented in this report. The fish list is arranged following fish family list;

	Source	Gray 1974	Polhemus et al 2008		Golder Assoc 2009		Jenkins and Boseto	Entura 2011	BRLi, RS Hevalao and TRHDP ESIA Report 2015		Guadalcanal Expedition 2015	David 2016	David TB and Robson SH, This study March 2016		IUCN Red List Status
	Sampled Area	Guadalcanal	SI	SI	Ngalimbiu	Matepono	Tetepare	Upper Catchments of Tina River	Chovohio, Kwara, Tinahulu, Metapona	Tina	Upper Catchments of Tina River	Chovohio, Kwara, Tinahulu, Metapona	Lungga River	Mbarande River	
	Year	1974	Nov 2004 to March 2005	July – Aug 2006	1998 - 2006	1998 to 2006	Sept 2006	Septr2015	March 2016	July 2014	Septr2015	March 2016	Mar 2016	Mar 2016	
Family	**Species**														
Carcharhinidae	*Carcharhinus melanopterus*													*x*	NT
Megalopidae	*Megalops cyprinoides*	*x*					*x*								DD
Anguillidae	*Anguilla marmorata*	*x*	*x*	*X*	*x*	*x*	*x*	*X*	*x*	*x*	*x*	*x*	*x*	*x*	LC
	Anguilla megastoma							*x*			*x*				DD

Muraenidae	*Gymnothorax polyuranodon*	*x*	*x*		*x*	*x*	*x*			*x*			*x*		LC
Ophichthidae	*Lamnostoma kampeni*								*x*			*x*			NA
	Scolecenchelys macroptera	x								x					NA
Chanidae	*Chanos*	x					x								NA
Poeciliidae	*Poecilia reticulate*					X									NA
	Gambusia holbrooki					X	x		*x*	x		*x*			LC
Hemiramphidae	*Hemiramphus far*	x													NA
	Ryncorhamphus georgii	x													NA
	Zanarchopterus dispar		x							x					NA
	Zenarchopterus sp?						x			x					
Syngnathidae	*Microphis manadensis*	x			x	X				x				*x*	NA
	Microphis brachyurus	x	x												NA
	Hippicthys spicifer	x													LC
	Hippicthys heptagonus	x													LC
	Microphis leiaspis		x		x	X				x				*x*	LC
	Microphis retzii	x	x		x	X			*x*	x		*x*		*x*	NA
	Microphis sp			X			x								

Tetraro gidae	*Tetraroge niger*								*x*			*x*			LC
Ambas sida	*Ambassis interrupta*								*x*			*x*			LC
	Ambassis macracanthus	x				X									DD
	Ambassis miops		x	X		X	x		*x*			*x*			LC
Serran idae	*Epinephelus polystigma*						x								DD
Terap ontida e	*Mesopristes argenteus*	x	x	X			x			x					LC
	Mesopristes cancellatus		x	X	x	X	x			x					LC
	Terapon jarbua	x		X			x			x					LC
	Amniataba caudavittata	x													NA
Kuhliid ae	*Kuhlia marginata*	x	x	X	x	X	x		*x*	x		*x*	x		LC
	Kuhlia rupestris		x	X	x		x		*x*	x		*x*			LC
Apogin idae	*Yarica hyalosoma*	x					x			x					LC
	Fribramia latralis						x								NA
	Apogon sp			X						x					
Caran gidae	*Caranx papuensis*		x				x								NA
	Caranx sexfasciatus			X		X			*x*	x		*x*	x		LC
	Caranx Ignobilis	x													NA
	Caranx sp?									x					

