Maldives Tsunami Reconstruction Program

USAID Contract No. 320-C-00-06-00001-00

Environmental Assessment for the Installation of Seawater Reverse Osmosis Facilities on Hinnavaru and Naifaru Islands in the Lhaviyani Atoll

Maldives Tsunami Reconstruction Program

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Prepared for

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Acronyms and Abbreviations

Symbol	Explanation
AGE	Acute gastro-enteritis
Aqua-Tech	Aqua-Tech Engineering & Supplies Pte. Ltd
ARI	Acute respiratory infection
bgs	below ground surface
CHIS	CH2M HILL International Services (contractual entity of CH2M HILL Ltd for this contract)
CHRE	CH2M HILL resident engineer
COP	Chief of party
DHF	Dengue hemorrhagic fever
EA	Environmental Assessment
EIA	Environmental Impact Assessment
ERC	Environmental Research Center
FAO	Food & Agriculture Organization – an agency of the United Nations
gpm	Gallons per minute
GoM	Government of the Maldives
HDPE	High density polyethylene (type of plastic used in pipe and tanks)
IEE	Initial Environmental Examination
IDC	Island Development Council
HDPE	High density polyethylene (type of plastic used in pipes)
IFRC	International Federation of Red Cross/Red Crescent
km	Kilometer
l	Liter
m	Meter
mg/l	Milligrams per liter
mm	Millimeter
mm/y	Millimeters/year
m^3	Cubic meter
m^3/d	Cubic meters per day
m^3/h	Cubic meters/hour
MEEW	Ministry of the Environment, Energy and Water (Maldives)
MTRP	Maldives Tsunami Reconstruction Program
MWSA	Maldives Water & Sanitation Authority
NGO	Non-government organization
PAH	Polyaromatic hydrocarbons
PCB	Polychlorinated biphenyls
PN	Project number (for CH2M HILL)
ppm	Parts per million
PVC	Polyvinyl chloride (type of plastic used in pipes)
SWRO	Seawater Reverse Osmosis
THP	Total petroleum hydrocarbons
USEPA	United States Environmental Protection Agency
USAID	United States Agency for International Development
WDC	Women's Development Council
WQ	Water quality
WSS	Water supply and sanitation (often used by USAID)

Executive Summary

USAID is providing assistance to the Government of the Maldives as part of a tsunami reconstruction program. One major component of the assistance is the installation of two 30-cubic meter per day seawater reverse osmosis desalination units on the islands of Naifaru and Hinnavaru.

This Environmental Assessment for the installation of the seawater desalination facilities on Naifaru and Hinnavaru islands in Lhaviyani Atoll in the Maldives has been carried out at the request of USAID in order to fulfill the requirement of the United States Environmental Regulation 22 CFR 216. The primary objective of the environmental assessment was to evaluate the potential impacts rendered by the construction of the components associated with the facility and recommend mitigation measures to minimize any adverse impacts. These components include: the intake and discharge pipelines in the sea; transmission and distribution pipelines on land; the building and associated facilities to contain the SWRO units and the operational phase of the facilities.

Sites for the construction of the facilities were selected by the Government of the Maldives in conjunction with the local Island Development Committees. The facilities will be constructed on sites that are about 500 square meters on Naifaru and 325 square meters on Hinnavaru. Storage for 30 cubic meters (a day's full production) will be provided on each island as will a 2 kilometer distribution system. The distribution system will serve about 10 community taps that will be located throughout the two communities.

Table ES.1 lists the major impacts and mitigation measures that are anticipated.

TABLE ES.1 Major impacts and mitigation measures

Environmental Impacts			Mitigation	
No.	Impact	Activity	Degree[1]	Measure
Impact on soil and terrestrial vegetation				
1	Loss of productive soil or vegetation by removal or erosion	Excavation for foundations and trenches for pipes. Most soil is only sand and there is almost no vegetation.	Low	Soil removed and piled should not be placed close to the shore to avoid erosion into the sea.
2	Loss of trees on the SWRO facility site on Hinnavaru	General construction activity within the boundary wall that has been constructed.	Moderate	A wall will be constructed on the eastern end of the site to separate the area with the trees from the rest of the site and no storage or construction activity will be allowed
Impact on freshwater resources				
3	Contamination of the freshwater lens by seawater discharges or dumping	Start-up and testing of the SWRO facility with seawater	Moderate	The brine discharge line and connecting drains in the SWRO facility site must be completed before any seawater is pumped to the settling tank so that there is a method to discharge it to sea.
4	Contamination of the freshwater lens by spillage of gasoline, oil	Storage of materials and servicing of mechanical equipment by the	Moderate	All lubricants and fuel must be stored in approved containers and servicing of equipment done in a

[1] Degree of impact without mitigation measures

TABLE ES.1 Major impacts and mitigation measures

Environmental Impacts			Mitigation	
No.	Impact	Activity	Degree[1]	Measure
	and other chemicals	contractor		manner to minimize spillage. Empty containers should be taken to the solid waste facility on each island.
Impact on marine environment				
5	Disturbance of aquatic habitats	Installation of the seawater intake and brine discharge lines	Low	The route and schedule of the placement of the pipelines will be coordinated with the local fishermen to insure that fisheries & anchorages are not disturbed. The concrete anchors and pipeline should be assembled on shore and floated into position to avoid dragging things on the sea bottom
6	Disturbance of aquatic habitats	Discharge of brine from the SWRO unit through the brine discharge pipeline	Low	Instead of the direct, end of pipe, discharge commonly used in Maldives, the last 10 meters of the discharge pipe will be perforated to spread the flow.
7	Disturbance of aquatic habitats	Intake of seawater by the seawater intake pipeline	Low	Flow into the 100-mm diameter pipe will be less than 20 gal/min, the intake will be a screen to keep out fish and it will be located off the sea bottom by about one meter.
General				
8	Increase in noise pollution	Construction	Low to Moderate	This will be limited in time as the actual construction activity will be less than about 4 months. The Naifaru site is far enough away from dwellings to have very limited affect but the Hinnavaru site will be more of a problem
9	Increase in noise pollution	Operating	Low to Moderate	The SWRO building and the boundary wall will reduce the noise level. Naifaru site is away from dwellings. Hinnavaru will be more of a problem as there are buildings immediately adjacent to the site
10	Spread of solid waste and other construction materials	Construction	Moderate	The contractor will be directed to move all construction debris to the solid waste disposal areas on each island at regular intervals
11	Discharge of disinfecting solution	The distribution main will be filled with a chlorine solution to disinfect it.	Moderate	The solution should be discharged into the harbor on Naifaru (Tap #1) and near the marine docking area on Hinnavaru (Tap #1). See Figures 2.5 and 2.7

Based on the assessment presented in this report, we have the following conclusions:

- The installation of the seawater reverse osmosis facilities and associated appurtences on the two project islands will not have a significant negative impact
- Positive impacts clearly outweigh the negative temporary impacts, which are minor and can be mitigated
- The project activities are compliant with laws and policies
- Preliminary approvals by the Government of the Maldives are being processed by the relevant agencies – Ministry of the Environment, Electricity and Water. And the Environmental research Center
- The project is socially acceptable; organizations representing beneficiary groups were consulted and are in support of the project at the time of writing
- There is a group of citizens on Hinnavaru that do not approve of the use of Site #2 for the installation of the seawater reverse osmosis facilities – The Ministry of the Environment, electricity and water has said that this does not represent the majority opinion on the island
- The issue of using Site #2 on Hinnavaru needs to be resolved by the Government of the Maldives
- USAID and CH2M HILL need to agree on what further measures, if any, should be employed in the investigation of Site #2 on Hinnavaru for possible contamination by the nearby abandoned power plant

It is recommended that the project go forward with due consideration to the mitigation measures contained in this report. And that the mitigation measures discussed in this report be carried out.

All relevant provisions and stipulations provided above with regard to mitigatory measures should be included in the contract documents. Additional cost items for these should be specified in the bill of quantities if necessary.

The potential for prior contamination of the soil at the Hinnavaru site must be ruled out prior to finalization as a site.

Section 1 – Introduction

1.1 Project Background

On December 26, 2004, a tsunami swept over the Maldives leaving many dead, missing, or displaced persons. Many of these were without basic shelter, food and water. Through USAID's Office of Foreign Disaster Assistance and other organizations, emergency relief reached many Maldivians and the focus of the efforts has now turned to reconstruction, livelihood restoration, and rebuilding lives and re-knitting communities.

Aside from assisting the Ministry of Environment, Energy, and Water (MEEW) with capacity development, community assessment, mobilization and environmental health, the project will improve services on the islands of Naifaru and Hinnavaru by the installation of two seawater reverse osmosis (SWRO) units that were donated by others to the Government of the Maldives (GoM). Depending upon availability of funds once the two RO units are completed, the project will also strive to procure some rainwater harvesting tanks, as well as procurement of additional SWRO units for other islands

In the spring of 2005, Aqua-Tech (a desalination unit manufacturer from Singapore) and Grundfos (a pump manufacturer headquartered in Germany) donated two 30-cubic meters per day (m^3/d) SWRO units to the GoM as part of the international tsunami reconstruction effort. As directed by the GoM, these units were delivered to the islands of Naifaru and Hinnavaru in crates and have been stored there ever since.

