*International Journal of Multidisciplinary and Current Research* ISSN: 2321-3124
*Research Article* Available at: http://ijmcr.com

# Environmental Impact Assessment for the Creation of a Lake in a Touristic Development Villages-A Case Study

**Rasha El Gohary***

Central Laboratory for Environmental Quality Monitoring, National Water Research Center, NWRC, MWRI, Cairo, Egypt;

Received 10 June 2017, Accepted 08 Sept 2017, Available online 13 Sept 2017, **Vol.5 (Sept/Oct 2017 issue)**

***Abstract***

*Tourism activity in Sharm el-Sheikh is considered the main economic base for the development of coastal areas in South Sinai Governorate, Egypt. The proposed Lake aims to create a romantic beach life with suitable conditions for bathing, water sports and other recreational uses of the touristic Resort with an efficient and economical manner. The surface area of the lake is about 30 feddans, and the amount of water stored in the lake is estimated at 111,000 $m^3$. The lake is well designed according to local conditions in Sharm El Sheikh and international standards. The objective of this study is to prepare Environmental Impact Assessment (EIA) methodology that follows the instructions of the Ministry of Environment. The EIA methodology used in this assessment is based on the method of calculating impact. This assessment has been prepared using approved methods (e.g. Sampling methods, collection of archival, and field data), taking into account the requirements identified by the groundwater sector of the Ministry of Water Resources and Irrigation. The procedures required to evaluate the exploitation of groundwater, drainage effects on the saline groundwater, and the receiving environment have been followed in accordance with the requirements of the Ministries of Irrigation and the Environment. The purpose of this study is to assess the effect of the proposed lake on the surrounding environment, with emphasis on the extent of the impact of the groundwater sources, and the dependence of the lake in the recharge water on saline groundwater as well as drainage in the same groundwater environment. A detailed study of previous relevant studies on natural resources and the natural environment carried out close to the proposed site, with attention to groundwater resources in the Sharm El Sheikh area and around the proposed site of the lake, included a number of studys on groundwater assessment and internal studys at Nabq and the Ministry of the Environment. Environmental impact assessment studys and studies have been reviewed for similar projects in the study area and surrounding areas. A list of references is provided at the end of this study.* ***The information used in this assessment was based on the following:*** *[Review previous studies and research -Technical specifications of lakeand operating elements* **-** *Hydrographic data collected during the drilling of feed and drainage wells* **-** *Field visit to the proposed site and analysis of water samples and soil* **-** *Interpretation of topographical maps, aerial photographs, and satellite images* **-** *Professional judgment based on long experience in the region and similar studies]. The study concluded that the proposed Lake study aims at creating the life of the beach with suitable conditions for bathing and other recreational uses of the Resort in an efficient and economical manner. The lake has been well designed according to local conditions in Sharm El Sheikh and international levels and the sensitivity of the surrounding marine and terrestrial ecosystem is considered. The proposed lake is not connected directly or indirectly to the sea. The lake will be fed by saline groundwater and drainage in the underground reservoir with a closed system. There is no significant difference between seawater salinity and the salinity of the original groundwater used in nutrition and wastewater from the operation of the lake.*

***Keywords:*** *Environmental Impact Assessment – Mitigation Measurements – Environmental Management Plan - Touristic Development Areas – Rescreational Lakes – Water Resources – Ground Water Wells*

## 1. Introduction

### *1.1. Background on the Environmental Impact Assessment (EIA) System*

The Government of the Arab Republic of Egypt (ARE) issued Law No. 4/1994 on the protection of the environment. Act No. 4/1994 addresses pollution from existing projects or installations as well as potential pollution from new facilities and existing expansions.

According to the law, new institutions must conduct an environmental impact assessment prior to the construction or implementation of the project or related expansions. The process of EIA is the systematic examination of the consequences aimed at preventing, or

*Corresponding author's ORCID ID: 0000-0003-2566-5474

mitigating the negative impacts on the environment, natural resources, health and social components and taking advantage of the positive impacts of the project. This examination gives the EIA model / study the following: Documentation of the results of the process.

- Analysis of potential environmental and social impacts of the project
- Analysis of project alternatives
- Include the results of the public consultation process
- Describes the necessary environmental management plan (EMP)

The Egyptian environmental impact assessment system is based on specific principles established by Law No. 4/1994 for the Protection of the Environment. In addition, the Egyptian Environmental Affairs Agency (EEAA) has developed detailed principles for the EIA system which include the following aspects:

- Identification of projects subject to the EIA
- Reference to environmental impact assessment rules and procedures
- Classification of projects according to their environmental impact and level of evaluation

The EIA system has been continuously reviewed and revised in Egypt since 1995. In 2002, EIA procedures were updated and EIA lists and publications updated. The continuous review and improvement of the EIA system is a legal requirement of Law No. 4/1994 where the system is reviewed every 5 years. The current environmental impact assessment guidelines relate to projects under the EIA are grouped into various categories of environmental impact assessment (A, B and C), (EEAA, 2009).

### *1.2. Study Summary*

Tourism activity in Sharm el-Sheikh is considered the main economic base for the development of coastal areas in South Sinai Governorate, Egypt. However, tourism development is usually carried out in the first grade areas, while the back areas, especially off-shore, suffer from direct sea access. There are large areas of land allocated to tourism activity almost lose their real estate value due to the occurrence in the back areas, but the technological development that took place in the establishment and operation of industrial lakes safely encouraged tourism investment in those territories The proposed Lake aims to create a romantic beach life with suitable conditions for bathing, water sports and other recreational uses of the touristic resort in an efficient and economical manner. The resort is located on the inland, away from the natural shoreline. Feeding the lake from coastal aquifers is a clean and highly reliable technique globally, as it allows saving at the initial treatment stage and does not affect the marine environment. The proposed lake is not connected directly or indirectly to the sea (5 km from the shoreline). The lake will be fed by pumping wells of saline groundwater as well as drainage in the underground reservoir and operating in a closed system meaning that the quantities of water that will be discharged to the environment will be restored once in order to enable nutrition and drainage to carry out in a safe manner, taking into consideration the safety of the surrounding environment. The technology used is a low-filtration system and water purification system with 100 time's lower doses of chemicals than is used in traditional swimming pools, thus preserving the environment. The surface area of the lake is about 30 feddans, and the amount of water stored in the lake is estimated at 111,000 $m^3$. The lake is well designed according to local conditions in Sharm El Sheikh and international standards. Lake water is suitable for use in all recreational purposes.

The main environmental problem for the establishment of inland lakes lies in the availability of a source of recharge water and the disposal of wastewater from the operation. Usually drainage to the sea or by underground injection into a saline groundwater layer. In this case, three alternatives were studied, and direct discharge to the sea was ruled out due to the high sensitivity of the marine ecosystem in Sharm El Sheikh. Moreover, direct drainage to the sea is not allowed due to risks to the coral reef ecosystem, which is the basis of the tourism economy in Sharm el-Sheikh. Injections into the aquifer have been selected. The proposed lake system includes nine feeding wells and nine drainage wells. The level of water and chemical variables in the lake will be automatically adjusted to meet international water quality standards. This will include pumping and drainage of 6000 $m^3$/day to adjust the level and salinity compensation. Feeding and drainage will be in the brine aquifer, wells are located in the direction of the natural groundwater flow. The proposed system of nutrition and drainage respects the environment and the sustainability of its resources. Several factors were also taken into account in the design of the production and drainage wells, such as: *the hydraulic properties of the subsurface layers, the relative concentration of the salts, the size of the feed and drainage, and the intervals between the wells.* By comparing the quality of the surrounding water, it was observed that there is no significant difference between seawater salinity and salinity of the original groundwater used in plant feeding as well as salinity of wastewater. It was found that the local flood will not cause any problem on the proposed study.

