Guidance Manual

for

Permitting Requirements in Texas

for

Desalination Facilities Using Reverse Osmosis Processes

Prepared for the

Texas Water Development Board

by

R. W. Beck, Inc.

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R. W. BECK
Guidance Manual for Reverse Osmosis Desalination Facility Permitting Requirements in Texas

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EXECUTIVE SUMMARY

Pursuant to Texas Water Development Board (the TWDB) Contract No. 2003-483-509, R. W. Beck was commissioned to develop a guidance manual for permitting desalination facilities using reverse osmosis (RO) processes in Texas. The objectives for the manual are to enhance the understanding of the permitting requirement for these types of desalination projects in Texas and to provide a tool for local communities and other stakeholders to use in the planning process for these facilities.

The manual includes:

1. An overview of the features of desalination facilities using RO processes;
2. A description of typical source water intake and concentrate disposal alternatives;
3. Guidance for estimating concept-level cost ranges for various facility configurations;
4. A technical evaluation of the permitting requirements for desalination facilities using RO processes in Texas;
5. A permit decision model to aid in the identification of permit requirements;
6. A brief description of the major activities necessary to obtain the key permits needed for these projects;
7. An example illustrating the use of the permitting model;
8. An estimate of the time typically necessary to obtain the key permits for a large seawater desalination project;
9. As requested, we are also including a copy of the Executive Administrator's comments, as Appendix 1.

RO desalination facilities that produce drinking water are typically divided into two brand classifications according to the type of source water or raw water that they use. One major category is brackish water facilities. The other is seawater facilities. Typically, brackish water is defined as having a total dissolved solids content of 600 to 25,000 milligrams per liter (mg/l) of total dissolved solids (TDS), while seawater usually contains 25,000 to 40,000 mg/l of TDS.

Both types of facilities include a raw water intake and processes for raw water pretreatment, RO desalination, product water post-treatment, and concentrate disposal. The raw water intake and concentrate disposal aspects of the projects typically have the potential for the most environmental impacts. Therefore, they are typically subject to extensive regulatory scrutiny and permitting requirements.

Tables 6-1, 6-2, and 6-3 summarize the key permits needed for facility construction, source water, and residual management. As shown, there are a variety of federal, state, and local permits related to the construction and operation of the project. Consequently, R. W. Beck believes project proponents should develop a permitting plan early in their development process, so they can identify what they will need to do to successfully fulfill the permitting requirements for their project.

Figure 7-1 provides a permit decision model addressing the permits needed for project development, new construction, and operation. This model provides a systematic approach for identifying major permit requirements via a set of decision tree analyses, once basic project features have been defined. Table 7-1 illustrates the use of the model for a large seawater desalination facility that is co-located with a power plant. Figure 7-2 provides a timeline for the illustration.

As shown, we anticipate that the TPDES permit will require approximately 21 months and will be one of the project's critical path components. Then, assuming a 24-month construction period on a one-month start-up, the project would require approximately 46 months to implement.

Brackish water facilities are more common than seawater facilities because they are generally less expensive to construct and operate. Seawater facilities are often larger, to take advantage of economics of scale to lower production costs. Ranges of costs for each type of facility are shown in Table 5-1 and 5-2.

Section 1
INTRODUCTION

Permitting risk is a critical component of the development of any project that should clearly be understood by any project owner or sponsor considering the development of a desalination project using RO processes. Permitting risk is a key factor, since it directly relates to the probability that a given project can be permitted at an economically acceptable cost. This in turn will have an impact on the amount of money at risk before all necessary, key permits can be obtained. Therefore, permitting risk typically receives considerable attention during the development phase of any project.

The risk in permitting can be exacerbated because U.S. experience with large-scale desalination projects is somewhat limited. Since desalination is generally more expensive than other options for drinking water suppliers, desalination projects are usually located in areas where options for other types of water supplies are limited. Consequently, desalination projects in the United States have generally been located in the southeastern and southwestern regions. While several states, including Texas, have some desalination facilities of various sizes using brackish water sources, large-scale seawater desalination experience is limited to Florida. Therefore, there is limited stakeholder guidance for the permitting of desalination projects based on precedents from facilities that are actually operating. In fact, the lack of guiding precedent and resultant uncertainty which regulators face when making regulatory decisions related to permit conditions are often cited as major impediments to the successful implementation of desalination projects.

RO is one of several membrane processes for water purification. Some, such as microfiltration, ultrafiltration, and nanofiltration, are not suitable for desalinating water. However, other types of membrane processes, such as electrodialysis reversal (EDR), could be used for desalination as well. EDR is a process where dissolved solids (salts) are removed by electronically-driven forces rather than filtration. Consequently, EDR product water is not mechanically filtered by the membrane. As a result, EDR is often applied in specific instances where contaminants such as bacteria and viruses, which typically need to be filtered for removal, are not contaminants of concern, and EDR is not included as a focus in this project.

There are some alternatives to desalination with RO. Thermal-driven evaporative processes such as multistage flash evaporation (MSF) are also widely used for seawater applications. Due to the aforementioned advances in RO technology during the last 15 years and the decrease in purified membrane water production costs, more of the newer facilities are using RO processes rather than MSF. Consequently, RO usage is increasing significantly in terms of the percentage of facilities utilizing this technology.

Section 2
OBJECTIVES

The objectives of this project are twofold. The first is to promote a better understanding of the requirements for desalination projects using RO processes in Texas. The second is to develop a guidance manual that local communities and other stakeholders may use as a tool when they consider planning or implementing these types of projects to produce drinking water. Therefore, the manual contains:

1. An overview of the features of brackish water and seawater desalination facilities that use RO processes;
2. A description of typical alternatives for source water intake and concentrate disposal;
3. Guidance for estimating concept-level cost ranges for various desalination facility configurations;
4. A technical assessment of the permitting requirements for brackish water and seawater desalination facilities in Texas;
5. A permit decision model to aid in the identification of the permit requirements;
6. A brief description of the principal activities necessary to obtain the key permits required for brackish water and seawater applications desalination projects in Texas;
7. An example illustrating the use of the permitting model; and
8. An estimate of the time typically needed to obtain the key permits for a large seawater desalination facility.

SECTION 3
OVERVIEW OF RO DESALINATION PROCESSES

RO evolved into a technically viable although relatively expensive process in the 1970s. Since then, as its product water costs have decreased, the technology has become a widely used process for water purification and desalination. RO is now used in a variety of industrial and municipal applications such as brackish potable water treatment, seawater desalination, wastewater treatment, and high-purity water production. Since RO is generally more expensive than other alternatives for drinking water supplies, it is not extensively used if other options are available. However, the attraction of RO as a desalination process for new drought-proof water supplies has led to the re-evaluation of water supply planning in virtually every water-supply-limited state. Consequently, RO for desalting brackish water and seawater is becoming more and more of a fixture in the toolbox for water supply planners and municipal and private water supply agencies.

RO is part of a family of membrane filtration processes. These include microfiltration, ultrafiltration, nanofiltration, and RO. The membranes for these processes have different pore sizes, which means that they are each capable of removing different size impurities. Table 3-1 illustrates typical sizes of material that can be removed by these filtration processes.

Table 3-1
Membrane Filtration Processes

Membrane Filtration Process	Approximate Size of Materials Removed (Microns)	Typical Materials in Size Range
Microfiltration	0.1 to 1.0	Turbidity, algae, paint pigments, mid-sized latex emulsions, bacteria and asbestos
Ultrafiltration	0.01 to 0.1	Carbon black, albumin protein, gelatin, viruses and colloidal materials
Nanofiltration	0.001 to 0.01	Large organic materials, such as pesticides, herbicides, sugar and synthetic dyes
RO	0.0001 to 0.001	Aqueous salts, such as sodium chloride, sodium sulfate and other small dissolved materials, such as metal ions

Membrane filtration processes are driven by pressure. Therefore, as membrane pore size decreases, treatment costs increase. As a result, RO is typically used where aqueous salts such as sodium chloride and other small dissolved materials are the contaminants of concern. Other, less expensive membrane filtration processes are used where larger materials, such as algae and bacteria, need to be removed, and desalination is not necessary.

Section 4
FACILITY KEY FEATURES

The salinity of the incoming source water used as raw water for the desalination process defines whether the facility is a brackish water or a seawater facility. Generally, brackish water is defined as having a total dissolved solids (TDS) content of 600 to 25,000 milligrams per liter (mg/l). However, in Texas, brackish water is typically found in the 1,000 to 10,000 total dissolved solids range (see also Section 5.2.4.1). Seawater usually contains total dissolved solids in the 25,000 to 40,000 mg/l range. The actual value is site-specific and can vary seasonally.

The USEPA secondary standard for total dissolved solids is 500 mg/l. As a result, brackish water and seawater desalination facilities using RO processes are typically used to produce product water with salt levels in the 250 to 500 mg/l range (note: secondary standards control contaminants that primarily affect drinking water aesthetic qualities).

Brackish water and seawater facilities both produce two effluent streams from a feedwater source, remove dissolved solids (salts) from one of their effluent streams to make product water, and concentrate the salts removed from the product water in a concentrate or waste stream. Consequently, brackish and seawater desalination RO facilities are similar in configuration and include:

- A raw water intake system;
- A pretreatment process to condition the raw water for a subsequent membrane desalination process;
- A concentrate disposal system;
- A post-treatment system to stabilize and disinfect the product water so that it is suitable for transmission, storage, and distribution; and
- Ancillary features, such as membrane cleaning systems, backup power and Supervisory Control and Data Acquisition (SCADA) systems.

Table 4-1 provides a summary of typical components used in an RO desalination facility. Figure 4-1 shows a general process schematic for a typical water RO desalination facility.

Table 4-1
Summary of Facility Key Features

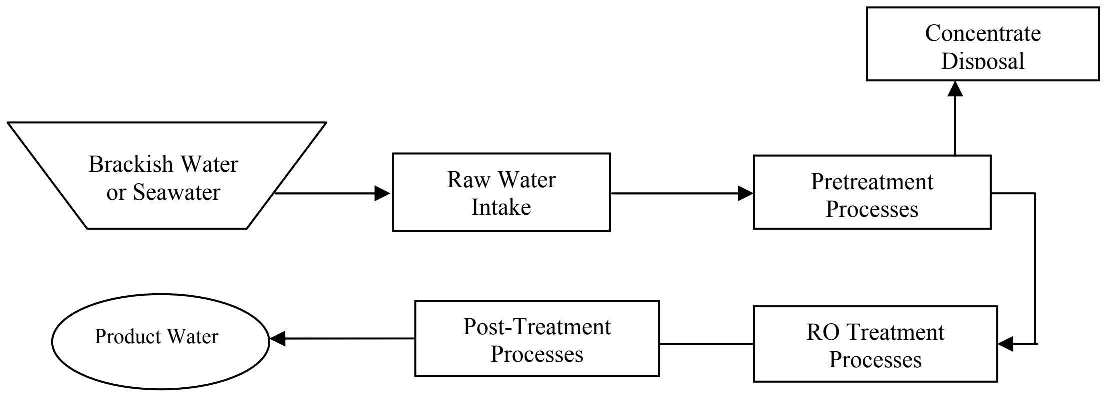
Raw Water	Seawater	Brackish
Intake		
	Surface Water Intake	Surface Water Intake
	Direct Intake	Direct Intake
	Existing Intake (Power Plant)	
	Groundwater	Groundwater
	Beach Wells[1]	Wells
Desalination Process		
Pre-treatment		
	Disinfection	Disinfection (typically not needed for groundwater sources)
	Chlorination/Dechlorination	Chlorination/Dechlorination
	UV	UV
	Ozonation	Ozonation
	Media Filtration	Media Filtration (typically not needed for groundwater sources)
	Sand/Multi-media Filtration	Sand/Multi-media Filtration
		Green Sand (Magnesium Hydroxide) Filtration
	Microfiltration	Microfiltration (typically not needed for groundwater sources)
	Chemical Addition	Chemical Addition
	Acidification	Acidification
	Anti-scalant Dosing	Anti-scalant Dosing
	Cartridge Filtration	Cartridge Filtration

Table 4-1
Summary of Facility Key Features

Raw Water	Seawater	Brackish
Desalination		
	Membrane Desalination (RO) (typically 800 – 1,200 psi)(2)	Membrane Desalination (RO, NF) (typically 50 – 600 psi)(2)
Post-treatment		
	Disinfection	Disinfection
	Chlorination	Chlorination
	UV Disinfection	UV Disinfection
	Stabilization	Stabilization
	Lime	Lime
	Other Chemical	Other Chemical
		Degasification (typically needed for water with high sulfur content)
Concentrate Disposal Methods		
	Surface Water Disposal	Surface Water Disposal
	Direct Sea Disposal	Direct Sea Disposal
	Mixed and Discharge with Power Plant Cooling Water	Mixed and Discharge with Power Plant Cooling Water
	Co-disposal with Waste Water	Co-disposal with Waste Water
		Other Surface Water Disposal
	Deep Well Injection	Deep Well Injection
	Brine Lines	Evaporation Basins
		Brine Lines

(1) Beach wells are not typically used if sites with power plants with once-through cooling water systems are available.
(2) Pressures shown are typical and are dependent upon influent water characteristics (source: AWWA "Water Treatment Plant Design," 1998).

Figure 4-1 – General Process Schematic for Desalination



4.1 Raw Water Intake

Seawater facilities typically use surface water as a raw water source. Brackish water facilities can either use surface water or groundwater as a raw water source. Typical surface water and ground water configurations are discussed below.

4.1.1 Surface Water Intake

A surface water intake usually consists of a direct intake of surface through a series of screens, weirs and pumps. The intake structure can be floating or fixed. The design typically must consider environmental issues, such as aquatic animal entrainment and mortality as well as scouring effects, which can affect raw water turbidity levels and subsequently, pretreatment requirements. Consequently, the surface water intake design can be a critical aspect of the facility and could require an extensive TCEQ evaluation.

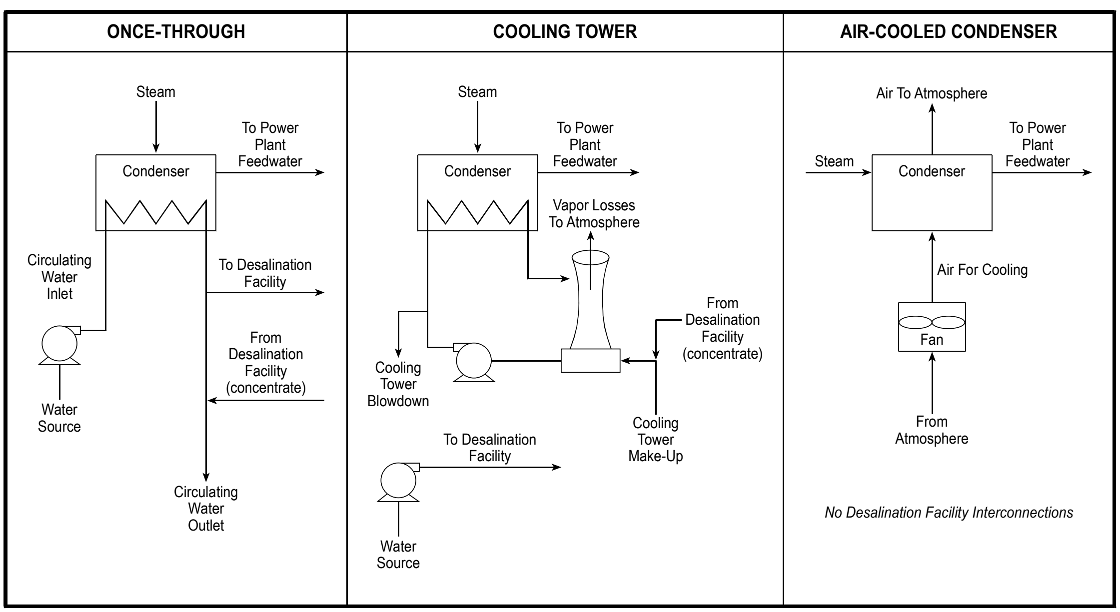
One variation which tends to mitigate the potential environmental issues is to use an existing intake such as that employed by a power plant with a once-through cooling water system. The surface water can then be withdrawn for the desalination facility after discharge from the power plant's condenser, so that there is essentially no additional aquatic animal entrainment or mortality, due to the design of the desalination facility intake.