	Scomberoides sp?						x			x					
Leiognathidae	*Leiognathus equulus*												x	*x*	LC
Lutjanidae	*Lutjanus argentimaculatus*	x	X	x		X	x		*x*	x		*x*		*x*	NA
	Lutjanus monostigma	x													NA
	Lutjanus fusenscens		X	x						x					NA
	Lutjanus fulvus						x								NA
	Lutjanus vitta									x					NA
Gerreidae	*Gerres oyena*												x		NA
	Gerres sp?									x					
Polynemidae	*Polydactylus* sp						x								
Mullidae	*Upeneus vittatus*												x		NA
Toxotidae	*Toxotes jaculatrix*	x	X		x										LC
Monodactylidae	*Monodactylus argenteus*	x					x								NA
Mugilidae	*Crenimugil crenilabis*						x		*X*			*x*	x	*x*	LC
	Chelon planiceps				x	X				x				*x*	NA
	Ellochelon vaigiensis						x			x					LC

	Moologarda seheli								*X*			*x*	x	*x*	NA
Cichlidae	*Oreochromis mossambicus*				x	X			*X*	x		*x*		*x*	NT
Rhyacichthyidae	*Rhyacichthys cf guilberti*							x	*X*		x	*x*		*x*	DD
Eleotridae	*Belobranchus segura*								*X*			*x*		*x*	NA
	Belobranchus sp.								X			x		x	
	Bunaka gyrinoides								*X*			*x*			LC
	Butis amboinensis		X			X				x					LC
	Butis butis								*X*			*x*			LC
	Eleotris fusca	x	X	x	x	X	x		*X*	x		*x*			LC
	Eleotris melanosoma						x							*x*	LC
	Hypseleotris guentheri	x			x	X	x								NA
	Hypseleotris sp.		X	x											
	Giuris hoedti		X	x			x		*X*			*x*		*x*	NA
	Giuris magaritacea						x		*X*	x		*x*		*x*	NA
	Ophiocara porocephala						x			x					LC
Gobiidae	*Glossogobius illimis*				x	X			X			*x*	x	*x*	NA
	Glossogobius sp. 1		X	x			x		x	x					

\Gobinae	*Glossogobius* sp. 2		X							x					
Gobiidae	*Awaous guamensis*			x					x			*X*			LC
	Awaous melanocephalus				x	X				x					NA
\Gobinellidae	*Awaous ocellatus*				x	X	x		x			*X*			NA
	Awaous sp?		X	x				x		x					
	Redigobius chrysosoma					X	x								LC
	Redigobius bikolanus		X				x	x	x						LC
	Redigobius leptochilus		X					x							NA
	Redigobius tambujon								x	x					LC
	Redigobius sp?			x					x						
	Schismatogobius marmoratus		X						x						NA
	Schismatogobius sp?						x		x	x					
	Stenogobius hoesei		X						x						LC
	Stenogobius sp?		X	x			x	X	x	x		*X*			
Gobiidae \Sicydiinae	*Lentipes multiradiatus*		X	x					x	x					NA
	Lentipes sp.							x	x	x					

	Lentipes solomonensis		X												DD
	Lentipes nov n. sp.										x				
	Lentipes kaaea										x				LC
	Sicyopterus lagocephalus		X	x			x	x	x	x	x	*X*	x	*x*	LC
	Sicyopterus longifilis		X		x	X	x		x	x					DD
	Sicyopterus sp.		X	x			x								
	Sicyopterus cyanocephalus				x	X				x	x	*X*	x	*x*	DD
	Sicyopterus stiphodonoides										x	*X*			NA
	Sicyopterus sp 1 (Blue colored)											*X*		*x*	
	Sicyoptuerus sp 2 (Yellowish Color)											*X*		*x*	
	Smilosicyopus fehlmanni		X					x	x						LC
	Sicyopus zosterophorum		X	x		X			x	x	x				NA
	Sicyopus discordipinnis		X					x	x	x					DD
	Sicyopus sp		X						x	x					
	Stiphodon surrufus		X					x	x	x					V
	Stiphodon pelewensis		X					x	x	x		*X*	x	*x*	DD
	Stiphodon rutilaureus		X	x			x	x	x	x		*X*			LC

