

## CHAPTER 6

### WASTEWATER TREATMENT AND EFFLUENT DISPOSAL

#### 6.1 INTRODUCTION

Modern municipal wastewater treatment plants are capable of efficient biological reduction of wastewater pollutants and producing high-quality effluent and biosolids (sludge). Municipal wastewater treatment can be implemented in either a “centralized” single plant or “de-centralized” as two or more wastewater treatment plants. Most municipal wastewater treatment facilities are generally designed for a service life of at least 50 years. This report recommends only two different treatment plant processes for Clinton; Sequencing Batch Reactor (SBR) or Membrane Biological Reactor (MBR). Other treatment process technologies mentioned in the *Wastewater Facilities Plan, Clinton WA*, March 1995, R.W. Beck, are recommended to be eliminated from further consideration.

A variety of modern wastewater treatment options can significantly improve the local environment, public health conditions and land utilization opportunities. Over the past decade many new technologies have been developed, tested and implemented for wastewater collection, treatment, and disposal which have expanded the viable options available for rural communities such as Clinton. The opportunity and ability to implement effluent reclamation and reuse has evolved significantly as well.

This plan considers the use of a relatively new wastewater treatment process option: Membrane Biological Reactor (MBR) which has only recently been marketed in this region. MBR process technology provides some expanded opportunities for municipal wastewater treatment for Clinton. Some key advantages of MBR process in comparison to other common wastewater treatment plants, are summarized as follows:

- Produces extremely high quality effluent that is ideal for effluent reclamation and reuse.
- Plant is efficient, easy to operate, highly reliable and has low maintenance needs.
- Very small footprint for plant tankage and equipment such that the whole facility can usually be installed inside a building.
- Small, “package plant” systems can be engineered and installed quickly and are ideal for de-centralized treatment using multiple small plants.
- A single, centralized plant can be engineered for future capacity expansions that can be done in small incremental steps at modest cost.

In addition, the opportunity and ability to implement effluent reclamation and reuse has evolved significantly. The State Legislature amended the 1992 Reclaimed Water Act in 1995, 1997 and 2001 and correspondingly the Washington Department of Ecology (DOE) and Washington Department of Health (DOH) promulgated numerous regulatory standards and design guidelines. Presently there are more than 30 municipal wastewater effluent reclamation and reuse projects in Washington state that are either constructed/functioning or in advanced planning stages. In 2001, Engrossed Substitute House Bill 1832 included an incentive program exempting 75 percent of the amounts received for reclaimed water services for commercial and industrial uses from the state public utility tax.

## **6.2 MEMBRANE BIOLOGICAL REACTOR (MBR)**

Membrane biological reactor process (MBR), also called immersed membranes, submerged membranes or microfiltration, is an activated sludge process that utilizes a physical barrier, a plate-type membrane, to separate the wastewater solids from the liquid. Membrane microfiltration technology for wastewater treatment is relatively new in the United States, however it has been in use in Europe and Japan for many years. MBR wastewater process equipment is being implemented for use or testing in increasing frequency in this region, including the following locations:

- Tulalip Tribes, Quilceda Village & Casino, Marysville, WA, 1.2 MGD
- Bandon Dunes Resort, Southern Oregon, 0.125 MGD
- Eagle Crest Resort, Central Oregon, 0.10 MGD
- City of Duvall, WA, Pilot plant
- Jamestown – S’Klallum Tribe, Seven Cedars Casino, Olympic Peninsula WA, 0.125 MGD
- West Point Wastewater Treatment Plant, King County, WA, Pilot plant
- Stevens Pass Ski Area, WA, 0.20 MGD
- City of Concrete, WA

The most significant difference between other activated sludge processes and the MBR process is that the MBR process does not require a clarifier or settling tank. This eliminates the problems, risks, challenges and costs associated with operation of most conventional activated sludge treatment plants to maintain a biomass that can consistently settle by gravity. Operation of the MBR plant is significantly simplified and controllable. In addition, the MBR process occupies a relatively small area because the mixed liquor suspended solids (MLSS) of the reactor tank are at a much higher concentration than ordinary activated sludge processes. An additional advantage of the MBR process is that it is ideally suited for biological nutrient removal (BNR) applications as coagulated metal salts are easily captured as phosphorous in the waste sludge. Nitrogen removal is inherently provided by the MBR process which is very important for effluent reclamation and reuse purposes.