4.1.1.1 Co-location with Power Plants

The advantages of co-location of a desalination facility using an RO process with a power plant are very dependent upon the configuration of the power plant cooling systems, and operation of the power plant. The advantages can include the use of the power plant's intake and discharge infrastructure, access to a source of heated water as raw water, and the possibility of blending the concentrate from the desalination process with the power plant's cooling water discharge. However, only certain power facilities are suitable as candidates for co-location. Typically, the operating regime and projected future service life of the power plant and the desalination facility must be compatible; the quality, quantity, and reliability of the power plant's cooling water must be satisfactory for use by the desalination facility; and the environmental impacts from the addition of a new desalination facility at the site must be acceptable.

Three types of cooling systems are generally used for power plant cooling. These include: (1) once-through cooling, (2) a wet cooling tower, and (3) an air-cooled condenser. Figure 4-2 shows schematics of these configurations.

Figure 4-2 – Three Major Types of Power Plant Cooling Systems



A power plant with a once-through cooling configuration provides the optimal cooling water system for co-location. With this configuration, the power plant circulates cooling water through a power plant's condenser once and discharges the heated water to the environs. Since the allowable cooling water temperature rise is typically limited as a condition of the power plant's National Pollutant Discharge Elimination System (NPDES) permit, a large amount of cooling water is typically needed for cooling purposes. As a result, this configuration allows heated water to be reused as raw water for a desalination facility after the cooling water exits the power plant's condenser. Then, the raw water source for the desalination facility does not require the intake of any additional ambient water, so that there is essentially no additional aquatic animal entrainment or mortality due to the desalination facility. In addition, if the flow of power plant cooling water is sufficient, the concentrate from the desalination process may be blended with the power plant's cooling water discharge without discernable environmental impacts. Since power plants with once-through cooling water systems generally use substantial amounts of water, their cooling water flow is often sufficient to accommodate concentrate blending.

A power plant with cooling towers reuses its cooling water rather than discharging it. In this configuration, the cooling water is heated as it passes through the power plant's condenser. Then it is cooled by evaporation in a cooling tower so that it can be reused as a cooling medium.

The evaporation in the cooling tower causes the impurities in the cooling water to increase or "cycle-up." Consequently, some of the cooling water needs to be discharged or "blown down" from the cooling tower to reduce the amount of contaminants that build up in the cooling process. Make-up water is added to the cooling loop to compensate for evaporative losses and blow-down water.

Since the cooling tower configuration does not provide a source of heated water for the desalination facility and may not have a large flow of cooling tower blowdown to provide capacity for blending the RO concentrate, the cooling tower configuration does not offer as many advantages as a once-through cooling water system. However, depending on the quality of the power plant's cooling water and make-up water and the quality of the concentrate from the desalination facility, some co-location advantages may exist. In specific instances where the cooling tower water chemistry can be adjusted to compensate for the additional salt, it may be possible to take advantage of the evaporative effect to dispose of the desalination facility concentrate by adding it as a portion of the makeup to the cooling tower. This possibility should be carefully evaluated on a case-by-case basis to ensure that it is feasible during the site evaluation stages of project development activities.

Some power plants use air-cooled condensers. In this cooling process, air is used to cool a power plant's condenser instead of water. These facilities use a very small amount of water for power generation, and none for cooling purposes. Therefore, power plants with air-cooled condensers typically do not offer significant co-location advantages for RO desalination processes.

In addition to the cooling system configuration, a power plant's operating regime should also be evaluated to determine if the regime is suitable for co-location. Power plant operating regimes may be classified in three categories: (1) base-load; (2) peaking; and (3) base-load/peaking. A power plant with multiple base-load electric generating units typically offers the most co-location advantages.

A base-load electric generating unit generates power more or less continuously. Consequently, this type of electric generating unit rarely goes offline and provides a constant source of power and a consistent cooling water flow. A power plant with multiple base-load electric generating units improves the reliability of the power and cooling water sources, as multiple electric generating units help prevent interruptions due to scheduled or unscheduled outages of any of the individual electric generating units at the power plant.

At a peaking power plant, power generation is normally restricted to operation during the periods of highest daily, weekly, or seasonal loads. Therefore, electric generation and cooling water usage are intermittent, based upon the need for power. As a result, a power station with a peaking type of operating regime will not provide a continuous or reliable source of electricity or cooling water for an RO desalination facility.

A base-load/peaking power plant is usually generating some power. However, the plant may operate on a reduced or low power production basis for the majority of time. If it is a power plant with multiple electric generating units, some are typically shut down during periods of reduced electric demand. Since the individual electric generating units may be operated intermittently, this type of facility does not provide a consistent cooling water flow or electric generation output.

Due to its operating regime, a power plant with multiple base-load electric generating units and once-through cooling offers the most advantages for co-location, since it provides a consistent and reliable cooling water flow that can be used as raw water for an RO process and for blending concentrate. Co-location with power plants that consist of one or two electric generating units or other operating regimes may limit desalination facility availability, if an insufficient amount of raw water or cooling water for potable water production or for concentrate blending is available. While co-location with these facilities may be economically feasible, each situation should be carefully evaluated on an individual basis. Reduced RO facility production will increase water production costs ($/acre-ft), as the debt service for the facility would be distributed over a reduced product water quantity. Therefore, it is more economical to operate the desalination facility on a full-time basis and near its production peak to minimize the cost per acre-foot of product water, due to the economic effect of debt service for the facility.

To determine if a power plant is a suitable candidate for co-location, it suggested, as a minimum, that the following studies be conducted:

- Environmental studies for impacts of concentrate discharge, including:
  - The ability to blend concentrate with cooling water discharge water;
  - The impact of blended concentrate flow on receiving waters; and
  - The impact of construction of pipelines and facilities.
- An evaluation of power plant operation addressing:
  - The viability of the long-term plan for continued operation of the power plant;
  - The power plant's operating regime – base-load with multiple electric generating units or other; and
  - The footprint available for the desalination facility.
- A raw water source evaluation, including treatability; and
- An evaluation of public perception and acceptance of the project at the subject location.

4.1.2 Groundwater Intake

The intake of groundwater as a raw water source using wells is commonly practiced throughout the United States. Wells usually consist of a casing pipe and a pump with either a submerged or above-surface withdrawal pipe. The intake is screened to minimize the withdrawal of sand from the well. For seawater desalination, beach wells can provide a means for raw water intake in lieu of raw water surface intakes. However, beach wells are not typically expected to be employed in Texas, since co-location opportunities exist for desalination facilities with power plants that have once-through cooling systems.

Groundwater typically has lower organic contaminant and turbidity levels than surface water. Consequently, the use of groundwater can lower RO process pretreatment requirements. As a result, when both are available, there is typically an opportunity for an economic trade-off between the selection of a groundwater or a surface water intake. A groundwater intake is generally more expensive than a surface water intake.

4.2 Desalination Processes

An RO desalination process to produce drinking water is generally composed of three major treatment steps:

- Pretreatment
- Desalination
- Post-Treatment

4.2.1 Pretreatment

The objectives of pretreatment are to condition the raw water to protect the RO membrane life and to maximize the efficiency of the RO process. Consequently, pretreatment is provided ahead of the membrane desalination to improve the quality of the feedwater to the membranes, remove larger debris, and remove and/or neutralize elements of the feedwater that may harm the membranes.

To achieve these pretreatment objectives, pretreatment steps for seawater and brackish water facilities using surface water as a source of raw water typically include screening, disinfection, suspended solids removal, and chemical addition. The disinfection and suspended solids removal steps are employed to control RO membrane fouling that can be caused by organics and suspended solids in the RO feedwater. Chemical addition is employed either to assist in the suspended solids removal process and/or to prevent scaling from sparingly soluble materials, such as calcium salts.

When the raw water quality permits, brackish water facilities using groundwater may be able to eliminate the pretreatment disinfection step and reduce their suspended solids removal processes substantially. However, depending on factors such as the hardness of the raw water, chemical addition to prevent scaling from sparingly soluble salts may still be needed.

As a general practice, pretreatment requirements should be established on the basis of a thorough raw water characterization and RO equipment manufacturer's requirements. In addition, they should be verified by pilot testing on the actual source water during the conceptual design phases of facility development activities. Therefore, when practical, the pilot testing program schedule and duration should be sufficient to show that the pretreatment processes are effective for the full range of source water characteristics selected for the facility's design basis.

4.2.1.1 Disinfection

Disinfection is often provided to control biofouling and biological activity in the membranes. As discussed above, the decision to employ disinfection should be based on raw water characteristics. Consequently, some disinfection regime is typically employed when surface water is used as a raw water source, and the need for routine disinfection for brackish groundwater sources should be established on a case-by-case basis.

Chlorination, ultraviolet irradiation, and ozonation are typical choices. Due to potential safety concerns about the use of chlorine gas, chlorine disinfection may be accomplished with sodium hypochlorite.

Since chlorine may damage the RO membranes and thereby significantly shorten membrane life, a dechlorination step with chemicals such as sodium bisulfite or sodium meta bisulfite is also required when chlorination is practiced.

Other forms of disinfection like UV may be used. However, due to the increase in cost above chlorination, other forms of disinfection such as UV are not as widely employed.

4.2.1.2 Filtration

There are two schools of thought concerning suspended solids removal steps. One option commonly consists of two stages of dual media filtration using a coagulant such as ferric sulfate. The other uses a membrane filtration process such as microfiltration (MF) or ultrafiltration (UF). A pilot testing program is typically employed to verify that the appropriate pretreatment filtration steps have been selected.

The selection between the two options is usually made by the facility designer on the basis of a balance between equipment installed cost, energy consumption and desired RO membrane life. MF and UF retreatment processes typically are thought to provide longer RO membrane operating life, but require higher equipment installed cost and energy costs.

Filtration is typically not needed for raw water taken from groundwater sources. However, a process such as Green Sand (Magnesium Hydroxide) filtration may be applied when excessive iron is a potential problem. Iron can also damage the RO membranes and thereby significantly shorten membrane life.

4.2.1.3 Cartridge Filtration

RO process equipment suppliers will also generally require a “belt and suspenders” approach to protect the RO membranes. Consequently, they will usually provide a cartridge filter ahead of the RO membranes as another protective device. However, the cartridge filter typically has a 5 micron pore size. As a result, it is not a replacement for either the media or membrane filtration pretreatment steps discussed above.

Cartridge filtration typically consists of stainless steel vessels in which long cylindrical cartridges are used to remove physical particles from the raw water prior to the membranes. Both brackish and seawater desalination facilities use cartridge filters to protect the membranes.

4.2.1.4 Chemical Addition

Chemical addition commonly consists of acid addition to prevent the precipitation of sparingly soluble materials such as calcium salts that can also significantly reduce membrane life. When necessary, the acid addition can be augmented by an anti-scalant to enhance the control of RO membrane scaling. Sulfuric acid is generally used for the acid addition step. Depending on the raw water constituents, both brackish and seawater desalination facilities may need to add acid addition and anti-scalants. While the need for acid addition and anti-scalants is usually revealed during membrane performance modeling, pilot testing is typically used to confirm the initial dosing that will be applied during facility startup.

4.2.2 Desalination with an RO Process

An RO desalination process uses a semi-permeable membrane that selectively allows water to pass through the membrane at a much faster rate than salts. In the process, the desalinated water passes through the membrane layer while the salt is rejected by the membrane. The recovery rate or the amount of desalinated water produced as a percentage of feedwater flow varies from 30 to 80 percent, depending on the salt content of the water, the pressure, and the type of membranes used. Consequently the process produces two effluent streams. One is a product water stream with a low salt content. The other is a waste stream in which the salts removed from the product stream are concentrated.

For seawater, recovery rates from 40 to 60 percent are typical depending on the seawater's salt content. The recovery rate can also be affected by factors such as the concentration of sparingly soluble salts in the feedwater, product water quality standards, single-stage versus two-stage RO process configurations, and reverse osmosis membrane train operating pressures. From an environmental perspective, recovery rate can be an important factor, as it is directly related to the amount of raw water that must be supplied to produce a given amount of product water.

Pressure is applied to the system to force the water through the membrane while leaving the salt behind. Since the driving force for the process is pressure, the amount of energy required to separate the water from the salt is directly proportional to the salt content of the solution. As a result, more energy is required to produce the same amount of water from solutions with higher concentrations of salt.

Brackish water membrane systems typically have higher recoveries and operate under lower pressures, ranging from 225 psi to 375 psi. Seawater RO systems typically have lower recoveries, due to the higher salt content and their operating pressure range is typically 800 to 1200 psi. The amount of product water that can be recovered from the raw water will change based on the raw water's salt content.

The energy requirements for an RO system in a seawater application are significant. A typical 50 mgd facility using seawater as a raw water source could require about 750 to 950 megawatt hours-per-day, or approximately 15 to 19 kW-hr/1000 gal. of product water (energy consumption also depends on other factors, including the required product water quality, the recovery rate, the seawater temperature and the use of energy recovery devices). This is equivalent to a continuous demand of 30 to 40 megawatts. Consequently, energy availability, and the electrical transmission and distribution system capacity, should be considered as part of the site selection criteria.

An RO system consists of several basic components including a feed pump to pressurize the system for the RO process, membrane elements contained in pressure vessels, and a cleaning system. Currently, the most common commercial membrane configuration is the spiral-wound element.

Depending on the desired salt content of the product water and the salt level in the feedwater, a one- or a two-stage RO system design may be selected. Typically, for cost reasons, the process will use a single-stage design rather than a two-stage design. For seawater systems, since the influent salt levels are high, a single-stage RO system can often be used, if product water salt levels of approximately 300 mg/l or higher can be tolerated. Otherwise, when needed, a two-stage system can be employed.

4.2.3 Post Treatment

4.2.3.1 Chemical Addition

Product water stabilization processes commonly include the addition of lime, carbon dioxide (recarbonation) and chlorine (sodium hypochlorite or chlorine gas). Lime and carbon dioxide are commonly used to stabilize the product water by increasing the product water alkalinity and adjusting pH. Chlorine is added to control biological activity in the product water storage, transmission, and distribution systems.

4.2.3.2 Degasification

When necessary, degasification of the product water may be performed to remove dissolved gases such as hydrogen sulfide. The degasified air is either vented to the atmosphere or is sent to a gas scrubber. Typically, degasification is more likely to be required for a brackish water facility than for a seawater facility.

4.3 Concentrate Disposal

The two most common options for concentrate disposal are deep well injection and direct surface water disposal. Both methods potentially have environmental impacts. Consequently, they are subject to environmental regulations and permit requirements.