In the fall of 2006, USAID contracted with CH2M HILL International Services (CHIS) to install and make operational the SWRO units. Aside from that task there were other subsidiary tasks related to community assessment and mobilization, community environmental health, and institutional strengthening.

1.2 Purpose of the Report

This Environmental Assessment (EA) for installation of SWRO facilities on Naifaru and Hinnavaru islands in Lhaviyani Atoll in the Maldives has been carried out at the request of USAID in order to fulfill the requirement of the United States Environmental Regulation 22 CFR 216[2]. The primary objective of this report is to evaluate the potential environmental impacts rendered by the construction of the components associated with the facility and recommend mitigation measures to minimize any adverse impacts. These components include: the intake and discharge pipelines in the sea; transmission and distribution pipelines on land; the building and associated facilities to contain the SWRO units and the operational phase of the facilities.

1.3 Scope of the Environmental Assessment

The scope and methodology of this EA consisted of two major parts. These were, first, the observation of the marine, terrestrial and socioeconomic situation in the project islands. Second, holding discussions with stakeholders and others on the project islands to understand and place the information gathered in the appropriate social context.

[2] The GoM has their own environmental requirements. It has been determined that these will be met by submitting what is referred to as an Initial Environmental Examination (IEE). This is discussed in Section 1.5

1.4 Stakeholder Consultation

The major stakeholders in the program are represented by the Island Development Councils (IDC) and non-government organizations (NGOs) on each island. These have been consulted in a series of meetings that have taken place in November, 2006 and March, 2007 on the project islands. Figures 1.1 and 1.2 illustrate some of the stakeholder consultations that have taken place during the project. Community response to the project is discussed further in Section 5.

1.5 Approvals Needed in Maldives

Relative to the environmental effects, the GoM requires that an Initial Environmental Examination (IEE) report be provided to the Environmental Research Center (ERC). This report was completed in March 2007 and has been reviewed by the ERC. In late April, the ERC sent a request for some follow-up information. This information has been provided to the ERC and is currently being reviewed.

FIGURE 1.1 Discussions with representatives of the Hinnavaru IDC on the location of the seawater intake

FIGURE 1.2 Conferring with the Naifaru IDC on the management plan for the SWRO facilities

Section 2 – Project Description

2.1 Description of the Project

The overall project has five elements, these are described in Table 2.1. Only one of them, Element III (Service Delivery) involves any construction that could impact the environment. This element calls for the installation of two donated SWRO units and the construction of the needed facilities to house the units, make them functional and deliver fresh water to the community. One 30-m^3/d SWRO unit was provided to each of the two project islands (Naifaru and Hinnavaru).

TABLE 2.1 Elements of the project

Element		Description
I	Project team building & coordination	General organization of the project and coordination with MEEW
II	Community assessment & mobilization	Working with the community to support the water project
III	Service delivery	Installation of two donated SWRO units
IV	Community environmental health	Assisting public health officials with awareness campaigns
V	Institutional strengthening at MEEW	Working with MEEW staff to increase their professional capacity

To make the units functional within the community it will be necessary to provide a:

- Central facility to house the SWRO unit as well as provide raw and product water storage, office or shop space, and pumps to distribute the water to the community
- Intake pipeline bringing seawater (for feed) to the unit
- Brine pipeline to discharge concentrate from the unit to the sea
- Pipeline to distribute fresh water to the community

The elements of the RO plant and distribution system are shown in Figure 2.1.

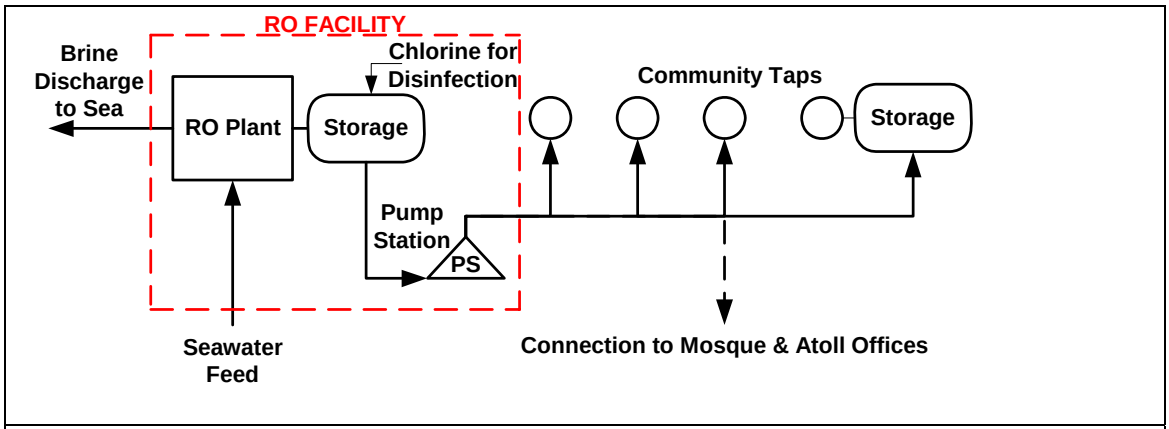

FIGURE 2.1 Major components of the community water system

The SWRO plant to be used on both islands is identical. Figure 2.2 shows the major components of the actual RO unit that will be used.

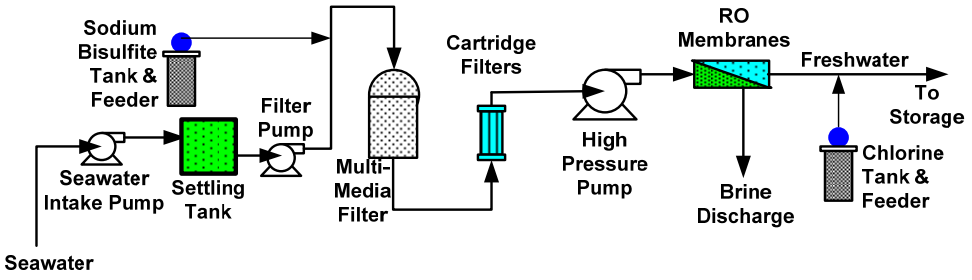

FIGURE 2.2 Major components of the seawater reverse osmosis unit

The unit will be installed in a building on a site on each island along with pumps, storage, etc. Figure 2.3 shows the general layout of the building which will house the SWRO equipment. The buildings on each island will be the same as will be the facilities that will be included within the building site. However the shape and size of the sites will be slightly different.

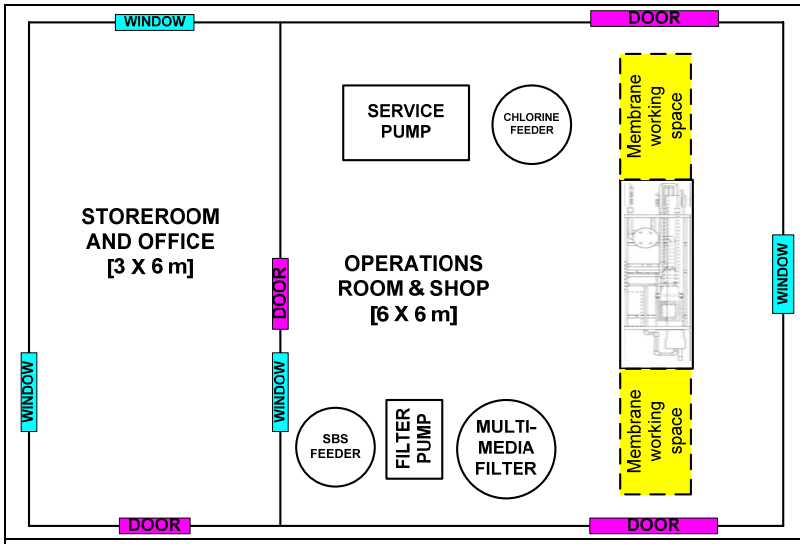

FIGURE 2.3 Layout of the building containing the SWRO unit

In addition to the building, each site will also contain: 1) a feedwater settling tank; 2) a generator; and 3) freshwater storage tanks. The facilities will be enclosed within boundary walls that are currently being constructed by the government.

2.2 Naifaru

Figure 2.4 illustrates the arrangement of the facilities on the site that was designated for Naifaru by the GoM. There may be some minor modifications of the arrangements to allow for special site conditions and discussions with the IDC. Figure 2.5 shows the layout of the facilities on the island.

The IDC selected the various sites for the community water taps on Naifaru. The CH2M HILL engineer determined the layout of the distribution system to match the tap locations selected by the IDC. The design of the distribution system is in the form of a loop which will enhance its hydraulic capacity. As the system increases in capacity, with the addition of another SWRO unit, the capacity of the distribution system can be easily increased by creating other hydraulic loops and adding piping to serve more people.