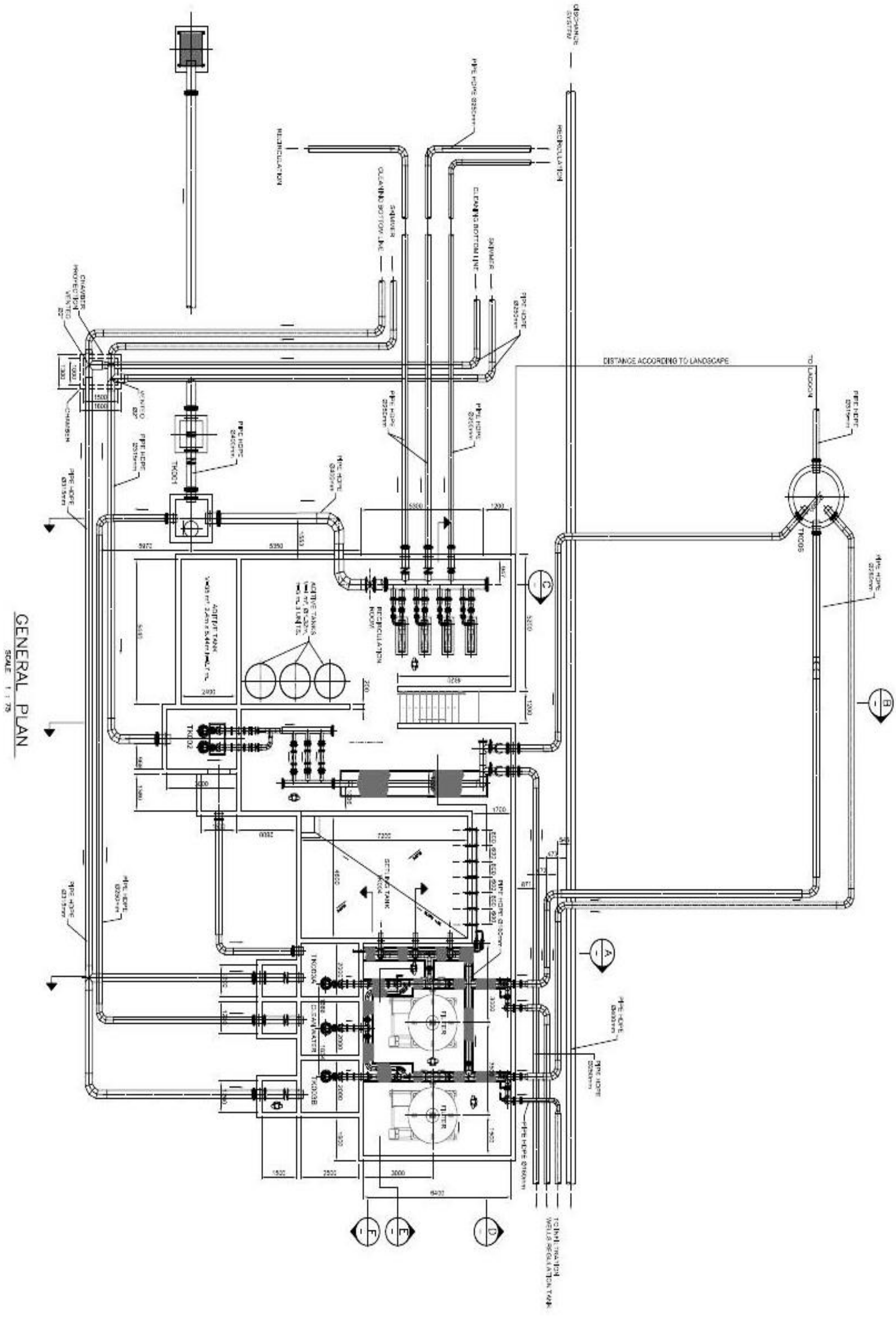
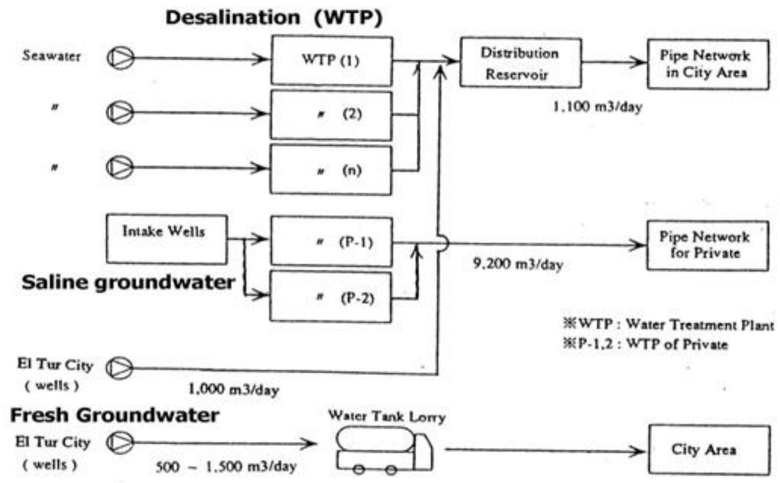
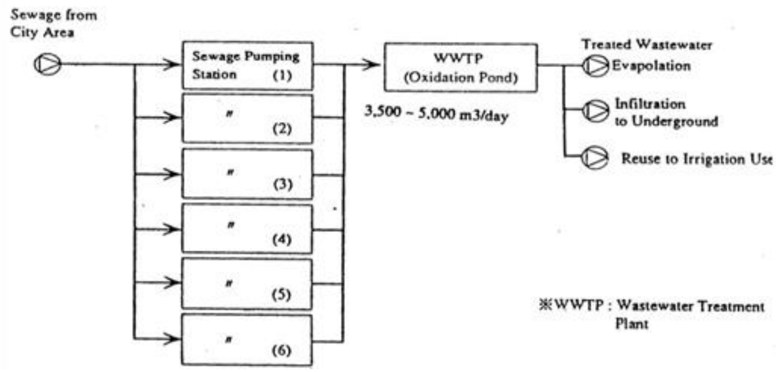



**Figure 1:** General plan of the proposed design for the crystal lagoon




**Outline of the Water Supply System**




**Outline of the Sewerage System**

**Figure 2:** Outline of the status quo of water supply and sewerage system in Sharm El- Sheikh City (JICA and WRRI, 1999)

The proposed lake has no significant impact on the marine and terrestrial environments of the region, but it has very low impact only on the saltwater aquifer. Long-term injections may alter groundwater quality, which may affect the aquifer in the long term. This very low impact can be mitigated by implementing mitigation measures, which include:

- Injecting wastewater into the lower part of the groundwater aquifer in the direction of the natural groundwater flow, with the feeding system and drainage system closed (retrieving wastewater again through the feeding wells).
- Monitoring the levels and quality of groundwater in the vicinity of the study, with the need to continue monitoring the main water quality indicators after the operation, to know the direction of the movement of wastewater and the extent of change in content over time, to intervene in a timely manner.
- Good and environmentally safe storage of chemicals used in water purification and proper disposal of drilling and construction waste by assembling and delivering them to an authorized contractor for disposal in designated areas.
- Taking into consideration the maximum limits of noise levels in accordance with the Executive Regulations of Law No. 4 of 1994

The study of establishing the current lake is urgently needed to ensure a source of attraction for inland coastal lands and the development of tourism activity in Sharm El Sheikh. This study is environmentally justified. There are no significant adverse effects on the terrestrial and marine ecosystem in the surrounding area. Based on these Environmental Impact Assessment (EIA) findings, we recommend authorization to establish the proposed crystalline lake study.

## 2. Materials, Methods, and Data Analysis

### *2.1. Description of establishing the proposed lake*

#### 2.1.1. Objectives and scope of the study

The development of coastal areas in South Sinai is very important for the growth of the Egyptian economy. However, development is usually done in the first grade areas, while the back areas, especially off the coast, suffer from direct sea access and other tourist attractions.

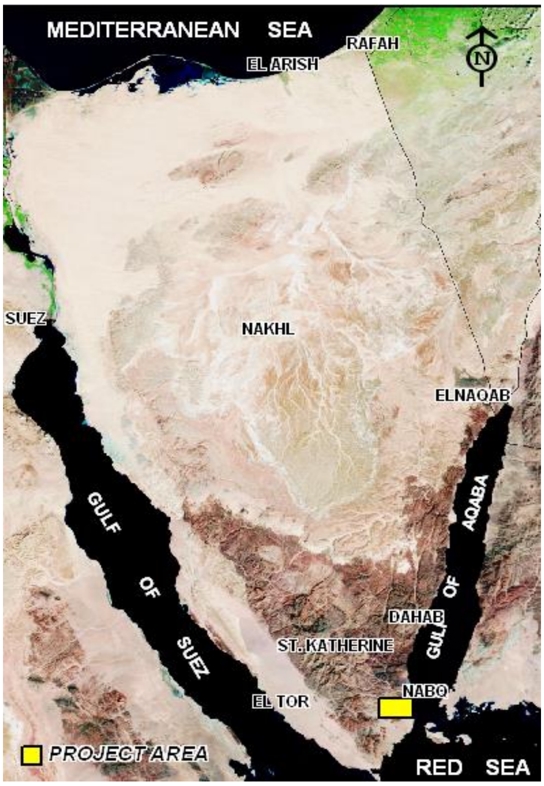




**Figure 3:** A satellite image and map showing the location of the proposed location of the study

The newly used techniques in the crystalline lakes attract investors to use this techniques for inland areas to gain added value for sustainable tourism development that were not previously available for such land (Inskeep, 1999, Embaby, 2004 and Metwally and Abdalla, 2006). Resortis located in the back area of hotels and tourist villages in the area of Nabq for tourist activities and the urgent need to find a water outlet, which compensates for the beach line and provides the visitors with a greater opportunity to enjoy, swim, and use some light water games. The system of feeding and drainage of the lake will be designed to be closed in the sense that the quantities of water that will be discharged to the environment will be restored once again in the storage and recovery, which will enable the feeding and drainage in a safe manner that takes into consideration the safety of the surrounding environment. The proposed Lakestudy aims to create a romantic beach life with suitable conditions for bathing, water sports and other recreational uses of the Resort in an efficient and economical manner. The resort is located on the inland land, away from the natural shoreline. The lake will be fed from saline groundwater wells as well as drainage in the same aquatic environment with a closed system.

