Section 7
Water Resources and Water Treatment Requirements

This section combines evaluations regarding water supply sources and water treatment infrastructure, for current conditions as well as for future requirements, and existing options to satisfy them. Both issues are highly interrelated because the characteristics of water sources will determine, among other factors, the type of water treatment necessary and therefore, feasible technological options.

As can be seen, there are a considerable number of water supply sources and potential and water treatment technologies, although not all of them are necessarily feasible for the study area's physical, economic and social conditions. As a result of this range of options and the high number of combinations that could be created among supply sources, and water treatment technologies, infrastructure location and the relationship among water and wastewater systems, it is necessary to carry out an exercise that allows for the identification of the most feasible options that warrant additional consideration and perform as *type* options for the creation of integrated alternatives.

It is important to highlight that the master plan constitutes only one of the multiple steps that should be taken towards starting-up specific infrastructure works. Once this plan, which establishes a future action framework, has been concluded, specific additional studies should be carried out during the elaboration phases of the preliminary projects and executive projects. The focus of these studies will be to review some of the plan's suppositions and recommendations. For example, a potential water source is the injection of high quality effluent into the Tijuana River aquifer for later extraction, disinfection, and distribution to the potable water system (further discussed in Section 7.1.2). However, the implementation of this option will require detailed studies on geo-hydrologic, geo-chemical and water quality characteristics (potential contamination) of the water table, which are beyond the master plan's scope. Once these studies have been concluded this alternative can be fine tuned and defined in greater detail with regards to such factors as pre and post-treatment needs, the location sites of the works necessary, and recharged water recovery rates.

Likewise, it is important to take into consideration the similarity that exists between some options at the level of detail level presented by a master plan. For example, there is an obvious and considerable difference between a seawater desalination plant and a conventional fresh water treatment plant. However, at the master plan level, the differences between a conventional plant and a direct filtering plant, both used for fresh water treatment, are not necessarily significant for a source such as the Colorado River. Once subsequent studies have been performed, the best option for each source and site selected can be determined in the most precise manner.

Despite the limitations inherent to this type of planning project, the alternatives recommended at the end of this process will be adequately detailed to allow the governing body to select the best set of actions and continue with the development of the recommended alternative.

7.1 Current and Potential Water Sources

7.1.1 Current Water Sources

The cities of Tijuana and Playas de Rosarito currently have five water supply sources: the Colorado River; surface runoff captured by the Abelardo L. Rodriguez Dam; and the Tijuana-Alamar, Rosarito and La Misión aquifers. However, even though there are several sources there is a considerable dependence on a single source, since 95 percent of the water supplied by CESPT in 2001 came from the Colorado River, while 4 percent was obtained from the Rio Tit

It is expected that the river will continue to be an important water source in the future, even though the amount of water that can be supplied by the river is limited by two main factors: the capacity of the Colorado River – Tijuana aqueduct and the river water rights of the cities of Tijuana and Playas de Rosarito. The current capacity of the aqueduct is 1,030.3 gal/s (3,900 l/s), of which 879.7 gal/s (3,300 l/s) are obtainable from CESPT. The remaining 150.6 gal/s (570 l/s) is either used by the City of Tecate or lost due to leaks and evaporation at the El Carrizo Dam. The State Commission for Water Services (COSAE for its Spanish acronym) has projected to upgrade the aqueduct to conduct the additional output of 343.4 gal/s (1,300 l/s), which would result in a total obtainable output for CESPT of 1,188.8 gal/s (4,500 l/s), assuming that Tecate will continue obtaining 47.5 gal/s (180 l/s) and that 10 percent of the flow will be lost. This net increase of 317 gal/s (1,200 l/s) has been considered in Section 6 to elaborate the needs projections.

Any plan to transport an even greater amount of water will require the construction of an additional aqueduct. Currently, studies have been carried out to determine the feasibility of building an aqueduct to be used exclusively by Mexico, or jointly with the United States. The joint construction would take advantage of the geographic conditions in each country and would offer economies of scale. At any rate, the construction of an additional aqueduct would be an expensive option with a relatively long implementation period.

CESPT does not have additional water rights; therefore any increase in the flow supplied by this source should be accompanied by obtaining additional water rights. Preliminarily, we have assumed that to acquire additional rights CESPT would need to sign a purchase agreement, given that the river flow is completely allocated to other consumers.

Water from the Colorado River is considered good quality water, even though this water must be made potable prior to distribution to the system. Water quality from this source allows water treatment through on line filtering, direct filtering or by conventional means of water treatment. The on line filtration consists of coagulation and filtering processes followed by disinfection, which is practical for water sources with relatively low turbidity. Direct filtering consists of coagulation, flocculation, filtering and disinfection processes. Last, conventional means of water treatment include the aforementioned processes plus sedimentation as an intermediate step between flocculation and filtering. The quality of water produced increases as the treatment processes increase. In addition, an increased level of treatment provides more flexibility in treating variable quality source water or waters. Therefore, the type of treatment recommended will depend on the water quality desired and the quality of the source. Section 7.3 evaluates the options for water treatment in more detail. It is sufficient to mention that at this moment additional exploitation of water from the Colorado River will require not only investment in transportation infrastructure and the purchase of water rights, but also in treatment infrastructure.

Groundwater

CESPT extracted a total of 38.6 gal/s (146 l/s) in 2001, of which 19.3 gal/s (73 l/s) came from the Tijuana-Alamar River aquifer, 5.8 gal/s (22 l/s) came from the Rosarito aquifer, and 13.5 gal/s (51 l/s) came from the La Misión aquifer. These extractions represent 4 percent of the total supply for that year. As was mentioned in Section 6, CESPT estimates that the production rate from the Tijuana-Alamar River can increase in a sustainable manner up to 113.6 gal/s (430 l/s). On the other hand, the production capacity of La Misión aquifer is considered equal to the current extraction rate of 13.5 gal/s (51 l/s); therefore increases in the extractions from this aquifer are not expected. The wells in the Rosarito aquifer have high levels of salinity as a result of seawater intrusion, therefore in the year 2001 they did not operate and it is expected that they will continue to be out of service in the future.

The water from the Tijuana-Alamar River aquifer has iron (Fe) and manganese (Mn concentrations higher than the limits established by the norm, therefore an Fe and Mn removal plant is currently under construction in the *Monte de los Olivos* area with a 66 gal/s (250 l/s) capacity. According to studies carried out by CESPT, this treatment capacity will be sufficient to recover 113.6 gal/s (430 l/s) that will be extracted from the aquifer, since not all the wells extract water with concentrations above the permissible limits. It is expected that water from the La Misión aquifer would not require additional treatment other than disinfection.

At this point in time, there is no data regarding other contaminants of potential health concern in the groundwater aquifers such as synthetic or volatile organics, possibly from leaking underground fuel tanks or unregulated industrial discharges. It is strongly suggested that an assessment of the water quality in the aquifer be made before investments for the additional extraction of water from this source are made.

Abelardo L. Rodriguez Dam

The Abelardo L. Rodriguez Dam has been a relatively inconsistent water source and is therefore considered to be of less importance. However, it could be a considerable source in years with abundant rain, as it happened in the 1993-1998 period. In 2001 the Dam provided only 1 percent of the total CESPT supply, or 9.5 gal/s (36 l/s). Besides the runoffs captured by the Dam, it received water from the Colorado River through the aqueduct that connects it to the El Carrizo Dam.

Given the relatively small importance of the Dam as a water *source,* even when it could play an important role in storing water from the Colorado River or highly treated effluent (see Section 9), it is assumed that the future water supply from this source will be minimal. Although any storage that may occur will be beneficial for CESPT, it has been documented that CESPT does not record what was obtained from the Dam to estimate future needs (see Section 6).