	Stiphodon semoni		X	x	x	X		x	x	x		X	x	x	DD
	Stiphodon sp.				x	X	x			x					
Gobiidae \Oxudercinae	*Periophthalmus argentilineatus*											*X*			NA
Scatophagidae	*Scatophagus argus*	x		x		X	x								LC
Siganidae	*Siganus vermiculatus*	x							(x)						LC
Sphyraenidae	*Sphyraena forsteri*											X			NA
Tetraodonidae	*Arothron immaculatus*	x													LC
	Arothron reticularis	x													LC
	Chelonodon patoca	x													LC
Antheneridae	*Antennarius biocellatus*	x													NA

2 METHODOLOGY

2.1 Approaches

Sampling was conducted from the river mouth, upstream at each site, around accessible fish habitats. The fish and crustacean specimens collected were kept alive in a plastic water buckets while sampling proceeded. The start and end time were recorded for each site. Specimens that required further taxonomical identification were retained for further examination, and the remainder of the catch were released into the stream.

2.2 Methodology

2.2.1 Study Site Selection

Seven sites were selected and surveyed during this survey. Two survey sites on Poha River downstream due to the river dry season. Five survey sites on Mamara River.

Sampling was conducted using dip nets and seine net were used to collect specimens. This style of sampling is restricted to use in areas of wading depth (to about 1.1 m). Apart from electro fisher the nest was also effective in riffles and snags, and under bank overhangs. Sampling tended to be concentrated in such areas and this will have influenced the species set collected at each site.

Poha River

Table 2 shows the stations in Poha River

No	Site Code	River	GPS Reading	Altitude (m)	Comment
1	PoS1	Poha	-9°24'50.04"S 159°53'41.01"E	5	Bottom river, estuary area
2	PoS2	Poha	-9°24'43.52"S 159°53'45.81"E	6	Bridge location

Mamara River

Table 3 shows the Mamara station and location surveyed

No	Site Code	River	GPS Reading	Altitude (m)	Comment
1	MaS1	Mamara	-9°24'8.62"S 159°53'23.01"E	6	Bottom water at coastline
2	MaS2	Mamara	-9°24'10.87"S 159°53'21.93"E	10	Bridge area
3	MaS3	Mamara	-9°24'12.61"S 159°53'19.02"E	13	Plant overgrowth areas, dominated by water plants
4	MaS4	Mamara	-9°24'28.97"S 159°53'18.10"E	16	Water cress farm upstream
5	MaS5	Mamara	-9°24'41.82"S 159°53'7.62"E	40	Water source

3 FINDINGS

3.1 Summary of trip

The freshwater team was deployed to the proposed New Capital City on 29th July 2020. The focus to conduct a detailed study of the Poha River and the Mamara rivers, identify local fauna of the rivers, describe types of freshwater habitat in the area and provide mitigation and management measures therein to be considered.

At Mamara Rivers the team travelled a total of 1.66 kilometers from the river mouth. Unlike at Poha River the team travelled a total distance of 630 meters but due to the dryness it is recommended if any assessment be done on wet season also.

At 0900am the team set off from Honiara the study rivers, at Mamara River and Poha River. Unexpectedly the team meet up with some community members within the Poha-Mamara vicinity. The team were able to conduct brief awareness on the development and its impact to the livelihood if considered. Such development can be fatally life threatening or brings good fortune to the local community and Solomon Islands as a whole.

Most concerned from the local community is the risk the development might pose to their local livelihood. The community mentioned that most of their basic livelihood comes from the two rivers. For example, Mamara River is their water source, which. They had to travel several kilometers to fetch for water. At Poha River, small post-larval or fish juveniles locally known as *manda* on certain time of the year brings food to the table all this if not considered is really a concern.

The trip went successful with the local community members support to access the areas the team wishes to visit. The results of the of the freshwater fauna are mentioned in this report.

3.1.1 Types of freshwater habitat

The team observed various habitat on which freshwater are found present. Generally, this habitat affects fish composition within rivers. There are four (4) major habitats that were identified in the two rivers.

