Appendix 9: Marine Ecological Assessment

Environmental Assessment Document

TA No: 6597 REG: Sustainable Capacity Development for Safeguards in the Pacific

Solomon Islands Urban Water Supply and Sanitation Sector Project

September 2022

Marine Ecological Assessment



Prepared by Marine Ecologist Specialist

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Acronyms

ADB	Asian Development Bank
cm	Centimeters
EIS	Environmental Impact Assessment
FD	Free Diving (sites)
GHA	Greater Honiara Area
GoSI	Government of Solomon Islands
GPS	Global Positioning System
km	Kilometers
m	Meters
MES	Marine Ecology Specialist
NRH	National Referral Hospital
SCUBA	Self Contained Underwater Breathing Apparatus
SD	SCUBA Diving (sites)
SPS	Safeguard Policy Statement - ADB
SW	Solomon Water (Solomon Island Water Authority)
TOR	Terms of Reference
UWSSSP	Urban Water Supply and Sanitation Sector Project

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1.0 EXECUTIVE SUMMARY

The Asian Development Bank (ADB), World Bank (WB), European Union (EU) and Solomon Islands Government (the government) have financed the Solomon Islands Urban Water Supply and Sanitation Sector Project (UWSSSP). The project will be implemented in a number of phases up until 2050. One of the component/Subprojects of the UWSSSP is the Honiara Wastewater Project which focuses on replacing existing waste water outfalls in a state of disrepair with new ones, installing sewers mains to expand and rehabilitate Greater Honiara Area (GHA) trunk Sever system and construction of new sewage pumping stations and rehabilitation of existing ones.

The sewer network will consist of a mixture of gravity mains and rising mains, together with a number of land-based pump stations that will be installed with two new outfalls. The works will allow the disconnection of over 14 existing short outfalls into the Mataniko river and foreshore areas of Honiara City. The subproject will include laying of 15.0 km of pipes split between gravity main (12.6 km) and rising main (2.4 km), ranging from DN200 to DN700 and constructed as PVC/HDPE, abandoning and bypassing the existing Point Cruz pumping station (PS) by installing a new gravity main to connect into the Central Markets PS, and the construction of four small PS. It will also include the construction of two outfall pumping stations (PS Ranadi Landfill and PS National Referral Hospital - NRH) that will pump the effluent into the ocean through two possible outfall pipes with an internal diameter of 400 mm and 800 mm respectively and a length of 500m for Ranadi and 350 m for NRH sites. These two outfalls will discharge into water depths of 40 m and 12 m respectively. Additional connections will include new sewered areas and also the communal septic tanks outfalls at Tuvaruhu and Vara Creek along the Mataniko River.

As part of the projects safeguard team, a Marine Ecology Specialist (MES) working directly with the project's Environmental Safeguards team was engaged to undertake a marine assessment of the marine benthic habitats and ecosystems associated with the two proposed new waste water outfall discharge pipelines scope of works. This report details the marine assessment findings, potential environmental impacts and recommended mitigation options.

A marine biological baseline assessment was undertaken on the coastal and marine biomes associated with both the intertidal and shallow subtidal marine habitats and benthic substrate within and surrounding the two proposed outfall pipeline sites. The in water marine assessments were undertaken during the period from Tuesday the 16th through to Thursday the 16th of August 2022 using a combination of free diving (snorkeling) and SCUBA diving qualitative and quantitative benthic habitat and resource assessment scientific visual survey methods.

In total, eleven (11) SCUBA dives were undertaken during the assessment. Six (6) SCUBA dives were undertaken at the Ranadi site ranging in water depth between 7 – 40 meters (m), whilst five (5) SCUBA dives were undertaken at the NRH site with a range of water depth between 5 – 11 m. Each SCUBA dive, once the sea floor was reached, data was recorded (photo/video) which included benthic biotic (fauna and flora) and abiotic resources. The area assessed differed between each dive and ranged between 36 m^2 and 144 m^2 for Ranadi and 25 m^2 and 256 m^2 for NRH. Total area assessed for all SCUBA

dive site locations for Ranadi was 496m^2 (0.0496 hectare) and 545m^2 (0.0545 hectare) for NRH.

In total, eight (8) Free dives (snorkeling) were undertaken during the assessment. Four (4) undertaken at the Ranadi site ranging in water depth between 1 – 4 m, and four (4) Free dives were undertaken at the NRH site with a range of water depth between 2.5 – 5m. Each Free dive recorded (photo/video) the benthic biotic (fauna and flora) and abiotic resources. The area assessed differed between each dive and ranged between 225 m^2 and 625 m^2 for Ranadi and 144 m^2 and 400 m^2 for NRH. Total area assessed for all Free dive site locations for Ranadi was 1,700m^2 (0.170 hectare) and 1,344m^2 (0.134 hectare) for NRH.

The marine baseline survey assessment findings associated with both proposed outfall pipelines will be incorporated into the project's EIS to ensure ADB Safeguard Policy Statement (SPS) and Government of the Solomon Islands (GoSI) environmental safeguard processes are incorporated into the development and management guidelines for the delivery of the project. Relevant maritime legislation, and regulations pertaining to marine resources of the Solomon Islands has been separately detailed in the project's EIS and as such is not repeated herein.

Detailed benthic habitat and resource assessment findings for each of the two proposed outfall pipelines are presented in the individual chapters of this report and should be referred for additional baseline information.

Key summary findings of the marine benthic assessment of the two proposed outfall pipeline direct and indirect Area of Influence is summarized below and includes:

- The foreshore and seabed substrate associated with both proposed outfall locations are relatively homogenous and similar throughout each area assessed. The substrate (sea floor) is characterized by a bottom layer of sand and alluvial soil sediment derived predominantly from terrigenous origin (rivers).
- Silt prevalence and benthic thickness appears to be relatively consistent throughout each outfall pipeline area assessed with water turbidity levels changing rapidly in shallower waters due to the prevailing weather and tidal conditions. Inshore water turbidity levels fluctuate at both site locations due to foreshore usage including vessel shoreline movement (e.g. Ranadi) and reclamation activities (both sites).
- Both proposed outfall site locations are in close proximity to large freshwater river systems which during high precipitation events result in high discharge rates have direct impacts on the water clarify, turbidity and salinity of the waters associated with both sites.
- The periodic high level of suspended sediment coupled with the significant benthic sediment layer (silt) on the sea floor has had a detrimental effect on the ability of sessile benthic marine resources to settle and survive. Thus there is no significant benthic resources located at both sites.
- A paucity of sessile benthic invertebrate species was recorded throughout the area.
- No coral reef systems were located at either proposed outfall site.

- Isolated small hard coral colonies were located attached to the foreshore rock revetment wall at the proposed Randai outfall site. These species are common primary colonizing hard corals and have a wide distribution throughout the Solomon Islands and neigbouring nation reefs. Their presence is a direct relationship to availability of a hard surface to colonize. It is envisaged that continued small scale and localized hard coral recruitment along this revetment wall will continue if settlement condition remain.
- Isolated colonies of soft corals including anemones (and their clown fish) were located at both sites, albeit in very low population numbers and diversity.
- Mobile invertebrates abundance and diversity was very low. They were dominated by burrowing Polychaete (marine worms) which were located at all sites assessed, albeit in low population densities. These benthic fauna resources are mobile and can adapt – survive to disturbances to the benthic substrate.
- Mobile vertebrates, including finfish were recorded in very low population and species numbers, the majority small plankitvores and/or algal feeding associated with a hard structure on the sea floor (e.g. rubbish). There was a noticeable lack of predatory finfish at both proposed site locations.
- Marine sea weed diversity and population densities were very low throughout the entire area assessed for both proposed outfall site locations and were dominated by two common brown species (*Padina sp.* and *Sargassum sp.).*
- Two species of sea grass (*Halophila ovalis* and *Halodule pinifolia*) were recorded in low population densities in shallow water to the east of the proposed pipeline location at the NRH site. These populations were limited in benthic surface area inhabited and are well outside (200 plus m) of the projects direct or indirect Area of Influence and no impacts are expected. No sea grass were located at the Ranadi site.
- No mangrove trees were recorded within the projects direct and/or indirect area of influence at both sites.
- There were no marine mammals and/or marine reptiles (turtles) within or in close proximity to the proposed outfall location sites. A pod of dolphins were recorded to the north (500 m) of the Ranadi site moving through the waters well outside the project site.
- The marine benthic environment associated with the proposed outfall sites contains anthropogenic vessel and land based community derived rubbish and floating plastic was common.
- There are no marine or coastal designated marine protected areas or areas of significant biodiversity within or in close proximity to the proposed outfall sites nor does the areas possess any sites of cultural, customary or heritage significance nor any national or international endangered, endemic or protected species within and adjacent to the proposed area of influence.
- The marine benthic substrate associated with the two proposed outfall sites location due to its environmental characteristics and past extensive foreshore and intertidal reclamation activities, the benthic habitat within the proposed areas have a very low marine biodiversity and can be considered to have a very low ecological habitat and value.

A summary of the key marine benthic Biodiversity Conservation and Sustainable Natural Resource Management status for the Ranadi and National Referral Hospital proposed

outfall pipeline using the ADB Safeguard Policy Statement Appendix 1 – section 8 are presented below.

Outfall Location Site	Marine Ecology	Impact Summary	Biodiversity Conservation & Sustainable Natural Resource Management Status		
			Modified Habitat	Natural Habitat	Critical Habitat/Species
Ranadi	Sea shoreline – open ocean – protected in part by adjacent islands. No coral reef, sea grass nor mangrove present. Marine coastal environment – full salinity, except surface waters during high rainfall. Small stream adjacent (east) to site, large river further east. Very limited (paucity of) benthic sessile invertebrate communities. Sand - Silt dominated benthic substrate. Extensive foreshore & intertidal reclamation – alteration. Highly disturbed ecosystem. No MPA or other managed areas.	Very minor ecological – resource impacts. No threats to areas marine (inshore & offshore) & coastal biodiversity. No endangered or endemic flora and fauna species present. Very small localized site specific footprint increase in suspended sediment during pipeline deployment. Very minor potential petrochemical spillage during construction. All localized to project footprint. All completely reversible and manageable.	Yes. Extensive foreshore and inshore coastal rehabilitation and alteration. Expected to continue in the future. Adjacent to Honiara land fill.	Well outside of proposed outfall alignment - Area of Influence.	None Recorded
NRH	Sea shoreline – open ocean – protected in part by adjacent islands. No coral reef, nor mangrove present. Sea grass recorded to east (well outside projects area of influence 200 m +). Marine coastal environment – full salinity, except surface waters during high rainfall and river (to the west) discharge	Very minor ecological – resource impacts. No threats to areas marine (inshore & offshore) & coastal biodiversity. No endangered or endemic flora and fauna species present. Very small localized site specific footprint increase in suspended sediment during pipeline deployment. Very minor potential petrochemical	Yes. Extensive foreshore and inshore coastal rehabilitation and alteration. Expected to continue in the future. Adjacent to Honiara main hospital.	Well outside of proposed outfall alignment - Area of Influence.	None Recorded

Outfall Location Site	Marine Ecology	Impact Summary	Biodiversity Conservation & Sustainable Natural Resource Management Status		
			Modified Habitat	Natural Habitat	Critical Habitat/Species
	during high rainfall events. Very limited (paucity of) benthic sessile invertebrate communities. Sand - Silt dominated benthic substrate. Extensive foreshore & intertidal reclamation – alteration. Highly disturbed ecosystem. No MPA or other managed areas.	spillage during construction. All localized to project footprint. All completely reversible and manageable.			

Potential Impacts: The impacts derived from the marine scope of works for both proposed outfall pipelines are expected to be very minor, localized to the immediate footprint of the works, and easily managed through standard engineering good practice mitigation measures. There are no threats to the area's marine and coastal biodiversity associated with the project. As such the potential impacts of the works on the marine environment are considered to be minor, temporary, mitigatable and overall insignificant.

Mitigation Measures: Recommended mitigation measures during the construction phase of the project should include; (i) the deployment of silt curtain/s around the foreshore and coastal inshore waters during all construction activities to directly manage and reduce the dispersion of benthic substrate (silt) disturbed during construction, and (ii) ensure due diligence when operating machinery during all work activities to prevent and manage petrochemical spillage and contamination of the waters associated with the proposed outfall pipelines.

The overall potential impact of the works on the marine biological environment is expected to be minor, localized and overall insignificant provided standard mitigation measures associated with good engineering practice as identified above are implemented. Furthermore due to the nature of potential minor impacts of the scope of works it is recommended that no specific marine monitoring program is required other than close supervision of the works to ensure that the above recommended mitigation measures are implemented and effective throughout the marine construction works.

2.0 INTRODUCTION

2.1 Background

Honiara, located on the north coast of Guadalcanal, the largest island in the country of roughly 5,300 km^2, is the capital city of the Solomon Islands and serves as the nation's economic, political, and educational center. The city of 22 km^2 accommodates 84,000 people out of Guadalcanal's total population of 223,000 according to the latest estimate by National Statistics Office. The city's water and waste water requirements are managed by the Solomon Islands Water Authority, referred to herein as Solomon Water (SW). The Authority is a Government of the Solomon Islands state owned enterprise mandated to provide municipal water and wastewater services to the nation.

The proposed project will focus on installing sewers mains to expand and rehabilitate GHA trunk Sever system, the construction of new sewage pumping stations and rehabilitation of existing ones and replacing existing waste water outfalls in a state of disrepair with new ones. The two proposed new sewage outfall pipelines include Ranadi site (Figure 1) and the National Referral Hospital (NRF) site (Figure 2).

Figure 1: Location of the Ranadi Proposed Outfall pipeline within Honiara city limits.

Figure 2: Location of the National Referral Hospital (NRH) Proposed Outfall pipeline within Honiara city limits.

Both proposed outfall site are located within the Honiara city limits and will be managed by the Solomon Water (SW).

2.2 Marine Baseline Assessment

A marine biological baseline assessment was undertaken on the coastal and marine biomes associated the intertidal and shallow subtidal marine habitats and benthic substrate within the proposed new alignment and adjacent areas of both proposed outfall locations. This information provides the biological baseline data for the background, discussion and conclusions sections in the body of the project Environmental Impact Statement (EIS) for both outfall sites associated with the UWSSSP (ADB TA-6597 REG).