Water stored in the Dam is made potable at the Abelardo L. Rodriguez water treatment plant. Water that could be stored in the Dam in the future, either by capturing it from surface runoffs or from importing it from the Colorado River or from highly treated wastewater effluents should be made potable before it is

distributed to the potable water system. Section 7.3 shows the potabilization options available for this source. It is sufficient to mention that the type of treatment necessary for water from the Dam will be higher than what is required for water from the Colorado River, since the Dam is susceptible to receiving runoffs from its basin, with greater turbidity and the possibility of contamination as the basin is developed.

7.1.2 Potential Water Sources

Nine potential water sources were identified, including some that are currently used, which are shown in Table 7-1. It should be mentioned that not all the alternatives offer the same potential in terms of quantity, quality and technical feasibility, policy, finance and public acceptance. Likewise, compliance with the sustainability criteria and the time necessary for implementing each alternative will be a variable and should be taken into consideration during its evaluation.

As we will see in more detail later on, a few of the options considered present obvious benefits in reducing the projected deficit; however, the additional amount of water or the reduction in the demand that would be obtained from its implementation would not be significant if compared to future needs. A few of these actions, such as the demand control program and public education campaigns, should be implemented by CESPT independently of the options selected, even though they are not selected as supply options per se.

Table 7-1 initially shows the feasibility of each option by grading from 1 to 3. Number 1 indicates the relatively high feasibility level; number 2 represents options with a moderate level of feasibility for implementation but with some obstacles; and number 3 indicates a low level of feasibility. Later, a brief discussion is presented on these options and its justification for grades assigned.

Table 7-1
Options for Potential Water Sources

Potential source	Feasibility level
1-1 Colorado River:	
Binational aqueduct	(1)
Mexican aqueduct	(1)
New Dam	(1)
Optimization of the use of existing infrastructure	(1)
1-2 Desalination:	
Desalination of seawater	(1)
- Combined with the generation of electricity	
- Unaided	
Desalination of brackish groundwater	(2)
1-3 Additional extraction of groundwater:	
New wells	(1)
Treatment of wells	(1)
1-4 Reuse of wastewater effluent:	
Secondary treatment plus chlorination	

Table 7-1 Options for Potential Water Sources	
- Specific users (If necessary, additional treatment at the point of use)	(1)
- Dual system (Irrigation, industrial, use in restrooms, etc.)	(2)
Secondary treatment plus filtering and chlorination	(3)
Tertiary treatment	
- For use as an intrusion barrier for seawater to the aquifer	(3)
- For industrial use	(2)
Tertiary treatment (micro-filtering and membranes)	(1)
- Recharge aquifers (Indirect potable use)	(1)
- Discharge to the Rodriguez Dam (Indirect potable use)	(1)
- Direct potable use	(3)
- Construction of a new storage container	(2)
1-5 Additional storage:	
Recharge aquifer and later extraction	
- From effluent	(1)
- From runoffs	(2)
- Of water from the Colorado River	(2)
New Dam	
- From effluent	(3)
- From runoffs	(2)
- Of water from the Colorado River	(1)
1-6 Optimization of the use of the basin and the container at Rodriguez Dam	(1)
1-7 Demand management:	
Legal and financial incentives, requirements for efficient sanitary facilities	(1)
Inverse pyramid rate structure	(1)
Public education	(1)
Dry toilets	(2)
1-8 United States Sources	
Emergency connection to San Diego (temporary)	(1)
Recharge to the aquifer and later extraction	(2)
SBIWTP South Bay	(1)

Colorado River

As was previously mentioned, the Colorado River currently represents the most important water source, providing around 95 percent of the CESPT supply. The river provides good quality water that only requires treatment through on line filtering, direct filtering or conventional treatment. These treatment options are relatively inexpensive and easy to operate. Likewise, the river represents a renewable and sustainable source that could have a long-term use.

The most important disadvantages that this source has are distance and the difference in elevation that would have to be overcome during its transfer; the lack of additional capacity in the Tijuana-Colorado river aqueduct; the need to obtain additional water rights, and the potential risk of a disruption in this imported water source due to earthquake damage of the aqueduct which could take weeks if not months to repair.

The first two disadvantages (distance, elevation, and lack of capacity) mainly represent an economic challenge given the high cost of the transfer infrastructure. However, there is also the limiting factor that the construction of a new aqueduct would take around 10 years, therefore reducing the feasibility of this project as a future source at medium term. Obtaining additional water rights would require negotiations with farmers and the National Water Commission (CNA for its Spanish acronym), as well as potential expenditures for its purchase.

As was previously mentioned, COSAE has considered upgrading the aqueduct to increase, at medium term (2008), the amount of water recovered for Tijuana and Playas de Rosarito from 879.7 to 1188.8 gal/s (3,330 to 4,500 l/s). On the other hand, there is a study for the construction of a new binational aqueduct, which includes among one of its alternatives the construction of a Dam to receive water from the river.

This will also require the expansion of existing treatment capacity and should include upgrades to the existing plants to improve current operations.

It is considered that this option is feasible and that it should continue being contemplated during the elaboration of alternatives.

Desalination

The Pacific Ocean represents an adjacent water source that is practically unlimited and sustainable, but with relatively high investment requirements in infrastructure and operation and maintenance. However, this represents a local source water that would reduce dependence on imported supplies and because the supply is the ocean, it is highly reliable and drought proof.

There are several seawater desalination technologies, even though for planning purposes, reverse osmosis is recommended, which is a tested technique that has experienced important progress in recent years. Reverse osmosis (RO) is a membrane process that uses pressure to transport water across a membrane while particles and solutes are retained. Other membrane processes include microfiltration, ultrafiltration, and nanofiltration. However, RO is the most effective in removing salts and low molecular weight solutes. However, it also requires the greatest pressure, and, consequently, energy to be effective. The pressures need to drive seawater across an RO membrane can be as high as 800 to 1,180 psi.

A typical plant consists of intake facilities and pumping, in-line filtration with sand media filters, pre-chemical conditioning treatment (dechlorination, cartridge filtration to remove particles down to 5 micron in size, and pH adjustment with sulfuric acid), high pressure feed pumps, reverse osmosis treatment, post-chemical conditioning treatment (lime to increase alkalinity and hardness, and chlorine disinfection), product water storage and pump station, waste treatment disposal (filter backwash, RO concentrate disposal, and spent membrane cleaning chemicals). Typically, approximately 50 percent of water that goes into the plant is disposed of as brine with high concentrations of dissolved solids, therefore these types of facilities have

considerable requirements for waste management. It is anticipated that the brine could be disposed of at sea without additional treatment although it may be preferable to dilute this discharge, if possible, with spent cooling water from a power plant.

The desalination can be implemented through the construction of a plant assigned exclusively for this purpose, or in combination with the construction of an existing or new energy plants. There are several proposals in the study area for the construction of electric energy plants, and CESPT could obtain certain benefits from combining a desalinating plant with these types of works, which should be analyzed in greater detail in the future. Benefits include joint usage of ocean intake and outfall facilities, use of the heated spent cooling water to increase the RO yield (increases as water temperature increases), and reduced energy costs associated with elimination of major transmission facilities.

Besides the desalination of seawater, there is the potential of desalinating water from brackish aquifers, like the one in Rosarito. The investment and operation and maintenance requirements for this option would be less than those for desalinating seawater. However, there is a lack of sufficient geo-hydrologic information regarding this aquifer, therefore a grade of 2 is assigned to this option in Table 7-1. In addition, recent experience has shown that this process does not reliably sustain a consistent safe yield as the transmissivity of the aquifer reduces over time due to particulate build up.

The desalination of seawater presents an important feasibility level, therefore it should be considered during the identification of water alternatives. The construction of a desalinating facility would require less time than the construction of the Colorado River aqueduct, which has preference as a short and medium term option. . In addition, the risk associated with this supply is very low as it is local and it is drought proof.