Pool, depth of over 1 meter

During the field trip the team observed that pool habitat of more than 0.5 to 1 meter are common in Marara River. The velocity ranges from 0.2 to 0.5 m/s. Unlike Poha River it is undergoing its dry season cycle having some areas of the channel a completely dry. Rich fauna is also found in this habitat; eels, Tilapia, jungle perch and gobies. The substrate is quite diverse from dominated by gravel, muck muddy and silt.

Riffles and running habitat

It is common to find lengthy stretch of rivers have riffles and running river parts. This true for Poha River however, the normal cycle of dryness from mid-year to late November has demonstrated no riffles and running habitat. Mamara River due to its steepness and rapid change in its elevation has this habitat. This riffle and running habitat velocity ranges from 0.5 meters to about 1 meters/second. This habitat's substrates are dominated by pebbles, cobbles, and gravel, naturally shivered by the flow and gravity of water column. Mainly fauna found in this habitat were mainly of gobies, grunters, tilapia, and some marine juveniles of *Lutijanuas spp* and *Caranx spp*.

Shaded holes and overgrowth habitat

This habitat creates a range of microhabitat that fish, snails, and other invertebrates a found present. There is fauna found to prefer overgrowth and some to prefer exposed areas. This habitat has its velocity flow controlled and the temperature seems stable with little sunlight penetration. This overgrowth, grass and legumes growing into the river side or growth of paragrass (*Brachiara spp*) freshwater plants, watercress (*Nasturtium spp*), water lily plants and *Eichhonia spp* which is dominated in Mamara River. The substrate is mainly of muck muddy, sand-silt and gravels. The fauna found in this habitat are mainly, tilapia, eels, freshwater prawns, and freshwater crabs.

Estuary habitat

This is found at the lower reach of the rivers. The velocity of such areas is nearly to stilt due the influence of the ocean (where dense and less dense medium met). The salinity can more seawater and can be more freshwater depending on the steepness of either medium. Poha River has more exposed region of this habitat. The substrate is dominated by settling silts, clay, gravel and muddy. At Mamara River, the sandy areas are dominated by limestone sediments and coralline gravels. This area is very diverse and mostly dominated by large predators; eels, mullet, tilapia, crabs, and other marine faunas.

Mamara/Poha under bridge habitat

The bridges of Poha and Mamara are representation of artificial habitat. At Poha River the bridge the post within the river had establish an aggregating medium where fish, snails and crabs are found also. At Mamara River creates a micro-habitat of shady-dark, hollow and pool area where larger and mature fish find refuge in. As observed the team found mature and large tilapia, eels, grunters, jungle perch, freshwater prawns, and crabs.

3.2 Freshwater Fauna

This section describes the fauna found in Poha and Mamara Rivers.

3.2.1 Poha-Mamara Fish (vertebrates) list

Table 4 shows the fish present and observed and likely to be present but not observed

	Sampled Area	**Poha River**	**Mamara River**	**Poha River**	**Mamara River**
		Confirmed present	***Confirmed Present***	***Probably present***	***Probably present***
Family	**Species**				
Anguillidae	*Anguilla marmorata*		X	X	
Muraenidae	*Gymnothorax polyuranodon*			X	X
Carangidae	*Carangoides malabaricus*		X	X	
	Caranx sexfasciatus		X		X
	Scomberoides sp?			X	
Cichlidae	*Oreochromis mossambicus*	X	X		
	Sarotherodon occidentalis		X		X
Hemiramphidae	*Zanarchopterus dispar*	X			
Syngnathidae	*Microphis manadensis*			X	X
	Microphis retzii		X		
Ambassidae	*Ambassis miops*	X	X		