The marine assessment was undertaken in August 2022 (16^{th} – $18^{th)}$ using a combination of SCUBA diving and free diving (snorkeling) qualitative and quantitative benthic habitat and resource assessment scientific visual survey methods.

In total, eleven (11) individual SCUBA and eight (8) free dives were undertaken at Randai and NRH sites respectively, and are describe in separate result and discussion sections below.

The assessments included documentation (written and photographic) of the shallow water benthic habitats including the shoreline and inshore intertidal and subtidal marine ecosystems at both locations. All assessments were undertaken during day light hours.

Each assessment site includes the outfall pipes proposed projects Direct Area of Influence (alignment of the outfall pipes) and assessment site adjacent (east and west) of the proposed outfall locations (Indirect Area of Influence) to provide a comprehensive marine description of the benthic marine ecosystems associated with all proposed areas.

2.3 Methods

The marine resource and ecological assessment utilized standard and acceptable international marine biological methods (English et al., 1997) and was performed by the project team's marine ecologist with in water (diving) and boat assistance from staff of Solomon Commercial Diving Services, a commercial dive company based in Honiara (Figure 3).

Figure 3: Field activities associated with the marine assessment of the two proposed outfalls.

SCUBA diving and Free diving (snorkeling) scientific visual survey methods were employed to assess and provide a general description of the shallow and deep water coastal reef systems and benthic habitats/sea floor respectively, associated with the two proposed outfall locations. The marine assessments in water field activities were completed over a period of three full days. Table 1 provides the date for the individual outfall site location assessment.

Table 1: Date of Marine Assessment at Each Outfall Location.

Outfall Site Location	Assessment Date
Randi Site:	Tuesday 16th of August
Randi Site:	Wednesday 17th of August
National Referral Hospital (NRH) Site:	Thursday 18th of August

The marine assessment included a qualitative and quantitative habitat and resource assessment of the existing coastal intertidal and subtidal marine environments associated

with each of the two proposed outfall pipe line locations including the extended area of influence of the projects scope of works.

Data collected included water depth, percent live coral cover, reef condition, dominant benthic forms, dominant hard coral genus and morphological forms, marine algae (turf, macro), seagrass, sediment types and physical description including water movements/currents. Digital photos and videos were taken of key biological features (biotic and abiotic) and a Global Positioning System (GPS) coordinates recorded for each assessment location (SCUBA and free diving) coastal reef system assessed.

Previous published reports associated with the marine environments of the Solomon Islands were reviewed and used for baseline data comparisons and references where available. There were no site specific scientific assessment reports located at the locations of the two proposed outfall locations.

In total, eleven (11) SCUBA dives were undertaken during the assessment. Six (6) SCUBA dives were undertaken at the Ranadi site (Figure 4) ranging in water depth between 7 – 40 meters (m), whilst five (5) SCUBA dives were undertaken at the NRH site (Figure 5) with a range of water depth between 5 – 11 m.

Each SCUBA dive, once the sea floor was reached, data was recorded (photo/video) which included benthic biotic (fauna and flora) and abiotic resources. The area assessed differed between each dive and ranged between 36 m^2 and 144 m^2 for Ranadi and 25 m^2 and 256 m^2 for NRH. Total area assessed for all SCUBA dive site locations for Ranadi was 496m^2 (0.0496 hectare) and 545m^2 (0.0545 hectare) for NRH.

In total, eight (8) Free dives (snorkeling) were undertaken during the assessment. Four (4) undertaken at the Ranadi site (Figure 4) ranging in water depth between 1 – 4 m, and (4) Free dives were undertaken at the NRH site (Figure 5) with a range of water depth between 2.5 – 5m.

Each Free dive recorded (photo/video) the benthic biotic (fauna and flora) and abiotic resources. The area assessed differed between each dive and ranged between 225 m^2 and 625 m^2 for Ranadi and 144 m^2 and 400 m^2 for NRH. Total area assessed for all Free dive site locations for Ranadi was 1,700m^2 (0.170 hectare) and 1,344m^2 (0.134 hectare) for NRH.

It is noted, due to the potential of sewage and/or hospital effluent discharge being present at the NRH coastal shoreline and excavation activities ongoing during the in water field assessment no free diving in water assessment along the shoreline was undertaken to ensure health of the dive team. The inshore areas were visually assessed from the survey vessel which was able to maneuvered close to the revetement wall enabling a clear understanding of the marine benthic environmental at this site.

Figure 4: The site location of the marine assessment survey sites undertaken during the marine benthic assessments– including 6 SCUBA Dive Sites (SD 1-6) and 4 free dive (FD 1-4) at the Proposed Randi Site.

Figure 5: The site location of the marine assessment survey site undertaken during the marine benthic assessments– including 5 SCUBA Dive Sites (SD 1-5) and 4 free dive (FD 1-4) at the Proposed NFH Site.

The total areas surveyed in meter squared and hectares for the individual assessment site locations for both SCUBA and Free Dives are presented in Table 2. Total area assessed for all SCUBA and Free dives was 1,889m^2 (0.188 hectare) and 2,196m^2 (0.219 hectare) for the Ranadi and NRH sites, respectively.

In total, eleven (11) individual SCUBA dives (six Randai and five NRH) and eight (8) free dive sites (4 Randi and 4 NRH) were undertaken and are describe in separate result and discussion sections below.

Table 2: Total Area in Meters and Hectares assessed for both proposed outfall site locations.

Site Location	m^2	ha
Ranadi Proposed Outfall Site		
SCUBA Dive 1 (SD1): Area covered 6 m x 6 m	36	0.0036
SCUBA Dive 2 (SD2): Area covered 6 m x 6 m	36	0.0036
SCUBA Dive 3 (SD3): Area covered 6 m x 6 m	36	0.0036
SCUBA Dive 4 (SD4): Area covered 12 m x 12 m	144	0.0144
SCUBA Dive 5 (SD5): Area covered 12 m x 12 m	144	0.0144
SCUBA Dive 6 (SD6): Area covered 10 m x 10 m	100	0.0100
Free Dive 1 (FD 1): Area covered 25 m x 25 m	625	0.0625
Free Dive 2 (FD 2): Area covered 20 m x 20 m	400	0.0400
Free Dive 3 (FD 3): Area covered 15 m x 15 m	225	0.0225
Free Dive 4 (FD 4): Area covered 90 m x 5 m	450	0.045
Total	**2,196**	**0.219**
Referral Hospital Proposed Outfall Site		

SCUBA Dive 1 (SD1): Area covered 5 m x 5 m	25	0.0025
SCUBA Dive 2 (SD2): Area covered 16 m x 16 m	256	0.0256
SCUBA Dive 3 (SD3): Area covered 8 m x 8 m	64	0.0064
SCUBA Dive 4 (SD4): Area covered 10 m x 10 m	100	0.0100
SCUBA Dive 5 (SD5): Area covered 10 m x 10 m	100	0.0100
Free Dive 1 (FD 1): Area covered 12 m x 12 m	144	0.0144
Free Dive 2 (FD 2): Area covered 20 m x 20 m	400	0.0400
Free Dive 3 (FD 3): Area covered 20 m x 20 m	400	0.0400
Free Dive 4 (FD 4): Area covered 20 m x 20 m	400	0.0400
Total	**1,889**	**0.1889**

3.0 Ranadi Outfall Proposed Site

3.1 Marine Site Description

The proposed new sewage outfall pipe line exits the shoreline ($9^0$25'.00.8"S and 160^0 00'387."E) and is proposed to extend 500 m directly offshore perpendicular to the shoreline (northerly direction) and will terminate approximately ($09^0$25'03.2"S $160^0$00'84.2"E) in 41 m of water (refer Figure 1).

Significant foreshore alteration has taken place along the coastline directly adjacent to as well as to the west and east of the proposed outfall coastal entry location. To the east Solfish, a commercial domestic fishing and trading company has reclaimed an extensive coastal area for operations including the development of a wharf approximately 300 m in length (Figure 6 a and b) that runs perpendicular to the shoreline and several large vessel permanent mooring sites (Figure 6 c and d) located approximately 200 m to the east of the proposed outfall pipe line. To the west the foreshore and coastal areas have been reclaimed to support vessel access to transfer timber and other domestic goods (Figure 7).

Figure 6: Coastal foreshore reclamation to the east of the proposed Ranadi outfall pipeline including Solfish infrastructure and vessel mooring sites.

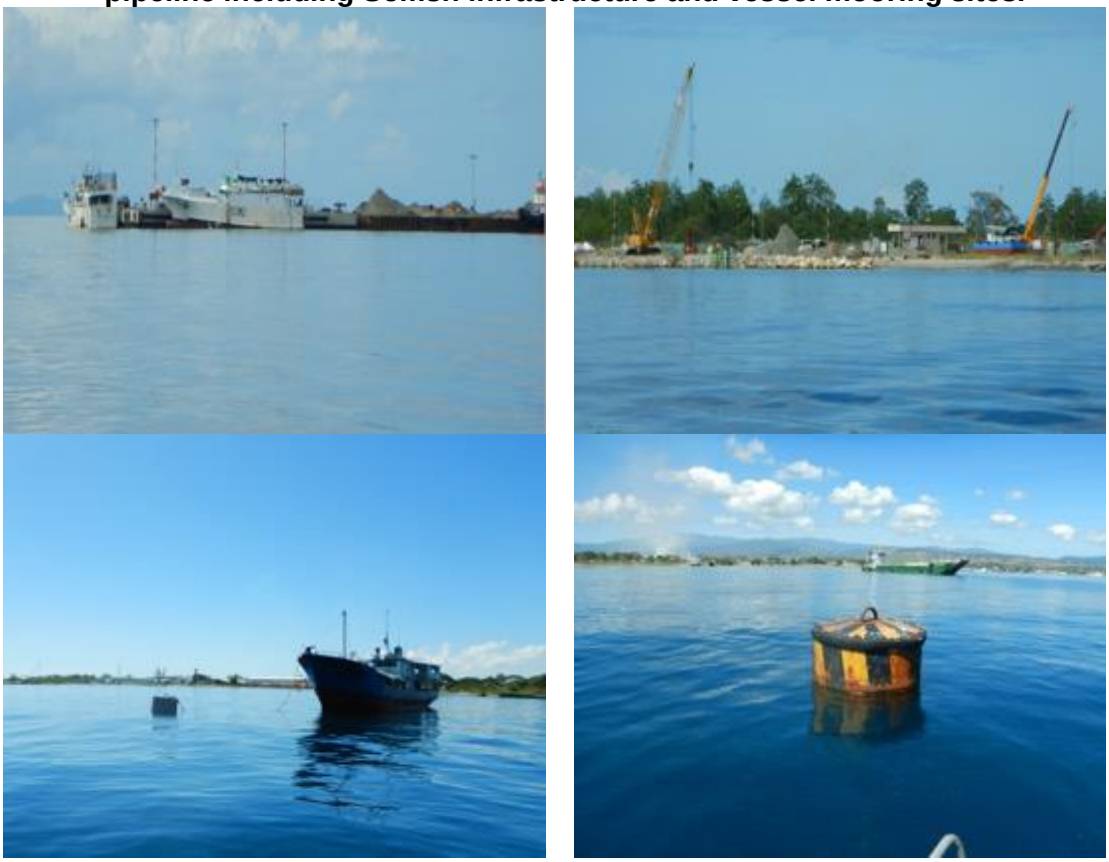


Figure 7: Coastal foreshore reclamation to the west of the proposed Ranadi outfall pipeline.

The proposed outfall site enters the foreshore directly north of the Honiara city waste landfill facility (Figure 8 a) and includes a small stream that receives runoff and material from the landfill site that enters the foreshore directly east (60 m) of the proposed outfall site. Water level and discharge rates of the stream fluctuate and are directly related to rainfall events. Sand is collected at the mouth of the stream and the shallow water foreshore, stockpiled adjacent to the stream and used for domestic building material (Figure 8 b and c). Directly to the east of the river mouth several ship wrecks are located in shallow water (Figure 8 d).

Figure 8: Honiara city waste landfill facility (a), location of the sand removed from the stream (b and c) and ship wrecks (d) to the east of the proposed Ranadi outfall pipe line.

The proposed outfall pipeline location is situated on an open beach shoreline running east to west with the ocean side to the north. There are no coral reef systems, seagrass beds nor mangroves associated with this area. The site is marine with the benthic substrate dominated by both terrigenous and marine (calcium carbonate) sediments. The subtidal benthic substrate extends seawards (north) and descends gradually to a depth of 40-42 m 500 meters from highwater mark at the proposed pipeline entry location. The benthic substrate consists of granular sand and finer sediment particles with the latter revealing highlight percentage levels as depth is attained. There is an absence of large size benthic substrate material (rocks, boulders etc) throughout the assessed area.

The foreshore and coastal waters directly adjacent to the proposed outfall entry point have been significantly altered by anthropogenic activities including extensive reclamation of the original shallow water intertidal and exposed beach areas (Figure 9). The coastline associated with the proposed outfall boundary is protected by a rock revetment seawall (calcareous limestone rock) designed to provide all year round protection from storm surge and waves whilst allowing deeper water access to the shoreline for coastal vessels.

Figure 9: The foreshore and shallow water environments directly adjacent to the Ranadi proposed outfall pipeline location.

During periods of high precipitation, the foreshore waters exhibit small fluctuations in salinity and increased turbidity due to the stream discharge and surface water runoff from neighboring land surfaces, however anecdotal information acquired suggests these changes are short lived and disperse quicky. The stream is a source of significant pollution (associated with the Honiara city waste fill site) including significant domestic waste (plastics and other rubbish), sewage and petrochemical products. This discharge has a direct impact on the marine water quality associated with the inshore and offshore waters associated with the proposed outfall pipeline.

3.2 Marine Baseline Site Description Ranadi Proposed Outfall – Results This section details the baseline survey results for the marine benthic abiotic habitat and biotic

resource (intertidal and subtidal) assessment undertaken along and adjacent to the proposed Ranadi outfall pipe line as specified in the Marine Ecologist and overall Environmental Assessment Terms of Reference (TOR). The assessment results and discussions are divided into two separate sections described herein.