2.1.2. Location

The proposed location of the study (Fig. 3) is located in the Nabq area of Sharm el-Sheikh between latitude 50 01 280 north and longitude 49 23 340 East. It is surrounded by the Wadi Om Adawi Delta and the south by Sharm El-Sheikh Airport. The site is located in the planned part of the tourist activities outside the boundaries of the Nabq Reserve, which was declared in 1992. Due to the proximity of the study to the Nabq Governorate, "Due to the environmental sensitivity of the area, where Nabqat is characterized by mangrove and Arak vegetation, the study in question is located in the mountainous lagoon away from the shore. The proposed location of the Lakeis about 5 kilometers from the shoreline. Sharm El Sheikh is an important area on the tourism development map locally and internationally (Frihy et al., 2006, GEAP, 2005, and UNEP / PERSGA, 1997).

Detailed description and general layout of the proposed lake has been designed according to the best conservation criteria to match the nature of the land, the quality of the recharge water and climatic conditions. The design takes into consideration project size, weather conditions (e.g. evaporation rates and temperatures) to achieve absolute benefit from these factors. The proposed lakes environmentally friendly and its water complies with the most stringent health standards and chemically tolerable limits making it suitable for water sports and bathing. The technology used is a low-emission filtration system and uses a method of disinfecting water with a system of regular doses that requires up to 100 times less in chemicals than is usually used in traditional swimming pools, thus preserving the environment. Lake water is suitable for use in all recreational purposes. The dimensions of the crystalline lake built up to about 500 meters in length, and the surface area is about 30 acres, and the volume of water stored in the lake up to about 111,000 cubic meters. The lake will be fed by pumping saline groundwater wells using feed pumps to the set of filters first and then to the treatment units that drive the water to the lake and then drain the sewage regularly in the direction of the collection tank of drainage water and from it to the drainage wells. The project executing company will provide a complete line of chemicals, plastic lined cushions and electronic devices for construction and maintenance to comply with environmental precautions. There will be telemetric control of the water level and the natural chemical parameters of the water. Operating valves will be provided to the system to meet the high water quality standards. The water level of the lake will be automatically regulated. The system will send a signal to start the production and drainage wells required to adjust the level and compensate the salinity.

The general layout of the proposed lake study and the distribution of the feeding and drainage wells and the contracted design indicators are shown in Figure 4, the basic units of the lake are compatible with local legislation and include the following:

- Feeding system (9 feeding wells including 7 workers + 2 reserves) as well as a pipeline linking the lake's feeding wells
- Plant slow sand precipitation and filtration
- Treatment and sterilization room (automatic addition of chlorine by dose) and injection of feeding water with sediment and blockages.
- Sewage system (9 drainage wells 7 working + 2 reserve + reservoir regulating the work of drainage wells and drainage pipeline)
- Bottom cleaning and scraping line, recycling rooms and machinery

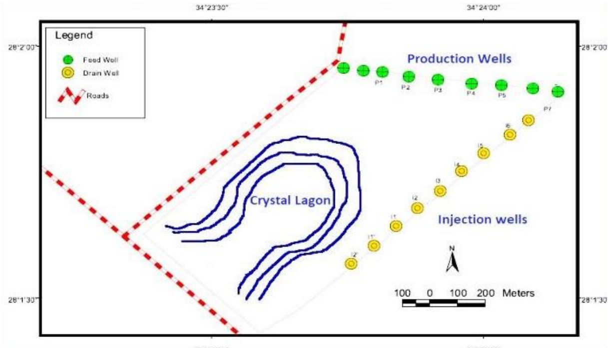



**Figure 4:** General layout of the lake and the distribution of feeding and drainage wells

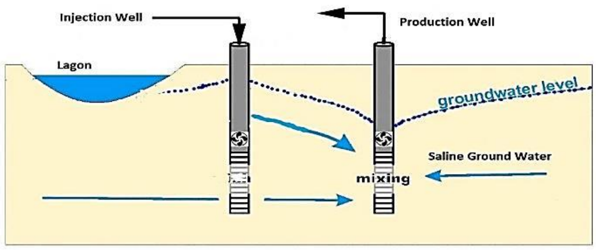



**Figure 5:** A proposed cross section of the proposed lake showing the mechanism of operation of the feeding and drainage wells in a closed system (the water that is discharged is re-pumped again).

*2.2 Study of Available Water Resource and the Impact of Flash Flood on the Study Area*

2.2.1 Topography and Geology

The topographic features of the area is characterized by the presence of beach plains restricted between the Gulf of Aqaba and the mountainous area in the east, and slopes toward the Gulf, while the geology of the area is characterized by many Gebles of different elevations, these Gebles composed of igneous and metamorphic rocks. The area is subjected to a strong tectonic movements, consequently some geological structures as faults, joints and others are formed, which may affect direct or indirect on groundwater occurrence, movement and direction, in addition to the Quaternary deposits which composed of sand, gravel, rock fragments and limestone as shown in Figure 6.

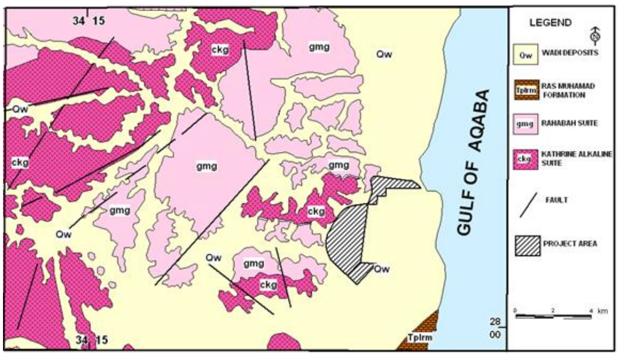



**Figure 6:** Geological Map of the study area.

2.2.2 Geophysical Investigation

Vertical electrical sounding method is used to determine indirectly the extent and nature of geologic materials beneath the surface. Thickness of unconsolidated materials, location of subsurface faults and depth of the basement rocks can be predicted via geophysical investigation. Consequently ten vertical electrical soundings were conducted through four profiles as shown Figure 7 and four geo-electric cross sections were constructed to illustrate the subsurface succession, as an example Figure 8. These geophysical investigation revealed that there is a suitable site for drilling test well of depth ± 150 m below the ground surface.

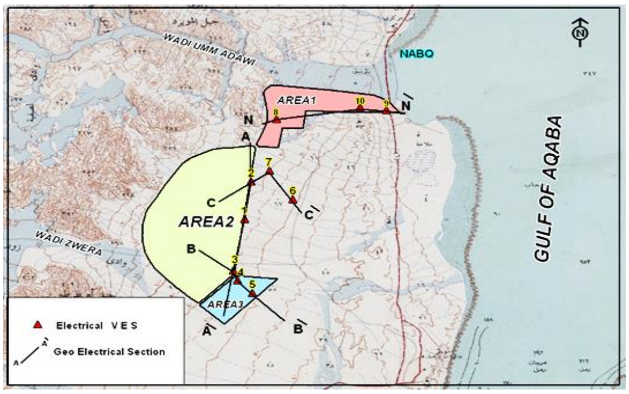



**Figure 7:** Location Map for the Geophysical Profiles

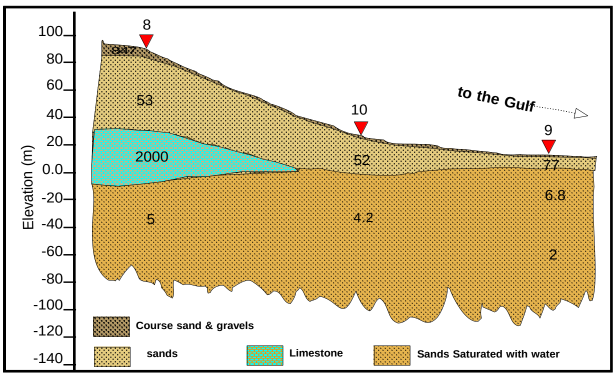



**Figure 8:** Geoelectric cross section B-B'

2.2.3 Hydrogeology

This study deals with the groundwater aquifers, were the area of the study is suffering from fresh water supply, and the main source of water is saline and very saline water which occur in the sedimentary succession, meanwhile the salinity depends mainly on the hydraulic connection to the Gulf and the pumping rates of the existing wells. From the available data collected from the existing wells, it concluded that the thickness of the sedimentary succession varying from 250 to 300 m nearby the coast and decreases gradually towards the mountainous area, the static water level ranges from 30 to 50 m below ground level therefore it seems that the groundwater flow goes towards the Gulf.

2.2.4 Survey

The necessary survey works have been carried out by using modern surveying tools to allocate the suitable sites for construction the industrial works in the main stream and its tributaries and to follow up the natural passage of flash flood, determination of the coordinates of those passages, conducted a number of cross sections and calibration curve to find out the relationship between the required distance for storage of flash flood and the expected volume of water in addition a contour map for the main stream.

2.2.5 Hydrology

A hydrological study has been carried out for the study basin. The basin area is about 16 $km^2$. A topographic map of scale 1:50000 is used to create the Digital Elevation Model (DEM) for study basin using Geographical Information System (GIS). The DEM and the resulted drainage network of the basin is shown in Figure 9.