Direct discharge to surface water would include discharge of the concentrate either directly to the Gulf of Mexico, saline water, or other surface waters, as may be environmentally acceptable. Direct discharge methods also include blending with existing discharges from power plant cooling water or wastewater treatment facilities. Blending can be an effective mitigating measure for environmental impacts.

As an alternative, when feasible, concentrate beneficial reuse through the use of brine lines may be considered. Typically, brine lines are used to inject brine in enhanced oil recovery processes via Class II wells.

Evaporation ponds may also be feasible for brackish water facilities in areas where the annual evaporation rate exceeds the net rainfall and sufficient land can be economically obtained. In these situations, the amount of land required will be directly related to the facility's recovery rate (percent of raw water converted to product water). For example, a five-million-gallon-per-day brackish water facility with an 80 percent recovery rate will need to dispose of one million gallons-per-day of concentrate.

4.4 Ancillary Features

Typical ancillary features include:

- Wastewater disposal (both domestic and plant)
- Product water conveyance and storage
- Emergency power generators
- Storm water basins/ landscaping

These facilities may or may not be required, depending upon site and project requirements.

Section 5
ESTIMATED RANGE OF COSTS

5.1 Cost Overview

Tables 5-1 and 5-2 provide a range of costs for seawater and brackish water facilities of various capacities, intake configurations, and concentrate disposal or beneficial re-use alternatives. Section 5.2 describes the basis of cost for each of the seawater and brackish water facility alternatives.

Table 5-1 shows that, for seawater facilities, direct intake and beach well configurations for raw water and direct discharge to surface water and deep well injection options are higher-cost alternatives. Similarly, the range of costs in Table 5-2 for brackish water facility concentrate disposal/re-use mechanisms shows that, when they can be employed, the options for co-disposal with wastewater, direct discharge to surface water and re-use via brine injection are much more cost-effective than evaporation basins or deep well injection.

Table 5-3 illustrates the use of Tables 5-1 and 5-2 by presenting the range of costs for two examples of seawater desalination facility configurations. Option 1 is a 25 mgd facility co-located with a power plant that utilizes the power plant's cooling water as a raw water source and blending for concentrate disposal. Option 2 is also a 25 mgd seawater facility. However, Option 2 includes stand-alone intake and concentrate disposal processes.

Based on the above 25 mgd seawater facility example, Table 5-3 also demonstrates that co-locating a seawater facility with a power plant typically provides a substantial cost savings. In addition, as explained in Section 4, co-location also helps mitigate facility environmental impacts. Consequently, when feasible, co-location with a power plant is generally a very attractive alternative for seawater desalination facilities.

Table 5-1
Seawater Desalination Facility Feature Cost Ranges
(TDS 35,000 ppm)

Facility			Intake Configuration			Concentrate Disposal or Beneficial Re-use Mechanism		
Capacity (mgd)	Cost Range[1] ($1,000)		Description	Cost Range ($1,000)		Description	Cost Range ($1,000)	
	Low	High		Low	High		Low	High
5	13,000	17,875	Use Existing Power Plant Intake from Surface Water Body	62	85	Discharge to Surface Water after Blending with Power Plant Discharge	48	66
	13,000	17,875	Direct Intake from Surface Water Body[2]	3,182	4,375	Direct Discharge to Surface Water[3]	1,455	2,016
	8,818	12,125	Beach Wells[2]	7,455	10,250	Deep Well Injection[3]	3,279	4,509
						Brine Lines[3] [4]	255	350
						Co-disposal with wastewater[3] [5]	255	350
10	22,909	31,500	Use Existing Power Plant Intake from Surface Water Body	133	183	Discharge to Surface Water after Blending with Power Plant Discharge	62	85

Table 5-1
Seawater Desalination Facility Feature Cost Ranges
(TDS 35,000 ppm)

Facility			Intake Configuration			Concentrate Disposal or Beneficial Re-use Mechanism		
Capacity (mgd)	Cost Range[1] ($1,000)		Description	Cost Range ($1,000)		Description	Cost Range ($1,000)	
	Low	High		Low	High		Low	High
	22,909	31,500	Direct Intake from Surface Water Body[2]	4,455	6,125	Direct Discharge to Surface Water[3]	1,818	2,500
	15,455	21,250	Beach Wells[2]	-	-	Deep Well Injection[3]	5,584	7,678
						Brine Lines[3] [4]	326	449
						Co-disposal with wastewater[3] [5]	326	449
25	53,000	72,875	Use Existing Power Plant Intake from Surface Water Body	62	85	Discharge to Surface Water after Blending with Power Plant Discharge	133	183
	53,000	72,875	Direct Intake from Surface Water Body[2]	6,364	8,750	Direct Discharge to Surface Water[3]	2,909	4,000
	35,182	48,375	Beach Wells[2]	-	-	Deep Well Injection[3]	-	-
						Brine Lines[3] [4]	701	964

Table 5-1
Seawater Desalination Facility Feature Cost Ranges
(TDS 35,000 ppm)

Facility			Intake Configuration			Concentrate Disposal or Beneficial Re-use Mechanism		
Capacity (mgd)	Cost Range(1) ($1,000)		Description	Cost Range ($1,000)		Description	Cost Range ($1,000)	
	Low	High		Low	High		Low	High
						Co-disposal with wastewater(3) (5)	701	964

(1) Assumes single-pass RO treatment configuration will be required. Includes pretreatment, RO membrane desalination, and post-treatment process costs, except costs for intake configuration; concentrate disposal mechanism; and land acquisition (with the exception of land for evaporation basins).
(2) Configurations using direct intake from surface water body or from beach wells are unlikely to be used for seawater desalination facilities if sites with power plants with cooling water systems are available. The cost of beach wells for high-capacity facilities is prohibitive and is not shown for 10 mgd and 25 mgd facilities.
(3) Configurations using direct discharge to surface water, deep well injection, brine lines, and co-disposal with wastewater are unlikely to be used for seawater desalination facilities if sites with power plants with once-through cooling water systems are available.
(4) Disposal via brine lines is prohibited by regulations. Brine lines are only feasible in circumstances where concentrate has a beneficial re-use.
(5) Co-disposal with wastewater is typically not feasible for larger seawater desalination facilities, due to its potential impact on biological processes used for facilities such as publicly owned treatment works (POTWs).

Table 5-2
Brackish Water Desalination Facility Feature Cost Ranges
(TDS 3,000 ppm)

Facility			Intake Configuration			Concentrate Disposal or Beneficial Re-use Mechanism		
Capacity (mgd)	Cost Range[(1)] ($1,000)		Description	Cost Range ($1,000)		Description	Cost Range ($1,000)	
	Low	High		Low	High		Low	High
3	4,091	5,625	Groundwater Wells	1,773	2,438	Co-disposal with wastewater	17	24
	6,364	8,750	Direct Intake from Surface Water Body	48	66	Deep Well Injection[(2)]	3,293	4,527
						Direct Discharge to Surface Water[(3)]	17	24
						Discharge to Surface Water after Blending with Power Plant Discharge	17	24
						Brine Lines [(4)]	17	24
						Evaporation Basins[(5)]	2,545	3,500
5	5,545	7,625	Groundwater Wells	2,491	3,425	Co-disposal with	24	33

Table 5-2
Brackish Water Desalination Facility Feature Cost Ranges
(TDS 3,000 ppm)

Facility			**Intake Configuration**			**Concentrate Disposal or Beneficial Re-use Mechanism**		
Capacity (mgd)	**Cost Range[1] ($1,000)**		**Description**	**Cost Range ($1,000)**		**Description**	**Cost Range ($1,000)**	
	Low	**High**		**Low**	**High**		**Low**	**High**
						wastewater		
	7,273	10,000	Direct Intake from Surface Water Body	62	85	Deep Well Injection[2]	3,293	4,527
						Direct Discharge to Surface Water[3]	24	33
						Discharge to Surface Water after Blending with Power Plant Discharge	24	33
						Brine Lines [4]	24	33
						Evaporation Basins[5]	5,091	7,000
10	9,000	12,375	Groundwater Wells	4,773	6,563	Co-disposal with wastewater	27	38
	11,364	15,625	Direct Intake from	77	115	Deep Well Injection	3,823	5,257

Table 5-2
Brackish Water Desalination Facility Feature Cost Ranges
(TDS 3,000 ppm)

Facility			Intake Configuration			Concentrate Disposal or Beneficial Re-use Mechanism		
Capacity (mgd)	Cost Range[1] ($1,000)		Description	Cost Range ($1,000)		Description	Cost Range ($1,000)	
	Low	High		Low	High		Low	High
			Surface Water Body					
						Direct Discharge to Surface Water[3]	27	38
						Discharge to Surface Water after Blending with Power Plant Discharge	27	38
						Brine Lines [4]	27	38
						Evaporation Basins[5]	---	---

(1) Includes pretreatment, RO membrane desalination, and post-treatment process costs, except costs for intake configuration; concentrate disposal mechanism; and land acquisition (with the exception of land for evaporation basins).
(2) Assumes a minimum well tubing diameter of six inches.
(3) Configurations using direct discharge to surface water are unlikely to meet regulatory requirements unless brackish water or seawater surface water bodies are available as receptors.
(4) Disposal via brine lines is prohibited by regulations. Brine lines are only feasible in circumstances where concentrate has a beneficial re-use.
(5) Evaporation basins are only feasible for small brackish water facilities, due to the amount of land required. Consequently, the cost of evaporation basins for 10 mgd brackish water facilities is not shown.

Table 5-3
Range of Costs for a Typical 25 MGD Seawater Desalination Facility(1) (2)

Option 1 Alternative	Range of Costs ($1,000) Low	High	Option 2 Alternative	Range of Costs ($1,000) Low	High
Use Existing Power Plant Intake from Surface Water Body	62	85	Direct Intake from Surface Water Body	6,364	8,750
Desalination Facility	53,000	72,875	Desalination Facility	53,000	72,875
Discharge to Surface Water after Blending with Power Plant Discharge	133	183	Direct Discharge to Surface Water	2,909	4,000
Total:	53,195	73,026		62,273	85,625

(1) Estimated range of costs obtained from Table 5-1, herein.
(2) Co-located with power plant.

5.2 Basis of Cost

5.2.1 General

All costs were estimated on an installed basis. WTCost, a cost-estimating program developed by I. Moch & Associates, et al., was used to develop the cost for each of the desalination facility configurations discussed here. Other references included previous reports prepared for TWDB (LBG-Guyton Associates, et al. and HDR, et al.). The range of costs for each raw water sourcing facility, and each treatment and brine disposal option, is minus ten percent and plus 25 percent.

The costs presented here assume that generic site conditions are encountered and that a conventional design-bid-build (DBB) procurement process will be employed. Consequently, foundation costs assume: a typical soil bearing value of 2,000 psf; minimal demolition of existing structures will be required; there are no historical structures, landmarks, or underground obstructions present; and, there are no site contamination issues requiring remediation. Therefore, a nominal contingency of five percent was included in the indirect costs.

It should be noted that the procurement process selected for project delivery can significantly affect the installed cost. While traditional project delivery methods such as DBB provide a high level of owner control, other methods, such as design-build-operate (DBO) and design-build-own-operate-transfer (DBOOT), can result in substantial savings. As a result, the impact of the project delivery method used should also be carefully considered when developing a cost estimate for a specific project.

Site-specific conditions vary greatly and should be taken individually into account when developing the costs for a specific project. As a result, product storage and delivery facilities and land costs (with the exception of land for evaporation basins) have not been included in the estimated range of costs, since these are expected to be very site-specific. Land for evaporation basins was included, since it is anticipated that evaporation basis would only be used in areas where land is relatively inexpensive and the volume of concentrate discharge is relatively small.

February 2004 was used as the base date for all costs, and Engineering News Record (ENR) indices (Construction Cost, Building Cost, Skilled

Labor, Materials, Steel Cost, Cement Cost and Labor Rate) were used to standardize the costs to the base date when possible. The exceptions to this procedure were the adjustments of the costs for brackish water wells and evaporation basins. In these two cases, a typical inflation rate of 2.5 percent per year was applied to the costs calculated as described.

5.2.2 Components of Indirect Cost

Indirect cost components were based on standard factors included in the WTCost program and were developed from the following assumptions:

- Interest during construction – six percent;
- Contingency allowance – five percent of the construction cost;
- Engineering and construction management services allowance-fifteen percent of the construction cost; and
- Working capital during construction – four percent of the construction cost.

5.2.3 Seawater Desalination

For the purposes of developing cost estimates, R. W. Beck assumed that the primary features of a seawater desalination facility would include the: (1) seawater supply, (2) pretreatment, (3) desalination, (4) post-treatment, (5) concentrate disposal, and (6) residual solids management systems.

5.2.3.1 Seawater Supply

Due to the advantages of sharing an intake structure, R. W. Beck anticipated that the seawater supply would be typically withdrawn from a power plant condenser cooling water discharge when suitable power plant facilities are available. However, open intakes or beach wells may also be utilized. Consequently, the range of costs for each of these three options has been provided.

The seawater characteristics used for the cost estimate are shown in Table 5-4. The total dissolved solids level of 35,000 mg/l was selected as a conservative value, based on the information presented by HDR, et al. It should be noted however, that actual source water characteristics are site-specific and should be verified during the early stages of project development activities.

Table 5-4
Characteristics of Seawater

Characteristic	Value	Characteristic	Value
pH	8.0	TOC	14.22 mg/l
Specific Gravity	1.022	Turbidity	0 NTU
Conductivity	53,966 µS/cm	TSS	1.3 mg/l
TDS	35,005 mg/l	Alkalinity, HCO_3	114 mg/l
Temperature - design	30° C	Alkalinity, CO_3	0.5 mg/l
Boron	0 mg/l	CO_2	2.13 mg/l
Barium	0.03 mg/l	Chloride	19,333 mg/l
Calcium	406 mg/l	Fluoride	1.3 mg/l
Iron	0.01 mg/l	Nitrate, as nitrogen	0.5 mg/l
Magnesium	1290 mg/l	o-Phosphate	0.07 mg/l
Manganese	0.002 mg/l	Sulfate	2,688 mg/l
Potassium	385 mg/l	Silica	0.0 mg/l
Sodium	10741 mg/l		
Strontium	14 mg/l		

Co-location with Power Plant Alternatives

An intake pipeline of one thousand feet in length was included to convey flow from the power plant condenser cooling water discharge pipeline to the desalination facility for each co-location alternative. The piping diameter was selected to provide the required flow at a maximum velocity of 5.0 fps. R. W. Beck also assumed that seawater supply piping screening requirements would be satisfied by the screening typically used for the power plant's cooling water intake. As a result, the need for a separate intake structure and/or screening would be eliminated.

It should be noted, however, that experience has indicated that these power plant features may need to be augmented. Therefore, the need for additional screening or a separate intake for cooling water should be evaluated on a site-specific basis.

Open Intake Alternatives

An intake pipeline of one mile in length and an intake structure equipped with coarse and fine screens were included for each open intake alternative. To address aquatic animal entrainment issues, the intake structure was sized to limit the maximum velocity of the seawater to 1.0 fps at the required flow. The intake piping diameter was selected to provide the required flow at a maximum velocity of 5.0 fps, sized for a maximum velocity of 5.0 fps at the required flow.

Beach Well Alternative

Beach well capacities ranging from 1.5 mgd to 7.0 mgd were used for the purposes of the Manual. At least two beach wells were included for each beach well alternative.