In total, six (6) SCUBA Dives (SD) ranging in water depth between 7 – 40 m and four (4) Free Dives (FD) ranging in water depth of 1-4m were undertaken at the Ranadi site during the assessment (refer Figure 4). The total area assessed for all SCUBA and Free dives was 144 m^2 and 1,700 m^2 respectively.

3.2.1 Marine benthic ecosystems associated with the direct area of influence of the proposed Ranadi outfall pipe line.

The assessment site locations of the marine benthic (abiotic and biotic) habitats and resources directly in line with the proposed Ranadi outfall pipe line fall within the projects Direct Area of Influence. As such lie within the potential area of impact associated with the deployment and operations of the proposed new outfall pipeline.

The intertidal and subtidal marine environments located within the proposed outfall pipeline are all but devoid of coral reefs and associated reef benthic resource due to the inshore areas past extensive and continued shoreline reclamation activities and deposition of sediments discharged from coastal rivers and streams adjacent to the site. Similarly, mangrove trees are absent and recent anecdotal information indicates that they have not been located at this site for an extended period of time.

The northern shoreline, directly adjacent (west) of the proposed outfall pipeline entry point location has been reclaimed and is bordered by a rock revetment breakwater which includes a small number of newly recruited hard coral colonies and associated marine resources. These benthic reef resources are highly modified and are impacted by past and existing activities associated with this area of shoreline.

In total, two (2) SCUBA Dives (SD 1 and SD 4) 40 m and 15 m depth respectively, covering a combined area of 170 m^2 and two (2) Free Dives (FD 2 and FD 4,) 4 m and 1-2 m water depth respectively, and an area of 850 m^2, covering a combined area of 1,020 m^2 marine ecological surveys were undertaken within the projects proposed direct Area of Influence. Figure 4 provides the assessment site locations and Table 3 provides the GPS location, water depth, distance from shore and general description of each site associated with the direct area of influence.

Table 3: Location and general information of the SCUBA and Free Dive sites undertaken within the direct area of influence at the proposed outfall at the Ranadi Site.

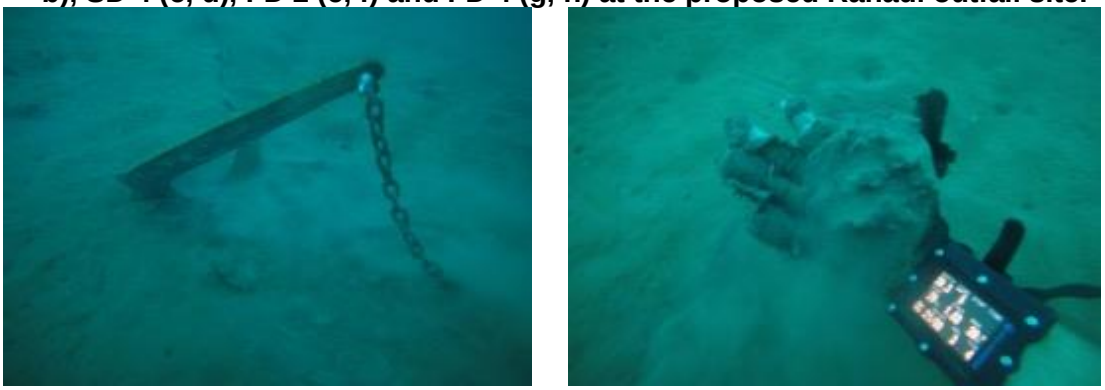
SCUBA Dive 1 (SD1)	➢ ($09^0$25’03.2”S $160^0$00’84.2”E). ➢ Located 512 m offshore from the high water mark and directly north of the proposed outfall water entry location. ➢ Anticipated outfall discharge location. ➢ Maximum depth of water 40 m.
SCUBA Dive 4 (SD4)	➢ ($09^0$24’99.5”S $160^0$00’74.0”E).

	➢ Located 340 m offshore from the high water mark and directly north of the proposed outfall water entry location. ➢ Maximum depth of water 15 m.
Free Dive 2 (FD 2)	➢ ($09^0$24'94.0"S $160^0$00'75.7"E). ➢ Located 70 m offshore from the high water mark and directly north of the proposed outfall water entry location. ➢ Maximum depth of water 4 m.
Free Dive 4 (FD 4)	➢ East ($09^0$24'96.8"S $160^0$00'79.0"E) and West ($09^0$24'99.9"S $160^0$00'75.3"E ➢ Located along the reclaimed revetment wall/dock directly west of the proposed outfall water entry location. ➢ Depth of water ranged between 1 and 2 m.

The shallow water intertidal and subtidal benthic substrate profile associated with the proposed outfall pipeline is similar throughout the area assessed. The benthic substrate profile gently decreases northwards (offshore) through a gentle slope reaching water depths of 40 m some 500 m offshore (the proposed outfall termination point).

The seabed substrate is relatively homogenous throughout the assessment site and is characterized by a bottom layer of coarse sand derived from terrigenous and coral reef origins with a thin top layer of fine sediment - silt originating from alluvial deposits. The sediment layer is more pronounced towards the offshore assessed areas, however fluctuations in the depth of the sediment layer and resulting water turbidity is directly related to weather conditions prevailing at any given time. These sediments do impact the water quality associated with the project site and have a direct impact on the benthic coral reef resources. It is noted that no coral or river derived rubble, rocks or boulders were located at any site during the assessment. Limestone rocks were present associated with the reclaimed rock revetment wall. Figure 10 provides representative photos of the benthic substrate at the four assessment sites (2 SCUBA and 2 Free Dives) associated with the direct Area of influence of the project.

Figure 10. Representative photos of the benthic substrate associated with SD1 (a, b), SD 4 (c, d), FD 2 (e, f) and FD 4 (g, h) at the proposed Ranadi outfall site.



The relatively high level of suspended silt and sand based substrate (refer Figure 10) located at all assessment sites and the lack of hard benthic structures (rocks, reef etc) has a significant detrimental effect on recruitment and survival of sessile benthic marine life. This has resulted in a paucity of sessile and mobile benthic invertebrate species. Nevertheless small numbers of marine worm (polychaetes) burrows were observed at all sites, however population densities were low (Figure 11a and b). These resources are mobile and can adapt to changes in the benthic sediment profile.

There were no mollusks (e.g. bivalves, gastropods, cephalopods), echinoderms (e.g. sea urchins, sea cucumbers) nor crustaceans (e.g. crabs, mantis shrimps) located at any assessments sites within the direct area of influence. The absence of these resources during the survey, specifically those that have an economic value (e.g. sea cucumbers)

may be attributed to the time of the assessment, however it is more likely be a direct result of fishing pressure.

The man made rock revetment wall located along the foreshore has provided a suitable hard substrate for invertebrates and algae to recruit, attached and survive as such three species of hard coral and one species of macroalgae were located. The dominate hard coral species was the small branching *Pocillopora demicornis* (Figure 11c), with both branching *Acropora sp*. (Figure 11d) and small encrusting *Porities sp.* (Figure 11 e) hard corals located in small isolated colonies. Hard coral percentage coverage on the rock revetment wall was less than 1%, however the age of the colonies located reflects the revetment walls construction resulting in hard coral age between 1- 3 years. Continued recruitment is expected on the rock revetment wall if localized environmental conditions remain conducive to hard coral planula larval settlement. There were no soft corals recorded at any site. The macroalgae *Padina sp.* was located in reasonable densities on both the rock revetment wall and attached to rubbish in close proximity to the wall (Figure 11 f). No sea grass were recorded during the assessment.

Figure 11: Marine Invertebrates polychaete burrows (a and b), hard corals (c and d) and macroalgae (e and f) located during the marine assessment within the direct area of influence of the proposed Ranadi outfall pipeline.

Finfish population numbers and species diversity were exceptionally low at all sites assessed within the direct area of influence with only a few individuals and species identified only at SD 4. This includes one specimen of lion fish (*Pterois volitans),* a small school of banner fish (*Heniochus diphreutes*) (Figure 12 a) and one specimen of juvenile red emperor (*Lutjanus sebae*) (Figure 12 b) all were associated with marine debris (providing habitat) and are common tropical finfish species within the Solomon Islands. Notably, there was an absence of herbivores (e.g. Acanthuridae, Scaridae) finfish species associated with the rock revetment wall, there absence maybe a result of the tide height and/or time of the assessment (midday) or their presence is naturally low. Similarly there were no top order finfish predators recorded.

No dugongs (*Dugong dugon*) nor marine turtles were recorded during the assessment nor was there any literature located that indicates marine turtles nested along this shore line in the past several decades.

Figure 12: Finfish species located during the assessment of all sites associated with the direct area of influence associated with the proposed Ranadi outfall pipe line.

During both assessment days and from anecdotal information obtained from the projects dive team, local fishers are found daily using hook and line bottom and mid water fishing within the area of the proposed outfall pipe line. Observations during the in water assessment of the fishes did not record any catches (Figure 13). There was no evidence of spearfishing in the proposed area, however swimming from the shoreline was observed.

Figure 13: Local fishers utilizing the waters near the proposed outfall location for subsistence activities.

The absence of predator finfish, the small size and population number of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived both situations are currently operating within the proposed outfall pipeline.

The marine benthic environment associated with the proposed outfall pipeline contained small amounts anthropogenic derived waste material and garbage (Figure 14) with higher numbers witnessed closer to the shoreline. The waste material is presumed to originate

either from land sources, especially the Honiara waste facility and stream or discarded from vessels.

Figure 14: Anthropogenic material and garbage located during the marine assessments within the direct area of influence of the proposed Ranadi outfall pipeline.

3.2.2, the assessment of the marine benthic ecosystem directly east and west of the proposed outfall pipe line (Indirect Area of Influence).

The assessment site locations of the marine benthic (abiotic and biotic) habitats and resources adjacent to the proposed Ranadi outfall pipe line fall outside the projects Direct Area of Influence. These sites have been assessed to provide detailed information on the benthic ecosystems and resources within the indirect Area of Influence including sites either side (east and west) of the projects direct physical and operational impact areas associated with the proposed new outfall pipeline.

The intertidal and subtidal marine environments located either side of the proposed outfall pipeline are devoid of coral reefs and the paucity of reef benthic resource due to the inshore coastal and foreshore areas past extensive and continued reclamation activities and deposition of sediments discharged from coastal rivers and streams adjacent to the site. Similarly, mangrove trees are absent and recent anecdotal information indicates that they have not been located at this site for an extended period of time.

The shoreline to the east of the proposed outfall pipeline entry point assessment site location are directly seaward of the stream and neigbouring reclamation areas whilst the shoreline to the west of the proposed outfall pipeline assessment site locations has been significantly altered due to the reclamation activities and is bordered by a rock revetment breakwater.

In total, four (4) SCUBA and two (2) free dives covering a total area of 1,116 m^2 was assessed for the indirect areas of influence associated with the proposed outfall pipeline.

The eastern side assessment site included two (2) SCUBA Dives (SD 3 and SD 5) 35 m and 7 m depth respectively, covering a combined area of 180 m^2 and one (1) Free Dive (FD 1) 3 m and an area of 625 m^2, covering a combined area of 805 m^2 marine ecological surveys.

The western side assessment site included two (2) SCUBA Dives (SD 2 and SD 6) 39 m and 12 m depth respectively, covering a combined area of 136 m^2 and one (1) Free Dive (FD 3) 4 m and an area of 225 m^2, covering a combined area of 361 m^2 marine ecological surveys. Figure 5 provides the assessment site locations and Table 4 provides the GPS location, water depth, distance from shore and general description of each site associated with the direct area of influence.

Table 4: Location and general information of the SCUBA and Free Dive sites undertaken to the east and west of the proposed Ranadi outfall Site.

SCUBA Dive 2 (SD2)	➢ ($09^0$25'14.7"S $160^0$00'51.5"E). ➢ Located 500 m offshore from the high water mark, 180 m west of the proposed outfall water entry location. ➢ Maximum depth of water 39 m.
SCUBA Dive 3 (SD3)	➢ ($09^0$25'80.5"S $160^0$00'80.1"E). ➢ Located 500 m offshore from the high water mark, 204 m east of the proposed outfall water entry location. ➢ Maximum depth of water 35 m.
SCUBA Dive 5 (SD5)	➢ ($09^0$24'89.9"S $160^0$00'96.4"E). ➢ Located 260 m offshore from the high water mark, 190 m east of the proposed outfall water entry location. ➢ Maximum depth of water 7 m.
SCUBA Dive 6 (SD6)	➢ ($09^0$24'88.6"S $160^0$00'75.2"E). ➢ Located 314 m offshore from the high water mark, 196 m west of the proposed outfall water entry location. ➢ Maximum depth of water 12 m.
Free Dive 1 (FD 1)	➢ ($09^0$24'88.6"S $160^0$00'85.1"E). ➢ Located 80 m offshore from the high water mark, 180 m east of the proposed outfall water entry location. ➢ Maximum depth of water 3 m.
Free Dive 3 (FD 3)	➢ ($09^0$25'00.2"S $160^0$00'69.9"E). ➢ Located 70 m offshore from the high water mark, 150 m west of the proposed outfall water entry location. ➢ Maximum depth of water 4 m.

The shallow water intertidal and subtidal benthic substrate profile to the east and west of the proposed outfall pipeline are similar and duplicate each other throughout the area assessed. Both areas are also very similar to the ecological areas associated with the direct area of influence (refer section 3.2.1). The benthic substrate profile gently decreases northwards (offshore) through a gentle slope reaching water depths of 35 m and 39 m east and west respectively of the proposed outfall pipeline termination point, 500 m offshore.

The seabed substrate is relatively homogenous throughout the assessment sites and is characterized by a bottom layer of coarse sand derived from terrigenous and coral reef origins with a thin top layer of fine sediment - silt originating from alluvial deposits. The sediment layer is more pronounced towards the offshore assessed areas and to the west, however fluctuations in the depth of the sediment layer and resulting water turbidity is directly related to weather conditions prevailing at any given time. These sediments do impact the water quality associated with the project site and have a direct impact on the benthic coral reef resources. It is noted that no coral or river derived rubble, rocks or boulders were located at any site during the assessment. Figure 15 and Figure 16 provides representative photos of the benthic substrate at the four assessment sites (2 SCUBA and 1 Free Dives) associated with the benthic assessment to the east and west respectively, of the Area of influence of the project.