Wastewater entering the MBR process is collected in an equalization tank in order to dampen the surge flows from pump stations, etc. and is screened to remove floatable or

grit materials of a size 1/8-inch or larger. A regulated amount of flow is then transferred to an anoxic tank where a recycle stream of flow from the MBR reactor tank is mixed with the influent wastewater that serves three purposes: removes nitrates, recovers lost alkalinity and improves filterability.

The MBR reactor is essentially a high concentration MLSS activated sludge process with an integral (in-tank) solid-liquid separation mechanism – membrane unit. Membrane units are available in two configurations: flat panels or hollow fibers. Flat panel membranes as used in the MBR process have many important advantages over the hollow fiber type, thus flat panel type membranes are recommended. Flat panel membranes are arranged in parallel assemblies called “cassettes”. The membranes have an average porosity of 0.4 microns and an effective porosity of 0.1 microns which is small enough to block virtually all bacteria and viruses. The diffuser case supports the membranes and houses the aeration diffuser equipment. As air bubbles are emitted at the diffuser in the bottom and channeled between each of the membrane panels, the aeration action serve three purposes: to transfer oxygen to the wastewater organisms for biological assimilation, sweep solids away from the surface of the membranes and to create a pressure gradient between the top and bottom of the membrane cassette.

Occasionally, a membrane cleaning procedure using bleach solution should be performed to remove fouling and restore optimum trans-membrane capacity. The cleaning process is fully automatic and takes only a few hours. Replacement of membranes should be anticipated at approximately 8-year intervals, however longer service life is possible under some conditions. The purchase cost of membrane units were previously rather high, however such costs have steadily declined due to higher production quantities and advancements in the manufacturing process.

The trans-membrane pressure gradient created by the system, forces water from the MLSS through the membrane into a permeate stream leaving the solids behind. The permeate (filtered) water is the effluent stream from the plant and is equal to or better than effluent from conventional activated sludge plants with tertiary treatment (sand or fabric filters).

Flow through the plant is regulated by a flow control valve on the permeate lines and liquid levels in the MBR tanks. The system is fully automated using programmable logic controllers (PLCs, computers).

Another significant advantage of the MBR technology is that increases in treatment capacity can be added in small increments by simply installing additional membrane cassettes in existing tanks. Equipment such as pumps and aeration blowers can be replaced and upsized at specific intervals because they usually have a service life of 10 to 15 years.

In summary, the key advantages of MBR process are as follows:

- No clarifier/settling tank necessary
- Accommodates small incremental expansions
- Produces high quality effluent (exceeds Class A reclaimed water standards for reuse)
- Small facility footprint
- Low operator attention, automated
- Nutrient removal capability

MBR treatment plants can be implemented in either of two ways: custom engineered (single-central) plant, or pre-engineered package (de-centralized) plant. The custom engineered plant would be used for the single, centralized treatment approach (Option 3) and would be very comparable to an SBR plant in which the process equipment is purchased and installed in site-built concrete tankage, process piping etc. The pre-engineered package treatment plants would be smaller in size and are mostly preassembled including tankage and process piping, pumps, blowers etc. and trucked to the site to be installed on a foundation. If MBR technology is used, pre-engineered package plants are proposed for the de-centralized system (Option 2).

### **6.3 SEQUENCING BIOLOGICAL REACTOR (SBR)**

The *Wastewater Facilities Plan, Clinton WA*, March 1995, R.W. Beck, presented a good summary description of the Sequencing Batch Reactor (SBR) process and some excerpts are repeated in the two following paragraphs. The technical evaluations and recommendations developed in that report related to the SBR process, are still considered reasonable and consistent with potential wastewater treatment technology to sewer the Clinton area. This document presents updated information for the SBR process related to capacity and costs that correspond better with the current population and land use criteria.

*(From the R.W. Beck Report):*

The sequencing batch reactor (SBR) is a form of the activated sludge process in which aeration and solids separation takes place in the same tank, eliminating the need for separate secondary clarifiers. The process employs a five-stage cycle: fill, react, settle, decant, and idle. During the fill stage, wastewater enters the tank and mixes with the settled biological solids remaining from the previous cycle. The tank is normally mixed during the fill stage and may be aerated. During the react stage, the mixed liquid is subject to aeration, causing oxidation of organic matter. Aeration and mixing are stopped during the settle stage, allowing solids to settle. Clarified supernatant is withdrawn during the decant stage. After decanting, some solids are wasted from the bottom of the tank to sludge processing facilities during the idle stage.

