Chapter 3: WATER RESOURCES

3.1 Introduction

In any development project, it is important to determine the volumes and source of potable water to sustain the project. In most cases there are various options or a combination of options to ensure an adequate supply of potable. However, there are various factors, such as economic, environmental and social factors that must be taken into consideration. In order to determine the water needs, it must first establish the purposes for which fresh water will be required. For the Big Cat project, water will be required for drinking and cooking, flushing, irrigation and cleaning.

3.2 Occupancy

Big Cat, upon completion is expected to be inhabited by a maximum of 140 persons. For the purposes of estimating the water needs of this proposed development, with an adequate contingency, water supply needs will be based on 80 gallons per person per day. Hence, at 100% occupancy, the total volume of a daily basis will be **11,200 gallons**. However, hotel occupancy for Belize is estimated at around 35-40% at any given time. However, for this project, water volume on a daily basis will be based on 11,200 gallons. Of this volume it is estimated that 70% will become waste and require treatment.

There are several freshwater supply options available to the proposed development. These include:

- Rainwater catchment in cisterns;
- Abstraction from coastal surface waters and desalination and/or;
- Purchase of bottled water.

Based on the annual rainfall for the area, which varies between 80 inches and 100-120 inches (Walker, 1973 and King et. al. 1989 and 1982.) collection of rainwater in cisterns would appear to be a viable option for potable water supply at project completion.

Considering the amount of rainfall, and considering the roof space available, indications are that rainwater catchment would also be able to supply over 100% of the development's water needs. Thus, it is safe to say the rainwater catchment would be able to suffice the water needs.

Abstraction of ground water, due to the location of the project is unlikely a viable option for the proposed development and was not considered in identifying the source of water.

Seawater abstraction and purification is likely to be both a technical and economically feasible option for potable water supply. Due to the location, the disposal of concentrated brine poses a potential negative impact on the marine ecosystems of the area. For example purification by reverse osmosis is able to recover approximately 40% of the source supply leaving some 60% of the reject water with a salinity of about 45ppt which would be 40% greater than seawater. Notwithstanding, being that water supply is limited, desalination will be used to supplement rainwater catchment. The project has factored in the cost a Reverse Osmosis Plant capable of producing 6,000 gallons of fresh water per day and an optional additional unit to be used as a back-up or if required during the peak of the tourism season.

There is no single best method of desalination. A wide variety of desalination technologies effectively remove salts from salty water (or extract fresh water from salty water), producing a water stream with a low concentration of salt (the product stream) and another with a high concentration of remaining salts (the brine or concentrate). Most of these technologies rely on either distillation or membranes to separate salts from the product water (USAID 1980, Wangnick 1998 and 2002, Wangnick/GWI 2005). Ultimately, the selection of a desalination process depends on site specific conditions, including the salt content of the water, economics, quality of water needed by the end user and local engineering experience and skills.

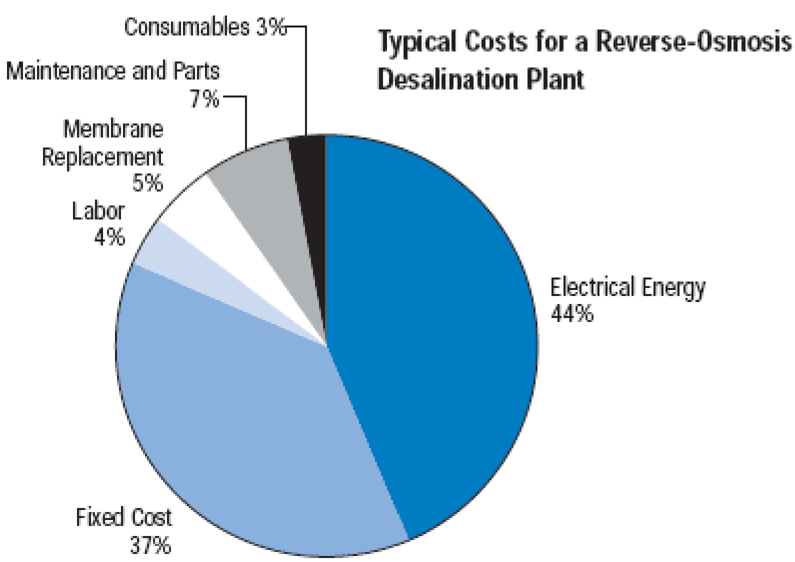
Considering the fact that desalination is a viable option, the environmental and economic factors have been taken into consideration.

3.3 *Energy Cost*

The cost of desalination has fallen in the recent years, but it remains an expensive water-supply option. The assumption that desalination cost will continue to fall may be false. Further cost reductions may be limited, and future costs may actually increase. However, Big Cat project has justified the cost over the lifetime of the facility, taking into account possible changes in the cost of energy and construction materials, limits to membranes performance, and other factors.

More energy is required to produce water from desalination than from any other water-supply or demand-management option in Belize. The future cost of desalination water will be more sensitive to change in energy prices than will other sources of water. In light of this, the Big Cat project has made sure that it has sufficient energy to meet its demands. In addition, the R.O. Plant will only be used on an as needs basis, but on a regular basis.

In producing fresh water by means of desalination, energy cost is the most restrictive factor. See below chart.



3.4 Health Concerns

While the quality of desalinated water is typically very high, a number of potential health concerns have been identified. End-use water quality of desalinated water quality of desalinated water is a function of source water quality, treatment processes, and distribution of the product water. Harmful contaminants can be introduced at each of these stages.