Figure 15. Representative photos of the benthic substrate associated with the eastern assessments sites of SD3 (a, b), SD 5 (c, d), FD 1 (e, f) at the proposed Ranadi outfall site.

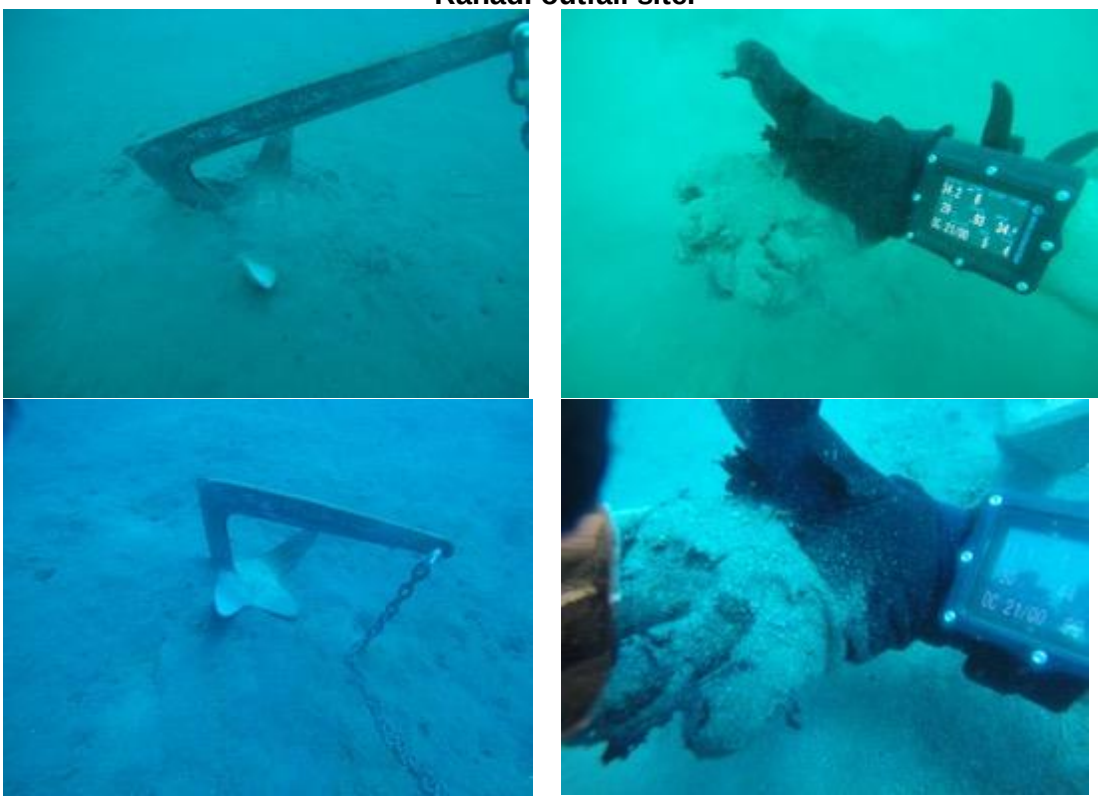
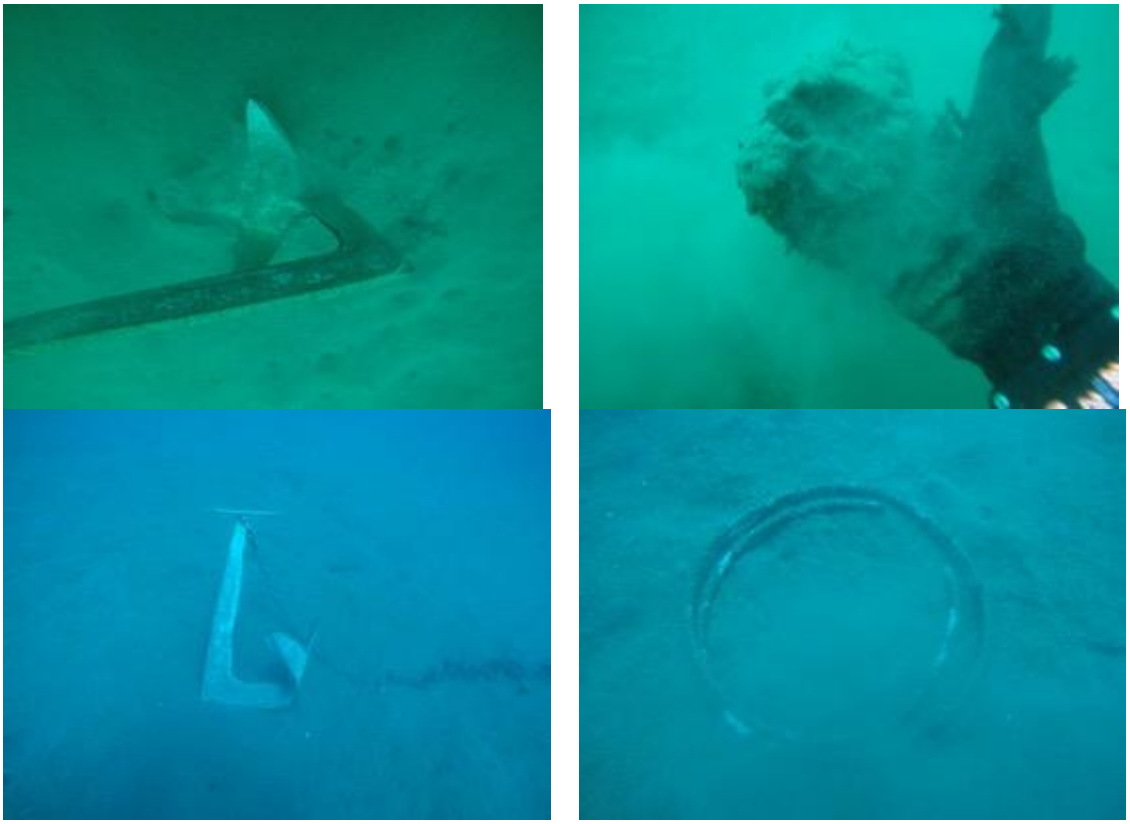


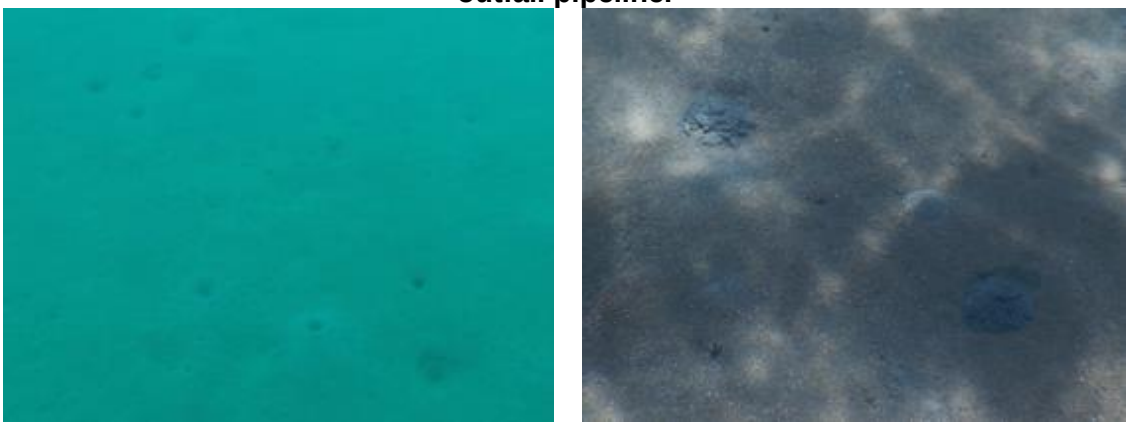
Figure 16. Representative photos of the benthic substrate associated with the western assessments sites of SD2 (a, b), SD 4 (c, d), FD 3 (e, f) at the proposed Ranadi outfall site.



The relatively high level of suspended silt and sand based substrate (refer Figures 15 and 16) located at all assessment sites and the lack of hard benthic structures (rocks, reef etc) has a significant detrimental effect on recruitment and survival of sessile benthic marine life. This has resulted in a paucity of sessile and mobile benthic invertebrate species. Nevertheless small numbers of a range of benthic mobile invertebrates and juvenile finfish were located during the assessment. Species diversity and numbers of invertebrates were higher at both the eastern and western assessments sites than those located directly within the proposed pipeline area of influence.

Marine worm (polychaetes) burrows were observed at all sites, however population densities were low at all sites assessed (Figure 17a and b). Two soft corals, one anemone (*Stichodactyla sp.)* and associated clown fish (SD 5) was located in 6 m of water and one sea pen (SD 2) was located at 38 m of water (Figure 17 c and d). These resources are mobile and can adapt to changes in the benthic sediment profile.

Figure 17: Marine Invertebrate polychaete burrows (a, SD 3 and b, FD 1), anemone including resident clown fish (c, SD 5) and sea pen (d, SD 2) located during the marine assessment of the eastern and western sites of the proposed Ranadi outfall pipeline.

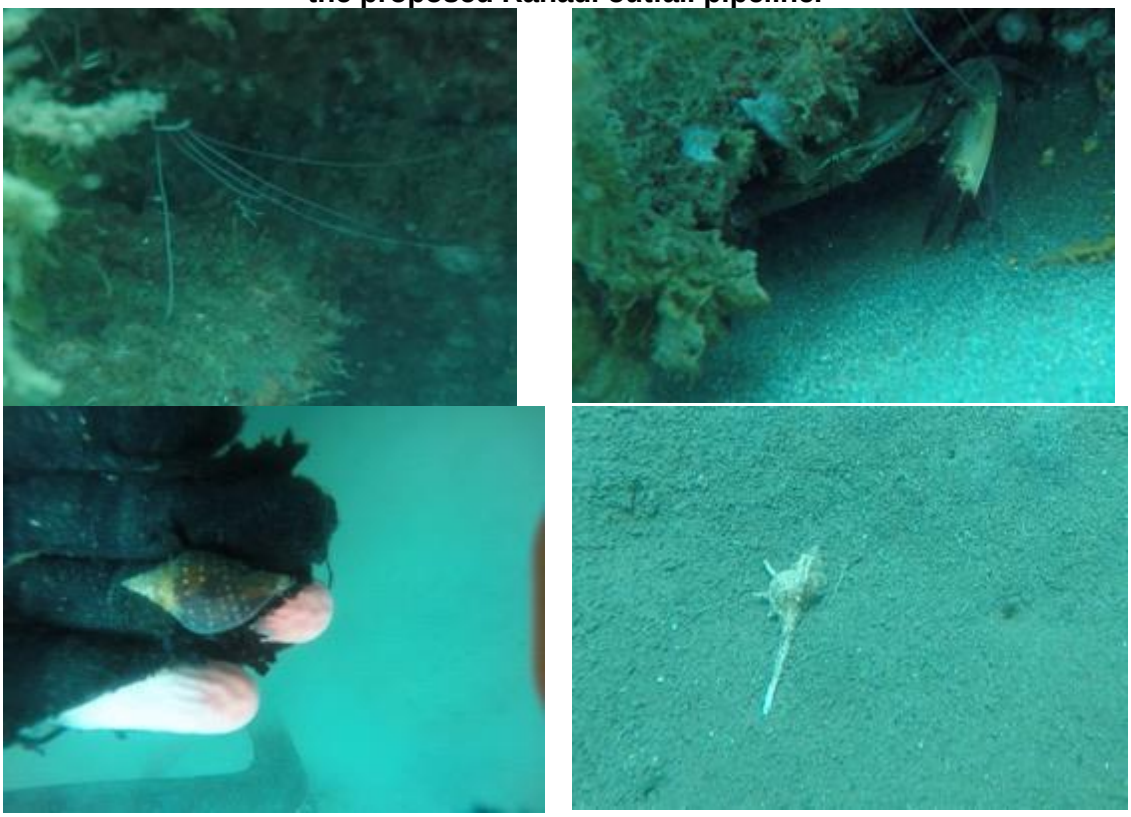


Echinoderms were located both within the eastern and western dive site locations, albeit in very low numbers and included 3 species of sea cucumber. One specimen of *Holothuria coluber* was located at each SD 2 (Figure 18 a) and SD 5, whilst two *Bohadschia sp* were located at SD 6 (Figure 18 b and c). In addition, a number of the black short spined sea urchin (*Diadema sp.)* were located moving through SD 6 (Figure 18 d).

Figure 18: Marine Invertebrate sea cucumbers (a, SD 2, b and c SD 6), and sea urchins (d, SD 6) located during the marine assessment of the eastern and western sites of the proposed Ranadi outfall pipeline.

Two decapod crustaceans were located at site SD 6 associated with a metal object on the sea floor, this included one specimen of each a coral banded cleaner shrimp (*Stenopus hispidus*) (Figure 19 a) and swimmer crab (*Etisus sp*.) (Figure 19 b). Two predatory gastropod mollusk were located, one alive (Figure 19 c) and buried under the substrate (Figure 19 d) and one dead shell (*Murex sp.)* at SD 6*.*

Figure 19: Marine Invertebrate crustaceans (a and b) and mollusks (c and d) located (SD 6) during the marine assessment of the eastern and western sites of the proposed Ranadi outfall pipeline.



There were no hard corals located during the assessment nor sea grass. Two species of macro algae were located during the assessments, the brown algae *Padina sp.* and

Sargassum sp. were located in very low population numbers, the former associated with the shallow water free dive sites (FD 1 and FD 3) (Figure 20 a) and the latter at SD 6 attached to rubbish (Figure 20 b).

Figure 20: Marine macro algae located during the marine assessment of the eastern and western sites of the proposed Ranadi outfall pipeline.

Finfish population numbers and species diversity were exceptionally low at all eastern and western sites assessed adjacent to the direct area of influence with only a few individuals and species identified at two sites, are common tropical finfish species within the Solomon Islands.

This includes small schools of juvenile banner fish (*Heniochus diphreutes*) (Figure 21 a), surgeon fish (*Acanthurus sp.)* (Figure 21 b), damselfish (*Pomacentrus sp*.) (Figure 21 c) all of which were associated with marine debris (SD 6) providing an artificial habitat for protection and clown fish (*Amphiprion sp.)* (SD 5) associated with an individual soft coral anemone (Figure 21 d). Notably, there was an absence top order finfish predators recorded.