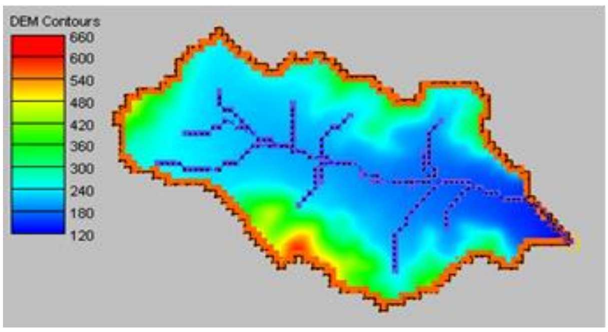



**Figure 9:** The DEM of the study basin

Daily rainfall data is collected in and around the study area. It is collected from the General Meteorological Authority (GMA) and WRRI stations. The closest rainfall station is Sharm El Shiekh station. The rainfall data for 24 years is used in HYFRAN statistical program to get the rainfall values for different return periods up to 100-year as shown in Figure 10.

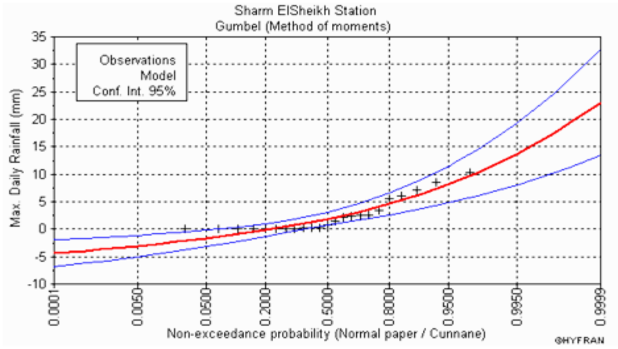



**Figure 10:** Statistical analysis of Sharm ElShiekh station

*2.2.5 Results and Recommendations*

*Results*

- The geological study concluded that the area composed mainly of igneous and metamorphic rocks and transported rock fragments and the lithological succession consist of wadi depsits and tertiary rocks that composed of sand and different size grained graved, basaltic intrusion and the presence of cracks and fissures that affects on groundwater movement and direction.
- The hydrological study showed that the area of study suffering from fresh water and it depends mainly on saline and very saline water and the groundwater flows toward the Gulf.
- Geophsical investigation attributed that, the groundwater occurs in the lower unit which thickness is differs from one place to another.
- It's clear from the estimated hydrological parameters that, there is no dangerous effect of the flash flood in the future infra-structure.

*Recommendations*

From the different studies on the area it is recommended drilling a test hole with depth of about ± 150 m from the ground surface in case of positive results it will be changed into productive well through which additional productive wells can be drilled.

*2.3. Reference Frame Rules and Environmental Information*

2.3.1. Legislative framework

Law No. 4/1994 of the Environment and its Executive Regulations issued by the Prime Minister's Decision No. 338 of 1995 stipulate that new facilities or projects should be subject to expansion in existing EIAs prior to issuance of a permit. The construction of the inland lake was classified in this study within the list of projects (C) due to the environmental sensitivity of Nabq and Sharm El-Sheikh. This may reflect the reserve for all potential environmental impacts due to the proposed crystalline lake, which may lead to significant environmental impact in some areas. Due to the small size of the lake and the quantity of replenishment water (6000 $m^3$/day), the EIA study will help to assess and describe any expected impacts of the lake on the surrounding environment in an organized manner that helps mitigate and avoid these impacts. Articles 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 34, 57, 58, 59, 60, 70.71 and 73 Of Law No. 4 of 1994, as amended by the Prime Minister's Decision No. 1741 of 2005, procedures and provisions for environmental impact assessment. Therefore, the EIA procedures for the project have been followed in accordance with the provisions of Law No. 4 of 1994 and its Executive Regulations. Materials dealing with the protection of the terrestrial and marine environment have also been taken into account, such as Law 102/1983 on natural reserves. The other relevant laws, as well as the requirements of South Sinai Governorate, were considered at the time of preparation of this study, and other local instructions regarding non-discharge directly to seawater were followed in the design of the drainage system for the project. No. 458 of 2007) have also been followed in the evaluation.Groundwater law has been specifically mentioned as a "waterway" also in the executive regulations of Law 48-1982 Decree No. 8 of 1982 on the protection of the Nile and waterways from pollution. 1983), setting standards and limits for different types of wastewater that could be discharged either in surface water or in groundwater, to protect water sources in relation to the direct release of liquid wastes. All environmental procedures and conditions necessary for safety and protection will be adhered to at all stages of construction and operation of the planned crystalline lake.

2.3.2. Curriculum

The arrangement of this study follows the instructions of the Ministry of Environment to prepare the Environmental Impact Study (EIAA, 2009) http://www.eeaa.gov.eg. The EIA methodology used in this assessment is based on the method of calculating impact (USEPA, 2006). This assessment has been prepared using approved methods (eg, Sampling methods, collection of archival, and field data), taking into account the requirements identified by the groundwater sector of the Ministry of Water Resources and Irrigation. The procedures required to evaluate the exploitation of groundwater and drainage effects on the saline groundwater and the receiving environment have been followed in accordance with the requirements of the Ministries of Irrigation and the Environment. The purpose of this study is to assess the effect of the proposed lake on the surrounding environment, with emphasis on the extent of the impact of the groundwater sources, and the dependence of the lake in the recharge water on saline groundwater as well as drainage in the same groundwater environment. A detailed study of previous relevant studies on natural resources and the natural environment carried out close to the proposed site, with attention to groundwater resources in Sharm El Sheikh area and around the proposed site of the lake, included a number of studys on groundwater assessment (Ramadan 2008); Shahatto 2003, Einav et al. 2002, Jica, 1999 and Dames and Moore 1985), and internal studys at Nabq and the Ministry of the Environment. Environmental impact assessment studys and studies have been reviewed for similar projects in the study area and surrounding areas. ***The information used in this assessment was based on the following:***

- Review previous studies and research
- Technical specifications of lake and operating elements
- Hydrographic data collected during the drilling of feed and drainage wells
- Field visit to the proposed site and analysis of water samples and soil
- Interpretation of topographical maps, aerial photographs, and satellite images
- Professional judgment based on long experience in the region and similar projects

2.3.3. Reference environmental information

Description of the existing environment Overview

Sharm El-Sheikh is a unique and environmentally sensitive tourist destination, surrounded by the Nabq Bay Nature Reserve and the southern side of Ras Mohammed Area. The proposed location of the study Figure 11 is located in the back area of Nabq along the Gulf of Aqaba. The Gulf of Aqaba is characterized by coral reefs and it is one of the most productive natural systems in the world. If these coral reefs are damaged, the complex balance of coral reefs will change permanently; therefore, the rate of production and biodiversity will decline, leading to subsequent negative economic consequences (UNEP, 1997). Direct discharge of water from the lake to the marine environment may lead to deterioration of the coral reef ecosystem. This can be avoided by discharging this water through injection wells in the saline groundwater reservoir. Sharm el-Sheikh is one of the most popular areas of South Sinai, which relies on tourism activities (GEAP, 2005). The proposed lake is about 5 km from the coastline and features a slight slope and rugged sandy terrain.The marine environment in Nabq area is characterized by spectacular scenery and clear water. The coastal waters of the coastline are shallow and very deep, moving inland, giving additional value to the place, which can be used for diving to see the underwater wonders of the Gulf. The corals are scattered and characterized by structural irregularities. The coral formations in the village interview are far removed compared to the northern and southern parts. The coastal strip of the Gulf of Aqaba in the southern region to the south of the Wadi Um Adawi delta is a flat plain with sabkhat and natural vegetation. The study is located in the mountainous region, which is about 5 km from Nabq Bay. There are no natural features on the site except some dry valleys that can be used in the open and green areas.


**Figure 11:** Satellite image showing the nature of the land around the proposed site

Land characteristics and uses (topography and drainage)

The Resort is located within a large project that includes plans for a number of tourist villages in the Nabq area on the west coast of the Gulf of Aqaba, north of the Naama Bay area in Sharm El Sheikh, about 20 km. Sharm El Sheikh International Airport is located about 10 km south of the site. There are no rivers or water channels in or near the site, or there are no any drainage systems of major valleys. The region cuts off some small dry wadis that descend from the west towards the Gulf of Aqaba, where their water is disposed of. However, the relatively large valleys, such as Wadi Um Adawi (with a feeding area of 340 $km^2$), drain northward from the proposed location to the Gulf of Aqaba. The proposed area is characterized by a gently wavy level surface, naturally protected from the western side by a series of medium-height Granite Mountains. The slopes of the earth surface range between 2 - 4 degrees and reflect a slight slope. The proposed land of the study is covered with gravel and medium and coarse sand. Soil analysis of the sites shows that the soil texture is sandy and calcium carbonate in general is very low (4.2%), alkaline soil with low salinity (total dissolved solids in soil not exceeding 1000 ppm) ). The land at the proposed site is currently unused and no human activities exist due to physiographic conditions and lack of fresh water and can be defined as barren land. The site has never been used in agricultural activity. The west coast of the Gulf of Aqaba in the coastal area of Nabq is a flat plain spread by sabkhat and natural plants such as palm trees, salt plants, mangroves, ponds, coral surfaces and tidal bays. However, these plants do not appear in the vicinity of the proposed location of the resort lake.