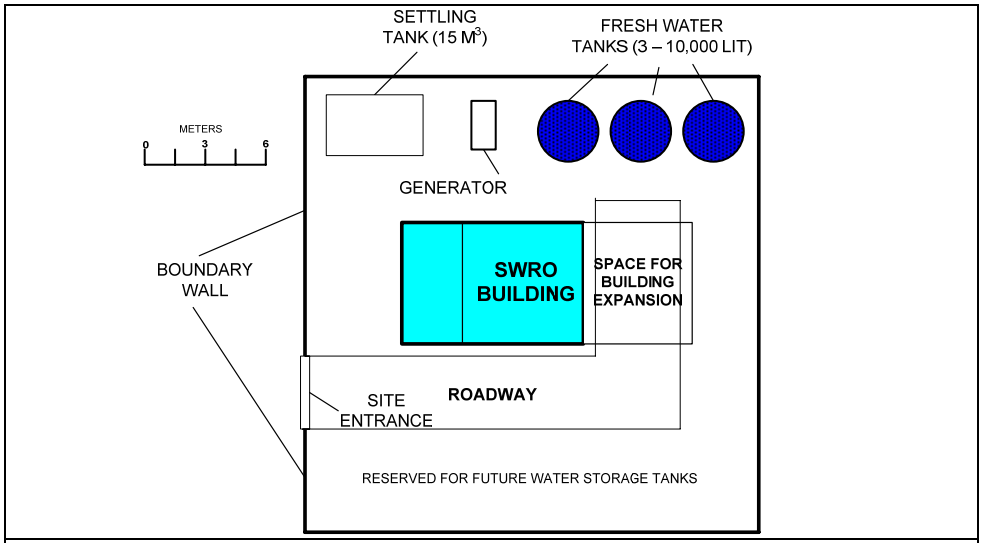

FIGURE 2.4 Arrangement of the buildings and other structures on the Naifaru SWRO site

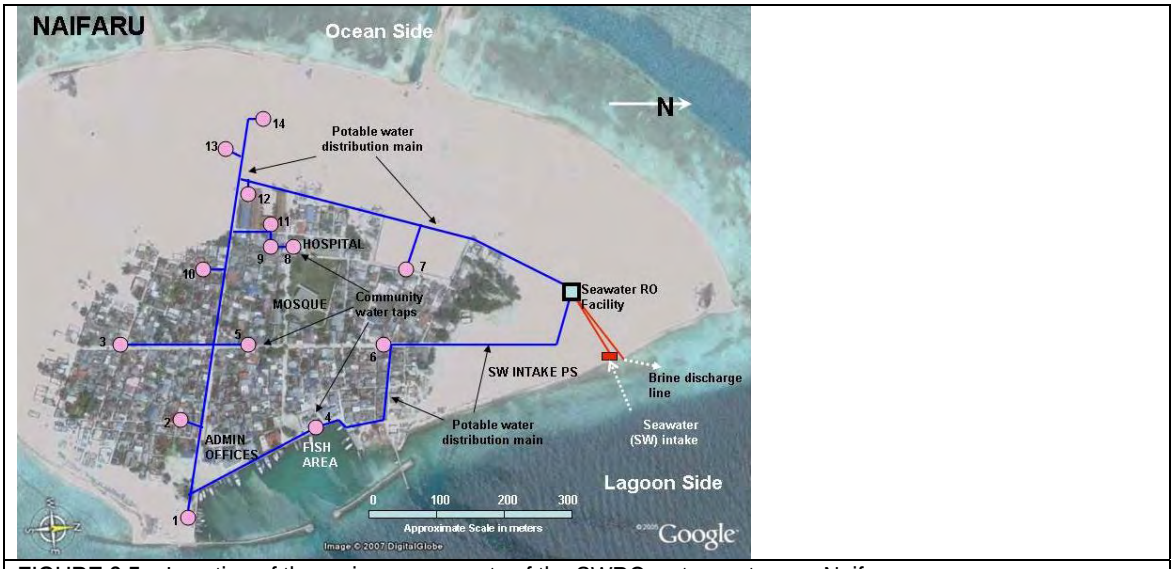

FIGURE 2.5 Location of the major components of the SWRO water system on Naifaru

2.3 Hinnavaru

On Hinnavaru CH2M HILL and USAID were shown two possible sites (here-in-after called Site #1 and Site #2). During the November visit, the CH2M HILL team stated that they greatly preferred Site #1 as it appeared to be technically more appropriate for the application than Site #2. The reasons for this included access to ocean-side seawater, an undeveloped site that was practically devoid of vegetation next to a radio-telephone tower, and less potential of noise disturbance for neighbors during operation. Although this was discussed on several occasions with the IDC, MEEW and others, CH2M HILL was instructed by MEEW to place the facility on Site #2[3]. One of the several technical disadvantages to using this site is the potential for prior contamination of the soil due to the location of an abandoned power plant adjacent to the site. Some very preliminary investigations were made using some basic tests for possible hydrocarbon contamination. These are described in the technical memorandum in Appendix A.

[3] It is still unclear to CH2M HILL why the IDC selected this particular site. Neither the IDC nor the GoM have provided a reason except that it is the one that the Hinnavaru IDC selected.

Figure 2.6 shows the layout of the components on the Hinnavaru site. This site has a smaller area and hence there is less room for future expansion. In addition the site is bordered on four sides by buildings which will have a negative affect on the attenuation of sound for the people occupying the adjacent buildings.

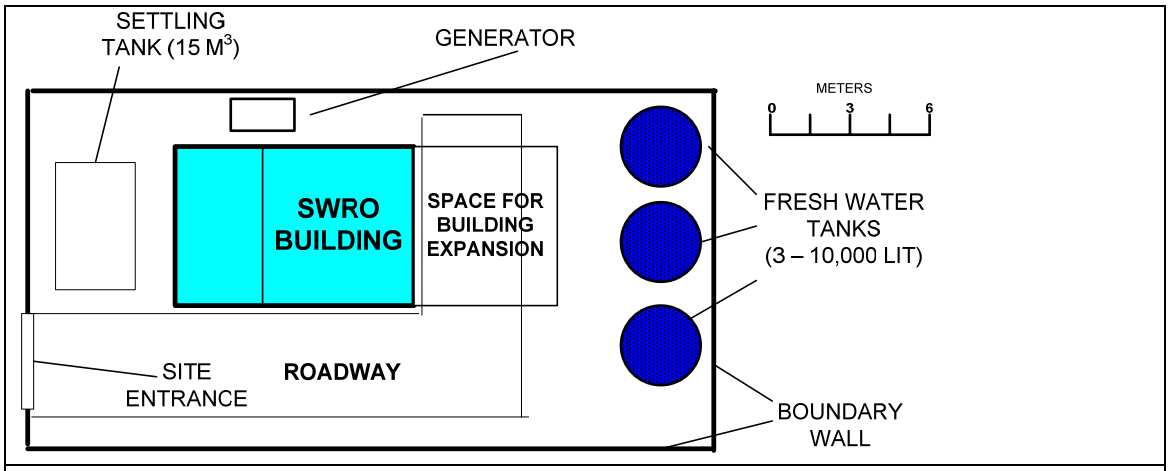

FIGURE 2.6 Arrangement of the buildings and other structures on the Hinnavaru SWRO site

The same elements are present in the facilities site as on Naifaru. In both the Naifaru and Hinnavaru sites, there will be a provision for freshwater storage for the equivalent of one day's production if operated 24 h/d.

The IDC on Hinnavaru provided CH2M HILL with the potential location of the community taps on the island. CH2M HILL made a pipe routing to enhance the hydraulic flow pattern. This distribution system can be readily expanded with the addition of other pipelines so as to increase the hydraulic loops in the system. On both islands, a 2-inch (50-mm) diameter, high density polyethylene (HDPE) pipe was selected for most of the system. The proposed layout for Hinnavaru is shown in Figure 2.7.

FIGURE 2.7 Location of the major components of the SWRO water system on Hinnavaru

2.4 Construction Activities

The major construction activities are listed in Table 2.2.

TABLE 2.2 Major construction activities

Activity	Description
Intake and discharge lines	These lines are installed in the sea. They are 100-mm (in diameter) plastic pipes that will be laid on the sea floor using specially constructed concrete blocks to hold them in place. The intake line is anticipated to be about 100 m in length while the discharge line would be about 50 m
Intake pump station	This is a small building with a footprint of less than 2-m^2 which would be located on the shore and would pump feedwater from the intake line to the SWRO unit.
Transmission mains	Since the SWRO facility is located some distance from the shore, pipelines must be installed to connect the intake (via the pump station) and the discharge lines to the SWRO unit. These are HDPE lines that are 100-mm in diameter.
SWRO facility	The facility is located in a walled area of about 550 m^2 and contains: a single story building (for the SWRO unit and an office); a settling tank for feed water; storage tanks for product water; and a small shed for an emergency generator.
Distribution system	This will be a 50-mm in diameter HDPE pipe about 2 kilometers (km) long that will distribute water to various public taps and users in the community.

2.5 Operational Activities

The major operational activities are listed in Table 2.3.