Well yield is very dependent on local geological conditions. As a result, well capacities can typically vary from 0.3 mgd to 7.0 mgd, depending on soil conditions. Therefore, an aquifer testing/hydrological investigation is necessary to define the hydraulic characteristics of the aquifer, to determine the requisite recharge and infiltration data necessary to predict the yield and define well design parameters (Collection Wells International provided base data for the range of costs estimates).

5.2.3.2 Pretreatment Alternatives

Configurations for Surface Water Alternatives

Pretreatment requirements are similar for surface water sources for facilities that are either co-located with power plants or with open intakes. Consequently, the cost for the surface water pretreatment alternative was based on a conventional pretreatment system consisting of: (1) disinfection using sodium hypochlorite or other similar material to control biological growth; (2) chemical addition to enhance multi-media filter performance and lower pH to prevent sparingly soluble salts from precipitating in the RO membranes; and (3) two-stage multi-media gravity filtration to remove suspended solids. Membrane filtration in lieu of multi-media gravity filtration was not included, since membrane filtration is a higher-cost option. As a result, membrane filtration is usually a site-specific choice that is selected when testing shows that multi-media gravity filtration is ineffective.

Configurations for Beach Well Alternatives

Due to the filtering action of the soil surrounding a beach well and the screening typically used in well construction, it is anticipated that beach wells would normally provide raw water with low suspended solids levels. Therefore, multi-media filtration would not usually be needed. Consequently, the cost estimates for pretreatment for beach well sources included disinfection and pH adjustment.

Pretreatment Process Selection

It should be noted that actual pretreatment requirements and process efficacy are dependent on source water characteristics and that the addition of an anti-scalant could also be required, depending on the characteristics of the water source. Consequently, actual process selection and the need for an anti-scalant should be verified on a source water-specific basis.

5.2.3.3 Desalination Process Alternatives

For the purposes of estimating the costs presented here, it was assumed that a typical single-stage reverse osmosis membrane system preceded by cartridge filters would be adequate. To provide some degree of redundancy, a minimum of two 50-percent-capacity reverse osmosis process trains were included for each alternative. While installed spare or standby RO trains were not included, a standby pump was included for all major pumping steps.

The following additional assumptions were used also used to develop the cost basis:

- Facility availability – 93 percent;
- Maximum production capacity per process train – 4.0 mgd;
- Reverse osmosis membranes per pressure vessel – 6;
- Product recovery - 50 percent;
- Design temperature for open surface water and beach well sources - 20^{o} C;
- Design temperature for power plant condenser cooling water sources - 30^{o} C;
- Energy recovery equipment - included; and
- Standby power facilities - not included.

5.2.3.4 Post-Treatment Alternatives

The post-treatment alternatives include typical unit processes consisting of: (1) lime addition for alkalinity adjustment to reduce product water corrosiveness, (2) acid addition for pH adjustment, and (3) disinfection via the addition of chloramines. The need for additional post-treatment steps, such as recarbonation, is a project-specific decision that should be established on the basis of applicable product water standards.

5.2.3.5 Concentrate Disposal Alternatives

The means for disposing of the concentrate stream from a seawater desalination facility typically includes co-disposal with power plant cooling water, direct discharge to surface water, and co-disposal with treated wastewater. Brine reuse can also be feasible in situations where a beneficial use can be identified. Consequently, a range of costs for each of the above concentrate disposal and reuse options was developed. The criteria used for each of these disposal options are summarized below.

Deep well injection and evaporation ponds are also potential possibilities. However, as explained here, they are generally not cost-effective. As a result, they are not normally expected to be used.

Co-Disposal with Power Plant Discharge Alternatives

These alternatives include a 1,000-foot pipeline to convey concentrate to a location downstream of the desalination facility intake pipeline in the power plant cooling water discharge pipeline, canal or conduit. The concentrate disposal pipelines were sized for a maximum velocity of 5.0 fps at the required flow.

Co-disposal with Wastewater Alternatives

The costs for the co-disposal with wastewater options were based on a one-mile pipeline to convey concentrate to a municipal wastewater outfall. The discharge pipelines were sized for a maximum velocity of 5.0 fps at the required flow.

Direct Discharge to Surface Water Alternatives

These alternatives would be used when the power plant discharge and wastewater co-disposal options are unavailable. The cost of these alternatives includes a one-mile discharge pipeline with a diffuser for the discharge of concentrate to a surface water body. The concentrate disposal pipeline was sized for a maximum velocity of 5.0 fps at the required flow.

Deep Well Injection Alternatives

The costs for deep well injection disposal of concentrate options were developed from the data provided by LBG-Guyton Associates, et al., which uses well tubing diameter and well depth to calculate construction cost. Well capacities per well ranged from 900 gpm to 1,400 gpm or approximately 1.3 to 2.0 mgd. A minimum of two wells was provided per facility. A well depth of 250 feet was used, since the aquifer beneath the Gulf is not usable for drinking water.

It should be noted that deep well injection of concentrate from large capacity seawater desalination facilities does not appear to be a cost effective option. As shown in Table 5-1, the cost for a seawater facility producing 5 mgd is estimated at approximately $4,000,000. Consequently, the deep well injection alternative was not incorporated into the range of costs for seawater desalination facilities with a production capacity exceeding 5 mgd.

Brine Line Alternatives

The brine line alternatives include a one-mile pipeline to convey concentrate to an approved brine reuse location. The discharge pipelines were sized for a maximum velocity of 5.0 fps at the required flow.

Evaporation Basin Alternatives

Evaporation basins are most appropriate for facilities with smaller concentrate flows and regions with high evaporation rates and lower land costs. Seacoast regions are not usually net evaporation areas. In addition, seawater facilities typically have relatively large concentrate quantities, since their recovery ratios are not expected to exceed 60 percent. As a result, seawater facilities do not typically meet the criteria normally associated with the practical and cost-effective use of an evaporation basin for concentrate disposal. Consequently, no costs were estimated for these concentrate disposal options for seawater facilities.

5.2.3.6 Alternatives for Other Residuals Disposal

Residual solids are typically dewatered and then sent to a landfill for disposal. Liquid residuals from the dewatering process were assumed to be disposed either with concentrate for the surface water discharge option or to a sanitary sewer for other concentrate disposal options. Consequently, the alternatives include the requisite thickener and filter belt filter equipment commonly used for this type of liquid-solids separation processing. The costs were combined with the overall costs for the desalination process, as they are relatively small compared to other process costs.

5.2.4 Brackish Water Desalination Alternatives

For the purposes of developing cost estimates, R. W. Beck assumed that the primary features of a brackish water desalination facility include the: (1) brackish water supply, (2) pretreatment, (3) desalination, (4) post treatment, (5) concentrate disposal, and (6) residual solids management systems.

5.2.4.1 Brackish Water Supply Alternatives

As explained by LBG-Guyton Associates, et al., brackish water sources in Texas typically range in salt content from 1,000 mg/l to 10,000 mg/l TDS. Raw water for the desalination process is typically withdrawn from groundwater wells or from open intakes. Consequently, the range of costs for both options is provided in this section.

The brackish water characteristics used in this document are shown in Table 5-5. The TDS level of 3,000 mg/l was selected as a typical representative value for brackish water wells. The other characteristics in Table 5-5 were obtained as nominal values from the WTCost cost-estimating program (developed by I. Moch & Associates, et al.). Therefore, it should be noted that actual source water characteristics are site-specific and should be verified during the early stages of project development activities.

Table 5-5
Characteristics of Brackish Water

Characteristic	Value	Characteristic	Value
pH	7.2	TOC	0.0 mg/l
Specific Gravity	1.0008	Turbidity	0 NTU
Conductivity	5,578 uS/cm	TSS	0.82 mg/l
TDS	3,000 mg/l	Alkalinity, HCO_3	125 mg/l
Temperature - design	20° C	Alkalinity, CO_3	0 mg/l
Boron	0 mg/l	CO_2	12.27 mg/l
Barium	0 mg/l	Chloride	811 mg/l
Calcium	110 mg/l	Fluoride	1 mg/l
Iron	0 mg/l	Nitrate, as nitrogen	0 mg/l
Magnesium	80 mg/l	o-Phosphate	0 mg/l
Manganese	0.0 mg/l	Sulfate	1,100 mg/l
Potassium	10 mg/l	Silica	12 mg/l
Sodium	815 mg/l		
Strontium	5 mg/l		

Groundwater Well Alternatives

Groundwater well capacities ranging from 900 to 1,400 gpm per well, or 1.3 to 2.0 mgd, were used as typical values for the purpose of developing the cost of these alternatives. However, it should be noted that yield is site-specific, since yield is directly related to local geological conditions. Consequently, an aquifer testing/hydrological investigation is necessary to define the hydraulic characteristics of the aquifer to determine the requisite recharge and infiltration data necessary to predict the yield and define well design parameters. Capacity often varies greatly from 0.3 mgd to 7.0 mgd, depending on soil conditions.

Direct Intake from Surface Water Body Alternatives

The direct intake alternatives assume: (1) an intake pipeline of one mile in length; and (2) that an intake structure equipped with coarse and fine screens will be constructed. To address issues related to aquatic animal impingement, the intake structure was sized for a maximum inlet velocity of 1.0 fps at the required flow. The intake piping was sized for a maximum velocity of 5.0 fps at the required flow.

5.2.4.2 Pretreatment Alternatives

Surface Water Alternatives

The cost of pretreatment alternatives was based on typical pretreatment requirements for surface water sources consisting of: (1) disinfection using sodium hypochlorite or other similar material to control biological growth; (2) chemical addition to enhance multi-media filter performance and lower pH to prevent sparingly soluble salts from precipitating in the RO membranes; and (3) 2-stage multi-media gravity filtration to remove suspended solids. Membrane filtration in lieu of multi-media gravity filtration was not included, since membrane filtration is a higher cost option. As a result, membrane filtration is usually a site-specific choice that is selected when testing shows that multi-media gravity filtration is ineffective.

Groundwater Well Alternatives

Due to the filtering action of the soil surrounding wells and the screening typically used in well construction, it is anticipated that groundwater wells would normally provide raw water with low suspended solids levels. Therefore, multi-media filtration would not usually be needed. Consequently, the cost estimates for pretreatment for groundwater well sources included disinfection and pH adjustment.

Pretreatment Process Selection

It should be noted that actual pretreatment requirements and process efficacy are dependent on source water characteristics and that the addition of an anti-scalant could also be required, depending on the characteristics of the water source. Consequently, process selection and the need for an anti-scalant should be verified on a source water-specific basis.

5.2.4.3 Desalination Process Alternatives

For the purposes of this document, R. W. Beck assumed that a typical single-stage reverse osmosis membrane desalination process preceded by cartridge filters would be adequate. To provide some degree of redundancy, a minimum of two, 50-percent-capacity reverse osmosis process trains were included for each alternative. While installed spare or standby RO trains were not included, a standby pump was included for all major pumping steps.

The following additional assumptions were also used to develop the cost basis:

- Facility availability – 93 percent;
- Maximum production capacity per process train – 4.0 mgd;
- Reverse osmosis membranes per pressure vessel – 6;
- Product recovery – 85 percent;
- Design temperature for open surface water sources – 20^{o} C;
- Design temperature for groundwater sources - 20^{o} C;
- Energy recovery equipment - included; and
- Standby power facilities - not included.

5.2.4.4 Post-Treatment Alternatives

The post-treatment alternatives include typical unit processes consisting of: (1) lime addition for alkalinity adjustment to reduce product water corrosiveness, (2) acid addition for pH adjustment, and (3) disinfection via the addition of chloramines. The need for additional post-treatment steps such as recarbonation is a project-specific decision that should be established on the basis of applicable product water standards.

5.2.4.5 Concentrate Disposal Alternatives

The means for disposing of the concentrate stream from a brackish desalination facility typically includes co-disposal with power plant cooling water or treated wastewater, direct discharge to surface water, deep well injection, and, for facilities with small concentrate streams, evaporation ponds may be feasible. Brine reuse can also be feasible in situations where a beneficial use can be identified. Consequently, a range of costs for each of the above concentrate disposal and reuse options was developed. The criteria used for each of these disposal options are summarized below.

Co-Disposal with Power Plant Discharge or Wastewater Discharge Alternatives

These alternatives include a one-mile pipeline to convey concentrate to a power plant or municipal wastewater outfall. The concentrate disposal pipelines were sized for a maximum velocity of 5.0 fps at the required flow.

Direct Discharge to Surface Water Alternatives

The cost of these alternatives includes a one-mile discharge pipeline with a diffuser for the discharge of concentrate to a surface water body. The concentrate disposal pipeline was sized for a maximum velocity of five fps at the required flow.

Deep Well Injection Alternatives

The costs for deep well injection disposal of concentrate options were developed from correlations provided by LBG-Guyton Associates, et al., which use well tubing diameter and well depth to estimate construction cost. A minimum well tubing size of six inches was used for all wells and a minimum of two wells was provided per facility. A well depth of 1,500 feet was assumed.

Brine Lines Alternatives

The brine line alternatives include a one-mile pipeline to convey concentrate to an approved brine reuse location. The discharge pipelines were sized for a maximum velocity of 5.0 fps at the required flow.

Evaporation Basin Alternatives

Evaporation basins are most appropriate for facilities with smaller concentrate flows and regions with high evaporation rates and lower land costs. The range of costs for these options was based on the following parameters:

- Membrane liner – 1.0 mm (40 mil) thick;
- Basin dike height – 3.0 feet;
- Net evaporation rate – 50 inches per year (approximate value obtained from TWDB historical data base); and

- Land cost – assumed to be $5,000 per acre.

Design parameters and the range of costs were based on a model presented by LBG-Guyton Associates, et al. The model includes basin area with 20 percent contingency, liner thickness, land cost, land clearing cost, and dike height.

It should be noted that, while the cost for all other desalination facility features does not include land costs, the cost of land was specifically included in the installed cost for evaporation basins, because land cost is a very large portion. For example, land is approximately 35 percent of the cost of an evaporation pond with a 3.0 mgd capacity.

5.2.4.6 Alternatives for Other Residuals Disposal

Residual solids are typically dewatered and then sent to a landfill for disposal. Liquid residuals from the dewatering process were assumed to be disposed either with concentrate for the surface water discharge option or to a sanitary sewer for other concentrate disposal options. Consequently, the alternatives include the requisite thickener and filter belt filter equipment commonly used for this type of liquid-solids separation processing. The costs were combined with the overall costs for the desalination process, as they are relatively small in compared to other process costs.

Section 6
PERMITTING REQUIREMENTS

Specific project features typically require permits that can have a significant impact on project feasibility, schedule, and cost. Consequently, permitting requirements should be a priority during the planning stages of project development activities. The alternatives selected for various project features, such as site selection, raw water sources, and concentrate disposal options, directly impact: 1) the permits needed; 2) the types, scope, and cost of the environmental investigations needed for the permitting process; and 3) the amount of time required to complete permitting activities. Therefore, a permitting plan should be developed in conjunction with the early stages of preliminary design to ensure that design and permitting activities are coordinated.

Other permits, such as building permits, are required for all types of projects. Typically, these are obtained through local government agencies.

Tables 6-1, 6-2, and 6-3 provide a summary of the major permits that may be required for desalination facilities in Texas. Table 6-1 addresses permits required for facility construction. Table 6-2 summarizes the permits related to feedwater for the facility. Table 6-3 discusses permits associated with residuals management. It should also be noted that other regulatory programs including, but not limited to, the Federal Clean Water Act, National Environmental Policy Act, Environmental Justice Program, Endangered Species Act, Fish and Wildlife Coordination Act, and National Estuary Program, and the State Coastal Zone Management Act, Floodplain Protection Program, Texas Optimization Program, Source Water Assessment and Protection Program, Galveston Bay Estuary Program, and Corpus Christi Bay Estuary Program, can also affect the requirements for desalination facilities using RO processes.