Terrapontidae	*Mesopristes argenteus*			X	
	Mesopristes cancellatus		X		X
	Terapon jarbua		X	X	
Kuhliidae	*Kuhlia marginata*	X	X		
	Kuhlia rupestris	X	X		
Lutjanidae	*Lutjanus argentimaculatus*	X	X		
	Lutjanus fusenscens	X			
Mugilidae	*Crenimugil crenilabis*			X	X
	Valamugil seheli		X		
Poeciliidae	*Gambusia holbrooki*			X	X
Rhyacichthyidae	*Rhyacichthys guilberti*			X	X
Eleotridae	*Butis amboinensis*			X	X
	Belobranchus	X	X		
	Eleotris fusca	X			X
	Giuris hoedti			X	X
	Giuris magaritacea			X	X
	Ophiocara aporos			X	X
	Ophiocara porocephala			X	X
Gobiidae	*Awaous guamensis*			X	X
	Awaous melanocephalus	X			
	Awaous ocellatus			X	
	Lentipes multiradiatus			X	
	Redigobius bikolanus		X		X
	Redigobius tambujon		X		X
	Schismatogobius marmoratus			X	X
	Stiphodon pelewensis		X		
	Stiphodon semoni	X	X		
	Stiphodon surufus	X			
	Stiphodon rutilaureus	X			

3.2.2 Invertebrates (freshwater snails)

Table 5 shows the freshwater snails collected during the field work.

	Sampled Area	Poha River	Mamara River	Poha River	Mamara River
		Confirmed present	Confirmed Present	Probably present	Probably present
Family	Species				
Neritidae	*Septiria porcellana*	X	X		
	Neritina pulligera		X	X	

	Clithon bicolor		X	X	
	Clithon spp		X	X	
	Neritina canalis		X	X	
Thiaridae	*Mellanoides plicaria*	X	X		
	Thiara spp	X	X		

4 ANALYSES

4.1 Freshwater fauna endemism

Most of the fish species recorded from this survey are native species. Depending on their environment and aquatic morphologies the fish are nearly present in any streams in the Solomon Islands. Only one always confused with Tilapia is found to be present in Mamara. The species is found throughout the Mamara River from the lower reaches to the upper reaches near to the source.

There are other species interested to be compared in this study with the northern basin rivers of Guadalcanal. It is interestingly that some species like the *Lentipes kolobangara* that is recorded at the upper catchment of Tina River (Mbeambea River-a tributary of Tina River at the altitude of about 750 meters an endemic species that is newly discovered in the Solomon archipelago especially on the islands of Guadalcanal, Kolobanagara (Western Province) and Choiseul (Keith et al 2016).Commonly such endemism is linked or associated to natural vegetation cover and unmodified flow of the river. It is to understand the function of river-forest system. It is clear the such system has stable condition of river flow, depth, temperatures, and well-oxygenated water thus the trophic system is well functioned.

4.2 Migration pattern and lifecycle

All the species identified in this report have migration patterns and lifestyle attached or adapted with the freshwater and the ocean. Apart from *Khulia spp*, *Anguilla spp*, some grunters (catadromous fish) the fish list is dominated by amphidromous fish species. These species spawn in clean upstream of freshwater, embroys drfts downstream during high water flows where they undergo a planktonic phase post-larva or *mada* (pronounced as *manda*) in Guadalcanal language) for over 100 days before returning to rivers (any rivers) to grow and reproduce depending on the rivers physio-chemical conditions.

4.3 Poha and Mamara River studies and documentation

Previous studies have provided a baseline data for the fish species documented on estuarine and freshwater systems in the Solomon Islands (Table 1). The studies on Gold Ridge rivers, the Tina River Catchment in 2010, 2013 and 2014 have recorded a total of 76 species from 35 genus and 18 families. The number of the fish species recorded were based on under water observations and fish photographic during snorkelling.

An in-depth reviewed of the fish recorded on the ESIA 2015 was carried out through in-depth literature, taxonomic analyses and validation and fish database verification. This is to update the correct representation and differentiate fish species in the Solomon Islands apart from other locations. Furthermore, the review provides the valid species name and the fish distributions as reported on Table 2.

Based on the in-depth literature and taxonomic reviews, a total of 24 valid fish species from 23 genus and 15 families were confirmed for the Poha and Mamara River (Table 4).