Additional Extraction of Groundwater

CESPT obtains approximately 4 percent of its water supply from wells in the Tijuana-Alamar River, Rosarito and La Misión. However, CESPT has stopped operating the Rosarito wells due to the high concentration of dissolved solids (salts) resulting from the intrusion of seawater into the aquifer. It is anticipated that these wells, which produced 5.8 gal/s (22 l/s) in 2001, will not be used again during the planning period.

On the other hand, the geo-hydrologic studies conducted by CESPT indicate that the extraction of the Tijuana-Alamar River aquifer could result in a sustainable increase of 113.6 gal/s (430 l/s), even though part of this water would require treatment for the removal of iron and manganese, which are found in a few wells in concentrations above the maximum permissible limits.

Based on the geo-hydrologic studies carried out by CESPT, it is estimated that additional water extraction from the Tijuana River aquifer is feasible and that it should be considered during the identification of alternatives. Given its small

contribution and water quality issues, it is recommended that extractions from the Rosarito aquifer not be included in availability projections. , In addition, it is recommended that wells from La Misión aquifer continue to use data and extraction rate equal to the current one.

The extraction increase from the Tijuana-Alamar River aquifer and the elimination of the Rosarito wells has already been contemplated in Section 6 for the water availability projections; therefore they will not be contemplated as an independent supply option.

Wastewater Reuse

Treated wastewater has the potential of being reused for non-potable purposes (irrigation of green areas, industrial use, etc.) as well as for indirect potable use. The type of reuse that could be feasible would depend on a series of factors, such as regulations enforcement, wastewater quality (presence of heavy metals and other toxic substances not easily removed by conventional treatment processes), effluent quality, characteristics of receiving bodies, and political and social feasibility (public acceptance), among others.

Table 7-1 identifies a series of potential types of reuse based on the water treatment level. Secondary treatment with chlorination would provide adequate quality for use in indirect contact with the public, such as irrigation of certain green areas, certain industrial uses and use in toilets, among others. Some types of users may require additional treatment at the site, before being used, as in the case of certain industrial processes. Another option is the construction of dual water systems, which would consist of a potable water distribution system and another of treated wastewater for reuse. The feasibility of this type of system would be greater in high or medium class residential zones, or in zones with a considerable concentration of industry and/or commerce.

The filtering of the secondary effluent would improve the quality of the effluent and would increase its reuse flexibility, even though this would probably continue being limited to uses similar to those previously described.

Tertiary treatment would increase the quality of the effluent even more and would open the possibility of reusing water in activities that require high quality levels. The possibility of the existence of industrial users interested in high quality water and injection of effluent to coastal aquifers to form barriers against the intrusion of seawater into the aquifer is contemplated for the study zone. Last, indirect potable reuse through the recharge of aquifers with high quality effluents (advanced treatment) for its later extraction is considered as an option worth evaluating, or for its discharge to the Abelardo L. Rodriguez Dam for storage.

The reuse of the water for non-potable purposes can be considered as a potential water source, however, it is unlikely for this water source to be large enough to significantly reduce the projected water deficit. The actual demand that could exist for non-potable reuse water is unknown, therefore is recommended that CESPT

evaluate in detail the wastewater market for non potable uses, and establish this type of reuse jointly with other measures guided towards the reduction of potable water use. Indirect potable reuse represents a potentially significant water source, since CESPT has a considerable amount of effluent (622.9 gal/s; 2,358 l/s in 2001), part of which could receive additional treatment for its later discharge to the environment, recovery and post-treatment. One of the important differences between indirect potable and non-potable reuse is that instead of depending on the existence of a wastewater market, the commission would be creating their own *market* for potable use.

Indirect potable water reuse will be considered during the evaluation of alternatives, even though there are some important obstacles that should considered during the implementation stage of this type of program. Advanced wastewater treatment is a technology that should be considered, although it can be expensive. Also, in addition to the advanced treatment infrastructure, effluent transfer works, storage, extraction and post-treatment would be required, which would increase the costs considerably. An additional potential obstacle is public and political acceptance, something that will be contemplated later on during the elaboration and evaluation of alternatives.

Although indirect potable reuse can be considered a viable option, a detailed assessment of the potential health risks of this approach must be made. Consideration must be made of the potential public health impacts from microbial and chemical contaminants found or likely to be found in wastewater. Documentation should be made of the potential contaminants that may be found in the wastewater and a stringent industrial pretreatment and pollution source control program should be implemented to reduce the risk from a wide variety of contaminants, especially those not readily removed in treatment.

The treatment requirements for indirect potable reuse should exceed those that apply to conventional water treatment facilities. In addition, reuse infrastructure will have to be maintained and properly operated at all times with sufficient on-line standby equipment to increase the reliability o the process. The industry practice at this time for indirect potable reuse is to follow secondary treatment with tertiary treatment for nutrient removal and then to use advanced treatment for tertiary effluent. Formerly, this consisted of lime clarification, followed by multimedia filtration, and then cartridge filtration and chemical pretreatment prior to reverse osmosis treatment. More recently, advances in membrane technology have allowed a microfiltration membrane process to replace the clarification and multi-media treatment process. Similar to desalination, the reverse osmosis effluent will require post-chemical treatment prior to is use either for groundwater recharge or to supplement a surface water supply.

There also need to be studies of the aquifer or the surface water system as it is recommended that the reuse water be retained in the natural system for at least one year before it is withdrawn for potable use. During this time, natural processes tend to reduce the concentrations of enteric microorganisms beyond what occurs via dilution alone and is considered an important public health barrier for indirect

potable reuse. Finally, it should be realized that implementation of an indirect potable reuse program should be one of last resort after all other possibilities – including other water sources, non-potable reuse, and water conservation – have been evaluated and rejected as technically or economically infeasible.

It should be mentioned that there is not sufficient information available at the present time, regarding hydrogeological, geochemical and water quality conditions from aquifers, necessary to specifically analyze the feasibility of the aquifer recharge with effluent. Additionally, the permeability, transmissivity, width and other properties useful to determine rates and the amount of recharge and extraction that can be accomplished is unknown. Likewise, the quality of water from the aquifers is not known in detail to be able to determine if the water extracted will preserve the quality level with which it was recharged. It is recommended that in the future, CESPT perform detailed studies in order to determine the feasibility of this type of project in a conclusive manner.

Additional Storage

In previous sections, the possibility of constructing a new Colorado River aqueduct that would probably require the construction of a new Dam was presented. Additionally, the option of recharging tertiary effluent to the aquifer and the Abelardo L. Rodriguez Dam for its storage and later extraction were discussed.

An additional water source that could be available with the construction of a new Dam would be the additional capturing of surface runoff. However, based on the experience that we have with the Rodriguez Dam, which is located in one of the most important basins in the study zone, is not recommended to include it as a practical option for meeting the objectives of the master plan.

Optimization of the Basin and Rodriquez Dam Container Use

As was previously mentioned, the Rodriguez Dam contributed only 1 percent of the water supply for Tijuana and Playas de Rosarito in 2001, however, this source can be considerable during periods of substantial rain. Due to the generally small magnitude of this source and its erratic behavior, it is not considered a significant, reliable water source.

Despite this, it is important to establish a program to optimize the operation of the Dam and protect its basin. Currently, the Dam receives water from the Colorado River through the aqueduct that connects it to the El Carrizo Dam. The levels at which it should operate and the capacity at which the Abelardo L. Rodriguez Water Plant will be used should be identified. In addition, under the plans that include the highly treated effluent discharged into the Dam, the form and flows at which the recharge and extraction should be carried out should be studied.

Currently, the Dam's basin is only partially developed. However, it is expected that the construction of Boulevard 2000 will set off its development, which could have consequences on the quality of stored water, either from runoff, from the Colorado River, or the advanced wastewater treatment plants. In addition, urban development

of the basin would increase runoff and change runoff patterns; possibly exceeding the capacity of the dam.