Climate and surface water (Rapid desert flood)

South Sinai is characterized by an arid climate where rainfall is rare. The range of air temperatures throughout the year varies from 40°C on the coastal plains to about 0°C on high mountain peaks. The average annual rainfall of South Sinai varies from 5 to 30 mm Figure 12 (JICA and WRRI, 1999). Local floods occur in South Sinai every few years of rapid rainstorms that occur in the first fall and spring and high-intensity rain in a short period.

The desert wadis respond to severe rainstorms differently depending on the area of the recharge area, their geological nature, their geomorphological status, and the indicators for each drainage basin. Most of the valleys in South Sinai are not equipped with hydrological devices to measure discharge of wadis during periods of sudden soles. Rainstorms less than 10 mm will be lost by evaporation even after a simple local surface runoff does not result in significant flooding (Ghodeif, 2002). This is the case at the proposed site where the maximum daily rainfall at Ras Nasrani station in Sharm El Sheikh was 10.3 mm, with the possibility of occurring once every 6 years. Therefore, the sudden local floods will not cause any problem on the proposed study. Moreover, the areas exposed to sudden flooding are located at the mouth of Wadi Um Adawi, which is far from the proposed site. It has been observed that the natural flood waters from these wadis do not impede normal life in Sharm El Sheikh according to the flood survey in South Sinai Governorate (JICA and WRRI, 1999).

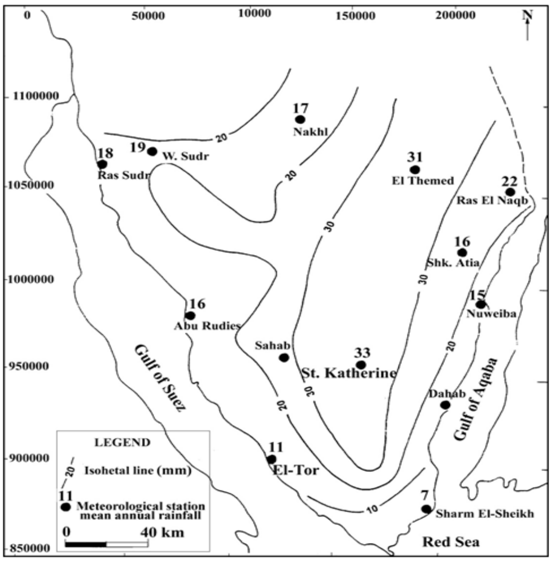



**Figure 12:** Mean annual rainfall in South Sinai (JICA & WRRI, 1999)

Egypt's hydrographic map identified the presence of a coastal aquifer in Sharm el-Sheikh that received limited subsurface recharge (RIGW / IWACO, 1988, updated 1999). The system of groundwater flow in Sharm el-Sheikh generally tends from the pre-Cambrian rocks splintered to the Gulf of Aqaba. It is heavily influenced by the system of eastern faults. The tectonic cisterns and troughs in the area are filled with rocks from the Mayosin sandstone, which are occupied by green and sandy sediments and coral reefs from the more modern four-day deposits. Recently, because of the use of aquifers for the recharge and drainage wells of desalination plants in Sharm el-Sheikh, the hydrographic level of the subsurface layers has improved (Infra-Consult 2004, and present work). The rock formation of the subsoil layers in the test wells drilled of the study area is explained in Figures 13&14 accordingly.The area generally lacks fresh groundwater and the presence of groundwater in the area is limited to saline and semi saline water. In the Myosin deposits (Arcozzi sandstone), which is the main groundwater reservoir in the study area and is located at a depth of 100 meters from the surface of the earth with a thickness of up to 120 meters. The quadruple quaternary formation extends from sand deposits along the eastern part to fossilized coral reefs and sandstone along the seashore. Coral reefs consist mainly of fossilized reefs (coral, bryozoans, and crinoids), which increases vertical hydraulic conductivity more than horizontal, thus allowing for feeding from sea water, which increases the productivity of wells. Groundwater in the study area is located at depths ranging from 58.32 to 69.56 meters below ground, and high yield wells (75to85$m^3$/h). The estimated hydraulic properties of the rock formation (Freeze & Cherry 1979); porosity ranges from 0.15 to 0.25. The groundwater reservoir in the study area was characterized by high mobility ranging from 2,300 to 10,600 $m^2$/day. The hydraulic slope in the studied area and surrounding areas is almost very high (about 0.00025). The aquifers in the region are hydraulically connected to the waters of the Gulf of Aqaba, which explains the high productivity of the dug wells.