4.4 Threats to aquatic habitat and fauna

It is obvious that physical and chemical alteration of the natural habitats and the physical conducive parameters will become a major threat to the freshwater fauna during the clearing and construction phase of the project.

The clearing of trees and the removal of the topsoil will lead to high sedimentation entering the river system. Sedimentation and suspended solids will finally enter estuaries and into the sea.
It is already known that poor agricultural, eco-friendly development and mining practices often result in erosion of soil and increased turbidity which may disrupt feeding success of fishes and other aquatic fauna (Gratwicke *et al*., 2002). Such poor practices have been document in the tropical Pacific and the adverse negative effect on the aquatic fauna was shown to be extremely drastic (Boseto 2006, Haynes 1999 and Jenkins *et al.* 2010). Low bridges, blockages from high piles of wastes or weirs reduce or block flow to an extent of lower reaches of waterways can no longer support aquatic life and migratory species such as eels and amphidromous species resulting in loss of their migratory paths and cannot complete their life cycles (Berkamp *et al*., 2000). Loss of aquatic habitat through development can cause a major loss to the biodiversity of the local area that has been affected. In this case the potential negative effect of high sedimentation runoffs will affect the habitats.

4.5 River morphology shift and changes

Loads of sediments disposed through runoffs or due to clearing of vegetation that controls such will change the riverbed and river structure. It is likely that sediments will settle on the riverbed covering food source for natural fauna growing on substrates in the river. This would mean no fresh algae for some fish to eat which will drive the aquatic life (fish, prawns, and snails) away.
Furthermore, sedimentation will cause water to become muddy and dirty and in turn will affect aquatic fauna in terms of their impairing visual, feeding and reproduction ability. Sediment loads over natural threshold capacity of rivers may also impact aquatic fauna by settling on the riverbed and other surfaces that are potential egg nesting sites. Finally, there is a potential for the river to dry up.

4.6 Water chemistry

The removal of topsoil and some core soil will lead to the introduction of new trace metal into aquatic systems. Eventually lower oxygen level of the water increases dissolved salts from soil degradation, high nutrients content, expecting greenhouse emissions (methane and carbon dioxide) in addition to temperature and turbidity. Such will have significant impacts on the organism compositions. Other publications had mentioned that natural decompositions can take decades or even centuries to rejuvenate. In addition, the use of heavy machinery for digging is likely to result in excessive hydrocarbons leaching into aquatic systems which will greatly affect physical water parameters. Once water chemistry is altered by a certain degree it will affect the survival, breeding and feeding of any aquatic fauna that can lead to massive mortality (Jenkins, 2009) or algal bloom.

4.7 Introduced species

The introduced fish species *Oreochromis mossabmbicus* was recorded in river systems in Guadalcanal since the 70s. However, a species always confused for Tilapia was identified, *Sarotherodon occidentalis*, it is known how this south African species is present in Guadalcanal. In this study *Oreochromis mossabmbicus* was found in pool and over shaded

areas and towards the ocean. It is clear that with such rivers being affected by uncontrolled or not monitoring programs, there will be a shift of fauna that will then affect livelihood of people depending on the rivers.
One thing for sure that despite any sort of threats that might cost losses to the native freshwater fish in the Tina catchment; the *Oreochromis mossabmbicus* will survive and populate the Guadalcanal river catchment. In the case of Tina River due to the depth, flow and gradient the *Oreochromis mossabmbicus* is far to present at the upper reaches, however if the flows are low (near to stagnant) and depth decreases there is high probability for this *Oreochromis mossabmbicus*, *Sarotherodon occidentalis* or other species (for example the mosquito fish, the *Gambusia affinis*).

4.8 Livelihood

Most of the aquatic species recorded from this survey form the basis of the food sources that the villagers in the surrounding villages depend on as their major protein intake. With growing dependency of easily available processed canned food most communities in Solomon Islands depend on processed food and on occasions take food from rivers or hunting. Based on the TRHDP ESIA report most of the people around Tina river catchment do not depend on their freshwater fisheries as source of protein. They only occasionally depended on the freshwater fishes. From interviews about the consumption of fish per day it is estimated to be about 300 grams per person per day as most of the protein were subsidized by processed tin food and Chinese noodles.