Table 6-1
Permit Requirement Summary by Topic
Facility Construction

Purpose of Permit	Process	Permit	Issuing Agency
Need Assessment for Desalination Facility	Approval to Construct New or Modified Public Water System	Public Water System Plan Review	Texas Commission on Environmental Quality (TCEQ)
Wastewater Treatment	Approval for New or Modified Wastewater Treatment Facilities	Summary Transmittal letter for Wastewater Treatment Facilities	TCEQ
Wetlands and Navigable Waters	Approval to Dredge or Discharge Dredge or Fill Material into State and Federal Waters and/or Wetlands	Section 401 and Section 404 Dredge and Fill Permit Environmental Impact Statement (as needed)	Army Corps of Engineers (USAC)
Wetlands and Navigable Waters	Section 10 – Approval for Construction within Navigable Waters	Permit Environmental Impact Statement (as needed)	USAC
Edwards Aquifer	Approval for Construction in the Recharge, Transition and Contributing Zones of the Edwards Aquifer	Edwards Aquifer Protection Program Application	TCEQ

Table 6-1
Permit Requirement Summary by Topic
Facility Construction

Purpose of Permit	Process	Permit	Issuing Agency
Air Emissions	Degasification and other Ancillary Equipment that Emit Air Pollutants	Air Permit - Construction of a New Source	TCEQ
Petroleum Storage Tanks	Approval for Above- and Below-Ground Petroleum Storage Tanks (if Applicable)	Petroleum Storage Tanks Registration	TCEQ
Petroleum Storage Tanks	Approval to construct Above- and Below-Ground Petroleum Storage Tanks (if Applicable)	Petroleum Storage Tanks Construction Notification	TCEQ
Buildings	Approval to construct New Buildings, including but not limited to a review of Structures, Plumbing, Electrical, and HVAC, etc.	Building Permit	City/County or both
Tree Removal	Approval for Tree Removal/Replacement	Tree Removal Permit	City/County or both

Table 6-1
Permit Requirement Summary by Topic
Facility Construction

Purpose of Permit	Process	Permit	Issuing Agency
Erosion Prevention	Approval for Erosion Prevention Plans for Construction	Erosion Permit	City/County or both
Road Crossings and Easements	Approval for Easements for Coastal, Miscellaneous, Upland Surface and Commercial Leases, and Submerged Lands	Easement	Texas General Land Office
Road Crossings and Easements	Approval for work in a Texas DOT Roadway or Right of Way	Utility Permit	Texas Department of Transportation
Road Crossings and Easements	Approval for Roadway and Public Way Crossings or Use	Right-of-Way/Easement Use	City/County or both
Railroad Crossings and Easements	Pipeline Crossing Over/Under Property and Tracks	Authorization for Crossings	Railroad Companies

Table 6-1
Permit Requirement Summary by Topic
Facility Construction

Purpose of Permit	Process	Permit	Issuing Agency
Cultural Resources and Landmarks	Review to Determine if Cultural Resources are Impacted and to Identify Mitigation Requirements. Simultaneously Conducted with the Review Processes for Federally Mandated Permits such as NPDES.	Project Review per Section 106	Texas Historical Commission
Cultural Resources and Landmarks	An Antiquities Permit Application is Needed if the Building or Site is a Designated Landmark Prior to Construction.	Antiquities Permit	Texas Historical Commission

Table 6-2
Permit Requirement Summary by Topic
Feedwater

Purpose of Permit	Process	Permit	Issuing Agency
Surface Water	Approval for Permanent or Temporary Water Rights to Surface Water	Water Rights Permit	TCEQ
Wells	Approval for Existing Wells	Water Well Registration	Local Groundwater Districts (Where Districts Exist)
Wells	Approval to Produce Water from Existing Wells	Permit to Produce Water	Local Groundwater Districts (Where Districts Exist)
Wells	Approval to Own and Operate Wells that Cross a High Production Threshold	Application for High-Impact Production Permit	Local Groundwater Districts (Where Districts Exist)
Wells	Approval for New Wells or Well Modifications	Water Well Construction and Alteration Permit	Local Groundwater Districts (Where Districts exist, otherwise none)
		Plan's Approval Prior to Construction	TCEQ

Table 6-2
Permit Requirement Summary by Topic
Feedwater

Purpose of Permit	Process	Permit	Issuing Agency
Wells	Approval for Well and Test Hole Installation	Well and Test Hole Permits	Local Groundwater Districts (Where Districts exist, otherwise none)
		Plan's Approval Prior to Conversion to Public Drinking Water Well	TCEQ

Table 6-3
Permit Requirement Summary
Residuals Management

Purpose of Permit	Process	Permit	Issuing Agency
Concentrate and/or Wastewater Disposal	Wastewater Disposal via Discharge to Surface Water	National/Texas Pollutant Discharge Elimination System - Wastewater (NPDES/TPDES)	TCEQ
Concentrate and/or Wastewater Disposal	Disposal via Class I Disposal Well(s)	TCEQ Class I Injection Well Permit, with RRC Oil & Gas Non-endangerment Letter.	TCEQ (Permit) RRC (Letter)

Table 6-3
Permit Requirement Summary
Residuals Management

Purpose of Permit	Process	Permit	Issuing Agency
Concentrate and/or Wastewater Disposal	Disposal via Class V Disposal Well(s)	Class V Injection Well Authorization to Permit	TCEQ
		Class V Injection Well Authorization Letter	TCEQ
		TCEQ Class V Injection Well Permit, with RRC Oil & Gas Non-endangerment Letter (under 30 TAC §331.9, the TCEQ executive director may require Class V injection wells to obtain a permit.)	TCEQ (Permit) RRC (Letter)
Concentrate and/or Wastewater Beneficial Reuse	Beneficial Reuse via Class II Well(s)	Groundwater Protection Recommendation Letter	TCEQ
		Class II Underground Injection Control Permit (UIC)	Railroad Commission of Texas

Table 6-3
Permit Requirement Summary
Residuals Management

Purpose of Permit	Process	Permit	Issuing Agency
Concentrate and/or Wastewater Disposal	Disposal via Publicly Owned Treatment Works (POTW) or other Wastewater Treatment Facility	National/Texas Pollutant Discharge Elimination System - Wastewater (NPDES/TPDES)	Local Regulatory Agency Authorized by TCEQ to Approve a Disposal Permit
Concentrate Disposal	Disposal via Evaporation Pond	Permit for Land Application of Water Treatment Sludge (TLAP)	TCEQ
Stormwater	Industrial Site Stormwater Disposal via Discharge to Surface Water	NPDES/TPDES	TCEQ

Table 6-3
Permit Requirement Summary
Residuals Management

Purpose of Permit	Process	Permit	Issuing Agency
Stormwater	Stormwater Disposal via Discharge to Surface Water during Construction Activities	NPDES/TPDES - General Permit TXR040000	TCEQ
Stormwater	Stormwater Disposal via Discharge to Separate Municipal Storm Sewer System/MS4	NPDES/TPDES - General Permit (TXR050000) Submit Notice of Intent (NOI) or No Exposure Certification (NEC) to Appropriate Municipal Sewer System Operator	TCEQ
Wastewater	Hydrostatic Testing Wastewater Disposal via Discharge to Surface Water	NPDES/TPDES - General Permit TXG670000	TCEQ
Onsite Sewage Facilities	Construct and Operate On-site Sewage Treatment Facilities	Local Permit	Local Regulatory Agency Authorized by TCEQ to Approve On-site Sewage Treatment Facilities

Table 6-3
Permit Requirement Summary
Residuals Management

Purpose of Permit	Process	Permit	Issuing Agency
Waste Disposal	Storage and/or Treatment of Commercial/Industrial Non-Hazardous Waste	Commercial Industrial Non-hazardous Waste Permit	TCEQ
Residual Solids	Sand/Multi Media Filtration Sludge Disposal	Registration	TCEQ
Air Emissions	Degasification and other Ancillary Equipment that Emit Air Pollutants	Air Permit - Title V Operating Permit	TCEQ

6.1 Federal

The majority of Federal permits that are applicable to brackish and sea water desalination include those by the Environmental Protection Agency (USEPA) and the Army Corps of Engineers.

Though several Federal agencies may have overall responsibility and provide review and comments, the responsibility for many permits has been delegated by USEPA to agencies in the State of Texas such as the TCEQ.

6.2 State

State agencies that may be administering, coordinating review or approving permits include:

- Texas Commission on Environmental Quality (TCEQ)
- Texas General Land Office
- Texas Department of Transportation
- Railroad Commission of Texas
- Texas Historical Commission

The majority of permitting activities are conducted by the TCEQ.

6.3 Local

Local City and County permits most often consist of building permits to ensure compliance with local building codes and rules. Additionally, some communities have special permitting requirements for removal and replacement of trees, right of way/ easement use, and methods for erosion control.

Groundwater conservation districts are local organizations that provide various permits pertaining to the use of ground water.

6.4 Other

Other permits include those required by railroads.

Section 7
PERMIT DECISION MODEL

7.1 Permit Decision Model Overview

Figure 7-1 presents information regarding a Permit Decision Model (the Model) that may be employed for a desalination facility with an RO process that uses either seawater or brackish water as raw water. The Model provides a systematic approach to identify major permit requirements via a set of decision tree analyses that may be used once basic project features have been defined.

The Model is divided into three main modules. The first is associated with raw water source permitting. The second applies to the permits required for all facilities. The third is used for concentrate and membrane cleaning solution disposal methods. Once decisions have been reached about the use of either groundwater or surface water as the raw water for the facility, and how concentrate and membrane cleaning residuals disposal will be conducted, the responses to a series of yes-no questions will provide the guidance needed to identify the major permits related to these processes.

The module for permits required for all facilities addresses the permits needed for project development, new construction, environmental permits and other operating permits. Once again, a series of yes-no questions guides the user through the permit identification process.

Section 7.2 illustrates the use of the Permit Model by summarizing the permitting requirements for typical Seawater Desalination Facility that is co-located with a power plant.

Figure 7-1

Permitting Model Overview for Desalination Facilities Using RO Technology in Texas