TABLE 2.3 Major operational activities

Activity	Description
Start-up and operation of the SWRO units	Seawater will be pumped into the facility, have some pretreatment in the settling tank and then, after further treatment passed through the reverse osmosis membranes. Both freshwater and brine will be produced. The fresh water will be pumped into the storage tanks and the brine returned to the sea.
Operation of the distribution system	Water pumped into the storage tanks will be disinfected using a chlorine solution. The water will then be pumped into the distribution system where it can be collected from the community taps or by direct connections rtro selected consumers.
Maintenance	The pumps and electrical equipment will need to be properly serviced and cleaned at regular intervals
SWRO shutdown	Special care will need to be followed to ensure that the reverse osmosis membranes are stored so that they are safeguarded from microbial and other deterioration.

Section 3 – Project Alternatives

3.1 General

This chapter describes project alternatives considered, including a no action alternative. The selection criteria leading to the final selection of the project components are also described. The RFP was very specific in stating that the project would consist of installing the donated SWRO units on the islands of Naifaru and Hinnavaru. The possible alternatives to be considered within the context of the project in Element III came in two areas. These were:

- The source of feedwater for the SWRO units
- The location of the site on Hinnavaru

The selection criteria leading to the final alternatives are given below.

- Technical feasibility
- Constructability
- Environmental acceptability
- Public acceptance
- Least cost alternative

This section presents essential features of the alternatives and the screening criteria leading to the final selection.

3.2 Alternatives Available

3.2.1 No Action Alternative

The no action alternative for the installation of the SWRO was not considered because USAID and the GoM had already agreed that this was to be the main component of the assistance that USAID was to provide.

3.2.2 Alternative Water Sources Option

USAID had originally proposed to use an inland well (borehole) to provide water to the SWRO unit. This had the potential to supply better quality water without constructing an intake in the surrounding sea. However, upon investigation, there appeared to be numerous potential problems with both assuring proper construction to avoid contaminating the freshwater lens and then being certain that a feedwater, in terms of salinity, suspended solids and quantity would be available once the wells were completed.

Technical Feasibility - The use of a borehole at the plant site would theoretically be a good idea. However, with the exception of one large plant in Malé, none of the other SWRO units in the Maldives appear to be using this concept. The feedwater for the large plant in Malé has a high level of hydrogen sulfide requiring an extra treatment step.

Constructability – This was a major problem in that CH2M HILL was unable to find a local contractor that had done a project like this in the Maldives. It would have required the importation of an international contractor adding significantly to project costs. In addition there was no assurance when completed; that the borehole would have produced sufficient water of the proper quality and quantity to operate the SWRO units.

Environmental Acceptability – The Environmental Research Center (ERC) in Maldives expressed some concern on whether the borehole could negatively affect the freshwater lens[4] on the islands. The borehole would need to be constructed through the lens and then seawater would be pumped through the well. Although the borehole would have specified a sealed annular space between the pipe carrying the seawater and the hole constructed for the well, there would have always been the risk that this would fail resulting in salt water entering the freshwater lens and contaminating the water which is a source of supply for the islanders.

Public Acceptance – This was a technical decision and the public was told the reason for the change at the IDC meetings in March, 2007, but it was not something that required their approval.

Least Cost Alternative – After all the projected difficulties with obtaining a contractor, sealing off the freshwater lens and taking the risk of constructing a well that would not deliver feedwater at a suitable flow and quality, it was determined that a seawater intake line would be the most cost effective.

In general the obstacles and uncertainty of construction and the potential problems associated with the borehole persuaded the CH2M HILL team that it was more certain and cost-effective to build a seawater intake line instead of a borehole. This information was transmitted to USAID, in the form of a memo.[5]

3.2.3 Alternative Sites for the SWRO Facilities

The GoM had selected the sites for the SWRO units on both islands before USAID finalized their Request for Proposal (RFP) in mid-2006. When the USAID pre-proposal team and the CH2M HILL project team visited the project islands in August and November, 2006, respectively, the teams were shown the pre-selected sites. On Naifaru a single site had been determined and included in the GoM master plan covering the development of the newly filled areas of the island.

On Hinnavaru, both teams were shown two different sites. One location (Site #1) was near the telephone tower on the north end of the island and the other (Site #2) near an abandoned power plant on the northeast shore. The Naifaru site is one that has a number of positive attributes and the CH2M HILL team determined that it was suitable for use as a facility site.

On Hinnavaru, the CH2M HILL team reviewed the two sites on the occasion of their first visit in November, 2007 and on subsequent visits and determined that Site #1 was preferable over Site #2. However the Island Development Council (IDC) on Hinnavaru has strongly expressed its preference for Site #2. CH2M HILL has outlined its concern with this site in a memo to USAID and MEEW[6]

TABLE 3.1 Comparison of sites on Hinnavaru

	Site #1 (Tower)	Site #2 (Power Plant)
Technical Feasibility	Technically no major problems except possibly some salt spray from being near the shore	Technically no major problems except that noise during operation could be a nuisance to the occupied buildings located are very close to the site
Constructability	No significant problem. A new recycling facility has taken some of the available space	Longer distance to the sea for an intake feedwater line. Also longer distance to connect to the main power source.
Environmental	No apparent significant problems	The abandoned power plant may have

[4] In the Maldives, a portion of the rainwater that falls on each island infiltrates through the surface and flows downward until it encounters the natural ocean water that exists below each island. Because the freshwater has a lower specific gravity than seawater, the freshwater floats on the surface of the seawater. It takes the shape of a lens with the deepest part of the freshwater lens being in the center of the island and the thinnest being along the edges of the island. Islanders place wells into this lens and draw this fresh water for uses such as cleaning, bathing, etc.

[5] CH2M HILL Report to USAID, *Preliminary Assessment Report for the Maldives Tsunami Reconstruction Program*, February 2007

[6] Memo De Mel to M. Gould dated Dec 21, 2006

TABLE 3.1 Comparison of sites on Hinnavaru

	Site #1 (Tower)	Site #2 (Power Plant)
Acceptability		contaminated the soil. Preliminary screening tests do not indicate contamination but USAID should consider more detailed investigations are required to confirm absence of contamination. There is a grove of tress inside the designated site that must be protected.
Public Acceptance	No information	A group of people on the island are strongly opposed to location of the SWRO at this site. They intimated that the facility might be damaged if built on Site #2[7]
Least Cost Alternative	May be slightly lower if additional site investigations & possible cleanup of Site #2 is needed.	Additional site investigation & longer intake & power line plus possible cleanup of any contamination, if detected, could add costs to this site.

3.3 Final Selection from Alternatives Considered

3.3.1 Feedwater Source

The project will be using a seawater intake as a source of feedwater.

3.3.2 Site on Hinnavaru

As of the beginning of May (2007) the GoM has directed the project to use Site #2 on Hinnavaru. CH2M HILL has asked the GoM to specify this in writing.

[7] Memo De Mel to S.A, Ibrahim (MEEW) dated April 10, 2007

Section 4 – Methodology

4.1 General

The EA was developed through a partnership of CH2M HILL staff, including the Chief of Party (COP) who is a water engineer with support from an environmental engineer, a construction engineer and representatives of the local IDCs which included fishermen. This team evaluated the baseline environmental conditions existing in the project sites, the potential impact of construction and operation activities, and proposed mitigation measures.

4.2 Site Reconnaissance

The team field staff carried out site reconnaissance to assess possible environmental concerns. During the site visits, the team performed the following activities:

- Visited all the sites of the project area, including the SWRO facility[8] , the proposed intake pump station, transmission lines (from pump station to SWRO facility) and the distribution system pipe routes where on-the-spot assessments were made in terms of potentially vulnerable ecosystems and communities.

- Visited the alternative site on Hinnavaru.

- Visually evaluated the ecology (flora and fauna) of the areas adjacent to the SWRO facility sites[9].

- Visually evaluated the ecology (flora and fauna) by swimming the proposed route of the seawater intake line on both islands with special attention being paid to presence (or lack of) marine vegetation and coral.

- Reviewed the sites with MEEW and Maldives Water & Sanitation Authority (MWSA) during a trip with their representatives in November, 2006.

- Had a number of meetings with a representative of the Atoll Office, the Deputy Minister for MEEW and the Chief of the Water & Sewerage Division (of MEEW) regarding the overall project and the site on Hinnavaru.

- Held meetings with the IDCs, WDCs and local NGOs on both islands.

- Held a meeting with a group of citizens on Hinnavaru who opposed the use of Site #2 for the SWRO facility.

- Met with the IDCs on both island relative to the location of the seawater intake lines.

[8] The GoM, through the IDCs on each island have constructed a masonry wall (referred to by them as a boundary wall) that demarcates each site.

[9] As seen in the figures in Appendix B, the Naifaru site is located in the middle of an essentially bare piece of ground that was recently filled in using sand from the seabed. The site on Hinnavaru is in the middle of urban development and there is only a few meters of ground between the outside of the boundary wall and adjacent buildings. Inside the Hinnavaru boundary wall are several large trees which CH2M HILL intends to protect and use as a public area.