For such areas around Mamara and Poha Rivers this can be true, however this a situation where opportunities to create alternative ideas comes about. For example, venture into aquaculture given the government is prioritising a New strand tilapia into the country, Nile GIFT Tilapia.

Other ventures of opportunity are to mitigate water storage by increasing storage of water by tanks, bore holes, or set Mamara to be a water source but with strict mechanism of access and monitor.

5 IMPACTS AND MITIGATION MEASURES

Environmental impacts can have a direct impact on the environment, contribute indirectly to a larger environmental change. This section reviews the potentially impacts to the freshwater fauna of Poha and Mamara Rivers.

5.1 Potential Impacts

1. Increase turbidity and subsequent sedimentation into freshwater system due to construction of roads, vegetation clearing and earthworks.
2. Spillage of hydrocarbons and other potential contaminants from high machineries, vehicles during transportation or handlings of materials/substances into the freshwater ecosystem
3. Increase of nutrient enrichment to the freshwater system from storm water runoffs, wastes water discharges from residents
4. Introduction of freshwater pests from substances/materials transported or excavated during clearing and construction phases

5. Introduction of litter and waste into rivers, surface flow rivers and streams contributing to degradation of water quality
6. Further introduction of invasive species may be a threat to the local fish species in the area
7. Increase vulnerability of migratory fish species due to habitat loss and spawning areas or habitat been destroyed

5.2 Mitigation and management measures

5.2.1 Promote eco-friendly approaches to the project

It is recommended that to mitigate and manage these impacts is to have thorough impact assessment by identifying risks that might eventuate during the development phases. Mitigating the risk of the project design versus the environment is crucial.

5.2.2 Identify key areas

Another recommendation for minimising impacts would be to identify sensitive sites for example, fishing sites, recreational sites, washing sites, water fetching sites, freshwater farm sites and potential zones for other economic developments for example eco-tourism activities.

5.2.3 Introduce buffer zones

Promoting buffer zones to certain sites is one of the mitigation measures crucial for this development. For example, at a certain point use of machinery is controlled or restricted. By introducing buffer areas creates a barrier zones to sensitive indicated areas.

5.2.4 Monitoring plan

Development of Monitoring plans for various risks is crucial for this project. The monitoring helps developments to be environmentally considerate. The monitoring plan is an operational plan to be done periodically; monthly, daily, or bi-monthly. Such monitoring should include monitoring if there will be a disastrous situation. For example, during an algal bloom, flora and fauna shifts, presence of certain indicator species are absent.

5.2.5 Point source pollution management

This management approach is identifying areas of outlets where easy to monitor. For example, ordure, disposal suites, discharge pipes, drainage ditches. In this management, the sites are coordinated and monitored regularly at given time. It is the responsibility of the New Capital City developer to set such plans in their EMMP.

5.2.6 Poor soil management

Poor soil management is associated with clearing of vegetation, clearing of topsoil, excavation, transportation of earthen materials, stockpiling of spoil, when excess soils are generated although termed as spoil soil they can be used at another site. This includes soil use for reclamation, Garden Park, green zones, or areas in Honiara might need. Other ways include widen embankments where possible, land contouring, landscaping mounds, landscaping treatments and noise mounds (if required).

Objectives includes;

- Minimise the amount of spoil generated
- Classify the spoil generated using recognised guidelines and its geotechnical characteristics

- Maximise the beneficial reuse of spoil onsite and offsite
- Manage excavation, storage, transport reuse ad disposal of spoil to minimise impacts and meet environment requirements

5.2.7 Drainage and erosion control

This mitigation measure is to establish a standard principles and practices during the planning and all through the life of the project development. This mitigation will highlight the importance of design, construction, maintenance and management of storm water drainage, erosion control and water quality facilities within the New Capital City.