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

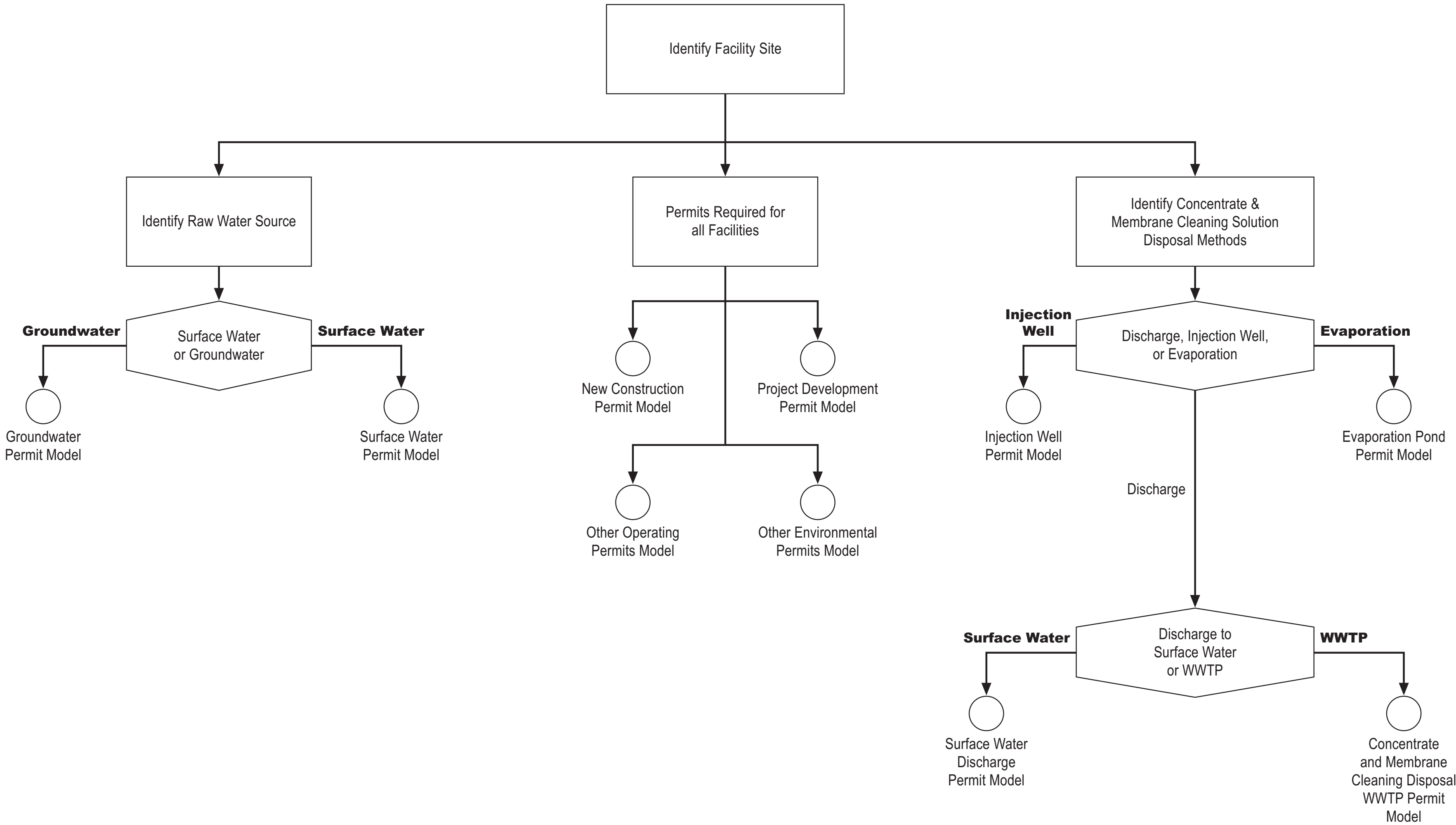


Figure 7-1

Groundwater Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

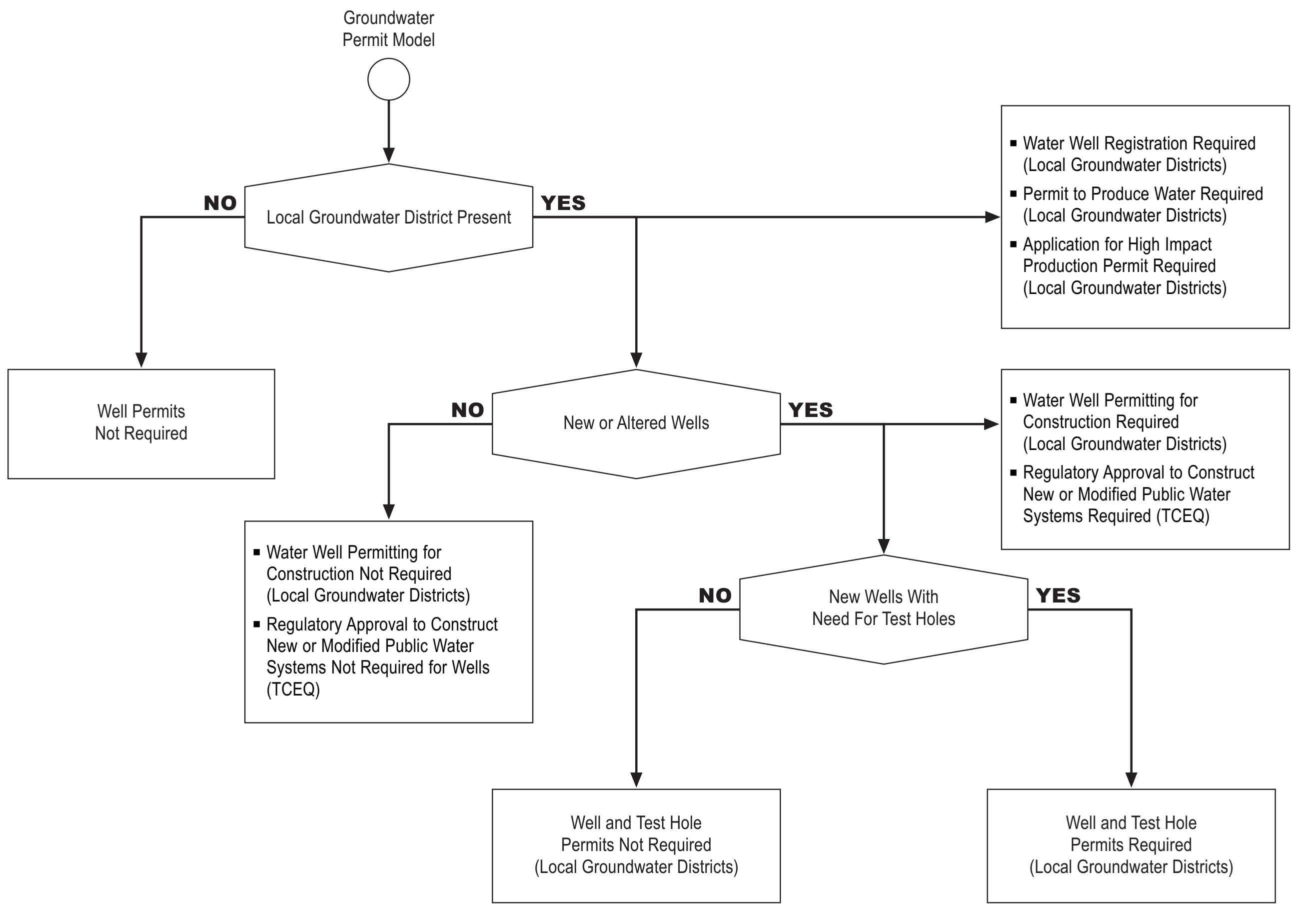
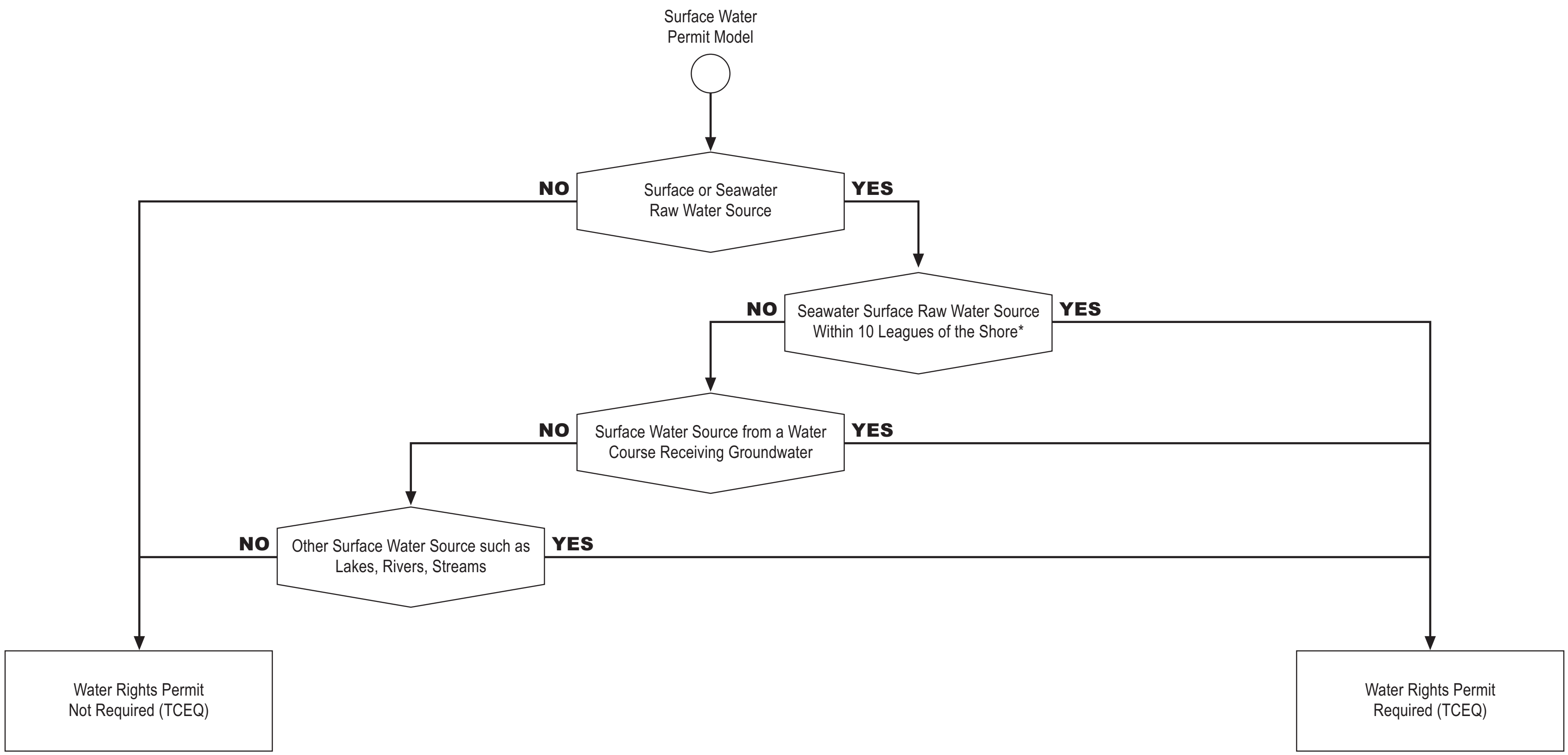


Figure 7-1

Surface Water Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model



* A marine league is typically defined as 3 nautical miles.

Figure 7-1
Other Operating Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

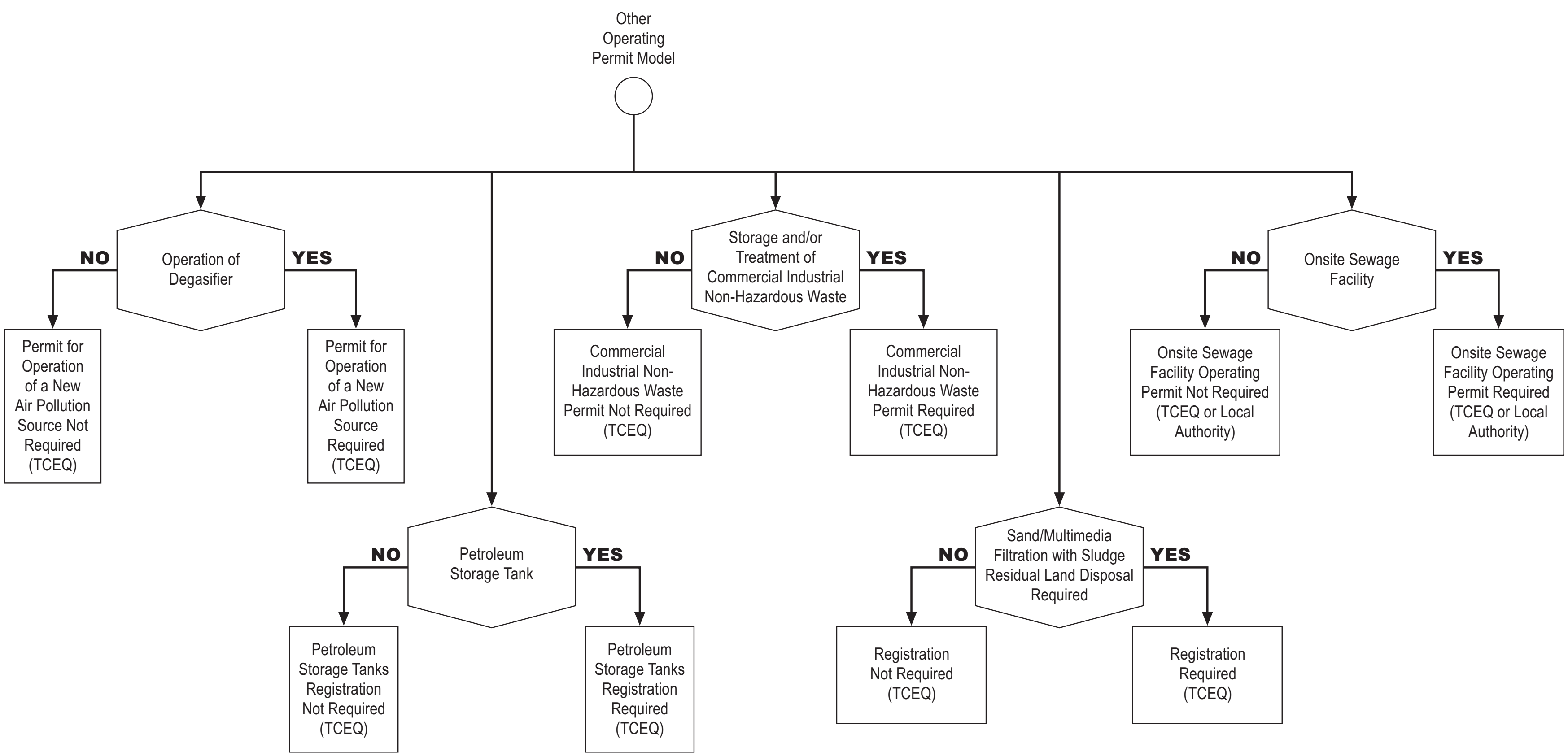


Figure 7-1
Other Environmental Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