4.3 Social Impact Assessment Methodology

The approach used in the social impact assessment included consultation with stakeholders and limited collection of socioeconomic data. In the consultation process, staff visited the project islands and met with the IDCs and local NGOs; conducted a survey of 130 households relative to water usage and knowledge of the new project; and held focus group meetings with local citizens on both islands[10]. The local IDCs assisted with the location of the seawater intake and brine disposal lines. See Figures 4.1 and 4.2.

FIGURE 4.1 A public meeting with the IDC and WDC on Hinnavaru to discuss the SWRO facility site and other related matters

FIGURE 4.2 A survey team is briefed before beginning the survey on Hinnavaru in March, 2007

FIGURE 4.3 The CH2M HILL COP discussing an issue with an Atoll Government official

FIGURE 4.4 A women's focus group meeting on water issues on Naifaru in March, 2007

Secondary data was collected from MEEW and USAID.

[10] This will be discussed in more detail in the report to USAID titled, *Environmental Health – Water Assessment for the islands of Naifaru and Hinnavaru*

4.4 Ecological Impact Assessment Methodology

Information on the biological environment and impacts on the ecology of the sites was collected during a field visit to each of the prospective sites. At the time of field visits, it was determined that in-depth ecological surveys were unnecessary given that the areas in particular, and the islands, in general, were already significantly disturbed.

Section 5 – Environment

5.1 Terrestrial

Both islands are part of the Lhaviyani Atoll. As such they are coral atolls whose surface is made up of unconsolidated calcareous materials. The location of the SWRO facility on both islands was selected by the IDCs with approval from the central government. CH2M HILL was not given an option of selecting a suitable site but has been instructed to work with the chosen sites. Aerial photos showing the location of the sites are shown in Appendix B.

On Naifaru, the site for the SWRO facility is located in an area that was recently reclaimed from the sea by filling in a shallow lagoon. This fill project approximately tripled the size of the original island. This new area in the vicinity of the SWRO facility is almost completely devoid of vegetation although some signs of plants beginning to sprout can be seen here and there. The SWRO facility will be one of the first buildings to be built on the new space on the north end of the island. As shown in Figure B.1, only 200 m further north, on the tip of the island, is an area that is being used as a solid waste deposit and disposal area. Inhabitants bring solid waste to the site and it is deposited on the shore and it appears that some of it is burned and other materials seem to make their way into the sea. A new recycling facility consisting of paved concrete pads to allow solid waste sorting and recovery has been recently constructed adjacent to the dumping area but as of March, 2007 was not in use.

Some random shallow pits were dug on the site of the SWRO facility and these generally contained unconsolidated calcareous sand and pieces of coral.

On Hinnavaru, the site is on an area that was reported to have been reclaimed from the sea some time (undetermined) in the past. This must have occurred more than 20 years ago as a number of buildings have been constructed around the site. A number of shallow pits were dug on the site and they contained unconsolidated calcareous sand and pieces of coral.

Figures 5.1 and 5.2 are photographs of the two sites.

FIGURE 5.1 The SWRO facility site inside the boundary wall on Naifaru – looking toward town

FIGURE 5.2 Site #2 on Hinnavaru after the boundary wall was constructed

As shown in Figure B.2, the site is surrounded by buildings. Some appear abandoned while others are obviously occupied. The most significant construction is between the site and the shoreline (east) where there is the abandoned power plant. This plant was reportedly constructed in the early 1990's and was abandoned a few years ago when the government electric company (STELCO) built a new

power generating station on the north end of the island. Among the abandoned facilities are an above ground fuel tank, several abandoned buildings and an abandoned diesel engine.

The western portion of the designated site contains a grove of three trees. Based on the diameters of the trunks, these trees appear to have been there for at least 20 years.

This is one of a few open areas on the island. It was reported by a number of inhabitants that this area was used as a playground and meeting area. The IDC has constructed a masonry wall about 1 m high around the site and made access available through a gate at the eastern end. At the time of the visit by CH2M HILL in March, 2007, the gate was locked which made public access difficult.

The depth to the groundwater on both sites is between 700 to 1200-mm below the ground surface. On Naifaru, solid waste was observed to be burning just to the north of the site for the SWRO facilities. These locations are shown in Figure B.1. There is smoke generated from this activity but it was observed to be generally blown away from the island.

5.2 Marine

The marine environment around the two islands has several major problems. They are due to the impact of dredge and fill operations, disposal of solid waste and disposal of liquid sanitary wastes.

As noted above, the size of Naifaru island has been significantly increased by filling of the adjacent lagoon with sand and coral that was obtained in the atoll. The high population density makes this type of activity very popular as more land area is needed. The gathering of material and filling of previous marine areas does impact the adjacent aquatic environment adversely. The shoreline is also used for the disposal of solid waste. It would appear that there has been some considerable effort of at least centralizing this function although there is evidence on both islands that some solid waste is randomly dumped along the shoreline. On both islands the populace disposes of sanitary wastes from toilets located in each household plot. These generally dispose of the resulting sanitary waste with a small septic tank with the overflow often connected to a small diameter collecting sewer that takes the liquid waste to the shoreline where it discharges into the sea. This is often done within 5 to 10 meters of the shoreline. In some cases the pipelines have been damaged and they discharge waste even closer to shore. See Figures 5.3 and 5.4.

FIGURE 5.3 Solid waste disposal on the shoreline

FIGURE 5.4 Sewage outfall - Hinnavaru

On Naifaru the marine area of concern is along the eastern edge of the northern tip of the island. This is where the seawater intake and brine discharge lines will be installed. Since this area has not been developed there are no sewage outfalls in the area. However this is a recently filled area and illustrated in Figure 5.5 there are piles of fill that line the shoreline. The coastal bottom consists

mostly of sand with minor vegetation out to the place (about 100 m offshore) where the bottom drops off.

On Hinnavaru the shoreline is more stable although there are some sewage outfalls along the edge. As seen in Figure 5.6, the shoreline directly southeast of the location of the proposed SWRO site has been filled with coral rock.

FIGURE 5.5 Piles of fill along the northeastern shore of Naifaru

FIGURE 5.6 Shoreline behind the abandoned power plant on Hinnavaru

This coral rock was probably placed to protect the shore alongside the now abandoned power plant from being eroded. The photo also shows a sewage outfall in the background.

The seawater intake and brine discharge pipes will be installed about 300 m north of the photo in Figure 3.4. The sea bottom in that area was sandy with bits of coral for the 100 m or so until the bottom drops off and this will be where the intake pipe will be installed.

Just beyond (further north) where the intake pipe will be installed, there is an active marine area where small commercial boats dock.

5.3 Socioeconomic Environment

In general the two project islands are not highly developed relative to the capital Malé and there appear to be only minimal public services available. In March, 2007 CH2M HILL made a survey of 130 households which represented about 12 percent of the population. The data from the survey is contained in a recent report to USAID[11]. This in addition to other data gathered from MEEW and elsewhere provides a picture of the socioeconomic situation of the islands.

5.3.1 Characteristics of the Population to be Served

Both islands have a population of about 4,000 people. The populace generally lives in single story, masonry block homes. The population density is high and the average household of those participating in the survey contained a little over eight people. Of those eight people, about 31 percent were 16 years of age or younger and adult females made up 37 percent while adult males the other 32 percent. It was reported that some homes have as many as three families living in them. In general, the number of people living in a household has increased in the past year making it even more crowded.

The age demographics for the project islands when compared to those published by the UN's Food & Agricultural Organization (FAO) for the Maldives in 2000 shows that these islands seemed to deviate from the norm. This is illustrated in Table 5.1.

[11] CH2M HILL (May 2007) *Environmental Health – Water Assessment for the islands of Naifaru and Hinnavaru*

TABLE 5.1 Comparison of demographic data

	FAO (all Maldives)	Survey (Project Islands)
Population that are children (percent)[12]	46%	31%
Population that are adults (percent)	54%	69%
Adult males (percent)	51%	46%
Adult females (percent)	49%	54%

Based on these data the populace on the project islands on average are older and has a higher percentage of females than the rest of the population in Maldives taken as a whole. The reason for this variation is not known.

The major occupation in the project islands is related to fishing, processing of fish and construction of ships. Naifaru has the Atoll Administration offices and the Atoll Hospital while Hinnavaru has a large sports complex. Neither Naifaru nor Hinnavaru have paved roads and there probably are less than 25 automobiles between the two islands and many of these are owned by the government. However the distances are very short and one can easily walk from place to place.

The main sources of water are collected rainwater and groundwater. The rainwater is used mostly for drinking and cooking while the groundwater is used for washing, bathing, sanitary flushing, gardening, etc. The quality of the groundwater varies but it always tends to be slightly saline and in some areas it is appears to be contaminated with sewage.

The Atoll Hospital provided the following information on disease rates on the two project islands during 2006. These are shown in Table 5.2.

TABLE 5.2 Number of people affected by diseases in 2006 on Naifaru and Hinnavaru[13]

Disease	Naifaru	Hinnavaru
Acute respiratory infections (ARI)	1654	568
Acute gastro enteritis (AGE)	602	186
Viral fever	1551	473
Conjunctivitis	47	39
Chickenpox	59	16
Dengue fever	143	35
Typhoid fever	1	
Mumps	41	38
Dengue hemorrhagic fever (DHF)	3	
Dengue shock syndrome	1	

Both islands had a severe spread of chickengunya (viral fever) in 2006. The high incidence of AGE could be an indication of sanitation and water problems. In the CH2M HILL survey 68 percent of the respondents said that they do not treat the rainwater that is collected from their roofs as they feel that it is safe.