This plan will apply to drainage improvements within the New Capital City and its operations throughout the years.

5.2.8 Summary of impacts and mitigation measures

	Development Phase	**Potential impact**	**Potential impact on Freshwater Ecology and Fauna**	**Mitigation measures**
Pre-construction and Construction	Phase 1 Planning initiation	Stakeholders Laws and regulation		
	Phase 2 Pre-construction and Excavation	Pre-construction site investigations (hydrology, topographical, geological, and geotechnical surveys) Site clearing (access road, building sites, quarries, work areas) Construction of off-site facilities (work areas, storage facilities) Traffic movements (heavy haul trucks, heavy machinery, light duty vehicles) Increase ponds, ditches and waterlog areas Human activities	Increase in suspended solids and siltation River pollution (oil, contaminant residues, infectious diseases, hazardous substances) Disturbance of aquatic habitats and aquatic life Disturbance of water uses Cumulative runoffs from cleared sites Changes in sediment dynamics downstream	Develop an Environment Management and monitoring Plan based on baseline data collected Pre-project physio-chemical and bacteriological water quality tests Identify significant and important sensitive area and bio indicator species for the project's development Identify standards for turbidity tests (TSS and TSD) from WHO water quality standards Develop a response plan to opportunity loss due to the development to address for example

		Petroleum storage facilities	creating blockades or barriers for aquatic migratory fish species Degradation of aquatic habitat Increase of water vector-borne diseases for example, malaria, hepatitis B etc... Spillages or leakages of fuel, oil, and other hazardous substances	water usage in the rivers Waste and Environmental Health program to promoted during the phases of development Forest management plan, focusing on rehabilitation, recreational sites, parks etc.
	Phase 3 Construction of facilities and infrastructure	Clearing of work sites On-site maintenance and work areas Building of houses and facilities towards supporting the development Building road access Changes in hydrology Human and activities increase in the projects site	Increase in suspended solids and siltation Impact on trophic resources i.e. flow of food within the freshwater system Increase solid wastes Increase of water vector-borne disease Water quality degradation Overfishing Increase invasive species in the area due to ecology or habitat shift	Prevent soil eroded from the project sites by encouraging sediment containment materials or using sumps Point source pollution management Spoil soil management Establish an environmental auditing program

Operations	Phase 4 Commissioning and Operations	City functional activities eventuate Human increasing to populate the area River pollution Rehabilitation	River pollution Increase sedimentation and siltation Disburdens on amenity values in the reduced access to livelihood sourced areas Changes in sediment dynamics from nearby clearance and development Water no safe to use due to pollution	Prevent soil eroded from the project sites by encouraging sediment containment materials or using sumps Point source pollution management Spoil soil management Establish an environmental auditing program Providing river-based supply with appropriate treatment systems and supply points for each village; Providing rainwater collection and storage tanks; Establishing alternative supplies from local streams, and; Providing borehole / ground water supplies, piped to several villages / hamlets. Transportation and distribution of clean water will be done by tanker truck on a regular basis. Restocking native Tina River fish into the reservoir to maintain a viable population, if successful, will reduce potential residual impacts to a level where they could be considered not significant, notwithstanding that

				the species assemblage will change.

6 CONCLUSION

The freshwater ecology and fauna of Mamara Rivers are significantly intact, however the Poha downstream is largely degraded and recent lack of rain has made it largely dry. Given the developments plan in the area there will be some impacts on the Mamara river as it will be harnessed for drinking and bottling.

It is the commitment of the Mamara New Capital City developer and the Government to harness and ensure the freshwater are protected and continue to give livelihood support to both the local community and the project as well.

The freshwater survey also observed that the Mamara river is very important for the livelihood of the community and settlers around the project site. The recommended mitigation measure will ensure that the river is protected and functioning. Most important is the proposal to establish the Mamara river nature reserves and the buffers zones for the riverbank. These will go a long way to maintain the freshwater biodiversity, habitats, and ecosystems and thus the quality of the water.

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