A small pod of the common Indo-Pacific bottlenose dolphin (*Tursiops aduncus)* was observed on the 16th moving through the sea to the north (500 m) of the proposed outfall termination point, the pod was not feeding when observed. Anecdotal information indicates small cetaceans move through these waters regularly.

No dugongs (*Dugong dugon*) nor marine turtles were recorded during the assessment nor was there any literature located that indicates marine turtles nested along this shore line in the past several decades.

Figure 21: Finfish species located during the assessment of the eastern and western sites associated with the proposed Ranadi outfall pipe line.

The absence of predator finfish, the small size and population number of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived both situations are currently operating within the proposed outfall pipeline.

There was no evidence of spearfishing in the proposed area, however hook and line fishing (refer section 3.1) and swimming from the shoreline was observed.

The marine benthic environment to the east and west of the proposed outfall pipeline contained small amounts anthropogenic derived waste material and garbage (Figure 22) with higher numbers witnessed closer to the shoreline. The waste material is presumed to originate either from land sources, especially the Honiara waste facility and stream or discarded from vessels.

Figure 22: Anthropogenic material and garbage located during the marine assessments to the east and west of the proposed Ranadi outfall pipeline.

3.3 Key Findings of the Randai Proposed Outfall Site Marine Assessment The proposed Ranadi outfall site does not impact on any marine (intertidal and subtidal) or coastal conservation and/or protected area, sites of cultural, customary or heritage significance nor any national or international marine, freshwater or coastal (terrestrial) endangered or protected species. Thus no impacts on critical habitats are associated with this project.

The key findings of the shallow and deeper water foreshore and marine benthic assessment of the proposed Ranadi outfall site location include:

- The foreshore and seabed substrate associated with the proposed outfall location are relatively homogenous and similar throughout the area. The substrate is characterized by a bottom layer of sand and alluvial soil sediment derived predominantly from terrigenous origin (rivers).
- Silt prevalence and benthic thickness appears to be consistent throughout the area with turbidity levels changing rapidly in shallower waters due to the prevailing weather and tidal conditions. In addition, inshore water turbidity levels fluctuate due to foreshore usage including vessel movement and reclamation activities.
- The periodic high level of suspended sediment coupled with the significant benthic sediment layer (silt) on the sea floor has had a detrimental effect on the ability of sessile benthic marine resources to settle and survive. Thus there is no significant benthic resources located within this site (e.g. no coral reef, sea grass bed).
- A paucity of sessile benthic invertebrate species was recorded throughout the area. Several isolated young hard coral colonies were located attached to the rock revetment wall developed for the reclamation of the foreshore. These species are common primary colonizing hard corals and have a wide distribution throughout the Solomon Islands and neigbouring nation reefs. Their presence is a direct relationship to availability of a hard surface to colonize. It is envisaged that continued small scale and localized recruitment along this revetment wall will continue if settlement condition remain.
- Polychaete (marine worms) burrows were located at all sites assessed and several species of sea cucumbers were located to the east, albeit in low population densities. These benthic fauna resources are mobile and can adapt – survive to disturbances to the benthic substrate.

- Mobile vertebrates, including finfish were recorded in very low population and species numbers.
- No coral reef, sea grass beds nor Mangrove trees were recorded within the projects direct and/or indirect area of influence.
- Marine sea weed diversity and population densities were very low throughout the entire area assessed and were dominated by two brown common brown species (*Padina sp.* and *Sargassum sp.).*
- There were no marine mammals and/or marine reptiles (turtles) within or in close proximity to the proposed outfall location site. A pod of dolphin were recorded to the north of the site moving through the waters well outside the project site.
- The marine benthic environment associated with the proposed outfall site contains anthropogenic vessel and land based community derived rubbish and floating plastic was common.
- There are no marine or coastal designated marine protected areas or areas of significant biodiversity within or in close proximity to the proposed outfall site nor does the area possess any sites of cultural, customary or heritage significance nor any national or international endangered, endemic or protected species within and adjacent to the proposed area of influence.
- The marine benthic substrate associated with the proposed outfall site location due to its environmental characteristics and past extensive foreshore and intertidal reclamation activities, the benthic habitat within the proposed area can be considered to have a very low ecological habitat and value.

3.4 Key Environmental Impacts

The proposed scope of works to construct and bury a new outfall pipe line perpendicular to the existing shoreline extending approximately 500 m offshore has a small environmental footprint both above and below water level. Impacts on the marine environment and coastal waters within and around the proposed pipeline are expected to be very minor, localized to the immediate footprint of the works, and easily managed through standard engineering good practice mitigation measures. There are no threats to the area's marine and coastal biodiversity associated with the project. As such the potential impacts of the works on the marine environment are considered to be very minor, temporary, easily mitigatable and overall insignificant.

The potential impacts of the project on the marine biological environment include:

- Localized and temporary increased suspended sediment levels adjacent to and either side of the proposed outfall pipeline potentially affecting marine habitats and associated resources during construction activities.
- Spillage/leakage of oil and other pollutants into the marine environment from plant and equipment used during the construction phase of the project.
- Benthic habitats associated with the footprint directly within and adjacent to the proposed pipeline are comprises almost exclusively of mud/silt sand substrate with a paucity of benthic sessile invertebrates. As such the benthic substrate habitat may be classified as a highly modified and disturbed benthic foreshore and marine habitat of low ecological value.

- The proposed scope of works as such will have a negligible potential impact on these habitats, its resources and is acceptable.
- There is potential for localized and temporary increased suspended sediment levels in the marine environment around the outfall as a result of the projects physical development. Such impacts are expected to be very minor due to i) the low habitat value of the benthic environment, ii) prevailing high suspended sediment conditions persisting at the site, and iii) the limited physical construction activities proposed.

3.5 Potential Impact Mitigation Measures

The potential impact of increased suspended sediment levels from the works can be further minimized through implementation of the following mitigation measures during the construction phase of the project:

- Deploy silt curtain/s around the foreshore and coastal inshore waters during all physical construction activities to directly manage and reduce the dispersion of benthic substrate (silt) disturbed during construction; and
- Ensure due diligence when operating machinery during all work activities to prevent and manage petrochemical spillage and contamination of the waters associated with the proposed outfall pipeline.

The contractor will be required to ensure all equipment is properly maintained and to follow all necessary precautions to prevent spillage of petrochemicals into the marine environment. Provided such measures are properly implemented the potential impacts on the marine environment will be insignificant.

The overall potential impact of the works on the marine biological environment is expected to be very minor, localized and overall insignificant provided standard mitigation measures associated with good engineering practice as identified above are implemented. Furthermore due to the nature of potential minor impacts of the scope of works it is recommended that no specific marine monitoring program is required during construction other than close supervision of the works to ensure that the above recommended mitigation measures are implemented and effective throughout the marine construction works.

4.0 National Referral Hospital (NRH) Outfall Proposed Site

4.1 Marine Site Description

The proposed new sewage outfall pipe line exits the shoreline ($9^0$26'.07.5"S and 159^0 58'30."E) just outside of the western boundary of the NRH and is proposed to extend 350m directly offshore perpendicular to the shoreline (northerly direction) and will terminate approximately ($09^0$25'53.7"S $159^0$58'18.3"E) in 14 m of water (refer Figure 2).

Significant foreshore alteration has taken place along the coastline directly adjacent to as well as to the west and east of the proposed outfall coastal entry location. To the east the shoreline includes reclamations for the Honiara cities main coastal road and individual/commercial property (Figure 23 a). Adjacent lies several old vessels that have been grounded and are in considerable state of disrepair (Figure 23 b).

To the west the foreshore and coastal areas have been reclaimed in the past to provide shoreline protection to the NRH and includes sand extraction and piling of terrigenous deposit associated with the mouth of the nearby river (Figure 23 c and d).

Figure 23: Coastal foreshore reclamation to the east (a and b) and west (c and d) of the proposed outfall pipeline associated with the NRH.

The proposed outfall site enters the foreshore directly east of the NRH eastern boundary. It's location is situated on a previously open beach shoreline running east to west with the ocean side to the north that has been significantly altered by extensive shoreline reclamation. There are no coral reef systems nor mangroves associated with this area.
The site is marine with the benthic substrate dominated by both terrigenous and marine (calcium carbonate) sediments. The subtidal benthic substrate extends seawards (north) and descends gradually to a depth of 14 meters 350 meters from highwater mark at the proposed pipeline entry location. The benthic substrate consists of granular sand and finer sediment particles with the latter revealing highlight percentage levels as depth is attained and to the west. There is an absence of large size benthic substrate material (rocks, boulders etc) throughout the assessed area.

The foreshore and coastal waters directly adjacent to the proposed outfall entry point have been significantly altered by anthropogenic activities including extensive reclamation of the original shallow water intertidal and exposed beach areas (Figure 24). The coastline associated with the proposed outfall boundary is protected by the successive development of rock revetment seawall (calcareous limestone rock) designed to provide all year round protection from storm surge. The original NRH revetement wall (refer Figure 23) during the field survey was being reclaimed by an additional extension of 50 m width along the entire shoreline by a local company.

Figure 24: The foreshore and shallow water environments directly adjacent to the NRH proposed outfall pipeline location.

During periods of high precipitation, the foreshore waters exhibit considerable fluctuations in salinity and increased turbidity due to the river discharge and surface water runoff from neighboring land surfaces. In addition, the reclamation activity undertaken along the shoreline at this site during the assessment period increase turbidity significantly when machinery was in operation (Figure 25). The river is a source of significant pollution (associated with the Honiara city) including significant domestic waste (plastics and other rubbish), sewage and petrochemical products. This discharge has a direct impact on the marine water quality associated with the inshore and offshore waters associated with the proposed outfall pipeline.

Figure 25: The foreshore and shallow water environments turbidity during reclamation activity adjacent to the NRH proposed outfall pipeline location.

4.2 Marine Baseline Site Description National Referral Hospital Outfall – Results

This section details the baseline survey results for the marine benthic abiotic habitat and biotic resource (intertidal and subtidal) assessment undertaken along and adjacent to the proposed HRH outfall pipe line as specified in the Marine Ecologist Specialist and overall Environmental Assessment Terms of Reference (TOR). The assessment results and discussions are divided into two separate sections described herein.

In total, five (5) SCUBA Dives (SD) ranging in water depth between 5 – 11 meters (m) and four (4) Free Dives (FD) ranging in water depth of 2.5 - 5m were undertaken at the NRH site during the assessment (refer Figure 5). The total area assessed for all SCUBA and Free dives was 545 m^2 and 1,200 m^2 respectively.

4.2.1 Marine benthic ecosystems associated with the Direct Area of Influence of the proposed NRH outfall pipe line.

The assessment site locations of the marine benthic (abiotic and biotic) habitats and resources directly in line with the proposed NRH outfall pipeline fall within the projects Direct Area of Influence. As such, lie within the potential area of impact associated with the deployment and operations of the proposed new outfall pipeline.

The intertidal and subtidal marine environments located within the proposed outfall pipeline are devoid of coral reefs and associated reef benthic resource due to the inshore areas past extensive and continued shoreline reclamation activities and deposition of sediments discharged from coastal rivers and streams adjacent to the site. Similarly, mangrove trees are absent and recent anecdotal information indicates that they have not been located at this site for an extended period of time.

The northern shoreline, directly adjacent (west) and in front of the proposed outfall pipeline entry point location has been reclaimed and is bordered by a rock revetment breakwater. This breakwater during the assessment was being extended by approximately 50 m seaward (north) resulting in considerable reclamation of the intertidal sea floor.

In total, two (2) SCUBA Dives (SD 1 and SD 5) 10 m and 5 m depth respectively, covering a combined area of 125 m^2 and one (1) Free Dive (FD 2) 2.5 m depth and an area of 400 m^2, covering a combined area of 525 m^2 marine ecological surveys were undertaken within the projects proposed direct Area of Influence. Figure 5 provides the assessment site locations and Table 5 provides the GPS location, water depth, distance from shore and general description of each site associated with the NRH site direct area of influence.

Table 5: Location and general information of the SCUBA and Free Dive sites undertaken within the direct area of influence at the proposed outfall at the NRH Site.

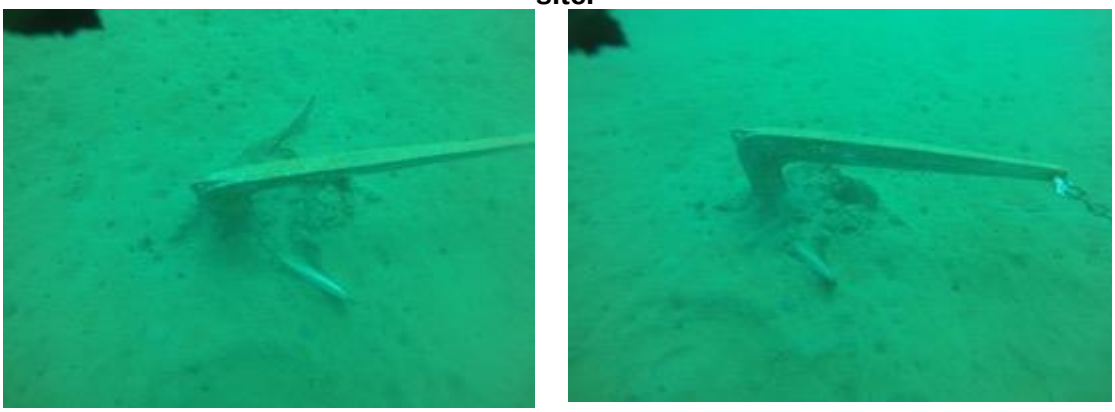
SCUBA Dive 1 (SD1)	➢ ($09^0$26’04.1”S $159^0$58’32.8”E). ➢ Located 300 m offshore from the high water mark and directly north of the proposed outfall water entry location. ➢ Anticipated outfall discharge location. ➢ Maximum depth of water 10 m.
SCUBA Dive 5 (SD5)	➢ ($09^0$25’94.8”S $159^0$58’30.5”E). ➢ Located 150 m offshore from the high water mark and directly north of the proposed outfall water entry location. ➢ Maximum depth of water 5 m.
Free Dive 2 (FD 2)	➢ ($09^0$26’03.6”S $159^0$58’30.8”E).