5.3.2 General Community Response to the Project

The survey in March, 2007, was taken near the end of the traditional dry season and at that time almost 65 percent of the households reported that their rainwater storage tanks were either empty or near empty. When a family's rainwater storage tank runs out of water they reported that they generally borrow from a neighbor's tank or from the mosque. The main mosque on both islands has both stored rainwater and a well that tends to have a higher water quality than most of the wells on the

12 The FAO counts people 15 years and older as adults. The CH2M HILL survey used 16 years and older.

13 Source – Mr. Faisal the general manager of the Atoll Hospital on Naifaru.

island. Almost none of the respondents reported using bottled water as a significant source of their water supply.

In the survey about 47 percent of the households claimed that they knew about the forthcoming USAID water project involving the installation of the SWRO units. About 63 percent of the respondents said that they would pay for water from a public system.

Figures 5.7 through 5.10 illustrate some of the water supply features that are noticeable in the project islands.

FIGURE 5.7 Residential street with rainwater tanks on Naifaru

FIGURE 5.8 Gutters designed for rainwater collection

FIGURE 5.9 Rainwater tanks at the main mosque in Naifaru

FIGURE 5.10 Small groundwater well on Hinnavaru

Section 6 – Impact Analysis and Mitigation

This section will describe the potential impacts of the construction and operation of the SWRO units and associated systems on the islands of Naifaru and Hinnavaru and the proposed measures to mitigate any adverse impacts.

6.1 Naifaru

There are a number of impacts to the island that will be associated with this project. The most significant are listed below.

6.1.1 Visual

It is proposed that the building used to contain the SWRO equipment on Naifaru will be a single storey concrete block building, resembling the construction of residential structures on the island. It will have a footprint of about 6 by 9 meters with a height to the roof beam of about 2.9 meters. Figure 4.1 is a photo of a home in Naifaru that resembles the building that will be built.

A traditional boundary wall has already been constructed by the local government around the site. The only other really visible structure will be the black HDPE storage tanks which are the same as the ones that are already on the island and part of the concrete settling tanks.

A small pump station will be constructed adjacent to the shoreline in the location shown on Figure 2.5. This will be similar to the ones built by the IFRC and will have a footprint of less than 2 square meters and be about 1.2 meters to the start of the roofline. A photo of a similar one is shown in Figure 6.2.

FIGURE 6.1 Similar structure to the SWRO building

FIGURE 6.2 Similar structure to the intake pump house

The distribution system will be buried and will have no visual impact except for the community taps. Figures 6.3 and 6.4 illustrate some of the community taps used by other donors in the Maldives.

FIGURE 6.3 A community tap

FIGURE 6.4 Another design for a community tap

Being that the site for the construction of the SWRO facilities is located in an area that has been designated for construction of buildings for municipal services, construction activities are already anticipated by the local populace and the style of the buildings will be in harmony with existing structures. Thus the construction and structures should not have an adverse visual impact.

6.1.2 Noise

There are several sources of noise. The most prominent will be the high pressure pump for the SWRO unit. This is a high pressure centrifugal pump that will make a whine-type noise. It is unknown at this time what the decibel level will be at the property line (boundary wall) of the Naifaru site. Fortunately the location of the site in the newly developed municipal-service area should not pose a problem at this time. This noise level should be kept in mind when locating future adjacent facilities.

6.1.3 Marine Environment

The marine environment will have some minor disturbance in the installation of an intake pipe (~ 50-mm diameter) made of HDPE. It will be laid on the bottom of the lagoon and weighted with concrete collars about every 6 to 8 meters as required to keep it in place. Care will be taken to minimize damage to any live corals or vegetation during the installation. The length of the intake will be approximately 100 meters. The location of the pipeline was determined in consultation with the IDC

during the visit of the project team in March, 2007, so as to have the least interference with the islander's marine activities while at the same time providing good quality seawater. The flow in the pipeline will be approximately 70 liters/minute (l/min) or 19 gallons per minute (gpm)

The brine disposal line will be constructed in a similar manner as the intake. The flow in the pipeline will be approximately 48 l/min (or 13 gpm). The length of the pipeline will be approximately 50 m. The final 10 meters of the pipe will be perforated so that the mixing zone for the brine will be extended over a larger area than just a point discharge from the end.

6.1.4 Freshwater Lens

One source of water for the islanders is groundwater. This water is derived from rainfall and accumulates as a freshwater lens under the island. It is important that this source of water is preserved. The only exposure to contamination of the freshwater lens will come from the intake and brine discharge lines that will go from the shoreline to the site of the SWRO. The location of the intake and discharge lines that transfer saline water between the sea and the SWRO facility has been made so as to minimize this distance.

The use of HDPE pipe means that there will be very few joints along the run. The pipes will be buried about 500-mm below ground surface (bgs) to reduce the potential for damage by foot or vehicular traffic.

6.1.5 Site Disturbance

The location of the site on newly filled land – thus highly environmentally disturbed – where no commercial activity has taken place within 100 m of the site should mean that there should not be any significant problems with disturbing the site for the construction of the building and other facilities. This site had already been approved and was incorporated in the MoHUD land use plan before this project began.

6.1.6 Construction Activity

The location of the construction on this small island will mean that there will be little vehicular traffic. There are less than ten vehicles on Naifaru and, due to the cost of landing machinery, the contractor is expected to add very few to this. There is little major excavation involved in building the buildings and it is possible that part of the distribution mains will be installed by hand excavating the trenches.

An impact could be the disposal of petroleum products and other undesirable materials on the ground which could affect the freshwater lens.

TABLE 6.1 Impacts of major construction activities – Naifaru

Activity	Possible Impacts
Intake and discharge lines	Disturbance of the sea bottom and corals when placing the pipelines and concrete anchors
Intake pump station	Disturbance to the shoreline during the installation of the pump station .
Transmission mains	Some minor soil disturbance in constructing the trenches to hold the pipelines and then backfilling the trenches.
SWRO facility	Minor excavation and then compacting soil; mixing concrete; trenching to install field piping and electrical service; noise during construction.
Distribution system	Some minor soil disturbance in constructing the trenches to hold the pipelines and then backfilling the trenches.

6.1.7 Operational Impact

The operation of the SWRO facility will result in the production of new source of potable water for the inhabitants of the island. While the capacity of the unit is insufficient to provide for all the water needs of the people, it will provide a basic supplement supply that can be used to augment the supply normally available in their rainwater tanks. In general it should improve the inhabitants' quality of life.

The additional impact to the environment due to the discharge of brine project should be minimal, especially when compared to the numerous sewage outfalls on the island.

6.2 Hinnavaru

There are a number of impacts to the island that will be associated with this project. The most significant are listed below.

6.2.1 Visual

It is proposed that the same building used to contain the SWRO equipment on Naifaru will be built on Hinnavaru. This will have a greater visual impact as the proposed site (Site #2) is located in a small park that is surrounded by buildings. The inclusion of the building, storage tanks, etc will mean that one of the few open spots within the settled area of the island will be filled in.

A traditional boundary wall has been constructed by the local government around the site. The only other really visible structure will be the black HDPE storage tanks which are the same as the ones that are already on the island and part of the concrete settling tanks.

A small pump station will be constructed adjacent to the shoreline in the location shown on Figure 2.6. This will be similar to the ones built by the IFRC and will have a footprint of less than 2 square meters and be about 1.2 meters to the start of the roofline. A photo of a similar one is shown in Figure 6.2.

The distribution system will be buried and will have no visual impact except for the community taps.

6.2.2 Noise

There are several sources of noise. The most prominent will be the high pressure pump for the SWRO unit. This is a high pressure centrifugal pump that will make a whine-type noise. It is unknown at this time what the db level will be at the property line (boundary wall) of the Hinnavaru site. Unfortunately the way that the site is situated in a small park surrounded by buildings will probably aggravate the noise level and if anyone lives or works in the surrounding buildings, the noise may be a nuisance. This will be even more noticeable if the SWRO plant is run during the evening and night hours.

6.2.3 Marine Environment

The marine environment will have some disturbance in the installation of an intake pipe (~ 50-mm diameter) made of HDPE. It will be laid on the bottom of the lagoon and weighted with concrete collars about every 6 to 8 meters as required. Care will be taken to avoid damage to live corals during the installation. The length of the intake will be approximately 50 to 150 meters. The location was determined in consultation with the IDC so as to provide the least interference with the islander's marine activities while at the same time providing good quality seawater. The flow in the pipeline will be approximately 70 l/min (19gpm).

The brine disposal line will be constructed in a similar manner as the intake. The flow in the pipeline will be approximately 48 l/min (13 gpm). The length of the pipeline will be approximately 50 m. The final 10 meters of the pipe will be perforated so that the mixing zone for the brine will be extended over a larger area than just a point discharge from the end.