Demand Management

There is a series of actions that CESPT is administering and that should continue, as well as a few new actions that should be implemented to manage water demand and with it reduce the deficit projected for the future. Education and awareness campaigns would assist in water conservation, although these should be implemented jointly with other programs such as leak detection and reduction, independently from the alternative selected.

The requirement for efficient hydraulic and sanitary facilities in homes, commerce and industry, as well as the construction of treated wastewater distribution systems in zones with concentrations of potential users, such as industrial parks, would also contribute to the demand reduction. Likewise, it would be favorable to promote the installation of dry toilets and urinals.

The establishment of a rate structure that promotes savings and discourages excessive use could be more persuasive than merely education campaigns. Under this plan the unit price for water would increase as the use increases, thereby promoting savings by favoring users of less resources.

It would be difficult for demand management programs to individually contribute in a significant manner to the reduction of water deficit. However, its joint implementation to other programs would provide important benefits.

United States Water Sources

There are plans for the use of emergency connections between Tijuana and San Diego during the 2003-2008 period to supply 158.5 gal/s (600 l/s). Currently, the governments of Mexico and the United States are negotiating the terms of an agreement for the use of the connection, which is expected to be ready at the beginning of the year 2003.This source is discussed in the demand projection in Section 6 for said period, but it cannot be considered as a potential source for the remainder of the planning period. In addition, the current agreement does not guarantee the availability of this supply at all times. If the San Diego County Water Authority member agencies have a need for this water, for example during higher demand summer months, then they have first rights to this water. Despite this, the connection will continue being a source of improvement for the city of Tijuana in case of an emergency; therefore we believe it is important to give reference to the agreement with the United States of America for the use of this connection.

The South Bay wastewater treatment plant in the city of San Diego produces a secondary effluent with potential for reuse. An option that was considered was to import secondary effluent from Tijuana for reuse. However, this option was discarded because as we will see in Section 8, Tijuana will have its own secondary treatment plants that will produce effluent of similar quality, located closer to potential points of reuse and under direct control of CESPT.

In a similar manner, the possibility of recharging the Tijuana River aquifer in United States territory was considered. However, unless the geo-hydrological studies can show that there are beneficial opportunities for doing this, there is a recommendation to evaluate the option of recharging only within Mexico.

7.2 Identification of Feasible Water Sources

Based on the discussion presented in the previous section, the most feasible options for additional water sources were identified for their consideration during the alternative elaboration and evaluation phases. A few of the options previously identified, such as the demand management program, non-potable reuse, management of the basin in the Rodriguez Dam, the improvement of wells, augmentation of the existing Colorado River supply via the existing aqueduct with the expansion and improvements in associated water treatment facilities, and the use of the emergency connection with the San Diego County Water Authority, are considered important beneficial projects that should be implemented independently from selected options or alternatives, but it is not recommended that they be considered as potential *additional* sources. Any reduction in potable water demand obtained from these actions should be considered as an additional benefit for the implementation of projects to improve identified sources.

Table 7-2 shows the potential water source options. These sources have been identified as those with the greater potential to solve the water deficit problem at least during the 20-year planning period, although alternatives such as the construction of a new Colorado River aqueduct could extend its benefits beyond this period.

Table 7-2
Options for Identified Additional Water Sources

1-1 Colorado River:	
Binational aqueduct	(1)
Mexican aqueduct	(1)
Optimization of the use of existing infrastructure	(1)
1-2 Desalination:	
Desalination of seawater	(1)
- Combined with generation of electricity	
- Unaided	
1-3 Additional extraction of groundwater:	
New wells	(1)
Well improvement	(1)
1-4 Wastewater effluent reuse:	
Tertiary treatment and advanced (micro-filtration and membranes)	(1)
- Aquifer recharge (indirect potable use)	(1)
- Rodriguez Dam discharge (indirect potable use)	(1)

7.3 Water Treatment Options

Once the most feasible water supply options had been identified, evaluation and identification options for water plants were made. Besides potential water sources, other factors such as regulation enforcement were taken into consideration as well as water quality goals recommended as part of this master plan, which are described below.

7.3.1 Potential Water Sources

As was discussed in the previous section, the water sources to be taken into consideration are the Colorado River, seawater desalination and indirect potable reuse. The additional extraction of groundwater from the Tijuana-Alamar River aquifer will be common to any alternative selected, and it has been included in the supply and demand projects in Section 6. The available needs and options for water plants vary considerably among the sources, as is described below.

7.3.2 Potable Water Quality Regulations

Mexican Official Standard NOM -127-SSA1-1994, which establishes quality permissible limits and types of treatment, as shown in Table 7-3 regulates potable water quality.

Table 7-3
Water Quality Permissible Limits Established by NOM-127-SSA1-1994

Parameter	Permissible limit
Total coliform organisms	2 NMP/100 ml 2 UFC/100 ml
Fecal coliform organisms	Not detectable NMP/100 ml Cero UFC/100 ml
Color	20 units of true color in the platinum-cobalt scale.
Odor and flavor	Nice (those that are tolerable will be acceptable for the majority of the consumers, as long as they are not the result of objectionable conditions from the biologic or chemical perspective).
Turbidity	5 units of nephelometric turbidity (UTN) or its equivalent in another method.
2,4 – D	50.00
Active substances to blue methylene (SAAM) (mg/l)	0.50
Aldrín y dieldrín (separate or combined)	0.03
Aluminum (mg/l)	0.20
Ammonia nitrogen (such as N) (mg/l)	0.50
Arsenic (mg/l)	0.05
Barium (mg/l)	0.70
Cadmium (mg/l)	0.005
Chlordane (total isomers)	0.30
Chlorides (such as Cl-) (mg/l)	250.00
Copper (mg/l)	2.00
Cyanides (such as CN-) (mg/l)	0.07

Table 7-3 **Water Quality Permissible Limits Established by NOM-127-SSA1-1994**	
DDT (total isomers)	1.00
Fluorides (such as F-) (mg/l)	1.50
Free residual chlorine (mg/l)	0.2-1.50
Gamma-HCH (lindane)	2.00
Heptachlorine and heptachlorine epoxide	0.03
Hexachlorobencene	0.01
Iron (mg/l)	0.30
Lead (mg/l)	0.025
Manganese (mg/l)	0.15
Mercury (mg/l)	0.001
Metoxychlorine	20.00
Nitrates (such as N) (mg/l)	10.00
Nitrites (such as N) (mg/l)	0.05
Pesticides (ug/l)	
pH (hydrogen potential) in pH units	6.5-8.5
Phenols or Phenolic compounds (mg/l)	0.001
Sodium (mg/l)	200.00
Sulfates (such as SO4=) (mg/l)	400.00
Total chrome (mg/l)	0.05
Total dissolved solids (mg/l)	1000.00
Total hardness (such as CaCO3) (mg/l)	500.00
Total trihalomethanes (mg/l)	0.20
Zinc (mg/l)	5.00
Source: Mexican Official Standard NOM-127-SSA1-1994	

In addition, the norm establishes that for those parameters for which the water source exceeds the maximum permissible limits, the water treatment shown in Table 7-4 should be applied. Alternatively, the water processes recommended through treatment tests can be applied.