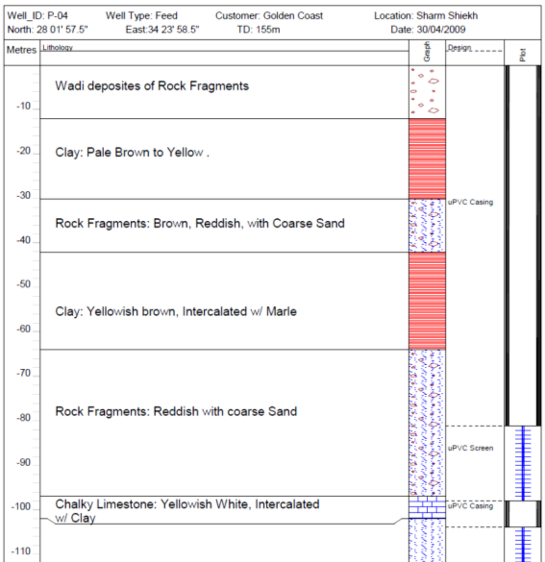



**Figure 13:** The subsurface lithology distribution in production well no. P4

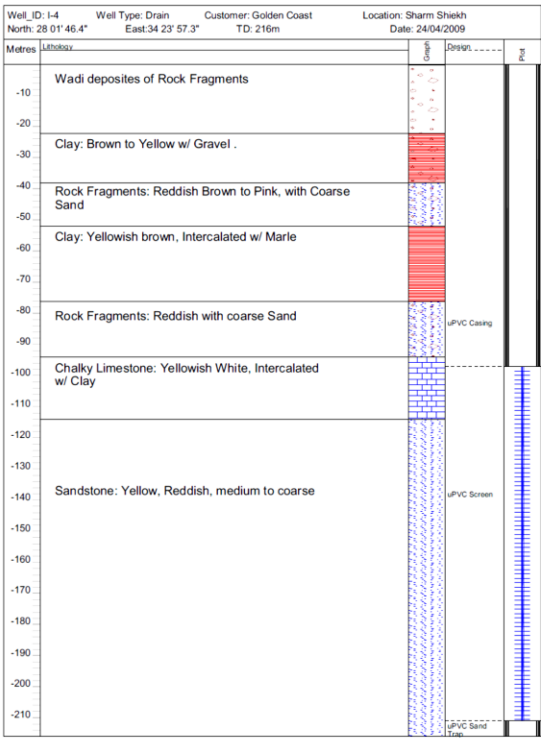



**Figure 14:** The subsurface lithology distribution in injection well no. I4

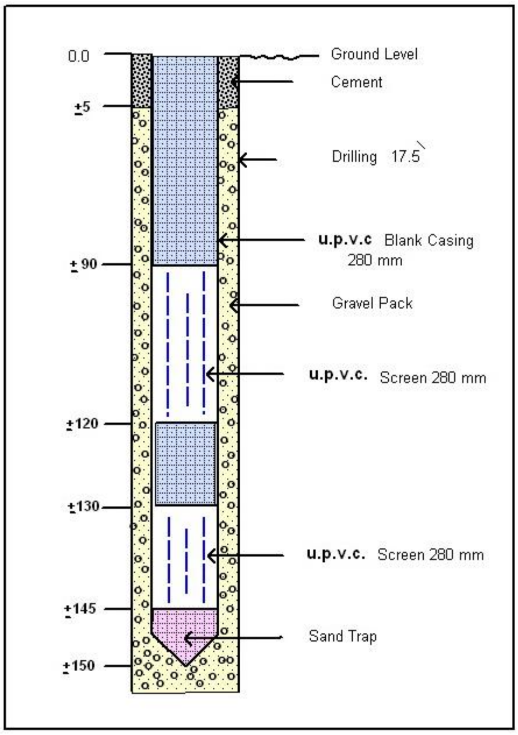



**Figure 15:** Proposed design for Production well and Injection wells to work in closed system (Injection & Recovery)

**Table 1:** The hydrological data of the wells

| Well No. | Type | Well Depth (m) | Plain Pipe Length (m) | Filtered Pipe Length(m) | Static Depth | Dynamic Depth (m) | Salinity | Discharge $m^3$/ hr | Effect of drag and drain on wells |
|---|---|---|---|---|---|---|---|---|---|
| P1 | production | 156 | 100.35 | 57 | 69.56 | 73.59 | Sea water | 75 | No Effect |
| P2 | production | 145 | 89 | 57 | 67.37 | 71.61 | Sea water | 77 | No Effect |
| P3 | production | 145 | 89 | 57 | 65.45 | 66.32 | Sea water | 87 | No Effect |
| P4 | production | 153.8 | 92.2 | 62.6 | 63.48 | 63.98 | Sea water | 85 | No Effect |
| P5 | production | 153.9 | 92.2 | 62.7 | 61.50 | 64.18 | Sea water | 77 | No Effect |
| P6 | production | 153.9 | 97.9 | 57 | 60 | 61.25 | Sea water | 75 | No Effect |
| P7 | production | 152.5 | 102.2 | 51.3 | 58.32 | 59.25 | Sea water | 87 | No Effect |
| I1 | Injection | 103 | 69.4 | 34.2 | 64.45 | 59.05 | Sea water | 64 | No Effect |
| I2 | Injection | 157 | 81.55 | 76.02 | 63.60 | 54.35 | Sea water | 50 | No Effect |
| I3 | Injection | 205.2 | 93.2 | 113 | 62.40 | 57.12 | Sea water | 60 | No Effect |
| I4 | Injection | 216.6 | 97.9 | 119.7 | 61.60 | 54.02 | Sea water | 61 | No Effect |
| I5 | Injection | 216.6 | 103.6 | 114 | 60.75 | 49.12 | Sea water | 60 | No Effect |
| I6 | Injection | 208.16 | 77.55 | 131.10 | 60.40 | 59.15 | Sea water | 64 | No Effect |
| I7 | Injection | 157 | 82.9 | 74.6 | 65.10 | 32.35 | Sea water | 25 | No Effect |

**Table 2:** Soil Analyses for Golden Coast sites (Soil samples taken at locations of Wells Nos. : 1, 2, 3, 4, 5, 6 and 7)

| [ | | | P. 1 | P. 2 | P. 3 | P.4 | P. 5 | P. 6 | P. 7 |
|---|---|---|---|---|---|---|---|---|---|
| Depth | | m | 0 – 2 | 0 – 2 | 0 – 2 | 0-2 | 0--2 | 0--2 | 0 – 2 |
| Total of Calcium Carbonate | | % | 4.20 | 0.00 | 0.00 | 0.00 | 0.50 | 2.52 | 0.00 |
| Saturation Percentage | | % | 17.00 | 20.00 | 20.00 | 24.50 | 20.00 | 20.00 | 20.00 |
| Sand Percent | | % | 90.00 | 88.75 | 88.75 | 88.75 | 88.75 | 85.00 | 78.75 |
| Clay Percent | | % | 8.75 | 8.75 | 9.75 | 8.75 | 10.00 | 15.00 | 15.00 |
| Silt Percent | | % | 1.25 | 2.50 | 1.50 | 2.50 | 1.25 | 0.00 | 6.25 |
| Texture | | Text | Sand | Loamy Sand | Sand | Sand | Loamy Sand | Loamy Sand | Sandy Loam |
| PH | | | 8.90 | 9.40 | 9.30 | 7.9 | 8.40 | 7.50 | 8.45 |
| E.C. | | (mmhos/cm) | 0.65 | 1.24 | 1.20 | 1.24 | 0.40 | 1.47 | 1.23 |
| T.D.S. | | (ppm) | 455.0 | 868.0 | 840.0 | 868.00 | 280.00 | 1029.00 | 861.0 |
| Anions | Carbonate | (meq/l) | 0.00 | 0.00 | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 |
| | Bicarbonate | (meq/l) | 7.00 | 1.00 | 0.50 | 7.00 | 6.00 | 1.00 | 1.00 |
| | Chloride | (meq/l) | 15.00 | 10.50 | 4.50 | 15.00 | 7.50 | 11.00 | 8.50 |
| Cations | Calcium | (meq/l) | 4.50 | 4.50 | 2.50 | 4.50 | 0.60 | 4.50 | 2.00 |
| | Magnesium | (meq/l) | 0.00 | 3.00 | 1.50 | 0.00 | 0.20 | 3.00 | 1.77 |
| Iron | | (mg/l) | 0.00 | 0.46 | 0.10 | 0.46 | 0.50 | 0.10 | 0.00 |

**Table 3:** Reference groundwater quality for Red Sea waters and Egyptian standards for potable water

| Parameter | Unit | Average Groundwater Sample | Red Sea Sample | Egyptian Drinking Water Standard Year 2007 |
|---|---|---|---|---|
| Ammonia (NH3) | mg/l | | | 0.5 |
| Nitrite (NO2) | mg/l | <0.2 | | 0.2 |
| Nitrate (NO3) | mg/l | 5.53 | | 45 |
| Turbidity | NTU | clear | | 1 |
| Temperature | C 0 | 34.5 | | |
| TDS | mg/l | 38563 | 44495 | 1000 |
| pH | | 7.3 | | 6.5-8.5 |
| Total alkalinity (CaCO3) | mg/l | 94 | 131 | |
| Total Hardness (CaCO3) | mg/l | 10584 | | 500 |
| Calcium hardness (CaCO3) | mg/l | | | |
| Calcium (Ca) | mg/l | 639 | 512 | 350 |
| Magnesium (Mg) | mg/l | 818 | 1535 | 150 |
| Sodium (Na) | mg/l | 11575 | 13850 | 200 |
| Potassium (K) | mg/l | 296 | 420 | |
| Chlorides (Cl) | mg/l | 19544 | 24663 | 250 |
| Sulfates (SO4) | mg/l | 2484 | 3384 | 250 |
| Iron (Fe) | mg/l | 0.18 | 1.3 | 0.3 |
| Manganese (Mn) | mg/l | 0.018 | | 0.4 |
| fecal coliform | unit/100ml | zero | | 2 units/100 ml |

Water quality

Table 3 shows the results of groundwater analyzes at the proposed site, which confirms that groundwater quality is not suitable for drinking or agriculture purposes and the water available in the groundwater reservoir is brackish water. (TDS = 38563 mg / L) This value is well above the Egyptian standards for good water (TDS = 38563 mg / L).
Groundwater used in nutrition is colorless, odorless, and average temperature is about 34.5 °C and pH 7.3. Salinity concentration is very high in the Red Sea waters, as it reaches about 44495 mg/L. There is no significant difference in salinity between the waters of the Red Sea and groundwater at the proposed site to feed the crystalline lake. The content of manganese and iron is far below the criteria for safe drinking water and safe operation of the proposed lake. According to the quality of groundwater, the only possible use of groundwater at the site is to feed the crystalline lake instead of direct discharge from the sea that disturb and harm the marine ecosystem.

Design of feeding and drainage wells for the proposed lake

The quantity of groundwater abstracted and the volume of water required to be injected into the ground depends on the operation of the lake and the efficiency of recycling and storage capacity. The proposed lake is designed to accommodate 111,000 $m^3$ at the start of operation and then to continue it required water supply and drainage equal 6000 $m^3$ to maintain the level of water in the lake. Therefore, the lake needs a groundwater recharge of about 6000 $m^3$/day, and then re-spent in the reservoir deep groundwater.

It is supposed to extract the recharge water from the seven wells of production from the groundwater reservoir at the same level as the drainage wells (seven wells) in order to operate in a closed system as the quantities of water being re-injected into the aquifer and then re-extracted in a closed cycle that helps to purify Natural water that has no effect on surrounding areas. The order of the production and drainage wells and their relation to the groundwater reservoir and the direction of the movement of groundwater are illustrated in Figure 16. The distance between the production wells and the drainage wells is about 100 meters.

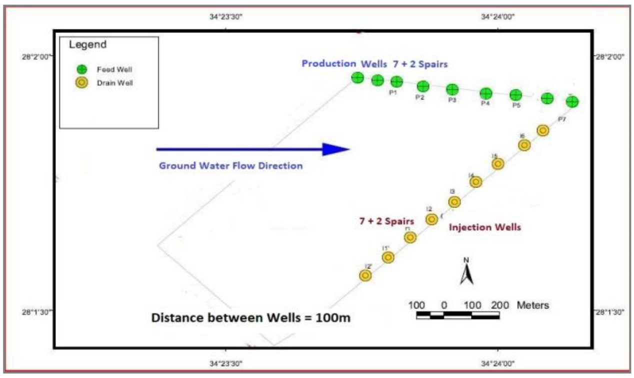



**Figure 16:** A flat map showing the proposed distribution of recharge and drainage well

The proposed design of the recharge and drainage wells has taken into account the surrounding local hydrogological conditions and practical considerations as shown in Figure 15. The production wells have been designed to obtain the highest low-yield productivity and continue to produce sand-free water. Production and drainage wells have been placed in the upper part of the aquifer to obtain saline groundwater and operate in a closed cycle. Drainage pumps for the lake should be placed away from the accommodation and recreation of guests of the Resort and in the back area. A fence of trees surrounding the pumps and generator site will not cause any expected environmental damage nor cause inconvenience to those in the area.