The water fed into the desalination system may introduce biological and chemical contaminants that are hazardous to human health. Biological contaminants include viruses, protozoa, and bacteria. Chemical contaminants include regulated and unregulated chemicals, xenobiotics (including endocrine disruptors, pharmaceuticals, and personal care products), and algal toxins (MCHD 2003). These contaminants are of particular concern if they are not removed during subsequent treatment process.

Boron, for example, is found in very low levels in average U.S. drinking water supplies (a survey of 100 U.S. drinking water supplies showed a median boron concentration of 0.03 milligrams per liter (mg/l)) (Mastromatteo and Sullivan 1994), but much higher levels are normally found in seawater (typically concentrations are between 4 and 7 mg/l). Boron in known to cause reproductive and developmental toxicity in animals and irritation of the digestive tract. It also accumulates in plants, raising concern about high boron levels in water used for irrigation or landscaping (ATSDR 1995). Concern has been expressed that boron may be found in desalinated water at levels greater that World Health Organization's provisional guideline of 0.5 mg/l (WHO 2003).

3.5 Water Distribution System

Rainwater will be filtered prior to being stored in the above ground cistern storage. The collective network of cisterns will be interconnect by PVC pipes (various size pipes and then reducing to ½ inch at the faucets) to the central storage located at the Resort Administrative Building. Here the water will be re-distributed via half inch PVC pipes to the respective units. Ultravoilet (UV lamp) purification systems will be installed at each potable water source.

Taking into consideration the possible boron content in the product water from the desalination plant, water from the R.O. Plant will be blended with rainwater, as a means of addressing the reduction of boron levels. In addition, the product water will still require ultraviolet treatment. In addition, the blending will reduce the acidity of the product water.

However, considering that the R.O. alters the chemical content of the product water, PVC pipes will be the preferred means of water distribution. The RO process lowers both the calcium and carbonate concentrations, which produces acidic product water that can corrode the distribution system if metal pipes are used. When this happens, iron, and other toxic metal, such as copper, lead, cadmium, zinc, and nickel can be leached from the distribution system.

3.6 Impacts of Water Intakes: Impingement and Entrainment

Intake water design and operation have environmental and ecological implications. R.O. Plants typically take in large volumes of seawater during operation. In recent studies it has been noted that "sea water… is not just seawater. It is a habitat and contains an entire ecosystem of phytoplankton, fishes, and invertebrates' (York and Foster 2005). Large marine organisms, such as fishes and invertebrates, birds and even mammals, are killed on the intake screen (impingement); organisms small enough to pass through the screens, such as plankton, eggs, larvae and some fish, are killed during the processing of the salt water (entrainment). The impinged and entrained organisms are then disposed of in the marine environment. Decomposition of these organism can reduce the oxygen content of the water near the discharge point, creating additional stress on the marine environment.

The effects of impingement and entrainment are species- and site-specific, and only limited research on the impacts of desalination facilities on the marine environment has been done. A recent overview of desalination seawater intakes, however, asserts that “environmental impacts associated with concentrated brine discharge have historically been considered the greatest single ecological impediment when siting a seawater desalination facility. However, recent analyses have noted that marine life impingement and entrainment associated with intake designs were greater; harder to-quantify concerns and may represent the most significant direct adverse environmental impact of seawater desalination” (Pankratz 2004).

3.7 Discharge of Concentrated Brine in the marine environment

Adequate and safe disposal of the concentrated brine produced by the plant presents a significant environmental challenge. A number of brine disposal options are available. These disposal methods include discharge to evaporation ponds, the ocean, and confined aquifers (NAS 2004).

Each disposal method, however has a unique set of advantages and disadvantages. Large land requirements make evaporation ponds uneconomical. Injection of brine into confined groundwater aquifers is technically feasible, but is both expensive and hard to ensure that other local groundwater resources remain uncontaminated. Sea discharge is the most common and least expensive disposal method (Del Bene et al. 1994), although this approach can have significant impacts on the marine environment. The notion that diluting brine water reduces the toxicity of brine is based on old adage, “Dilution is the solution to pollution.” While this may be true for some brine components, such as salt, it does not apply to others.

Because brine is typically twice as saline as the feedwater, it has a higher density than the receiving water and exhibits a distinct physical behavior. As a general rule, brine follows a downward trajectory after release. If brine is released from an outfall along the seafloor, as is typical, it tends to sink and slowly spread along the ocean floor. Mixing along the sea floor is much slower than at the surface, thus inhibiting dilution and increasing the risk of ecological damage (Chesher 1975). Other factors are also important, however. Brine behavior varies according to local conditions (i.e., bottom topography, current velocity, and wave action) and discharge characteristics (i.e., concentration, quantity, and temperature) (Del Bene et al. 1994, Einav and Lokiec 2003).

However, considering that only a small amount of feedwater will be required, which in turn will generate a low volume of brine, sea discharge is the most technically and economically feasible option. Considering that the main lagoon has a relatively lifeless eco-system, some of the brine would be discharged via a diffusion system along the waters edge. The remaining brine will be discharged to the north of the caye, which supports much less marine life and thus having significantly less impacts to the marine environment.

3.8 Water Quality Monitoring Programme

The Big Cat project, considering that the success of this project depends significantly on a healthy marine environment is committed to ensure the sustained and improved water quality of the project area. From the marine survey conducted which is attached, it can be noted that high nutrients level has been impacting the marine environment and promoting algal growth. This would likely be associated to high levels of nitrates. Whilst there are areas that support little marine biodiversity there are also areas thriving with marine species, including corals, fishes and invertebrates.

Big Cat project Water Quality program includes the quarterly testing of the following parameters: BOD5, Nitrates, Phospates, Total Suspended Solids, Turbidity, Total Fecal Coliforms, and grease and oils.

A total of six samples will be taken from around the entire caye for testing, including one sample from the effluent from the wastewater treatment plant.