Table 7-4 **Water Treatment Established by NOM-127-SSA1-1994**	
Parameter	**Water treatment**
Biologic contamination	
Bacteria, helminthes, protozoan and virus	Disinfection with chlorine, chlorine compounds, ozone or ultraviolet light
Physical characteristics and organoleptic	
Active substances to blue methylene	Adsorption in activated carbon
Aluminum, barium, cadmium, cyanide, copper, total chrome and lead	Ionic exchange or reverse osmosis
Ammonia nitrogen	Coagulation-flocculation-sedimentation-filtration, deaeration or column *desorcion*.
Arsenic	Coagulation-filtration-precipitation-filtration; any or the combination of them, ionic exchange, or reverse osmosis.
Chemical components	
Chlorines	Ionic exchange, reverse osmosis or distillation.
Color, odor, flavor and turbidity	Coagulation-filtration-precipitation-filtration; any or their combination, adsorption in activated carbon or oxidation
Fluorides	Reverse osmosis or chemical coagulation
Hardness	Chemical softening or ionic exchange

Table 7-4
Water Treatment Established by NOM-127-SSA1-1994

Iron and/or manganese	Oxidation-filtering, ionic exchange or reverse osmosis.
Mercury	Conventional process: coagulation-filtering-precipitation-filtering, when the supply source contains up to 10 micrograms/l. Special processes: in granular activated carbon and reverse osmosis when the supply source contains up to 10 micrograms/l; with powder activated carbon when the supply source contains more than 10 micrograms/l.
Nitrates and nitrites	Ionic exchange or coagulation-filtration-sedimentation-filtration; any or their combination.
Organic matter	Oxidation-filtering or adsorption in activated carbon
Pesticides	Adsorption in granular activated carbon.
pH (hydrogen potential)	Neutralization.
Phenols or phenolic compounds	Adsorption in activated carbon or oxidation with ozone
Sodium	Ionic exchange
Sulfate	Ionic exchange or reverse osmosis
Total dissolved solids	Coagulation-filtration-sedimentation-filtration and/or ionic exchange
Trihalomethanes	Aeration or oxidation with ozone and adsorption in granular activated carbon.
Zinc	Distillation or ionic exchange
Source: Mexican Official Standard NOM-127-SSA1-1994	

7.3.3 Quality of Identified Water Sources

Colorado River

The treatment options available for each type of source depend on the water quality. The water from the Colorado River is currently treated through two pulsator water plants, which can be considered a variation of the conventional water plants. This type of plant removes conventional parameters (suspended solids, turbidity, biologic contaminants) and reduces the concentration of other parameters such as arsenic, some metals and some organic compounds.

Table 7-5 summarizes the information on water quality available for the year 2001 at the entrance of the El Florido Water Plant. As can be seen, the monthly average concentrations for parameters sampled are below the maximum permissible limits, even before treatment. An outcome of this observation is that water from the Colorado River, in combination with a water plant could easily meet the minimum quality requirements. Based on this, the next section recommends quality goals greater than regulatory requirements, which can be obtained relatively easy. . The mission of any modern drinking water agency, such as CESPT, should be to provide a safe and potable drinking water that more than minimally meets general standards but which strives to consistently optimize the drinking water quality at a reasonable cost.

Table 7-5
Colorado River Water Quality (Monthly Averages for 2001)

Parameters	Units	Effluent Year 2001			NOM 127 SSA1 1994 Modification 2000
		Average	Minimum	Maximum	
Odor		Odorless			Odorless
Apparent Color	ClPt	9	5	25	20 REAL
Turbidity	UTN	0.9	0.7	4.0	5
Aluminum	mg/l Al	<0.04			0.20
Arsenic	mg/l As				0.05
Cianide	mg/l CN^-	<0.015			0.07
Chlorides	mg/l Cl	148	131	169	250
Copper	mg/l Cu	<0.015			2.00
Total Chrome	mg/l Cr	<0.015			0.05
Detergents	mg/l SAAM	0.04	0.01	0.08	0.50
Total Hardness	mg/l $CaCO_3$	337	320	370	500
Fluorides	mg/l F	0.64	0.55	0.68	1.50
Iron	mg/l Fe	<0.06			0.30
Manganese	mg/l Mn	0.10	<0.03	0.60	0.15
Mercury	mg/l Hg.				0.001
Nitrates	mg/l N	1.07	0.80	2.00	10.00
Nitrites	mg/l N	0.02	<0.005	0.12	1.00
Ammonia Nitrogen	mg/l N	0.30	<0.1	0.71	0.50
pH	pH	7.78	7.50	8.20	6.5 - 8.5
Lead	mg/l Pb.	<0.007			0.010
Sodium	mg/l Na	156	140	180	200
Total Dissolved Solids	mg/l	837	800	905	1000
Sulfates	mg/l SO_4	327	316	354	400
Zinc	mg/l Zn.	<0.04			5.00
Total Coliform Organisms	NMP/100 ML	91	0	>240	absent
Analyzed Parameters without Mexican Norms					
Total Alkalinity	mg/l $CaCO_3$	123	106	144	
Boron	mg/l B	0.20	<0.07	0.70	
Calcium	mg/l Ca	78	70	85	
Conductivity	usiemens/cm	1,340	1,290	1,450	
Calcium Hardness	mg/l $CaCO_3$	195	176	212	
Magnesium Hardness	mg/l $CaCO_3$	142	120	160	
Silver	mg/l Ag	<0.07			
Magnesium	mg/l Mg	35	29	39	
Silica	mg/l SiO_2	12.09	10.80	12.90	

Source: Laboratory of the Abelardo Rodríguez Water Treatment Plant, Potable Water Department, Operation and Maintenance Sub-department of CESPT, 2002.

Aquifers

Table 7-6 presents the results of the physical and chemical analyses undertaken in 2001 for groundwater wells in operation in the Tijuana River, La Misión, and Playas de Rosarito aquifers. This data is repeated from Section 2 of the master plan and only includes wells that have less than 4 months of data (wells 3, 36, 56, 17, and 14 in the Tijuana River aquifer, wells 4 and 5 of La Misión aquifer, and wells 1 and 3 of the Playas de Rosarito aquifer).

In general, the water extracted from the Tijuana River aquifer is higher in color and turbidity than the other aquifers. This implies that the aquifer is influenced by surface water at various points. The fecal coliform levels were consistently reported below 2 MPN / 100 ml. This water and the water extracted from the Playas de Rosarito aquifer is chlorinated and the samples are extracted before chlorination. All of the water had concentrations of chloride and sodium below the established Mexican limits. The highest levels of iron and manganese were found in the Tijuana River aquifer wells, and the highest levels of fluoride were found in the La Mission wells. In both cases, the concentrations were below the Mexican standards. Apparently, the wells in Playas de Rosarito had problems with the levels of manganese. As expected, these wells also had the highest levels of total dissolved solids, sodium, chloride, and total hardness, which can be attributed to saltwater intrusion as a consequence to the proximity of the wells to the ocean. The samples were taken for the fulfillment of corresponding analyses, primarily in the first six months of 2001.

Seawater

The treatment of seawater is controlled mainly by the removal of salts and low molecule weight solutes. The typical constituents in seawater requiring removal are total dissolved solids (TDS), chlorides and sodium, with trace amounts of arsenic, barium, cadmium, chromium, copper, fluoride, iron, manganese, mercury, nickel, selenium, silver, sulfates, and/or zinc requiring some level of removal as well. Typical seawater quality in this area would start with SDT of 28,000 to 36,000 mg/l, turbidity of 1 to 10 NTU, total organic carbon of 1 to 4 mg/l, and a pH of 8 to 8.5. Product water quality would be <350 mg/l SDT, ~190 mg/l chlorides, <10 mg/l nitrate as NO_3, and <10 mg/l as sulfate with undetectable levels of other constituents.

The technologies for saltwater desalination in use consist mainly of membranes or distillation. The technological advances in the membrane industry, as well as high-energy requirements for distillation, currently make the first option more desirable.