Monuments and other sites of historical and cultural importance

There are no places of significant cultural or archaeological value located in or near the proposed site area of the station.

*2.4 Predicting impacts and estimating clear environmental impacts*

Overview

This part of the study refers to the potential environmental impacts of each of the study phases (*construction and operation*) of the planned Crystal Lake. Unlike the quality and health of the water used in the lake, its fitness for swimming and other recreational activities, environmental protection issues are also evident when the effects of industrial lakes are considered to be in the surrounding environment (WHO, 2007). According to the design of the proposed lake in terms of the source of the recharge water and the nature of the environment receiving the drainage resulting from the operation of the lake. We can distinguish that the most important impact will be on the groundwater environment. Tourism development may pose a serious threat to both the marine environment and the tourism sector itself, which relies on the environment, if not planned and developed on the basis of environmental correct and effective implementation of environmental instructions.

It turned out that the direct exchange of the waters of the lake to the sea cause invisible damage in the short term marine life, especially coral reefs (UNEP, 1997), but there are alternative options for the disposal of waste water resulting from the lake including direct discharges to the sea shore, or exchange in underground tanks and recovery again closed system (injection & recovery) in addition to pools and lakes evaporation. Coastal environmental protection system (as a result of feeding water withdrawn or drainage water injection) and the protection of groundwater pollution will deserve more attention. Drainage in underground tanks must take into account the movement regional groundwater that assists diffusion and mixing processes that significantly reduce the contaminants associated with wastewater, this option has been followed by the proposed study.

Liquid waste disposal alternatives in Sharm El Sheikh Disposal of liquid waste can have adverse effects on amenities, water quality, crops and people's health. Thus, the important effluents from the industrial lake are drainage water to sustain its operation. There are alternatives to disposal of wastewater from operation.

Direct drainage on the sea

This is usually not an effective option, however, because of economic conditions, it can be considered for smaller projects in environmentally sensitive beaches. Depends on effective mitigation, but during the calm weather, mitigation will be simple and the impact on the coastal environment will be high (Einav et al, 2002). Direct drainage on the shore can cause pollution of the coastal strip and reduce the effects of mixing and natural mitigation of pollutants rather than reducing (Purnama et al. 2003). This option has been excluded from use because of the high environmental restriction in Sharm El Sheikh due to the presence of coral reefs and the highly sensitive ecosystem in the region.

Drainage in the underground reservoir (injection & recovery)

This option involves re-injecting wastewater from the lake into the groundwater reservoir through the drainage wells to the aquifers that feed the lake, which usually contains saline groundwater and is unsuitable for drinking or agriculture. This option is possible in the project environment where there are underground layers with large capacity and suitable hydrographic characteristics of the discharge process with the possibility of monitoring the drainage process. Despite its relatively high cost, this procedure is highly used in Sharm el-Sheikh because of the appropriate hydrogelic conditions and high sensitivity to the coastal environment in the region. This option was chosen for the proposed lake.

Direct drainage on the local drainage network

Due to the high salinity of the wastewater from the lake and the containment of some pollutants as a result of purification of water chlorine and impurities treatment and also due to limited capacity of the drainage network and treatment plant, this option is unlikely. In addition, the local regulations in Sharm El Sheikh prohibit the direct disbursement of such projects to the drainage network, so we have excluded this option.

Effects on the marine environment

Marine resources close to drainage sites may be affected by the content and quality of the components in the wastewater, the discharge method used, the process of withdrawal and the quantities of recharge water. The components produced in the wastewater are partly dependent on the processing and recycling technology used in the lake, the quality of the recharge water, the quality of the water produced, the pre-treatment and remote treatment, cleaning, and storage methods used.

The withdrawal of recharge water directly from the sea usually results in loss of marine species as a result of collisions and capture (California Coastal Commission, 1993). Collisions occur when marine species collide with catch filters, and catch occurs when some species are withdrawn with feeding water into the pumps and killed during treatment. Feeding water outlet can also affect marine resources by adjusting sea currents in the intake area, to remove these effects must be used beach wells.

The discharge of saline solution directly to the sea will lead to disruption of the marine ecosystem and loss of marine species (Einav et al., 2002, Hoepner et al., 2002; UNEP, 1997). Although the wastewater from the operation of the lake contains salts almost equal to the salinity of sea water, but contains some of the materials resulting from the purification and treatment of the water of the lake and therefore affect the marine environment receiving much more than the salinity of the receiving environment, more than those of the receiving environment. Chemicals used during treatment, washing of production lines and cleaning of lake operating equipment will often contaminate the marine environment. Due to the high negative impact of feeding and drainage operations on the marine ecosystem, the marine environment has been excluded from the Lakefeeding or discharge of wastewater. The lake is not connected directly or indirectly to the sea (5 km from the shore). We can conclude that the establishment and operation of the proposed lake will have little impact on the surrounding marine environment

Effects on land resources

The establishment of the proposed lake will have a very insignificant effect on terrestrial resources. Land cover in the immediate area where the lake will be built includes almost equipped land for tourism activities within the area allocated to the resort. Land is barren the lake site currently has no structures, agricultural activities, or other significant uses of land. The construction of the lake in practice will have no effect on plants or animals within the study area, nor will have a significant impact on the current use of the land. Therefore, the proposed lake will not remove or disturb any productive uses of the land in the study area.

Effects on socio-economic issues and archaeological sites with important historical and cultural value

The establishment and operation of the lake will not have any significant social or economic effects, except providing employment opportunities for the local population in the vicinity of the study area and provide them with a view of the picturesque lake. There are no residential communities in the area around the site due to lack of potable water or agriculture. There are no significant cultural, archaeological or historical sites in and around the study area, ***so we do not expect the proposed lake to have any impact on important cultural, archaeological or historical features in the region.***

Effect on the local groundwater reservoir

Due to the use of the aquifer environment to recharge the lake and discharge its water, from the point of view of the groundwater sector there are two potential problems that can affect the local aquifers. One is the extraction of groundwater for the purpose of nutrition and the rate of decline in the associated groundwater table and the other problem related to the mechanism and place of water injection drainage resulting from the operation of the lake. The main aquifer consists of sandstone and rough coarse sandstone inclusions. The groundwater reservoir used can be classified as a good reservoir in terms of productivity and drop rate due to hydraulic contact with seawater. Unacceptable landing will not occur, away from production wells, during water withdrawal and the range of impact will be limited according to the mathematical model used in the area (Ramadan, 2008 and Shahatto, 2003). The original groundwater at the site salinity reaches about 38563 mg/L, making it unsuitable for domestic use or for agriculture when compared to Egyptian standards for potable water. In addition, groundwater is not used close to the site, mainly due to the high salinity of groundwater.The groundwater reservoir in the region has high mobility, ranging from 2,300 to 10,600 $m^2$/day. The rate of decline from pumping for a day (75$m^3$/h) did not exceed 2 m. Thus, the extraction of 6000 $m^3$/day of groundwater to feed the lake is possible. The high mobility of the groundwater tank indicates the high absorption capacity of drainage of 6000 $m^3$/day of wastewater through seven drainage wells distributed in the direction of groundwater flow. As a result of the use of a closed feed and drainage system, wastewater will be re-pumped back to feed after mixing with the original groundwater and greatly mitigated by the natural processes of dispersion and dispersion (natural processes), thus creating no serious environmental hazard.

The accidental spillage of waste water is unlikely to have any significant impact on groundwater if it is carefully managed, controlled and purified. The surface layer near the proposed site is a hard-liner, which will significantly reduce the leakage and restrict the pollutant movement that arises from accidental spillage any other leaks in the desalination unit. For the above reasons, it can be concluded that the proposed lake has a very low impact on the local aquifer, mainly due to the discharge of lake water. This can be managed carefully and thus will pose no serious environmental risk to the quality of the groundwater.

Impact on existing groundwater users

Groundwater near the site is generally not used due to high salinity. There are no groundwater users in the estuary or source of groundwater in the study area that may affect the operation of the plant. Due to the high productivity of the aquifer and its hydraulic connection with seawater, withdrawing 6000$m^3$/day from the saline groundwater to feed the lake will not adversely affect any current groundwater users due to the proximity of the Gulf of Aqaba and its work as a feeding limit.

*Drainage in waterways*

There is no discharge or emission of open water bodies (may affect freshwater plants and animals or marine waters). This has been discussed in that part dealing with the impact on the marine environment. The only liquid release will be directed to the saline groundwater reservoir. Human health will not be affected as this drainage will go into the aquifer and be re-used in nutrition, especially since the original groundwater is not used for irrigation or for public water supply. By comparing the expected drainage volume (6000 $m^3$/day) of wastewater and its salinity (38563 mg / L) for reference data for the quality of groundwater received. Note that there is no significant difference between the salinity of the wastewater and the salinity of the groundwater used in feeding the plant. A number of criteria such as turbidity, temperature, dissolved oxygen, salinity (TDS) and bacteria must be monitored during operation to anticipate potential changes in water quality over the long term.