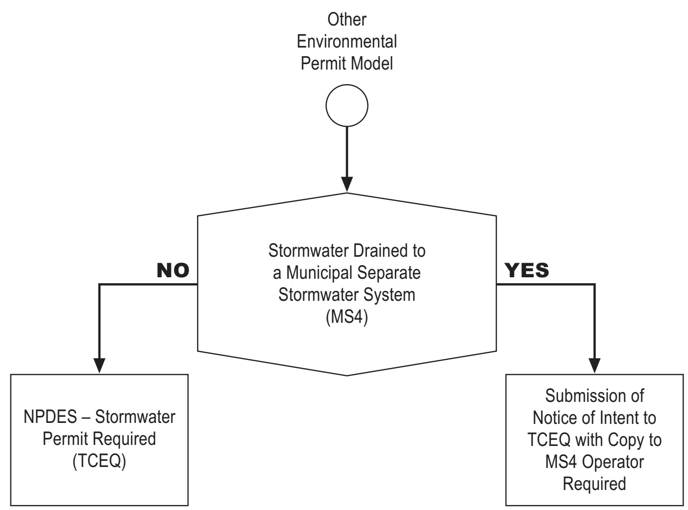


Figure 7-1

Project Development Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

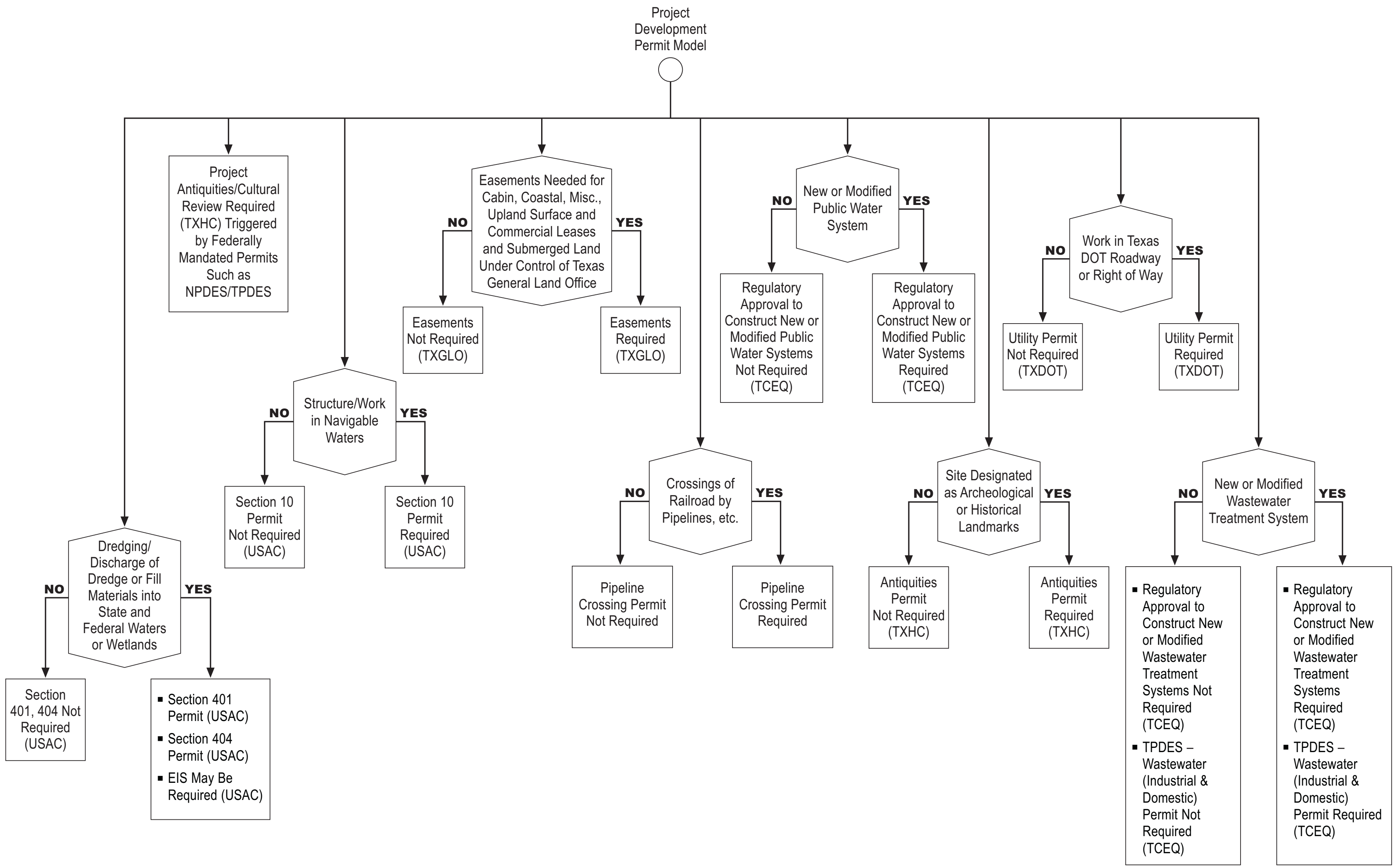


Figure 7-1

New Construction Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

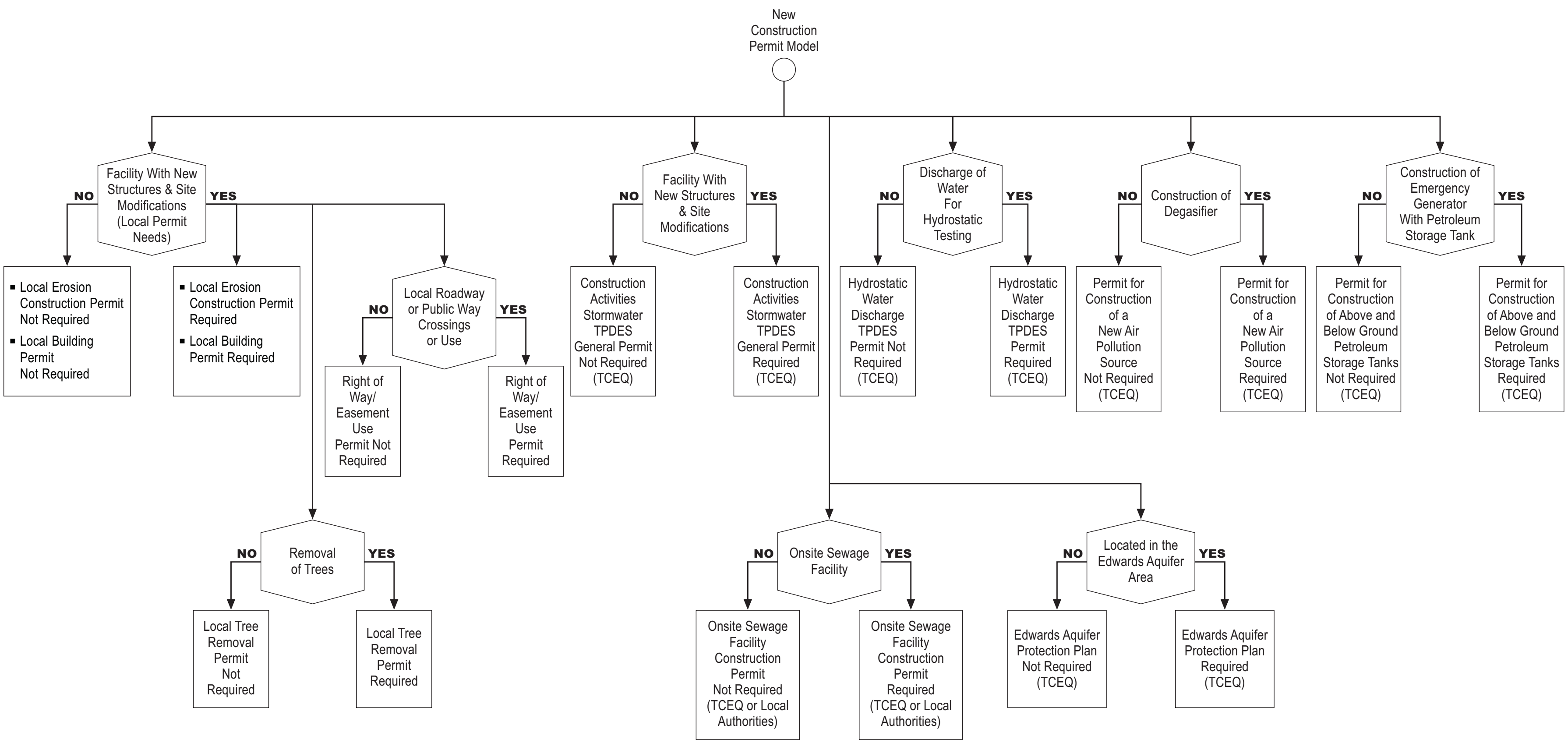


Figure 7-1

Concentrate Disposal
Injection Well Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

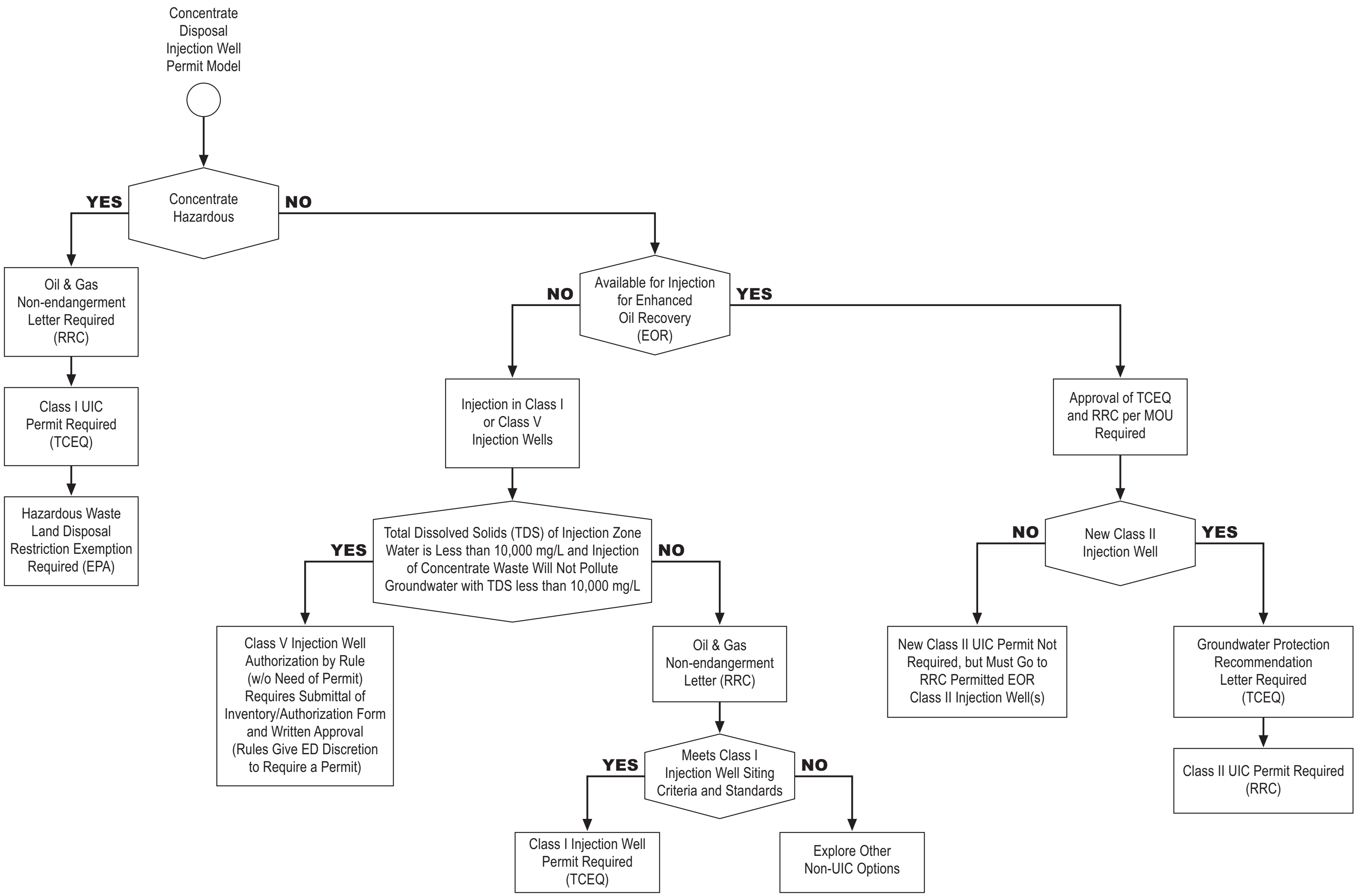


Figure 7-1

Concentrate Disposal
Surface Water Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

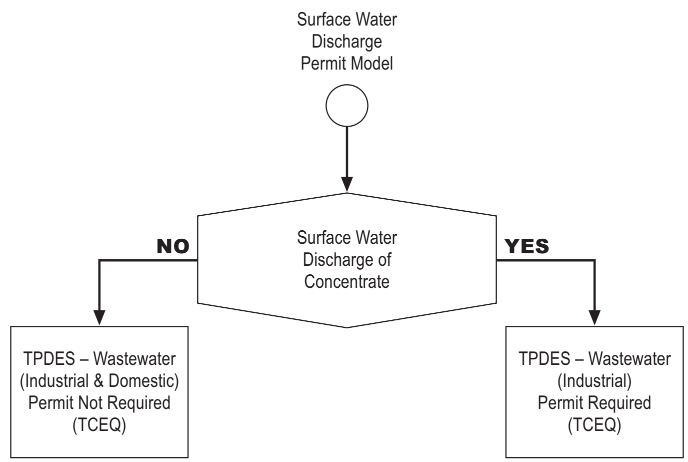


Figure 7-1

Concentrate and Membrane Cleaning Disposal
WWTP Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model

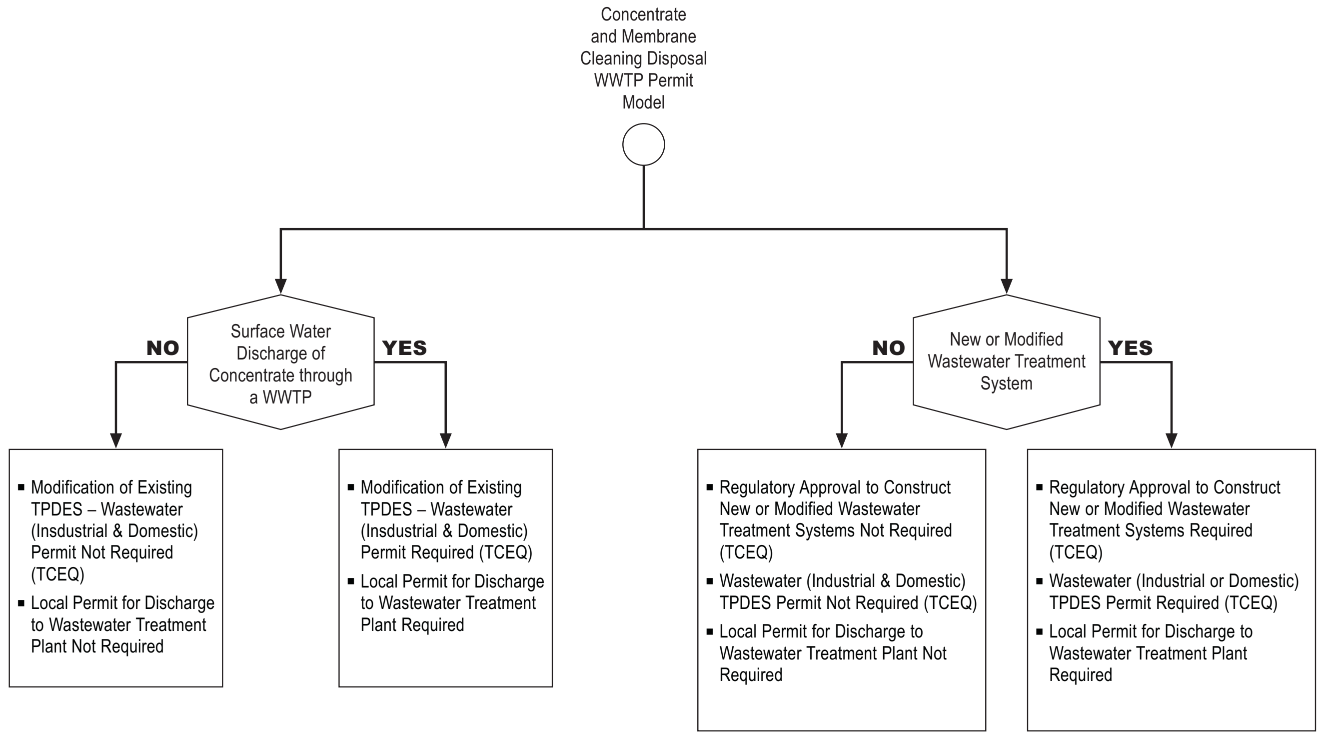
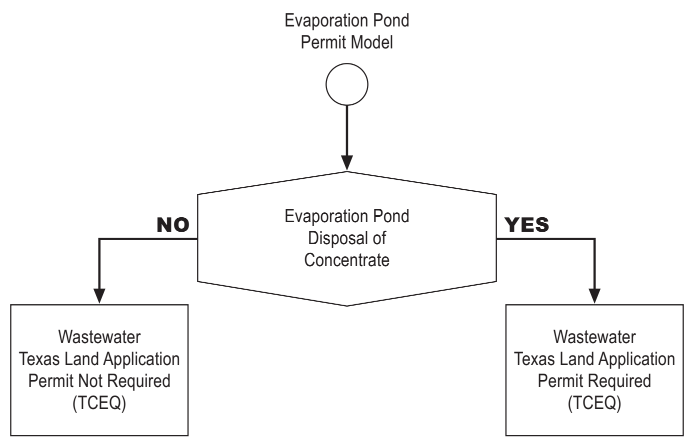


Figure 7-1

Concentrate Disposal
Evaporation Pond Permit Model

Texas Water Development Board Guidance Manual – Reverse Osmosis Desalination Facility Permit Model



7.2 Seawater Desalination Facility Example

7.2.1 Permit Requirements

For the purposes of this illustration, the permitting requirements are based on the following assumptions about major project features:

1. The power plant utilizes seawater as coolant for a once-through condenser cooling water process (Figure 4-2, in Section 4, shows the power plant cooling water configuration and RO facility interconnections);
2. Surface water withdrawn from the power plant's condenser cooling water discharge will be used as a raw water source;
3. Concentrate will be disposed via discharge to the power plant's condenser cooling water discharge at a location downstream of the raw water intake for the Desalination Facility;
4. Sewage will be discharged to a Publicly Owned Treatment Works;
5. Storm water will be discharged to separate municipal storm water sewer for disposal;
6. RO membrane cleaning wastes will be disposed via a Publicly Owned Treatment Works; and
7. The project will include a new product water transmission pipeline.

Table 7–1 presents a summary of the permitting requirements for the seawater desalination facility described above. In addition, the table also presents a listing of primary prerequisites and estimated permitting process time intervals for the major permits associated with the example.