	➢ Located 50 m offshore from the high water mark and directly north of the proposed outfall water entry location. ➢ Maximum depth of water 2.5 m.

The shallow water intertidal and subtidal benthic substrate profile associated with the proposed outfall pipeline is similar throughout the area assessed. The benthic substrate profile gently decreases northwards (offshore) through a gentle slope reaching water depths of 14 m some 350 m offshore (the proposed outfall termination point). Due to the close proximity of the river (to the west) it is envisaged sedimentation levels, turbidly and subsequent water depths may change during periods of intensive precipitation and subsequent river discharge.

The seabed substrate is relatively homogenous throughout the assessment site and is characterized by a bottom layer of coarse sand derived from terrigenous and coral reef origins with a thin top layer of fine sediment - silt originating from alluvial deposits. The sediment layer is more pronounced towards the offshore assessed areas, however fluctuations in the depth of the sediment layer and resulting water turbidity is directly related to weather conditions prevailing at any given time. The foreshore and coastal reclamation activities, including bucket dredging (refer Figure 24 f)) at the time of the assessment significantly elevated turbidity (suspended sediments) throughout the site. These sediments do impact the water quality associated with the project site and have a direct impact on the benthic coral reef resources. It is noted that no coral or river derived rubble, rocks or boulders were located at any site during the assessment. Figure 26 provides representative photos of the benthic substrate at the three assessment sites (2 SCUBA and 1 Free Dives) associated with the direct Area of influence of the project.

Figure 26. Representative photos of the benthic substrate associated with SD1 (a, b), SD 5 (c, d) and FD 2 (e, f) direct area of influence at the proposed NRH outfall site.



The relatively high level of suspended silt and sand based substrate (refer Figure 26) located at all assessment sites and the lack of hard benthic structures (rocks, reef etc) has a significant detrimental effect on recruitment and survival of sessile benthic marine life. This has resulted in a paucity of sessile and mobile benthic invertebrate species. Nevertheless small numbers of marine worm (polychaetes) burrows were observed at all sites, however population densities were low (Figure 27 a). These resources are mobile and can adapt to changes in the benthic sediment profile.

There were no mollusks (e.g. bivalves, gastropods, cephalopods) nor crustaceans (e.g. crabs, mantis shrimps) located at any assessment site within the direct area of influence. One individual sea cucumber, *Holothuria coluber* was located at SD 1 (Figure 27 b). The absence of these resources during the survey, specifically those that have an economic value (e.g. sea cucumbers) may be attributed to the time of the assessment, however it is more likely be a direct result of fishing pressure.

The brown macroalgae *Padina sp.* and *Sargassum sp.* were located in very small densities (FD 2) in isolated depression pockets within the sea floor. All plants located were not attached and as such have been carried into the site via water and current action. There was no evidence that natural sessile individuals are located within this area. (Figure 27 c and d). No sea grass were recorded during the assessment.

There were no hard or soft corals recorded at any site, nor was there any evidence of local recruitment associated with the revetment breakwater wall.

Figure 27: Marine Invertebrates polychaete burrows (a), sea cucumber (b) and macroalgae (c and d) located during the marine assessment within the direct area of influence of the proposed NRH outfall pipeline.

Finfish population numbers and species diversity were exceptionally low at all sites assessed within the direct area of influence with only a small school of yellow tail scad (*Atule mate*) seen moving through the area (they are not resident benthic fin fish) and are a common tropical finfish species within the Solomon Islands. The absence of predator finfish, the small size and population number of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived both situations are currently operating within the proposed outfall pipeline.

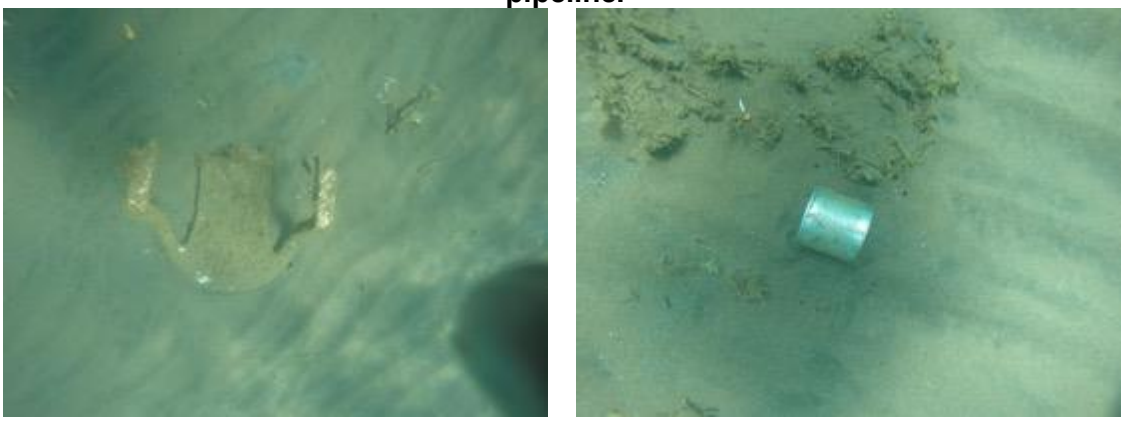
No dugongs (*Dugong dugon*) nor marine turtles were recorded during the assessment nor was there any literature located that indicates marine turtles nested along this shore line in the past several decades.

There was no evidence of spearfishing in the proposed area, however hook and line fishing (refer section 3.1) and swimming from the shoreline was observed.

The marine benthic environment associated with the proposed outfall pipeline contained small amounts anthropogenic derived waste material and garbage (Figure 28) with higher

numbers witnessed closer to the shoreline. The waste material is presumed to originate either from land sources or discarded from vessels.

Figure 28: Anthropogenic material and garbage located during the marine assessments within the direct area of influence of the proposed NRH outfall pipeline.



4.2.2, the assessment of the marine benthic ecosystem directly east and west of the proposed NRH outfall pipe line (Indirect Area of Influence).

The assessment site locations of the marine benthic (abiotic and biotic) habitats and resources adjacent (east and west) to the proposed NRH outfall pipe line fall outside the projects Direct Area of Influence. These sites have been assessed to provide detailed information on the benthic ecosystems and resources within the indirect Area of Influence including sites either side (east and west) of the projects direct physical and operational impact areas associated with the proposed new outfall pipeline.

The intertidal and subtidal marine environments located either side (east and west) of the proposed outfall pipeline are devoid of coral reefs and the paucity of reef benthic resource due to the inshore coastal and foreshore areas past extensive and continued reclamation activities and deposition of sediments discharged from coastal rivers and streams adjacent to the site. Similarly, mangrove trees are absent and recent anecdotal information indicates that they have not been located at this site for an extended period of time.

The shoreline to the east and west of the proposed outfall pipeline entry point has been significantly altered due past and current shoreline reclamation activities including significant rock revetment breakwater development located throughout the majority of the shoreline site (refer Figure 24).

In total, three (3) SCUBA and three (3) Free dives covering a total area of 1,364 m^2 was assessed for the indirect areas of influence associated with the proposed outfall pipeline.

The eastern side assessment site included one (1) SCUBA Dive (SD 2) 11 m water depth covering an area of 256 m^2 and two (2) Free Dive (FD 1 and FD 3) 5 m and 2.5 m water

depth respectively, covering an area of 544 m^2, covering a combined area of 800 m^2 marine ecological surveys.

The western side assessment site included two (2) SCUBA Dives (SD 3 and SD 4) 9 m and 5 m water depth respectively, covering a combined area of 164 m^2 and one (1) Free Dive (FD 4) 5 m water depth and an area of 400 m^2, covering a combined area of 564 m^2 marine ecological surveys. Figure 5 provides the assessment site locations and Table 6 provides the GPS location, water depth, distance from shore and general description of each site associated with the direct area of influence of the proposed NRH outfall pipeline.

Table 6: Location and general information of the SCUBA and Free Dive sites undertaken to the east and west of the proposed outfall at the NRH Site.

SCUBA Dive 2 (SD2)	➢ ($09^0$26'02.5"S $159^0$58'40.0"E). ➢ Located 290 m offshore from the high water mark, 215 m east of the proposed outfall water entry location. ➢ Maximum depth of water 11 m.
SCUBA Dive 3 (SD3)	➢ ($09^0$25'86.5"S $159^0$58'20.6"E). ➢ Located 290 m offshore from the high water mark, 150 m west of the proposed outfall water entry location. ➢ Maximum depth of water 9 m.
SCUBA Dive 4 (SD4)	➢ ($09^0$25'94.3"S $159^0$58'20.1"E). ➢ Located 180 m offshore from the high water mark, 150 m west of the proposed outfall water entry location. ➢ Maximum depth of water 5 m.
Free Dive 1 (FD 1)	➢ ($09^0$26'02.6"S $159^0$58'42.0"E). ➢ Located 120 m offshore from the high water mark, 180 m east of the proposed outfall water entry location. ➢ Maximum depth of water 5 m.
Free Dive 3 (FD 3)	➢ ($09^0$26'02.1"S $159^0$58'40.6"E). ➢ Located 50 m offshore from the high water mark, 180 m east of the proposed outfall water entry location. ➢ Maximum depth of water 2.5 m.
Free Dive 4 (FD 4)	➢ ($09^0$26'02.9"S $159^0$58'20.2"E). ➢ Located 50 m offshore from the high water mark, 150 m west of the proposed outfall water entry location. ➢ Maximum depth of water 5 m.

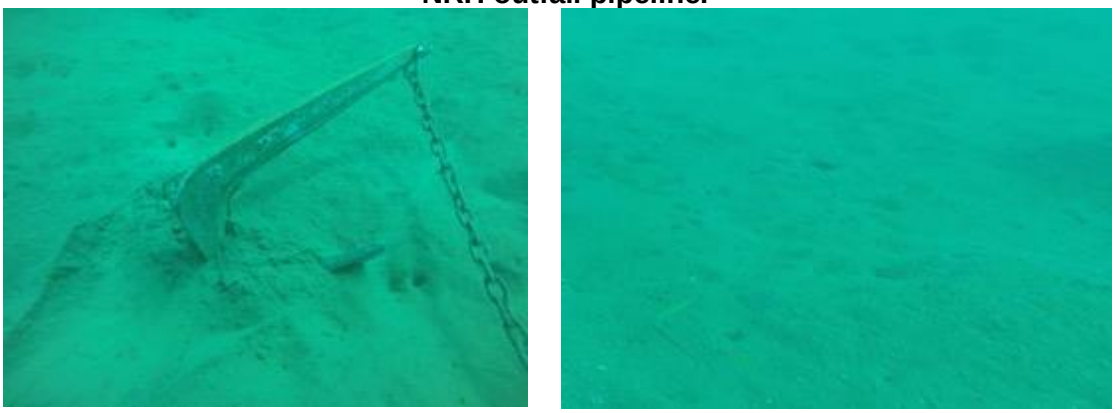
The shallow water intertidal and subtidal benthic substrate profile to the east and west of the proposed outfall pipeline are similar and duplicate each other throughout the area assessed. Both areas are also very similar to the ecological areas associated with the direct area of influence (refer section 4.2.1). The benthic substrate profile gently decreases northwards (offshore) through a gentle slope reaching water depths of 14 m and 15 m east and west respectively of the proposed outfall pipeline termination point, 350 m

offshore. Due to the close proximity of the river (to the west) it is envisaged sedimentation levels, turbidly and subsequent water depths may change during periods of intensive precipitation and subsequent river discharge.

The seabed substrate is relatively homogenous throughout the assessment sites and is characterized by a bottom layer of coarse sand derived from terrigenous and coral reef origins with a thin top layer of fine sediment - silt originating from alluvial deposits.
The sediment layer is more pronounced towards the offshore assessed areas and to the west (closer to the river mouth), however fluctuations in the depth of the sediment layer and resulting water turbidity is directly related to weather conditions prevailing at any given time. The foreshore and coastal reclamation activities, including bucket dredging (refer Figure 24 f)) at the time of the assessment significantly elevated turbidity (suspended sediments) throughout the site, but was more pronounced towards the west of the site.

These sediments do impact the water quality associated with the project site and have a direct impact on the benthic coral reef resources. It is noted that no coral or river derived rubble, rocks or boulders were located at any site during the assessment. Figure 29 and Figure 30 provides representative photos of the benthic substrate at the six assessment sites (3 SCUBA and 3 Free Dives) associated with the benthic assessment to the east and west respectively, of the Area of influence of the project.

Figure 29. Representative photos of the benthic substrate associated with the eastern assessments sites of SD2 (a, b), FD 1 (c, d), FD 3 (e, f) of the proposed NRH outfall pipeline.