*Audio pollution (noise)*

The operation of the crystalline lake uses modern environmental safety techniques but the noise caused by the operation of high pressure pumps and turbines is noisy. Noise effect Pump and machine room operation is not allowed close to a residential center without the use of technical means of mitigation (UNEP 2001). Pumps and generators are preferred away from the lake with some mitigation measures, such as the use of some means to reduce the noise level in the curtain building around the pumps.

*2.5. Mitigation*

Mitigation strategy

The mitigation strategy aims to develop mitigation measures capable of minimizing potential negative impacts from the establishment and operation of the planned lake, or to maximize the benefits of positive impacts. Based on this, it is accepted that appropriate mitigation practices are part of the study construction and proposed expansion process. All the instructions approved by Law No. 4 of 1994 on the Environment and its Executive Regulations and Law No. 48 of 1982. Regarding the protection of waterways from pollution has been taken into consideration. In addition, the Ministry of Health's instructions regarding drinking water standards (resolution 458 of 2007) have also been followed. The terms of the contract with the drilling company, the company supplying and installing the pumps, the treatment units or the operating companies are also emphasized for the use of natural materials with a lower environmental impact on the surrounding natural resources. The lake working system will include a full line of chemicals, plastic lined cushions and electronic devices for construction and maintenance to comply with environmental safeguards. There will be permanent automatic control to regulate the water level and chemical variables in the lake water. The system will send a signal to start the production and drainage wells required to adjust the water level and compensate the salinity. A closed system will be installed to feed the lake and discharge its water in the groundwater aquifer, so that the wastewater will be returned to the feed once it has been naturally treated in the storage and recovery tank.

Specific mitigation actions

The study in general has no significant impact on the surrounding marine and terrestrial environments, however it has a very low impact on the aquifer. The following actions should be applied to ***minimize potential adverse impacts and to improve the proposed lake's operating efficiency:***

- In the case of manual drilling we should add non-toxic and naturally biodegradable (eg Polyflip) and safe disposal of any residues produced by the drilling.
- Injecting wastewater into the lower part of the groundwater aquifer in the direction of the natural groundwater flow, with the feeding and drainage system operating in a closed system (ie retrieving wastewater once again through the feeding wells).
- Monitoring the levels and quality of groundwater in the study, with the need to continue monitoring the main water quality indicators after operation (e.g. pH, TDS, temperature, dissolved oxygen, bacteria, chlorides, iron and manganese) to determine the direction of the movement of wastewater and the extent of change in content over time, To intervene in a timely manner.
- Good and environmentally safe storage of chemicals used in water purification and proper disposal of drilling and construction waste by assembling and delivering them to an approved contractor for disposal in designated areas.
- Pollution of soil and groundwater by the accidental spillage of chemicals, fuel, oil that should be minimal by applying good local protection techniques. In the event of any such spillage, the means and procedures shall be available in place for the rapid remediation and repair of any leakage effectively.
- Observe the maximum limits of noise levels of the Executive Regulations of Law No. 4 of 1994, with the construction of sound-proof curtains on the pumps of the treatment units to reduce the noise level.
- Pumps and operating machines should be placed away from the accommodation and recreation of the guests of the village and in the back area and the establishment of a fence of trees around them so not to cause any environmental damage.

- General instructions should be followed to protect the environment and mitigation procedures for any human activities (such as security instructions, wildlife protection, building design, solid waste disposal, etc.)
- Identify and prepare places to collect water samples during all feeding, processing and drainage steps so that they are easily accessible, equipped and designated for regulatory authorities and self-monitoring.

## Conclusion

- The proposed Lakestudy aims at creating the life of the beach with suitable conditions for bathing and other recreational uses of the resort in an efficient and economical manner.
- The lake has been well designed according to local conditions in Sharm El Sheikh and international levels and the sensitivity of the surrounding marine and terrestrial ecosystem is considered.
- The proposed lake is not connected directly or indirectly to the sea.The lake will be fed by saline groundwater and drainage in the underground reservoir with a closed system.
- There is no significant difference between seawater salinity and the salinity of the original groundwater used in nutrition and wastewater from the operation of the lake.
- Due to the nature of the aesthetic study and the clean technology used, the proposed lake has no significant adverse effects on the terrestrial and marine ecosystem of the surrounding area, with only a very low impact on the groundwater reservoir.
- This very low effect in the long run may lead to a change in water quality in the groundwater reservoir. This can be mitigated by mitigation measures, which include the operation of a closed system feeding and drainage system, giving sufficient time for mixing and dilution to operate efficiently and continuously monitoring groundwater level and quality.
- Some complementary mitigation measures have been put in place to improve the efficiency of lake operation and to preserve the surrounding environment.
- The study serves the country strategy in the development of South Sinai and represents an extension of the tourism projects established in Sharm el-Sheikh.
- The back areas, especially off-shore, suffer from direct sea access, which is also a tourist attraction, with almost no real value, and it recommend to use this technique used in designed the recereational lake to increase the values of back areas.

## Acknowledgements

The corresponding author expresses her gratitude to Prof. Ahmed Azmy, former dean of the Higher Technological Institute, Cairo, and to Prof. Tarik Tawfic, former director of the Central Laboratory for Environmental Quality Monitoring, Ministry of Water Resources and Irrigation, Cairo, who moderated this paper and in that line improved the manuscript significantly. She also is immensely grateful to professors in National Water Research Center, Cairo for their comments on an earlier version of the manuscript, although any errors are her own and should not tarnish the reputations of these esteemed experts.

## References

[1]. Bentor Y. K. and Eyal, M. (1987), "The geology of southern Sinai its implications for the evolution of the Arabo-Nubian massif", Volume 1 – Jebel Sabbagh sheet – Jerusalem – the Israel Academy of Sciences and Humanities.
[2]. California Coastal Commission (1993),"Seawater desalination in California", www.coastal.ca.gov/desalrpt.
[3]. EEAA, (2009) ,"A Guide to EIA Basics and Procedure", http://www.eeaa.gov.eg
[4]. Einav R., Harussi K., Perry D. (2002)," The footprint of the desalination process on the environment", Desalination 152 (2002) 141-154.
[5]. Embaby, M., (2004)," Towards an Ecotourism Development and Planning in the Red Sea Coastal Zones", International Conference: Future Vision and Challenges for Urban Development, Cairo, Egypt.
[6]. Freeze R., Cherry J. (1979)," Groundwater", Prentice Hall, Englewood Cliffs NY. 604 p.
[7]. Frihy, O.E., Ali N. Hassan, Walid R. El Sayed, Moheb M. Iskander, Mohamed Y. Sherif (2006)," A review of methods for constructing coastal recreational facilities in Egypt (Red Sea)", Elsevier B.V., ecological engineering 27 p. 1–12
[8]. Ghodeif, K., (2002)," Management and Protection of ground water in El-Qaa Plain, Sinai, Egypt", Ph. D. dissertation, Geology Institute, Adam Mickiewicz University, Poznan, Poland. 193 p
[9]. Hopner Th., Lattemann S. (2002)," Chemical impacts from seawater desalination plants – a case study of the northern Red Sea", Desalination 152 (2002) 133-140.
[10]. Infra – Consult (2004)," Study and evaluate the influence of production wells on groundwater reservoir ", Hilton Sharm Dreams Plant (unpublished report)
[11]. JICA and WRRI, (1999)," South Sinai Groundwater Resources Study", Internal report – Ministry of Water Resources and Irrigation, WRRI, Cairo.
[12]. Metwally, M., and Abdalla, S., (2006)," An Approach to Sustainable Tourism Development in Coastal Area-Egypt", Housing and Building Research Center J. Cairo, Egypt.
[13]. Purnama, A., Al-Barwani, H., Al-Lawatia, M. (2003)," Modeling dispersion of brine waste discharges from a coastal desalination plant", Desalination 155: 41-47
[14]. Ramadan, A. A, (2008), "Optimum pumping-injection system for saline groundwater desalination in Sharm El Sheikh", MSc Thesis.
[15]. RIGW/IWACO, 1988, updated (1999), "Hydrogeological Map of Egypt, 1:2000, 000" Cairo, Egypt.
[16]. Shahatto, S. (2003)," Environmental Impact of Development in Coastal Areas: Desalination", MSc. Thesis, University of Tübingen, Centre for Applied Geoscience (ZAG), Tübingen, Germany.
[17]. South Sinai Governorate Development and Environmental Action Plan (GEAP 2005 ), SEAM programme, internal report. South Sinai & EEAA.
[18]. UNEP,) 2001): Seawater Desalination in Mediterranean Countries: Assessment of Environmental Impact and Proposed Guidelines for the Management of Brine. UNEP (DEC)/MED WG. 183/Inf.6, 2001.
[19]. UNEP/PERSGA (1997): Assessment of Land-based Sources and Activities Affecting the Marine Environment in the Red Sea and Gulf of Aden. UNEP Regional Seas Report and Studies No. 166, United Nations Environmental Programme,
[20]. USEPA,) 2006): Impact Rating Methodology for EIAs (internal report).
[21]. WHO, (2007): Desalination for Safe Water Supply "Guidance for the Health and Environmental Aspects Applicable to Desalination" Geneva.