6.2.4 Freshwater Lens

One source of water for the islanders is groundwater. This water is derived from rainfall and accumulates as a freshwater lens under the island. It is important that this source of water is preserved. The only exposure to contamination of the freshwater lens will come from the intake and brine

discharge lines that will go from the shoreline to the site of the SWRO. The location of the intake and discharge lines that transfer saline water between the sea and the SWRO facility has been made so as to minimize this distance.

The use of HDPE pipe means that there will be very few joints along the run. The pipes will be buried about 500-mm below ground surface (bgs) to reduce the potential for damage by foot or vehicular traffic.

6.2.5 Site Disturbance

The area provided by the IDC for this site includes a small rove of trees at the western end. It is the intention of the project to not touch these trees. A wall will be built to separate the trees from the facility site and the IDC will be requested to construct a non-gated entrance on the western end of the boundary wall so that people can have easy access to this green area.

6.2.6 Construction Activity

The location of the construction on this small island will mean that there will be little vehicular traffic. There are less than ten vehicles on Hinnavaru and, due to the cost of landing machinery, the contractor is expected to add very few to this. There is little major excavation involved in building the buildings and it is possible that part of the distribution mains will be installed by hand excavating the trenches.

An impact could be the disposal of petroleum products and other undesirable materials on the ground which could affect the freshwater lens.

TABLE 6.2 Impacts of major construction activities – Hinnavaru

Activity	Possible Impacts
Intake and discharge lines	Disturbance of the sea bottom and corals when placing the pipelines and concrete anchors
Intake pump station	Disturbance to the shoreline during the installation of the pump station .
Transmission mains	Some minor soil disturbance in constructing the trenches to hold the pipelines and then backfilling the trenches.
SWRO facility	Minor excavation and then compacting soil; mixing concrete; trenching to install field piping and electrical service; noise during construction.
Distribution system	Some minor soil disturbance in constructing the trenches to hold the pipelines and then backfilling the trenches.

6.2.7 Operational Impact

The operation of the SWRO facility will result in the production of new source of potable water for the inhabitants of the island. While the capacity of the unit is insufficient to provide for all the water needs of the people, it will provide a basic supplement supply that can be used to augment the supply normally available in their rainwater tanks. In general it should improve the quality of life.

The additional impact to the environment due to the discharge of brine project should be minimal, especially when compared to the numerous sewage outfalls on the island.

6.3 Mitigation

Table 6.3 lists impacts and mitigation measures.

TABLE 6.3 Major impacts and mitigation measures

Environmental Impacts			Mitigation	
No.	Impact	Activity	Degree[14]	Measure
Impact on soil and terrestrial vegetation				
1	Loss of productive soil or vegetation by removal or erosion	Excavation for foundations and trenches for pipes. Most soil is only sand and there is almost no vegetation.	Low	Soil removed and piled should not be placed close to the shore to avoid erosion into the sea.
2	Loss of trees on the SWRO facility site on Hinnavaru	General construction activity within the boundary wall that has been constructed.	Moderate	A wall will be constructed on the eastern end of the site to separate the area with the trees from the rest of the site and no storage or construction activity will be allowed
Impact on freshwater resources				
3	Contamination of the freshwater lens by seawater discharges or dumping	Start-up and testing of the SWRO facility with seawater	Moderate	The brine discharge line and connecting drains in the SWRO facility site must be completed before any seawater is pumped to the settling tank so that there is a method to discharge it to sea.
4	Contamination of the freshwater lens by spillage of gasoline, oil and other chemicals	Storage of materials and servicing of mechanical equipment by the contractor	Moderate	All lubricants and fuel must be stored in approved containers and servicing of equipment done in a manner to minimize spillage. Empty containers should be taken to the solid waste facility on each island.
Impact on marine environment				
5	Disturbance of aquatic habitats	Installation of the seawater intake and brine discharge lines	Low	The route and schedule of the placement of the pipelines will be coordinated with the local fishermen to insure that fisheries & anchorages are not disturbed. The concrete anchors and pipeline should be assembled on shore and floated into position to avoid dragging things on the sea bottom
6	Disturbance of aquatic habitats	Discharge of brine from the SWRO unit through the brine discharge pipeline	Low	Instead of the direct, end of pipe, discharge commonly used in Maldives, the last 10 meters of the discharge pipe will be perforated to spread the flow.
7	Disturbance of aquatic habitats	Intake of seawater by the seawater intake pipeline	Low	Flow into the 100-mm diameter pipe will be less than 20 gal/min, the intake will be a screen to keep out fish and it will be located off the sea bottom by about one meter.

[14] Degree of impact without mitigation measures

TABLE 6.3 Major impacts and mitigation measures

Environmental Impacts			Mitigation	
No.	Impact	Activity	Degree[14]	Measure
General				
8	Increase in noise pollution	Construction	Low to Moderate	This will be limited in time as the actual construction activity will be less than about 4 months. The Naifaru site is far enough away from dwellings to have very limited affect but the Hinnavaru site will be more of a problem
9	Increase in noise pollution	Operating	Low to Moderate	The SWRO building and the boundary wall will reduce the noise level. Naifaru site is away from dwellings. Hinnavaru will be more of a problem as there are buildings immediately adjacent to the site
10	Spread of solid waste and other construction materials	Construction	Moderate	The contractor will be directed to move all construction debris to the solid waste disposal areas on each island at regular intervals
11	Discharge of disinfecting solution	The distribution main will be filled with a chlorine solution to disinfect it.	Moderate	The solution should be discharged into the harbor on Naifaru (Tap #1) and near the marine docking area on Hinnavaru (Tap #1). See Figures 2.5 and 2.7

Section 7 – Environmental Management and Monitoring Plan

7.1 Management

Table 7.1 presents a plan that will minimize adverse environmental and social impacts for the installation of the SWRO facilities on both Naifaru and Hinnavaru.

TABLE 7.1 Environmental management plan

Environmental Issue		Mitigation Measures
1. Protection of soil and terrestrial vegetation		
1.1	Disposal of excess soil	Excess soil (generally sand) should be used to build up the road grade where needed or disposed of as the CH2M HILL Resident Engineer (CHRE) on the site directs
1.2	Protection of major vegetation	The contractor may not remove any major vegetation without the written consent of the CHRE. The trees at the Hinnavaru site are to be protected from damage by constructing a small wall to separate them from the remainder of the site within the boundary wall
1.3	Erosion of soil	While working adjacent to the sea, care must be taken to avoid placing excess soil in a place where it could be washed away into the sea.
2. Protection of the freshwater lens		
2.1	Contamination of the freshwater lens from seawater	Before any testing of any of the units with seawater, the brine line and relevant drains connected to it must be completed. No testing with seawater can occur without the consent of the CHRE
2.2	Contamination of the freshwater lens by other materials	All storage of lubricants, chemicals and fuel and their use to service equipment must be approved by the CHRE. All used containers must be disposed of in a manner approved by the CHRE
3. Protection of the marine environment		
3.1	Disturbance of corals and vegetation during the installation of the brine and seawater intake pipelines in the sea.	A written plan for the installation of the pipelines must be approved by the Engineer. This plan needs to include consultation with the various island IDCs so as not to create a problem with the fisheries. The goal of the activity is to minimize the disturbance of the sea bottom, marine vegetation and corals.
4. General protection		
4.1	Noise during construction and start-up	The contractor should schedule activities which generate excessive noise to be done during the daylight hours. Activities that will generate excessive noise that may take place after dark must be scheduled and approved by the CHRE.
4.2	Disposal of construction debris, sanitary, and solid waste	The contractor is to have a written plan that is approved by the Engineer on how he plans to dispose of these wastes in a safe and environmentally sensitive manner as is appropriate for the islands..
4.3	Disposal of disinfecting solutions	The contractor is to have a written plan that is approved by the Engineer on how to dispose of this solution in a safe and environmentally sensitive manner.

7.2 Monitoring

Table 7.2 presents an initial monitoring plan that CH2M HILL will use to monitor the compliance of the construction contractor for this project. A number of factors, including methods and frequency of reporting will be determined after the award of the construction contract. At this time the means and methods will be finalized. At this time we believe that this will be handled most efficiently as part of the monthly status report.