Table 7-6
Groundwater Quality (Monthly Averages for 2001)

Parameters	Units	NOM 127 SSA1 1994 modification	Tijuana/Alamar River Aquifer			La Misión Aquifer			Playas de Rosarito Aquifer		
		2000	Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
Odor		Odorless	Odorless			Odorless			Odorless		
Taste		Tolerable	Tolerable			Tolerable			Tolerable		
Color	ClPt	20 REAL	11.1	5.0	30.0	5.0	5.0	5.0	5.6	5.0	10.0
Turbidity	UTN	5	2.0	0.2	11.6	0.7	0.1	1.1	0.8	0.4	2.5
Aluminum	mg/l Al	0.20	<0.04			<0.04			<0.04		
Arsenic	mg/l As	0.05	<0.04								
Cianide	mg/l CN^-	0.07	0.020		0.066	<0.015			<0.015		
Residual Chlorine	mg/l Cl2	0.2 - 1.5	1.1	0.2	3.2				0.9	0.2	3.0
Chloride	mg/l Cl	250	580	320	880	374	350	412	1,511	354	3,620
Copper	mg/l Cu	2.00	<0.015		0.021	<0.015			<0.015		0.022
Total Chrome	mg/l Cr	0.05	<0.015			<0.015			<0.015		
Detergents	mg/l SAAM	0.50	0.14	<0.015	0.28	0.03	0.01	0.07	0.04	<0.015	0.10
Total Hardness	mg/l CaCO3	500	749	144	1,360	149	100	234	1,322	700	3,500
Flourides	mg/l F	1.50	0.79	0.36	1.25	5.06	3.47	6.70	0.50	0.33	0.64
Iron	mg/l Fe	0.30	0.32	<0.06	4.40	<0.06		0.11	<0.06		
Manganese	mg/l Mn	0.15	0.48	<0.033	0.87	<0.033		0.04	0.16	<0.033	1.50
Mercury	mg/l Hg.	0.001	<0.00005								
Nitrates	mg/l N	10.00	1.74	0.60	5.80	0.85	0.60	1.80	2.57	1.60	4.00
Nitrites	mg/l N	1.00	0.063	<0.005	0.53	0.021	<0.005	0.078	0.008	<0.005	0.134
Ammonia Nitrogen	mg/l N	0.50	0.84	0.00	2.43	0.19	0.03	0.52	1.62	0.23	6.10
pH	pH	6.5 - 8.5	7.0	6.8	7.1	7.3	6.9	8.4	7.0	6.8	7.1
Lead	mg/l Pb.	0.010	<0.007			<0.007			<0.007		
Sodium	mg/l Na	200	357	290	425	298	250	390	478	160	1,100
Total Dissolved Solids	mg/l	1000	1,800	1,000	2,400	993	895	1,080	3,218	1,340	6,700
Sulfates	mg/l SO4	400	310	138	480	166	88	210	336	160	516

Table 7-6
Groundwater Quality (Monthly Averages for 2001)

Parameters	Units	NOM 127 SSA1 1994 modification 2000	Tijuana/Alamar River Aquifer			La Misión Aquifer			Playas de Rosarito Aquifer		
			Average	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum
Zinc	mg/l Zn.	5.00	<0.015		0.168	0.063	<0.04	0.161	0.522	0.056	1.970
Total Coliform Organisms	NMP/100 ML	Absent	<2			<2			<2		
Parametros Analizados Sin Norma Mexicana											
Alkalinity	mg/l CaCO3		393	210	538	56	36	70	255	126	350
Boron	mg/l B		0.58	<0.07	2.20	3.13	1.40	4.40	0.79	<0.07	1.90
Calcium	mg/l Ca		184	40	324	44	35	62	382	160	857
Conductivity	usiemens/cm		2,993	1,700	4,000	1,597	1,420	1,690	5,524	2,200	11,610
Chemical Oxygen Demand.	mg/l O2		226	1	560	114	110	118	503	400	680
Calcium Hardness	mg/l CaCO3		406	42	810	75	34	154	887	300	2,140
Magnesium Hardness	mg/l CaCO3		228	10	550	23	8	80	603	72	1,620
Phosphate	mg/l PO4		0.08								
Silver	mg/l Ag		<0.07			<0.07			<0.07		
Magnesium	mg/l Mg		80	47	107	9	2	19	271	135	393
Silica	mg/l SiO2		25	18	122	54	8	116	58	11	117
Dif. Anion - Cation	%		-0.19	-1.90	1.20	0.35	-0.10	1.30	-0.13	-1.20	1.20

Source: Laboratory of the Abelardo L. Rodríguez water treatment plant, Department Potable Water, Operation and Maintenance Sub-department, CESPT 2001.

Wastewater Effluent

As can be seen in Section 8, the wastewater treatment plants proposed as part of this master plan will provide secondary treatment. The effluent from these plants will comply with the discharge limits established for receiving bodies such as the Pacific Ocean, but it will require additional treatment for certain types of reuse, specifically those with indirect potable purposes.

The effluent stored in the aquifer and the Abelardo L. Rodriguez Dam should present a level of quality that considerably reduces the risk of contaminating these receiving bodies and should provide a level of acceptable safety to the final user. Based on this, the portion of the effluent of the secondary treatment plants that will be used for this purpose should receive advanced treatment. As was mentioned in the previous section, , this includes tertiary treatment for nutrient removal, microfiltration for general particulate removal, and for removal of salts, low molecular weight solutes, and trace elements. Any plan to implement indirect potable reuse of wastewater should include clear effluent criteria for the treatment process.

7.3.4 Water Quality Goals Recommended for the Master Plan

As previously seen, compliance with the Mexican Regulations for turbidity can be easily met and surpassed by surface water treatment plants. Also, it is anticipated that the limits established for pathogens, which currently include only indicator organisms (fecal and total coliforms), can be easily met. Additional research should be performed to find a way to remove *Giardia* and viruses. Table 7-7 shows the quality limits recommended for the master plan for certain parameters and approved by the Binational Technical Committee. The parameters not shown in the Table will be governed by NOM-127-SSA1-1994.

Table 7-7
Goals for Potable Water Quality Recommended for Certain Parameters

Parameter	Direct filtration or in line	Conventional water plant
Turbidity	<1 UTN in 95% of monthly samples, 5 UTN maximum	<0.5 UTN in 95% of monthly samples, 1 UTN maximum
Primary disinfection	3-log (99.9%) reduction of *Giardia* with 2-log (99%) reduction in filtration and 1-log (90%) in disinfection 4-log (99.99%) virus reduction with 1-log (90%) reduction in filtration and 3-log (99.9%) in disinfection	3-log (99.9%) Giardia reduction with 2.5-log (99.7%) reduction in filtration and 0.5-log (68%) in disinfection 4-log (99.99%) virus reduction with 2-log (99%) reduction in filtration and 2-log (99.9%) in disinfection
Total coliforms	Absent	Absent

7.3.5 Water Options Available for Each Source

Water plant options were specifically identified and evaluated for each one of the previously identified sources, due to the water quality differences that exist between them, specifically with regards to the concentration of dissolved solids (in seawater), and potential contaminants (for indirect potable reuse). The following are the options available for each source, while the next section identifies water plant options for each one of the potential sources.

Colorado River

The waters from the Colorado River can be treated through conventional processes, similar to those currently used, or through their variants, such as direct filtration or in line filtration. Conventional treatment consists of coagulation, flocculation, sedimentation and filtration processes. This type of treatment is used widely for surface waters that have a high turbidity. The conventional treatment is applicable to a relatively wide range of turbidity, color, and odor levels, which gives this option great flexibility. Likewise, the sedimentation and filtration processes contribute to the disinfection of water through the physical removal of organisms and the removal of particles, which reduces disinfection requirements at the end of the process and improves reliability. Lastly, the charge rate of filters in this process is relatively high (up to 585 $m^3/m^2/day$ or 10 gallons per minute per square foot).