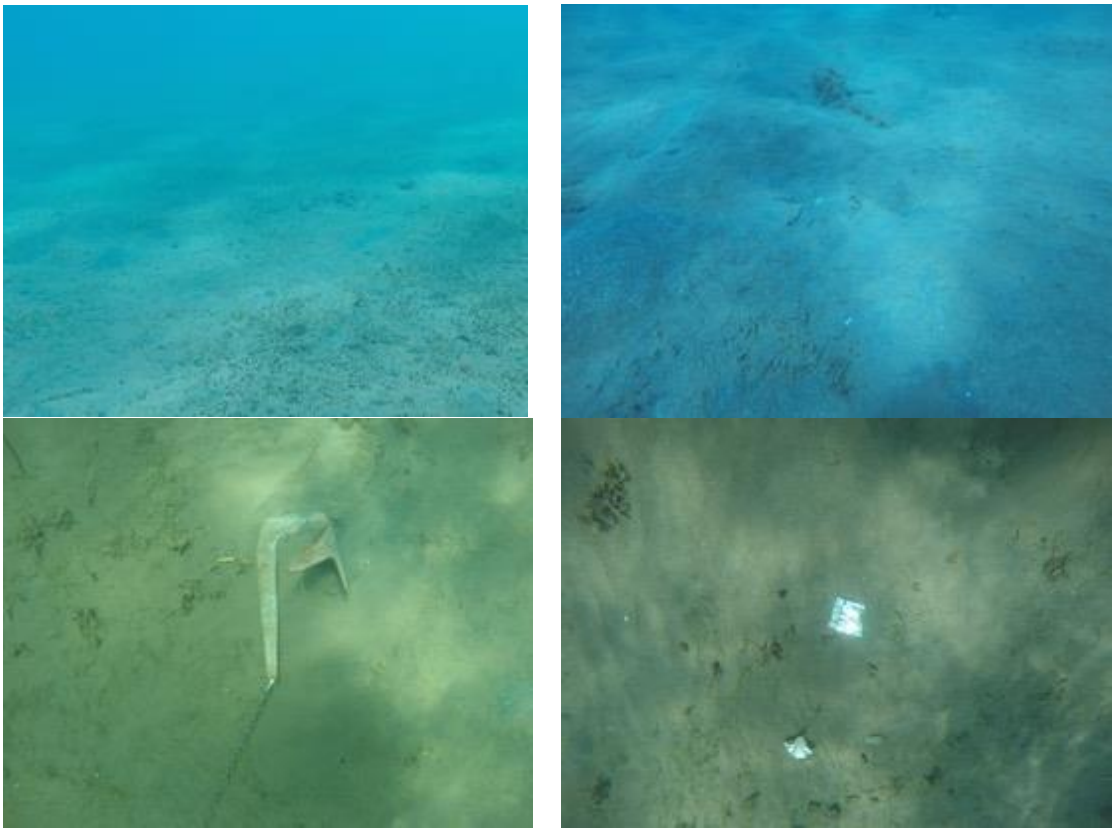
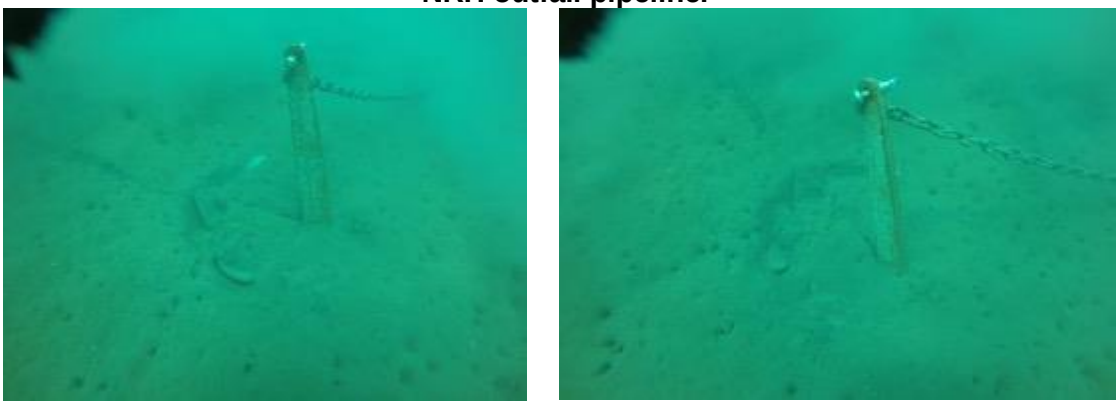


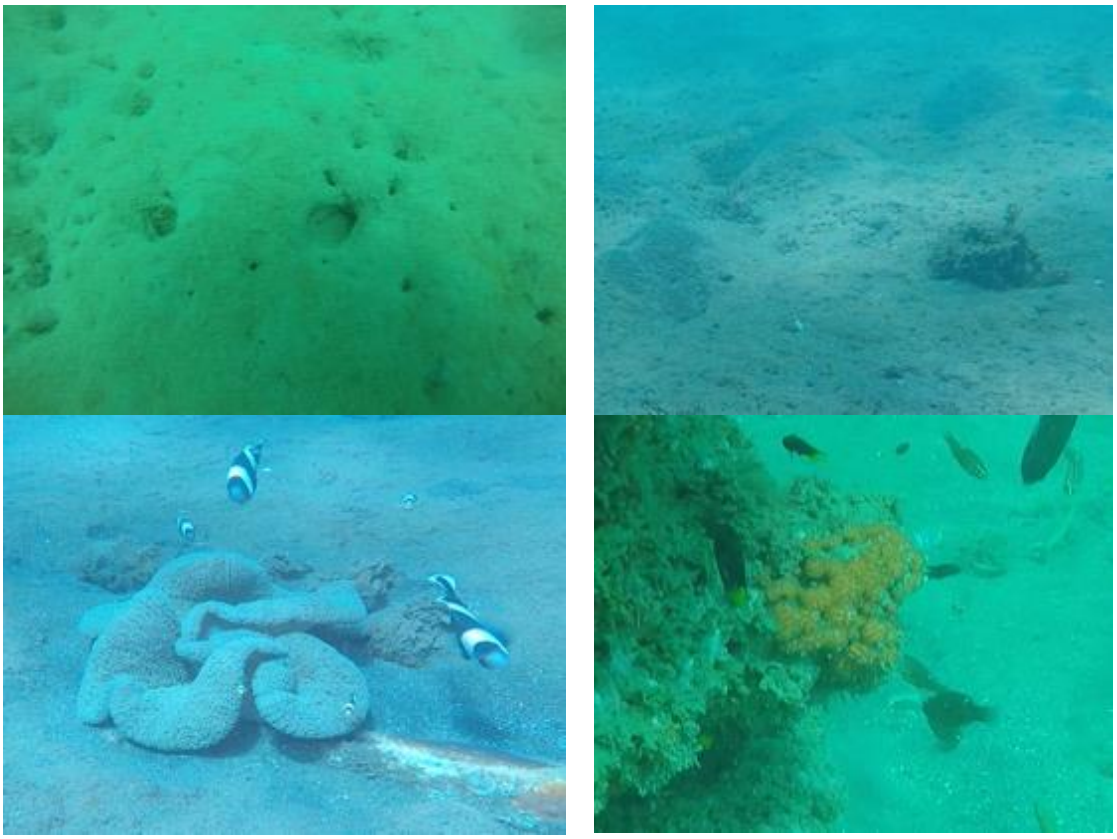
Figure 30. Representative photos of the benthic substrate associated with the western assessments sites of SD3 (a, b), SD 4 (c, d), FD 4 (e, f) of the proposed NRH outfall pipeline.



The relatively high level of suspended silt and sand based substrate (refer Figures 29 and 30) located at all assessment sites and the lack of hard benthic structures (rocks, reef etc) has a significant detrimental effect on recruitment and survival of sessile benthic marine life. This has resulted in a paucity of sessile and mobile benthic invertebrate species. Nevertheless small numbers of a range of benthic mobile invertebrates and juvenile finfish were located during the assessment. Species diversity and numbers of invertebrates were considerably higher at the eastern assessments sites and both the eastern and western assessments sites had significant higher numbers and diversity (albeit very low) than those located directly within the proposed pipeline area of influence.

Marine worm (polychaetes) burrows were observed at all sites, however population densities varied between sites with higher numbers recorded to the east. (Figure 31a and b). One anemone (*Stichodactyla sp.)* (soft coral) and associated clown fish (FD 1) and anemone shrimp was located in 5 m of water (Figure 31 c). These resources are mobile and can adapt to changes in the benthic sediment profile. A number of species of marine sponges (Figure 31 d) were located attached to hard benthic structures, when present.

Figure 31: Marine Invertebrate polychaete burrows (a, SD 3 and b, FD 1), anemone including resident clown fish (c, FD 1) and marine sponges (d, SD 2) located during the marine assessment of the eastern and western sites of the proposed NRH outfall pipeline.



Two species of sea cucumber (Echinoderms) were located at two eastern assessments site locations. One specimen of *Holothuria coluber* was located at FD 1 (Figure 32 a), whilst eight *Holothuria coluber* were located at SD 2 (Figure 32 b).

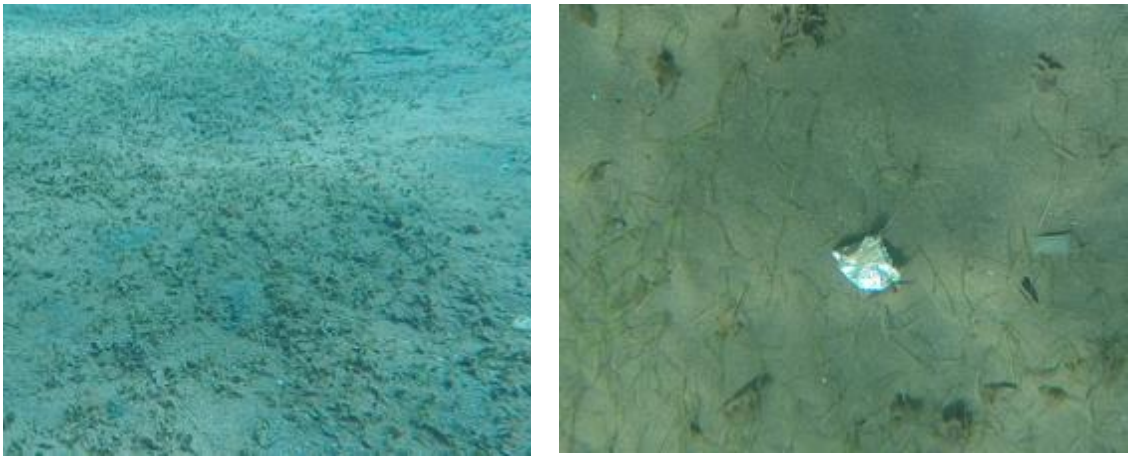
Figure 32: Marine Invertebrate sea cucumbers (a, FD 1, b SD 2), located during the marine assessment of the eastern sites of the proposed NRH outfall pipeline.


There were no hard corals, Mollusks (clams, shells etc) nor commercial crustaceans located during the assessment.

Two species of macro algae were located during the assessments, the brown algae *Padina sp.* (Figure 33 a) and *Sargassum sp*. (Figure 33 b) were located at 4 assessment sites (SD 2, SD 3, FD 1 and FD 3) and two assessment sites (SD 2 and SD 3) respectively, all at very low densities and associated with hard substrate (rock or rubbish).

Two species of sea grass. Were located during the assessment, both in the shallow waters to the east of the proposed outfall pipeline situated well outside the area of influence (200 plus m to the east). *Halophila ovalis* (Figure 33 c) was recorded only at FD 1 site and covered an area of approximately 300m^2 of the sea floor. *Halodule pinifolia* (Figure 33 d) was recorded on at FD 3 site and covered an area of approximately 150 m^2 of the sea floor. Both sea grass populations showed low sea floor density coverage and appeared to be struggling with the fine sediment present at both sites.

Figure 33: Marine macro algae (a and b) and sea grass (c and d) located during the marine assessment of the eastern and western sites of the proposed NRH outfall pipeline.

Finfish population numbers and species diversity were exceptionally low at all eastern and western sites assessed adjacent to the direct area of influence with only a few individuals and species identified at three deeper water sites, (SD 2, SD 3 and FD 1). All finfish were associated with marine debris providing an artificial habitat for protection or associated with a sea anemone. All are common tropical finfish species within the Solomon Islands.

This includes small schools of juvenile damselfish (*Pomacentrus sp*.) (Figure 34 a), cardinal fish (*Apogon sp.*), fusiliers (*Caesio sp*.), one grouper (*Epinephelus sp*.) located at SD 2 (Figure 34 b), a juvenile snapper (*Lutjanus sp.)* (FD 1) (Figure 34 c) and clown fish (*Amphiprion sp.)* (SD 2) associated with an individual soft coral anemone (Figure 21 d). Notably, there was an absence top order finfish predators recorded.

No dugongs (*Dugong dugon*) nor marine turtles were recorded during the assessment nor was there any literature located that indicates marine turtles nested along this shore line in the past several decades.

Figure 34: Finfish species located during the assessment of the eastern and western sites associated with the proposed NRH outfall pipe line.


The paucity of predator finfish (one individual grouper located), the small size and population number of individual finfish present and absence of subsistence and commercially valuable invertebrates indicates a high level of resource harvesting and/or an environment not conducive to support these resources. It is perceived both situations are currently operating within the proposed outfall pipeline.

There was no evidence of spearfishing in the proposed area, however hook and line fishing (refer section 4.1) and swimming from the shoreline was observed.

The marine benthic environment to the east and west of the proposed outfall pipeline contained small amounts anthropogenic derived waste material and garbage (Figure 35) with higher numbers witnessed closer to the shoreline. The waste material is presumed to originate either from land sources or discarded from vessels.

Figure 35: Anthropogenic material and garbage located during the marine assessments to the east and west of the proposed NRH outfall pipeline.


4.3 Key Findings of the NRH Proposed Outfall Site Marine Assessment

The proposed NRH outfall site does not impact on any marine (intertidal and subtidal) or coastal conservation and/or protected area, sites of cultural, customary or heritage significance nor any national or international marine, freshwater or coastal (terrestrial)

endangered or protected species. Thus no impacts on critical habitats are associated with this project.

The key findings of the shallow and deeper water foreshore and marine benthic assessment of the proposed NRH outfall site location include:

- The foreshore and seabed substrate associated with the proposed outfall location are relatively homogenous and similar throughout the area. The substrate is characterized by a bottom layer of sand and alluvial soil sediment derived predominantly from terrigenous origin (rivers).
- Silt prevalence and benthic thickness appears to be consistent throughout the area with turbidity levels changing rapidly in shallower waters due to the prevailing weather and tidal conditions. In addition, inshore water turbidity levels fluctuate due to foreshore usage specifically foreshore and intertidal reclamation activities.
- The periodic high level of suspended sediment coupled with the significant benthic sediment layer (silt) on the sea floor has had a detrimental effect on the ability of sessile benthic marine resources to settle and survive. Thus there is no significant benthic resources located within this site (e.g. no coral reef).
- A paucity of sessile benthic invertebrate species was recorded throughout the area. Polychaete (marine worms) burrows were located at all sites assessed and several species of sea cucumbers were located to the east, albeit in low population densities. These benthic fauna resources are mobile and can adapt – survive to disturbances to the benthic substrate.
- Mobile vertebrates, including finfish were recorded in very low population and species numbers.
- No coral reefs, hard and soft corals nor Mangrove trees were recorded within the projects direct and/or indirect area of influence.
- Marine sea weed diversity and population densities were very low throughout the entire area assessed and were dominated by two common brown species (*Padina sp.* and *Sargassum sp.).*
- Two species of sea grass (*Halophila ovalis* and *Halodule pinifolia*) were recorded in low population densities in shallow water to the east of the proposed pipeline location. These populations were limited in benthic surface area inhabited and are well outside (200 plus m) of the projects direct or indirect Area of Influence and no impacts are expected.
- There were no marine mammals and/or marine reptiles (turtles) within or in close proximity to the proposed outfall location site.
- The marine benthic environment associated with the proposed outfall site contains anthropogenic vessel and land based community derived rubbish and floating plastic was common.
- There are no marine or coastal designated marine protected areas or areas of significant biodiversity within or in close proximity to the proposed outfall site nor does the area possess any sites of cultural, customary or heritage significance nor any national or international endangered, endemic or protected species within and adjacent to the proposed area of influence.
- The marine benthic substrate associated with the proposed outfall site location due to its environmental characteristics and past extensive foreshore and intertidal

reclamation activities, the benthic habitat within the proposed area can be considered to have a very low ecological habitat and value.