Most small municipal SBR plants consist of two parallel tanks. With two reactor tanks operating in parallel, the influent is directed only to one of the tanks at any one time so that no influent enters a tank during the react, settle, decant and idle stages. Critical components of an SBR system include the aeration system, the decant system and the control system. Jet aeration is quite common because of its ability to mix independent of aeration. Diffused air systems with separate mixers are also used.

#### **6.4 EFFLUENT DISPOSAL, RECLAMATION AND REUSE**

There are two basic options for disposal of treated wastewater effluent from a central wastewater treatment plant at Clinton; marine deepwater discharge outfall into the adjacent Possession Sound or local onsite reclamation and reuse. If the wastewater effluent is treated to a high level (Class A per Washington State Dept. of Ecology and Washington Dept. of Health) then there are opportunities to utilize the reclaimed water for a variety of beneficial uses. Such beneficial uses include; landscape irrigation, groundwater recharge, stream augmentation and wetlands. Golf course irrigation at Holmes Harbor is a good example of one of the first efforts in Washington State to implement wastewater effluent reclamation and reuse. The MBR process is capable of producing Class A effluent without additional treatment steps, however the SBR process would need an additional treatment step involving tertiary (sand bed or fabric filter) filtration (Option 4, Chapter 7). Effluent discharged to a marine outfall does not need to be of high quality and is considered practical only with the SBR process at secondary standards (Option 5, Chapter 7).

The following discussions summarize the current knowledge and intentions regarding the potential use of tertiary treated wastewater effluent for local beneficial needs and for disposal by subsurface drip irrigation methods.

##### **Subsurface Drip Systems**

Subsurface drip systems are proposed as the primary means of disposing of treated effluent in the early years of operation when flows are small. It is not intended to be the sole long-term method of effluent disposal. Subsurface drip systems would be planned, built and operated in accordance with the requirements of the *Interim Recommended Standards and Guidance for Subsurface Drip Systems, DOE and DOH, January 15, 2002* together with input from the local health officer. Subsurface drip systems provide a safe and reliable means of applying water (treated wastewater) to the near-surface soils where it is available for vegetative uptake but can also percolate deeper into the soil – similar to a septic system drainfield. For the purposes of this study, it is assumed that the primary drip system would be installed at the local baseball field / park area on a portion of the 2.3-acre site. In addition, the 40-acre DNR property may also provide suitable area for a subsurface drip system. Both of these sites are anticipated to have soils that will be conducive to this use. More extensive examination of the soils at candidate sites would be conducted later during development of the Capital Facilities Plan. Subsurface drip systems can often be installed without re-grading the land and

without removing existing trees. Additional sites may also be added, as they become available. The main advantage of subsurface drip systems is that people are never exposed to the reclaimed water. In addition, subsurface drip systems can operate almost continuously, 12-months per year except during repairs or perhaps during exceptionally wet weather events that oversaturate the soils. Containment ponds with a minimum of 20 days of emergency storage will be provided.

**Existing and Future Potential Uses for Reclaimed Water**

It is recommended that the long-term strategy for effluent disposal be based on implementing multiple methods of reclamation and reuse. It is recommended that a number of different reuse options be developed to reduce the risk of deficiencies or overloading. It would be important to provide a high level of flexibility to operate the reuse sites at optimum conditions and loadings. In addition to subsurface drip systems, the next-best method for water reuse is for seasonal vegetation irrigation such as turf grass, pastures, landscaping, orchards, plant nurseries etc. These uses could provide an opportunity to reduce the use of potable water. Other environmental-based reuse opportunities include streamflow augmentation, wetland discharge and groundwater recharge. All of these opportunities should be studied in greater detail in the Capital Facilities Plan. Planning and regulatory approval for these environmental-based methods, require more time and cost to implement but do offer valuable benefits.