The conventional treatment process is simplified and the investment costs are reduced through direct filtration processes (coagulation-filtration-filtration) or in line filtration (coagulation-filtration). However, these processes are only effective for waters with low turbidity, color and odor and they support smaller charge rates (less than 264 $m^3/m^2/day$ or 4.5 gallons per minute per square foot). The water quality must also be stable without significant fluctuation that might occur if the source is impacted by local runoff or if periodic algae blooms occur. Likewise, disinfection requirements at the end of the process are greater.

The background regarding river water quality presented in Section 3 indicates that the water from this source could probably be treated through direct or in line filtration, which is effective for waters with low concentrations of turbidity and the cost is less compared to conventional treatment. However, the information available is not sufficient to finally determine if this degree of treatment will be sufficient. In addition, during the rainy season when waters from the river stored in Dams are combined with local runoff, the turbidity concentrations in raw water could exceed the water plant design criteria. Lastly, for alternatives that include indirect potable reuse as a supply option, flexibility is required to store water from the river in combination with high quality effluent, or with the previously mentioned runoff.

Seawater

The main parameter that needs to be removed in order to treat seawater is dissolved solids (salts). The two most frequently used methods of desalination include the use of membranes and distillation. In recent years membranes have been the technique of choice due to technological advances and for its lesser energy requirements. The

main membrane technologies available are reverse osmosis, micro filtration, and ultra filtration.

Reverse osmosis is an effective high-pressure process to remove dissolved solids, particles and microbiological contaminants. Due to the existing potential for the clogging of membranes, it is necessary to install a pre-treatment process before the membranes, such as the coagulation-filtration processes, or chemical compound additives. Likewise, after membrane treatment the water should be disinfected and conditioned to prevent or reduce corrosion in the transfer and distribution lines. Of the three membrane technologies previously mentioned, reverse osmosis is the most efficient for the removal of dissolved solids in high concentrations.

The micro and ultra filtration processes are effective low-pressure systems for the removal of particles and microbiological contaminants at a range of 0.01 to 0.1 microns, therefore they are not suitable for desalination of water with high concentrations of dissolved solids, such as seawater. These processes have similar pre- and post-treatment requirements to those of reverse osmosis.

Indirect Potable Reuse

The treatment needed for indirect potable reuse consists of two or more stages. First, secondary treatment of wastewater is required, as described in Section 8. Secondary treatment will remove the majority of the organic matter, suspended solids and pathogen organisms. However, other parameters, such as metals, organic compounds, salts and viruses, will not be removed effectively through this process. The secondary effluent will be appropriate for disposal into the sea and for certain types of non-potable reuse, but not for potable use.

After secondary treatment, the portion of the secondary effluent that will be reused should be treated at a more advanced level before being discharged into the receiving body (Dam or aquifer).

Lastly when water is extracted from the receiving body for its potable use, it should be treated once again to eliminate potential pollutants that may have contaminated the receiving body during storage.. The type of post-treatment will depend on the characteristics of the receiving body and its susceptibility to the contamination or mixture with water from other sources.

The main options for advanced wastewater treatment are tertiary treatment (removal of nutrients), dilution with water from other sources (for example the Colorado River) or the use of membranes.

Tertiary treatment would notably improve the quality of the secondary effluent, mainly through the additional removal of nutrients, particles and microbiological organisms. This type of effluent has a greater potential for reuse than secondary effluent, but it would be difficult to comply with the necessary quality limits needed for indirect potable reuse. The capability of this type of treatment to remove viruses,

metals, organic compounds and other parameters is not sufficiently high to guarantee the health of the users.

The dilution of the secondary effluent with water from other sources, such as the Colorado River, would reduce the concentration of contaminants but would not result in the *removal* of those contaminants, which could continue being a public health risk, especially with regards to biological contaminants.

Membranes represent the option with the greatest capability to produce high quality water. The reverse osmosis process, which is explained in the previous section, is appropriate for the removal of dissolved solids, metals, organic substances and pathogen organisms that may be present in the effluent. However, given the quality of the effluent in relation to suspended solids and other types of particles, it is convenient to add some type of pre-treatment that eliminates particles of a larger size to reduce membrane clogging and increase efficiency. Micro filtration is an option that is commonly used in combination with reverse osmosis for this purpose. As was explained in the previous section, micro filtration is also a process based on membranes, but with a porosity designed for the retention of thicker particles.

7.4 Identification of the Most Feasible Water Treatment Options

Due to the differences in water quality that exist between the various previously identified water sources, the following description of the evaluation and identification of water plant options for each source is provided.

Colorado River

As was seen in the previous sections, water from the Colorado River is of a good quality and it can be treated with relatively simple and economic systems, such as direct filtration or in line filtration. However, given that the water from the river is stored in either the El Carrizo Dam or the Abelardo L. Rodriguez Dam, where stored water is mixed with surface runoff from local basins and could be combined with advanced effluent from treatment plants, it is convenient for planning purposes to consider the use of an advanced water treatment method. However, it should be mentioned that once the master plan has been concluded and the preferred alternative has been selected, additional water quality and treatment studies that reduce treatment requirements and costs should be carried out.

Seawater

Reverse osmosis represents the only desalination option that warrants consideration in the master plan. The technological advances in membrane technology, combined with the major energy requirements from other options, has allowed reverse osmosis to be applied and considered in other cities throughout the United States and Mexico.

Indirect Potable Reuse

Of the options presented in the previous section, reverse osmosis is the one that guarantees the highest level of water quality, which is of great importance in the

master plan, since health risks and contamination of receiving bodies of water should be minimized as much as possible. A micro filtration process that will eliminate larger particles will precede the reverse osmosis process to reduce the likelihood of membrane clogging which will in turn increase efficiency.

The reverse osmosis effluent discharged into the Dam should be treated once again when extracted from the Dam for its distribution. The process that is recommended for post-treatment is conventional treatment, for the same reasons as were discussed for the Colorado River water.

Lastly, the reverse osmosis effluent injected into the aquifer will not be treated after its extraction for distribution, except for the chlorination process commonly carried out in wells. However, it should be mentioned that it will be necessary to carry out a detailed study of the water quality and geo-hydraulic characteristics of the aquifer before implementing this alternative, in order to establish whether or not the quality of the injected water will be maintained while stored in the aquifer.

Table 7-8
Prioritized Water Plant Options

Water Source	Water Plant Option
Colorado River	Conventional water plant (coagulation-filtration-sedimentation-filtration)
Seawater	Reverse osmosis
Indirect potable reuse	Micro filtration-reverse osmosis

7.5 Identification of Potential Sites for the Construction of Water Treatment Plants

The selection of sites to build water plants was carried out taking into consideration the availability of land, location of water sources, location of current and future service zones, and the demand expected in each one of these zones based on development plans from both municipalities and land use. Future service areas include zones that are currently lacking potable water service, as well as future growth zones.

For planning purposes, the identification of potential sites was done at a general level. In subsequent phases it will be necessary to identify, evaluate and select specific sites based on more detailed studies and facility plans. The potential sites identified in this plan will help determine the general area in which the facilities of this plan should be located.

The demands in each service zone were estimated by using population projections and water demand presented in Sections 5 and 6, for current and future conditions.

As a first step eight potential sites were identified (including two desalinization plant construction sites) in base maps developed for this study, which include topography, planimetry of the urban area and projected growth zones. Later, the sites identified in the maps were toured to determine the feasibility of their use. Based on the field trips the list of potential sites was reduced to the five sites shown in Figure 7.1.

It is important to clarify that within the following stages of the study pre-project and project, it should be necessary to evaluate and select the exact location of the lot based on the following: the real dimensions of the plant, geology of the land, the title to the land and the acquisition value of the land.

The eight potential sites identified are briefly described below.

Alamar Site
This site is located on the banks of the Alamar River on the east zone of Tijuana, 100 m.o.s.l. This site is located on the lower part of the city on the right bank of the Alamar River, therefore in order to send water to any regulation tank in the city, pumping would be required. A portion of the wastewater will be subjected to advanced treatment before being extracted from and injected into the Tijuana and Alamar River aquifer as part of the indirect potable reuse program.