4.4 Key Environmental Impacts

The proposed scope of works to construct and bury a new outfall pipe line perpendicular to the existing shoreline extending approximately 350 m offshore has a small environmental footprint both above and below water level. Impacts on the marine environment and coastal waters within and around the proposed pipeline are expected to be very minor, localized to the immediate footprint of the works, and easily managed through standard engineering good practice mitigation measures. There are no threats to the area's marine and coastal biodiversity associated with the project. As such the potential impacts of the works on the marine environment are considered to be very minor, temporary, easily mitigatable and overall insignificant.

The potential impacts of the project on the marine biological environment include:

- Localized and temporary increased suspended sediment levels adjacent to and either side of the proposed outfall pipeline potentially affecting marine habitats and associated resources during construction activities.
- Spillage/leakage of oil and other pollutants into the marine environment from plant and equipment used during the construction phase of the project.
- Benthic habitats associated with the footprint directly within and adjacent to the proposed pipeline are comprises almost exclusively of mud/silt sand substrate with a paucity of benthic sessile invertebrates. As such the benthic substrate habitat may be classified as a highly modified and disturbed benthic foreshore and marine habitat of low ecological value.
- The proposed scope of works as such will have a negligible potential impact on these habitats, its resources and is acceptable.
- There is potential for localized and temporary increased suspended sediment levels in the marine environment around the outfall as a result of the projects physical development. Such impacts are expected to be very minor due to i) the low habitat value of the benthic environment, ii) prevailing high suspended sediment conditions persisting at the site, and iii) the limited physical construction activities proposed.

4.5 Potential Impact Mitigation Measures

The potential impact of increased suspended sediment levels from the works can be further minimized through implementation of the following mitigation measures during the construction phase of the project:

- Deploy silt curtain/s around the foreshore and coastal inshore waters during all physical construction activities to directly manage and reduce the dispersion of benthic substrate (silt) disturbed during construction; and
- Ensure due diligence when operating machinery during all work activities to prevent and manage petrochemical spillage and contamination of the waters associated with the outfall pipeline.

The contractor will be required to ensure all equipment is properly maintained and to follow all necessary precautions to prevent spillage of petrochemicals into the marine environment. Provided such measures are properly implemented the potential impacts on the marine environment will be insignificant.

The overall potential impact of the works on the marine biological environment is expected to be very minor, localized and overall insignificant provided standard mitigation measures associated with good engineering practice as identified above are implemented. Furthermore due to the nature of potential minor impacts of the scope of works it is recommended that no specific marine monitoring program is required during construction other than close supervision of the works to ensure that the above recommended mitigation measures are implemented and effective throughout the marine construction works.

5.0 POTENTIAL IMPACTS TO THE MARINE ENVIRONMENT ASSOCIATED WITH THE DEVELOPMENT OF THE TWO OUTFALL PIPELINES

5.1 Key Summary Findings of the Marine Assessment

Detailed benthic habitat and resource assessment findings for each of the two proposed outfall pipelines are presented in the individual chapters of this report and should be referred for additional baseline information.

Key summary findings of the marine benthic assessment of the two proposed outfall pipeline direct and indirect Area of Influence is summarized below and includes:

- The foreshore and seabed substrate associated with both proposed outfall locations are relatively homogenous and similar throughout each area assessed. The substrate (sea floor) is characterized by a bottom layer of sand and alluvial soil sediment derived predominantly from terrigenous origin (rivers).
- Silt prevalence and benthic thickness appears to be relatively consistent throughout each outfall pipeline area assessed with water turbidity levels changing rapidly in shallower waters due to the prevailing weather and tidal conditions. Inshore water turbidity levels fluctuate at both site locations due to foreshore usage including vessel shoreline movement (e.g. Ranadi) and reclamation activities (both sites).
- Both proposed outfall site locations are in close proximity to large freshwater river systems which during high precipitation events result in high discharge rates have direct impacts on the water clarify, turbidity and salinity of the waters associated with both sites.
- The periodic high level of suspended sediment coupled with the significant benthic sediment layer (silt) on the sea floor has had a detrimental effect on the ability of sessile benthic marine resources to settle and survive. Thus there is no significant benthic resources located at both sites.
- A paucity of sessile benthic invertebrate species was recorded throughout the area.
- No coral reef systems were located at either proposed outfall site.
- Isolated small hard coral colonies were located attached to the foreshore rock revetment wall at the proposed Randai outfall site. These species are common primary colonizing hard corals and have a wide distribution throughout the Solomon Islands and neigbouring nation reefs. Their presence is a direct relationship to availability of a hard surface to colonize. It is envisaged that continued small scale and localized hard coral recruitment along this revetment wall will continue if settlement condition remain.
- Isolated colonies of soft corals including anemones (and their clown fish) were located at both sites, albeit in very low population numbers and diversity.
- Mobile invertebrates abundance and diversity was very low. They were dominated by burrowing Polychaete (marine worms) which were located at all sites assessed, albeit in low population densities. These benthic fauna resources are mobile and can adapt – survive to disturbances to the benthic substrate.

- Mobile vertebrates, including finfish were recorded in very low population and species numbers, the majority small plankitvores and/or algal feeding associated with a hard structure on the sea floor (e.g. rubbish). There was a noticeable lack of predatory finfish at both proposed site locations.
- Marine sea weed diversity and population densities were very low throughout the entire area assessed for both proposed outfall site locations and were dominated by two common brown species (*Padina sp.* and *Sargassum sp.).*
- Two species of sea grass (*Halophila ovalis* and *Halodule pinifolia*) were recorded in low population densities in shallow water to the east of the proposed pipeline location at the NRH site. These populations were limited in benthic surface area inhabited and are well outside (200 plus m) of the projects direct or indirect Area of Influence and no impacts are expected. No sea grass were located at the Ranadi site.
- No mangrove trees were recorded within the projects direct and/or indirect area of influence at both sites.
- There were no marine mammals and/or marine reptiles (turtles) within or in close proximity to the proposed outfall location sites. A pod of dolphins were recorded to the north (500 m) of the Ranadi site moving through the waters well outside the project site.
- The marine benthic environment associated with the proposed outfall sites contains anthropogenic vessel and land based community derived rubbish and floating plastic was common.
- There are no marine or coastal designated marine protected areas or areas of significant biodiversity within or in close proximity to the proposed outfall sites nor does the areas possess any sites of cultural, customary or heritage significance nor any national or international endangered, endemic or protected species within and adjacent to the proposed area of influence.
- The marine benthic substrate associated with the two proposed outfall sites location due to its environmental characteristics and past extensive foreshore and intertidal reclamation activities, the benthic habitat within the proposed areas have a very low marine biodiversity and can be considered to have a very low ecological habitat and value.

5.2 Key Environmental Impacts of Both Proposed Outfall Site Locations The proposed scope of works to construct and bury a new outfall pipe line perpendicular to the existing shoreline extending approximately 500 m and 350 m offshore for the Ranadi and NRH respectively, have a small environmental footprint both above and below water level at both sites. Impacts on the marine environment and coastal waters within and around the proposed pipelines are expected to be very minor, localized to the immediate footprint of the works, and easily managed through standard engineering good practice mitigation measures. There are no threats to the area's marine and coastal biodiversity associated with the project. As such the potential impacts of the works on the marine environment are considered to be very minor, temporary, easily mitigatable and overall insignificant.

The potential impacts of the project on the marine biological environment include:

- Localized and temporary increased suspended sediment levels adjacent to and either side of the proposed outfall pipelines potentially affecting marine habitats and associated resources during construction activities.
- Spillage/leakage of oil and other pollutants into the marine environment from plant and equipment used during the construction phase of the project.
- Benthic habitats associated with the footprint directly within and adjacent to the proposed pipelines are comprises almost exclusively of mud/silt sand substrate with a paucity of benthic sessile invertebrates. As such the benthic substrate habitat may be classified as a highly modified and disturbed benthic foreshore and marine habitat of low ecological value.
- The proposed scope of works at both sites as such will have a negligible potential impact on these habitats, its resources and is acceptable.
- There is potential for localized and temporary increased suspended sediment levels in the marine environment around the outfall as a result of the projects physical development. Such impacts are expected to be very minor due to i) the low habitat value of the benthic environment, ii) prevailing high suspended sediment conditions persisting at the site, and iii) the limited physical construction activities proposed.

5.3 Potential Impact Mitigation Measures

The potential impact of increased suspended sediment levels from the works can be further minimized through implementation of the following mitigation measures during the construction phase of the projects:

- Deploy silt curtain/s around the foreshore and coastal inshore waters during all physical construction activities to directly manage and reduce the dispersion of benthic substrate (silt) disturbed during construction; and
- Ensure due diligence when operating machinery during all work activities to prevent and manage petrochemical spillage and contamination of the waters associated with the proposed outfall pipeline.

The contractor will be required to ensure all equipment is properly maintained and to follow all necessary precautions to prevent spillage of petrochemicals into the marine environment. Provided such measures are properly implemented the potential impacts on the marine environment will be insignificant.

The overall potential impact of the works on the marine biological environment is expected to be very minor, localized and overall insignificant provided standard mitigation measures associated with good engineering practice as identified above are implemented. Furthermore due to the nature of potential minor impacts of the scope of works it is recommended that no specific marine monitoring program is required during construction other than close supervision of the works to ensure that the above recommended mitigation measures are implemented and effective throughout the marine construction works.

5.4 Key Biodiversity Status of the Ranadi and NRH proposed outfall site Locations.

The key marine benthic biodiversity conservation and Sustainable Natural Resource Management status of each of the seven wharfs are presented in Table 7. The table has been developed according to the ADB Safeguard Policy Statement Appendix 1 – Safeguards Requirements 1 : Environment, Section 8: Biodiversity Conservation and Sustainability Natural Resource Management Status definitions.

Table 7: A summary of the key marine benthic Biodiversity Conservation and Sustainable Natural Resource Management status for the Ranadi and National Referral Hospital proposed outfall pipeline.

Wharf	Marine Ecology	Impact Summary	Biodiversity Conservation & Sustainable Natural Resource Management Status[1]		
			Modified Habitat[2]	Natural Habitat[3]	Critical Habitat/Species[4]
Ranadi	Sea shoreline – open ocean – protected in part by adjacent islands. No coral reef, sea grass nor mangrove present. Marine coastal environment – full salinity, except surface waters during high rainfall. Small stream adjacent (east) to site, large river further east. Very limited (paucity of) benthic sessile invertebrate communities. Sand - Silt dominated benthic substrate. Extensive foreshore &	Very minor ecological – resource impacts. No threats to areas marine (inshore & offshore) & coastal biodiversity. No endangered or endemic flora and fauna species present. Very small localized site specific footprint increase in suspended sediment during pipeline deployment. Very minor potential petrochemical spillage during construction. All localized to project footprint. All completely reversible and manageable.	Yes. Extensive foreshore and inshore coastal rehabilitation and alteration. Expected to continue in the future. Adjacent to Honiara land fill.	Well outside of proposed outfall alignment - Area of Influence.	None Recorded

[1] ADB Safeguard Policy Statement (2009) Appendix 1 – Safeguards Requirements 1 : Environment, Section 8: Biodiversity Conservation and Sustainability Natural Resource Management Status.

[2] **Modified Habitat**. Where the natural habitat has apparently been altered (SPS, 2009).

[3] **Natural Habitat**. Land and water areas where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area's primary ecological functions (SPS, 2009).

[4] **Critical habitat** is a subset of both natural and modified habitat that deserves particular attention. Critical habitat includes areas with high biodiversity value, including: (i) habitat required for the survival of critically endangered or endangered species; (ii) areas having special significance for endemic or restricted-range species; (iii) sites that are critical for the survival of migratory species; (iv) areas supporting globally significant concentrations or numbers of individuals of congregatory species; (v) areas with unique assemblages of species or that are associated with key evolutionary processes or provide key ecosystem services; and (vi) areas having biodiversity of significant social, economic, or cultural importance to local communities (SPS, 2009).

Wharf	Marine Ecology	Impact Summary	Biodiversity Conservation & Sustainable Natural Resource Management Status[1]		
			Modified Habitat[2]	Natural Habitat[3]	Critical Habitat/Species[4]
	intertidal reclamation – alteration. Highly disturbed ecosystem. No MPA or other managed areas.				
NRH	Sea shoreline – open ocean – protected in part by adjacent islands. No coral reef, nor mangrove present. Sea grass recorded to east (well outside projects area of influence 200 m +). Marine coastal environment – full salinity, except surface waters during high rainfall and river (to the west) discharge during high rainfall events. Very limited (paucity of) benthic sessile invertebrate communities. Sand - Silt dominated benthic substrate. Extensive foreshore & intertidal reclamation – alteration. Highly disturbed ecosystem. No MPA or other managed areas.	Very minor ecological – resource impacts. No threats to areas marine (inshore & offshore) & coastal biodiversity. No endangered or endemic flora and fauna species present. Very small localized site specific footprint increase in suspended sediment during pipeline deployment. Very minor potential petrochemical spillage during construction. All localized to project footprint. All completely reversible and manageable.	Yes. Extensive foreshore and inshore coastal rehabilitation and alteration. Expected to continue in the future. Adjacent to Honiara main hospital.	Well outside of proposed outfall alignment - Area of Influence.	None Recorded

6.0 BIBLIOGRAPHY

English, S., Wilkinson, C. & Baker, V., (Ed). 1997. Survey manual for Tropical Marine Resources, 2nd Edition. Australian Institute of Marine Science publication. 390pp.