TABLE 7.2 Preliminary monitoring plan

Indicator	Indicator Definition	Data Source	Data Collection Method	Frequency	Frequency & Mode of Reporting to USAID	Primary Responsibility
Objective #1 – Construction contractor compliance with requirements stipulated in Table 7.1						
Establish reporting mechanism	Mechanism to monitor contractor compliance	Field construction manager	Discussion – this is to be incorporated in the CCM[15]	Prior to finalizing the construction contract	To be covered in the monthly status report	CH2M HILL Resident Engineer (CHRE)
Compliance with the EMP in Table 7.1	Fulfill all requirements	Construction contractor & CHCM	Spot checks and review of compliance issues	Monthly or as needed if problem arises	In the monthly status report	CHRE
Objective #2 – Protection of the freshwater lens						
Completion of the brine discharge line from the SWRO facility to the sea and associated drains	Observation	Construction contractor & CHRE	Observation	Before any seawater is pumped to the SWRO facility	In the monthly status report	CHRE
Storage and use of lubricants and chemicals	Observation	Construction contractor & CHRE	Observation	Monthly or as needed if problem arises	In the monthly status report	CHRE
Objective #3 – Protection of the marine environment						
Care in the planning and installation of the intake and discharge pipelines in the sea	Observation	Construction contractor & CHRE	Observation including snorkeling to observe finished work	At the time of the installation	In the monthly status report	CHRE
Objective #4 – Protection of the environment						
Noise during construction	Listening and discussions with residents	Construction contractor & CHRE	Observation	Monthly or as needed if problem arises	In the monthly status report	CHRE
Disposal of construction debris, sanitary and solid waste	Observation	Construction contractor & CHRE	Observation	Monthly or as needed if problem arises	In the monthly status report	CHRE
Disposal of disinfecting solutions	Observation	Construction contractor & CHRE	Observation	Monthly or as needed if problem arises	In the monthly status report	CHRE

[15] CCM – Contractor's Construction Manual

Section 8 – Conclusions and Recommendations

8.1 Conclusions

Based on the assessment presented in this report, we have the following conclusions:

- The installation of the SWRO facilities and associated appurtences on the two project islands will not have a significant negative impact
- Positive impacts clearly outweigh the negative temporary impacts, which are minor and can be mitigated
- The project activities are compliant with laws and policies
- Preliminary approvals by the GoM are being processed by the relevant agencies – MEEW and the ERC
- The project is socially acceptable; organizations representing beneficiary groups were consulted and are in support of the project at the time of writing
- There is a group of citizens on Hinnavaru that do not approve of the use of Site #2 for the installation of the SWRO facilities – MEEW has said that this does not represent the majority opinion on the island
- The issue of using Site #2 on Hinnavaru needs to be resolved by the GoM
- USAID and CH2M HILL need to agree on what further measures, if any, should be employed in the investigation of Site #2 on Hinnavaru for possible contamination by the nearby abandoned power plant

8.2 Recommendations

It is recommended that the project go forward with due consideration to the mitigation measures contained in this report. And that the mitigation measures discussed in this report be carried out.

All relevant provisions and stipulations provided above with regard to mitigatory measures should be included in the contract documents. Additional cost items for these should be specified in the bill of quantities if necessary.

The potential for prior contamination of the soil at the Hinnavaru site must be ruled out prior to finalization as a site.

Appendix A – Hinnavaru Memo

Preliminary Analysis of Soil Samples, Hinnavaru, Maldives

PREPARED FOR: USAID/Colombo, Sri Lanka

PREPARED BY: CH2M HILL

DATE: May 6, 2007 PROJECT NO: 350735

In reviewing the location selected by the Island Development Council (IDC) for the seawater reverse osmosis (SWRO) facility on Hinnavaru, it was observed that adjacent to the site there was a small abandoned power plant which included an abandoned diesel engine and an above ground fuel tank. Apparently the power plant had been installed in the early 1990's and operated until after the tsunami when a new power plant was constructed at the northern tip of the island and this plant was abandoned. The location of the facility versus the power plant is shown below in Figure 1.

FUGURE 1 Location map

The concern was that perhaps the activities at the power plant may have contaminated the soil at the location where the SWRO facility will be built. In consultation with USAID, it was decided that samples of soil would be taken and analyzed to see if there were any indications or contamination. This sampling would be done in March during the visit of the CH2M HILL team to Hinnavaru on other matters. Since this would be only for the purpose of a general survey, it was determined that the sampling would be done by the team members going on the trip. These members are trained to do this type of sampling but rather than bring specialists from out of country it was agreed with USAID that this would be an efficient first step.

This memo is to present the results of the screening analysis of soil samples collected from the project site at Hinnavaru, Maldives.

Sample Collection

Soil samples were collected based on the screening analysis protocol described in the 'Method Statement for Soil Sampling at Hinnavaru Site, Maldives' dated March 15, 2007. Samples were collected from three locations on the project site – two locations were on the property line of the project site towards the abandoned power plant and one location was at the centre of the site. The samples were composited and equal amounts were distributed into three sample bags labeled H1, H2 and H3. The sample bags were air freighted through DHL Couriers to the Shriram Test House, New Delhi for analysis.

Sample Analysis

The soil samples were analysed for the following parameters:

- Total Petroleum Hydrocarbons
- Polychlorinated Bi-phenyls
- Polyaromatic Hydrocarbons
- Total Chromium (Cr)
- Cadmium (Cd)
- Lead (Pb)

Results and Discussion

Table 1 presents the results of the soil analysis. All the constituents analysed except Total Petroleum Hydrocarbons, were below the method detection limits. To put this data in perspective with international standards a comparison was made of the detection limits and results used during the initial screening at Hinnavaru with preliminary remediation goals (PRGs) of the USEPA Region 9 for soils, shown in Table 2. A conservative comparison was made with PRGs for residential soils. The PRGs are used to set goals for remediation of contaminated soils.

TABLE 1 Results of the soil screening analysis at Hinnavaru

Sample ID	Test Results					
	Total Petroleum Hydrocarbon (TPH) (ppm)*	Polychlorinated Biphenyls (PCB) (ppm)	Polyaromatic Hydrocarbons (PAH) (ppm)	Cr (on dry basis) (ppm)	Cd (on dry basis) (ppm)	Pb (on dry basis) (ppm)
H1	1	< 0.2	< 0.04	< 0.5	< 0.05	< 1
H2	0.9	< 0.2	< 0.04	< 0.5	< 0.05	< 1
H3	1	< 0.2	< 0.04	< 0.5	< 0.05	< 1

- Detection Limit – 0.1 ppm

TABLE 2 Comparison of detection limits used by Shriram Test House , New Delhi with preliminary remediation goals recommended by USEPA, Region 9

Parameters	Shriram Test House Detection Limit (ppm)	PRG for residential soils (ppm)	Remarks
TPH	0.1	-	PRGs are available for individual TPH constituents. Review of soil remediation literature for TPHs in California shows prescribed cleanup levels ranging from 20 to 100 ppm. These levels are specified by regulatory agencies in Waste Discharge Requirements for specific sites undergoing remediation.
PCB	0.2	0.22	All detection limits used by the laboratory and all sample detections are below the PRGs for residential soils recommended by USEPA Region 9
PAH	0.04	0.11	
Cr	0.5	210.00	
Cd	0.05	37.00	
Pb	1	150.00	

Based on the comparison of data in Table 1 with the PRGs in Table 2 it appears that all detections in the samples from Hinnavaru are below the PRGs for residential soils.

It must be noted that this was an initial screening exercise to determine presence of soil contamination.

The sampling effort[1] did not detect any excessive contamination but this has to be balanced against the proximity of the site to the abandoned power plant. Based on the above results there is not a clear cut reason, besides the proximity, to carry out additional confirmatory sampling and analysis using on standard methods of soil sampling e.g., ASTM / USEPA. However this should be discussed with USAID's environmental specialists to obtain their concurrence and agreement on the way forward.

[1] Remember that this was a very basic sampling effort done by untrained staff

Appendix B – SWRO Facility Site Locations

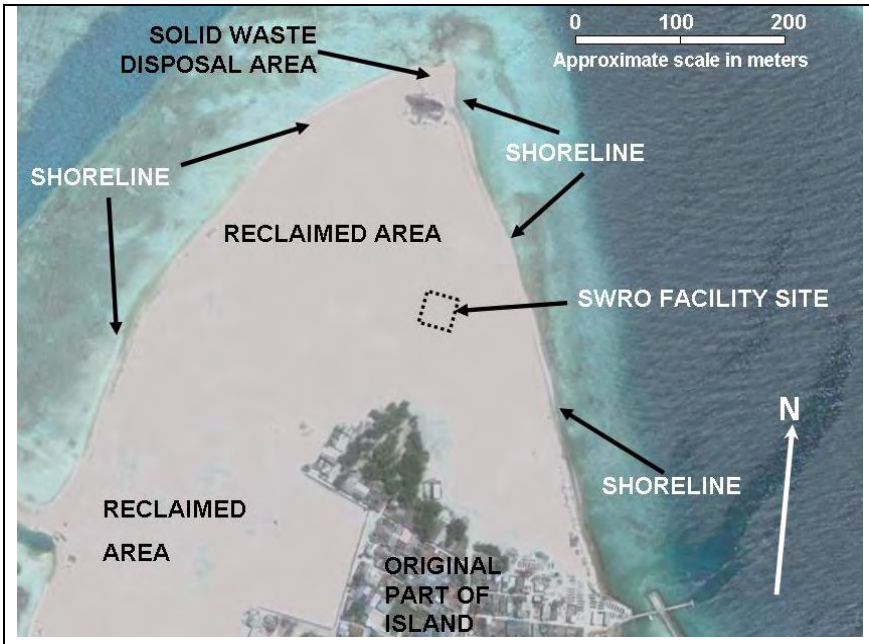

FIGURE B.1 SWRO Facility site location - Naifaru

FIGURE B.2 SWRO Facility site location - Hinnavaru