El Carrizo Site
This site is located to the east of Tijuana and to the north of the El Carrizo Dam, aligned with the Dam's curtain, 450 m.o.s.l. The whole urban area of the city and areas where future growth is expected can be seen from this site. Additional water from the Colorado River could be recovered at this site, as a result of the strengthening and expansion of the existing aqueduct system.

El Florido Site
This site is located to the northeast of the El Florido Water Plant and is bordered by the water plant lot. Its elevation is 240 m.o.s.l. and it services approximately 70 percent of the current and future urban area in the city of Tijuana. It will require pumping to send water to the east side of the city, where future residential and industrial settlements are planned. At this plant water from the Colorado River would also be treated, or it could be used to treat water from the Abelardo L. Rodriguez Dam, which would be transported by the existing pressure line that connects it to the El Florido Water Plant.

Expansion of the Abelardo L. Rodriguez 1 Site
The current site of the Abelardo L. Rodriguez Water Plant has a surplus of land that would allow, if necessary, the expansion of this plant. The land is located at 75 m.o.s.l, which is above 20 to 30 percent of the city's area. Therefore it would be necessary to pump water to the parts of the city that are above the water plants elevation.

Abelardo L. Rodriguez 2 Site
This site is being considered for the construction of the new plant, and it is located to the south of the Abelardo L. Rodriguez Dam, aligned with the Dam's curtain, at an elevation of 225 m.o.s.l. A plant at this site could treat water from the Dam, which would originate at the Colorado River or through highly treated effluent discharges as part of the indirect potable reuse.

This site is located above approximately 50 percent of the current and future urban area. Therefore pumping is required from this site to provide service to those portions of the city found at a higher elevation.

Fraccionamiento Valle Dorado Site
This site is located on the south part of Tijuana and close to the subdivision of the same name, and it is located at 400 m.o.s.l. This site is one of the highest to the south of Tijuana and it overlooks the entire urban area of the Tijuana River basin (Playas de Tijuana) and the existing and future growth areas in the northern zone of the municipal seat of Playas de Rosarito.

The plant located in this site will be used in those alternatives that contemplate the construction of a new Colorado River aqueduct. The construction of a plant in this site will require a conveyance line from the aqueduct delivery point.

Besides the areas proposed for the water plants, two additional sites were proposed for the desalination plants.

Playas de Tijuana Desalinating Site
This site is located to the South of Playas de Tijuana and west of the Tijuana-Ensenada toll highway. The level of the land at this site is approximately 90 m.o.s.l., therefore seawater would have to be pumped to this point for its desalination and later to the distribution tanks.

Rosarito Desalination Site
The second proposed site is located to the north of the Playas de Rosarito and to one side of the hydro-power plant. The site is located at an elevation of 45 m.o.s.l. As with the previous site, it will require pumping water from the sea to the desalinating plant and later from the desalinating plant to any part of the city of Playas de Rosarito or Tijuana.

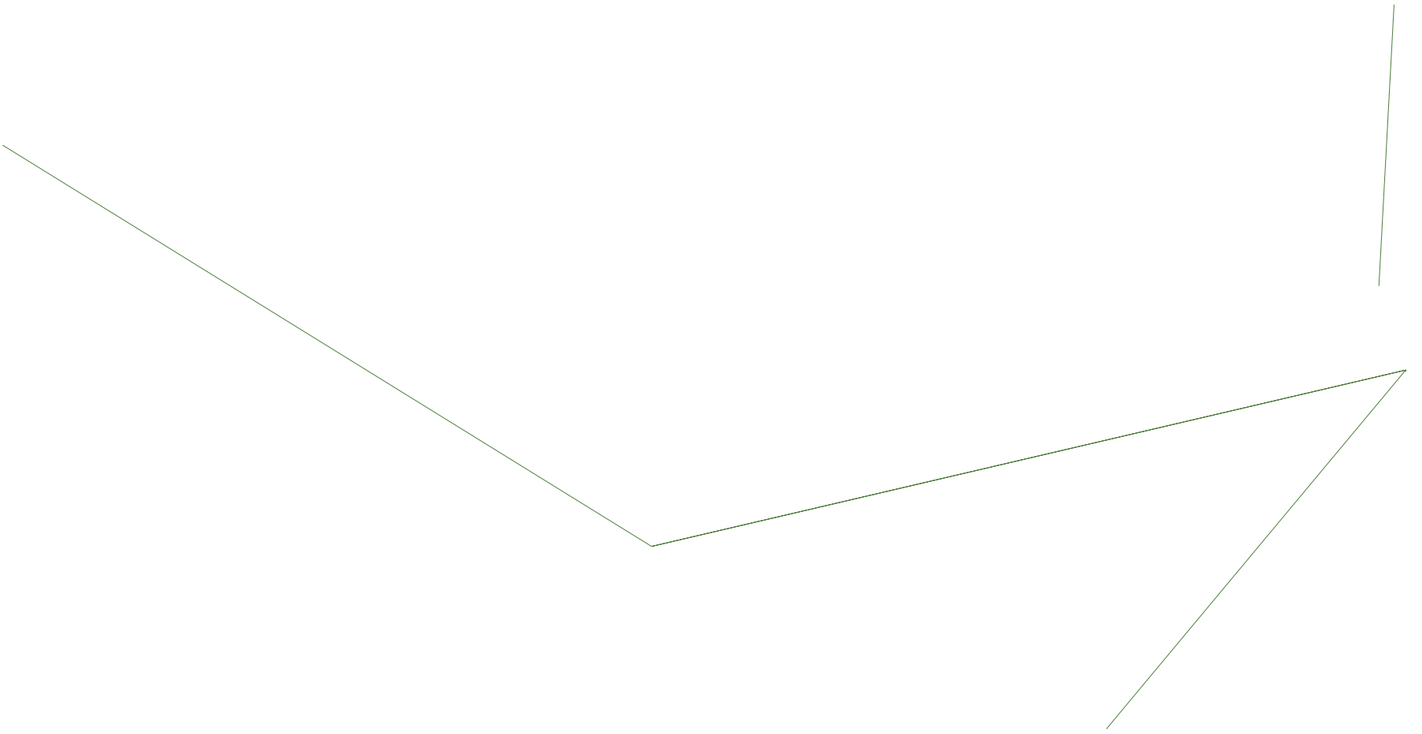
Most Feasible Site Identification
The criteria for identifying the most feasible proposed sites to develop alternatives were the following:

- Land availability
- Feasibility of construction
- Land geography
- Surface geology of the zone
- Near the supply source
- Accessibility level for feeding water

- Recovery feasibility
- Level of control of the supply area
- Possibility for short term development
- Convenience for transporting equipment and material used at the plant (roads)
- Current and future use of soil

Of the previously described sites for the construction of water plants, two were discarded and four were accepted. The sites that were discarded are El Carrizo and Abelardo Rodriguez 1 (site of the current plant). El Carrizo was discarded due to geographic conditions, which include prominent gradients. In addition, the site is far from the urban area, which would result in high pumping requirements.

The El Carrizo site would also present other important advantages due to the high lot it has, as well as its closeness to the dam In later phases of the master plan, the feasibility of utilizing the El Carrizo and Valle Dorado sites must be studied in detail. On the other hand, the Rodriguez 1 site has a limited surface that would make it difficult to build a new plant or expand the existing plant.

The other four sites (Alamar, El Florido, Rodriguez 2 and Fraccionamiento Valle Dorado) were accepted for the integration of water supply alternatives, which are presented in Section 9.

With regards to the two proposed sites for the desalination plants the one located in the City of Tijuana was discarded, close to Playas de Rosarito, because it did not have sufficient space for construction.