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[1]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
Desalination Facility Permits						
1. Surface water intake [2]	Surface Water Permit Model	Water Rights Permit	Source Water Withdrawal	TCEQ	Preliminary (30%) Specifications and Drawings[2]	12 months from application
2. Surface water discharge	Surface Water Discharge Permit Model	TPDES	Concentrate & Other Wastewater Discharge	TCEQ	Waste characterization and quantity Water quality information for the waste streams and the receiving water body Preliminary (30%) Specifications and Drawings[2]	18 months from application: 12 months for TCEQ application review and comments resolution, and 6 months for notice and appeals process

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[(1)]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
3. Storm water discharge to separate municipal storm sewer	Other Environmental Permit Model	NOI to TCEQ with copy to MS4 Operator	Storm water Discharge to Separate Municipal Storm water Sewer	TCEQ	Storm Water Pollution Prevention Plan	48 hours from submittal of NOI (provisional coverage subject to wastewater testing)
4. Discharge of dredge/fill material in wetlands for intake and discharge piping construction	Project Development Permit Model	Section 404 Permit	Source Water Withdrawal and Concentrate Discharge Pipelines	USAC	Preliminary (30%) Specifications and Drawings[(2)] Mitigation Plan	9 months from application – includes 3 months for resolution of comments received from the public
5. New or Modified Public Water System	Project Development Permit Model	Approval for New or Modified	Need Assessment and	TCEQ	Feasibility and Needs Assessment	90 days from the completion of the

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[1]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
		Public Water System	Engineering Review for New Desalination Facility		Study (Preliminary Engineering Report) Pilot test data Construction (90%) Drawings and Specifications	prerequisites: 30 days for TCEQ Review, 30 days to respond to TCEQ comments, and 30 days for second TCEQ review.
6. Antiquities Review	Project Development Permit Model	Review Letter	Antiquities Impact Assessment	Texas Historical Commission	Preliminary (30%) Specifications and Drawings including demolition plans[2]	60 days from submittal of notice to the commission
7. New buildings	New Construction	Building Permit	New Buildings	Local Agency	Construction (90%) Drawings	30 days from submittal

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[(1)]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
	Permit Model				and Specifications	
8. Site work	New Construction Permit Model	Local Erosion Permit	Site Construction	Local Agency	Construction (90%) Drawings and Specifications[(2)]	30 days from submittal
9. Tree removal	New Construction Permit Model	Tree Removal Permit	Site Construction	Local Agency	Construction (90%) Drawings[(2)]	30 days from submittal
10. Local roadway or public way crossings	New Construction Permit Model	Utility Permit	Utility connections	Local Agency	Application	30 days from application
11. Storm water discharge during construction	New Construction Permit Model	TPDES	Storm water Discharge During Construction	TCEQ	Construction (90%) Drawings and Specifications[(2)] Construction Schedule[(2)]	48 hours from submittal of NOI (provisional coverage subject to wastewater

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[1]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
						testing)
12. Discharge of Water for Hydrostatic Testing	New Construction Permit Model	TPDES	Hydrostatic Test Water Discharge	TCEQ	Construction (90%) Drawings and Specifications[2] Construction Schedule[2] Notice of Intent	48 hours from submittal of NOI (provisional coverage subject to wastewater testing)
13. RO Membrane Clean-in-place (CIP) Waste Disposal via WWTP	Concentrate and Membrane Cleaning Disposal WWTP Permit Model	Local Permit for Disposal via Discharge at Publicly Owned or Other WWTP	CIP Wastes & Sewage	Local Agency	Waste characterization and quantity Construction (90%) Drawings and Specifications[3]	90 days from application

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[1]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
Product Water Transmission Pipeline Feature Permitting Requirements						
1. Discharge of dredge/fill material in wetlands	Project Development Permit Model	Section 404 Permit	Product Water Transmission Pipeline	USAC	Preliminary (30%) Specifications and Drawings[2] Mitigation Plan	12 months from application – includes 6 months for resolution of comments received from the public
2. Discharge of Water for Hydrostatic Testing	New Construction Permit Model	TPDES	Product Water Transmission Pipeline	TCEQ	Construction (90%) Drawings and Specifications[2] Construction Schedule Notice of Intent	48 hours from submittal of NOI (provisional coverage subject to wastewater testing)
3. Railroad	Project	Pipeline	Product Water	Railroad	Application	60 days from

Table 7-1
Typical Seawater Desalination Facility and Product Water Transmission Pipeline Permitting Requirements[(1)]

Facility Feature	Permit Model	Permit	Reason	Agency	Prerequisites	Schedule
Crossings	Development Permit Model	Crossing Permit	Transmission Pipeline	Company		application
4. Work in DOT Roadway or Right of Way	Project Development Permit Model	Utility Permit	Product Water Transmission Pipeline	TXDOT	Application	30 days from application

(1) Seawater Desalination Facility co-located with a power plant that uses a once-through cooling system.
(2) Needed for withdrawal of seawater for desalination facility feedwater.
(3) Typically needed by applicant as background information so that application, NOI, or other documentation for regulatory agencies can be prepared by applicant.

7.2.2 Typical Permitting Timeline

Figure 7-2 consolidates the time interval information provided in Table 7-1 into an overall permitting schedule. As shown, it is expected that the schedule for the TPDES permit would be a critical path component.

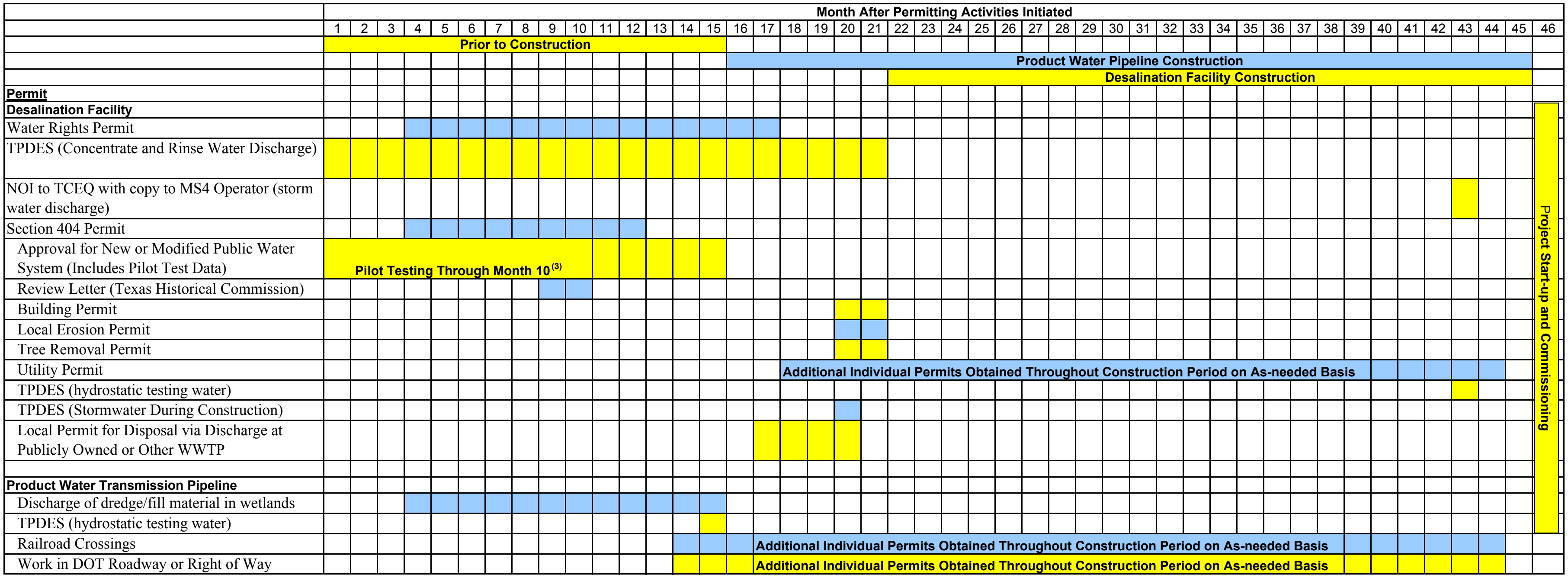
Obtaining the Water Rights Permit and the Approval for New or Modified Public Water System (Includes Pilot Test Data) can also be lengthy processes. However, since the raw water source in this example is seawater, challenges due to prior water rights seem unlikely. Similarly, assuming that: (i) development activities associated with the needs assessment activities; and (ii) an effective pilot testing program for the Approval for New or Modified Public Water System, are both conducted in a timely manner, it is not likely that they will be critical path components of the schedule.

Assuming a three-month application preparation period for the TPDES permit, the estimated time for the permitting process prior to the start of facility construction is then approximately 21 months for this seawater desalination facility scenario. A 24-month construction period with a one-month commissioning period were also selected as typical durations based on previous experience. Consequently, the duration from the start of permitting activities to the end of the commissioning period is estimated to be approximately 46 months.

It should be noted that the potential effect of challenges to water rights for brackish water facilities where prior rights are much more likely to exist, could significantly extend the schedule for a water rights permit. Consultation with the Texas Commission on Environmental Quality has indicated that challenges have the potential to extend Water Rights permitting to two years or longer. In such an event the water rights permit could become a critical path component and should be considered when developing a permitting plan and schedule for a brackish water facility.

Dated: July 7, 2004

Figure 7-2
Typical Permitting Schedule for a Seawater Desalination Facility
Co-located with a Power Plant with a Once-Through Cooling System



Notes:
1 Assumes permitting activities are initiated in Month 1.
2 Durations shown above include permit application preparation activities.
3 TCEQ requires a minimum of 90 days of pilot testing for its review process. In R.W. Beck's opinion, an extended pilot testing duration is typically needed to confirm that facility design is compatible with the seasonal fluctuations in raw water quality commonly experienced.

Section 8
REFERENCES

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3. AWWA, "Membrane Practices for Water Treatment," 2001.
4. I. Moch Associates, in association with Boulder Research Enterprises and the United States Bureau of Reclamation, "WTCost," 2003.
5. SJRWMD, "Technical Memorandum B.6., Applicable Rules and Regulations for Seawater Demineralization," 2002.
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7. Personal communications: Larry Karns, R. W. Beck, with Collector Wells International, Inc.
8. Mickley, Michael C., Mickley & Associates, U.S. Department of the Interior Bureau of Reclamation, "Membrane Concentrate Disposal: Practices And Regulation Final Report Agreement No. 98-FC-81-0054, Desalination and Water Purification Research and Development Program Report No. 69," September 2001.
9. Personal communications Howard Steiman, R. W. Beck, with Anthony Bennett, et al., Texas Commission on Environmental Quality.

Appendix 1
EXECUTIVE ADMINISTRATOR'S COMMENTS ON DRAFT REPORT

ATTACHMENT 1

TEXAS WATER DEVELOPMENT BOARD

Contract No. 2003-483-509
Review Comments of the Draft Final Report
"Guidance Manual for Permitting Requirements in Texas for Desalination Facilities Using Reverse Osmosis Processes"

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1. An executive summary is needed at the beginning of the report.
2. In the introduction, only RO is mentioned for desalination, and not EDR or others (indicate differences, reason/preference for RO). The material on EDR and RO from Section 3 may be moved to the introduction section.
3. Page 4-1- Brackish water definition should be clearly indicated...Page 4-1 text indicates 600-25,000 while Section 5.2.4.1 refers to 1,000 – 10,000 mg/l. Please show consistent numbers.
4. Several typos need to be corrected. For example, Sections 4.1.1.1, 4.2.1.2, 4.2.1.4, 4.2.2, 5.2.3.1 (open intake alternative), Section 6, Figure 7-1 (WWTP), and others. There are numerous little squares showing up in the text in various places. After corrections, please read the report fully at least once, before submitting the final copy
5. Section 4.2.1 - Third Paragraph, second line. - Please insert the word pretreatment before the word disinfection.
6. Section 4.2.1.1 - first paragraph, second line - please insert "may be accomplished with" in place of "is generally practiced"
7. Section 4.2.3.1 - second line - please insert "chlorine (sodium hypochlorite or chlorine gas)" in place of "sodium hypochlorite"
8. Section 4.3 - Concentrate Disposal, paragraph 3 - "Typically brine lines are used to inject brine as part of the extraction process of petroleum from the ground and the brine re-injected." Comment: It sounds like the term "brine line" refers to the pipeline that conveys brine to a site or operation for beneficial reuse of the brine. Such sites may include Class II injection well specifically permitted by the RRC for enhanced oil recovery (EOR). It would seem clearer if the references to brine lines made this point (about Class II Wells).
9. Section 5.2.4.5 - Please correct TBWD to TWDB.
10. Table 5-1
    - Delete the word 'Nominal' ('Nominal' may indicate an insignificant amount of TDS, which is not true for 35,000 ppm).
    - Do the costs include pretreatment cost, if so, indicate in footnote 1. Specify if the pretreatment is conventional or MF.
    - The table is unclear. Footnote 1 seems to refer to many processes. Footnote 1 says it excludes cost of intake, yet the intake configuration is shown with an asterisk (1).

    Please improve tables 5-1 and 5-2, especially the footnote explanations.

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11. Table 5-3 - 25 mgd SWRO - The cost figures for discharge to surface water blending seem to be incorrect. Should it not be 133 and 183 instead of 48 and 66?
12. Table 6-1 - there is reference only to CSX Railroad Corporation. What about other railroad companies?
13. Table 6-1 - Comment: Make correction to line item as noted below:

Purpose of Permit	Process	Permit	Issuing Agency
Wells	Approval for New Disposal Wells ~~or New Groundwater Wells for Feedwater~~	~~Ground Water/Protection Recommendation Letter (surface casing for well bores)~~ TCEQ Class I Injection Well Permit, with RRC Oil & Gas Non-endangerment Letter	TCEQ(permit) & RRC (letter)
		Class V Injection Well Authorization or Permit	TCEQ
		- Class V Injection Well Authorization Letter	TCEQ
		- TCEQ Class V Injection Well Permit, with RRC Oil& Gas Non-endangerment Letter (Under 30 TAC §331.9, the TCEQ executive director may require Class V injection wells to obtain a permit.)	TCEQ(permit) & RRC (letter)

14. Table 6-1, third row, wells, approval of new wells or well modifications. Though not permitted, TCEQ must approve any plans for new wells or modifications prior to construction.
15. Table 6-1, fourth row, wells, approval for well and test hole. Though not permitted, TCEQ must approve any plans for new wells or modifications prior to construction. TCEQ does not have to approve test holes until it is decided that it will become a public drinking water well.
16. Some items seem to have been repeated in Table 6-1. For example, wells for feedwater and disposal are shown under facility construction, and again under feedwater and under residual management. What exactly does facility construction include? Avoid repeating items.
17. Table 6-1 extends into several pages. Please break it down into different tables. For example, Table 6-1 for facility construction, Table 6-2 for feedwater, etc.

18. Table 6-1 - Comment: Make correction to line item as noted below:

Purpose of Permit	Process	Permit	Issuing Agency
Concentrate and/or Wastewater Disposal	Disposal Via Class I Disposal Well(s)	TCEQ Class I Injection Well Permit, with RRC Oil & Gas Non-endangerment Letter	TCEQ(permit) & RRC (letter)
Concentrate and/or Wastewater Disposal	Disposal Via Class V Disposal Well(s)	Class V Injection Well Authorization or Permit - Class V Injection Well Authorization Letter - TCEQ Class V Injection Well Permit, with RRC Oil & Gas Non-endangerment Letter (Under 30 TAC §331.9, the TCEQ executive director <u>may</u> require Class V injection wells to obtain a permit.)	TCEQ TCEQ TCEQ(permit) & RRC (letter)

19. Table 6-1 - Concentrate and or wastewater disposal - This is a permit, not a registration as contained in the Permit column, if they are referencing wastewater disposal.
20. Table 6-1 - Sand/multimedia filtration sludge disposal - these are not called TLAPs. It is still a registration though.
21. Table 7-1 - please indicate the permit(s) that may be needed from different agencies for direct withdrawal of seawater for raw water intake (coastal zone commission, coast guard/federal permits)?
22. Table 7-1 - 'Texas Antiquities Committee' may be incorrect. It's probably the Texas Historical Commission (THC). Please confirm.
23. Table 7-1 No. 13 - CIP – What does the acronym stand for?
24. Figure 7-1 - "Project Development Permit Model," for the Reverse Osmosis Desalination Facility Permit Model, there is a reference to "Crossings of CSX Railroad by Pipelines." There is a similar reference on Table 7-1 for "Product Water Transmission Pipeline Feature Permitting Requirements" as item #3. It seems that this should be generalized to include other railroads as well.
25. Figure 7-1 - What is a league? Please explain with an asterisk.
26. Page 7-19, figure 5-1, Approval for new or modified PWS. - TCEQ requires a minimum of 90 days of pilot test data with at least 30 days at the design flow rate. Consulting engineers may wish to pilot for an extended period of time, but TCEQ requests that all data in the pilot be submitted with the plans and specifications.