**Estimated Annual/Seasonal Volume of Reuse Water**

The total amount of reclaimed water is essentially equal to the quantity of sewage flow generated by the community. It is proposed that the reuse strategy attempt to maximize the beneficial influence on the potable water facilities by substituting potable water uses with reclaimed water and recharging the aquifer. Wetlands and stream augmentation will be pursued if deemed beneficial to the environment or wildlife. The following table (Table 6.1) shows the various reuse methods proposed and the approximate reclaimed water allocation proportions:

**TABLE 6.1  
RECLAIMED WATER / REUSE ALLOCATION STRATEGY**

<b>YEAR</b>	<b>1- 5</b>	<b>6-10</b>	<b>15- 20</b>	<b>20+</b>
<b>APPROXIMATE REUSE WATER VOLUME, gpd</b>	<b>100,000</b>	<b>130,000</b>	<b>150,000</b>	<b>165,000</b>
Subsurface Drip Systems	70%	40%	25%	10%
Vegetation Irrigation	30%	25%	20%	20%
Groundwater Recharge	0%	25%	40%	50%
Wetlands and Stream Discharge	0%	10%	15%	20%

## **Level of Treatment Required**

The recommended minimum level of treatment for reclaimed water is Class A as defined by the Water Reclamation and Reuse Standards published by DOE and DOH. This high quality effluent is safe for human contact and provides the greatest number of private and public reuse opportunities including irrigation of food crops, open-access landscape irrigation and industrial water. In addition, other more environment-based or community-based reuse opportunities can be more readily implemented such as streamflow augmentation, wetland discharge and groundwater recharge. Although the MBR process does not involve coagulation (with chemical filter aids) as stipulated in the Criteria for Sewage Works Design manual for Class A reclaimed water, it is anticipated that DOE and DOH will waive that requirement.

## **Ability of Treatment Method to Meet Standards**

The reuse water quality achieved by MBR treatment is typically far superior to that obtainable from conventional filtration methods plus disinfection. Typical values for microfiltration are <0.2 NTU turbidity, non-detectable levels of total coliform bacteria and 3 to 4-log removal of viruses. It is proposed that chlorine will be applied to the reuse water in accordance with reuse regulations and dechlorination will be used where necessary.

If Option 4 (SBR with tertiary filter. See Chapter 7 ) is utilized, there may need to be extra emergency storage volume available in order to detain "off-spec" effluent. The most common method of tertiary filtration is continuously backwashing sand filters however, fabric filters also perform very well. These filtration methods typically depend upon chemical filter aids and disinfection to remove suspended solids and bacteria to acceptable levels.

The MBR (microfiltration) process is more reliable and would need only minimal emergency storage volume. The microfiltration membrane (MBR) is actually capable of producing Class A reclaimed water without chemical aids or disinfectant.

## **Considerations related to Potable Water Supply and Water Rights Evaluation**

In 1982, the USEPA designated the aquifers beneath Whidbey and Camano Islands as sole-source aquifers. The Clinton Water District currently has sufficient water rights and facilities for current and near-term needs but has no immediate alternatives for additional new potable water supply. Long-range water supply for CWD is somewhat uncertain.

## **Reclaimed Water Distribution System**

It is anticipated if the reclaimed water is collected as part of a centralized collection system, the distribution pipelines would extend to selected sites that would be identified

in the Capital Facilities Plan (yet to be produced) and would include; subsurface drip disposal, vegetation irrigation, wetlands discharge, stream augmentation and groundwater recharge. It is recommended that a distribution network be extended at the same time the collection sewers are constructed. The design and construction will meet the requirements of the Criteria for Sewage Works Design, however based on current standards, it is not possible to joint-trench reclaimed water with sewer mains or potable water pipes. Significant cost savings would be realized if that requirement could be relaxed. The de-centralized treatment plant option will provide the ability to utilize reuse at dispersed locations near each respective treatment plant.

### **Technical Feasibility**

The potential exists to implement many of the different water reclamation and reuse methods as defined in the Water Reclamation and Reuse Standards by DOE and DOH. One potential strategy would be based on a phased sequence of planning and implementation that begins with subsurface drip systems and evolves to other methods as deemed appropriate by the Capital Facilities Plan. Placing high priorities on reuse opportunities could offset potable water demands and improve the aquifer by direct recharge and/or controlling seawater intrusion. Where appropriate, environment-based reuse will be implemented.

### **Economic Feasibility**

MBR wastewater treatment process technology (Options 2 and 3, Chapter 7) does not rely on chemicals or disinfectants to achieve Class A quality reclaimed water and the cost of membranes is actually declining. Consequently, the ongoing operating and maintenance cost for MBR technology to produce reclaimed water, is expected to remain more stable and predictable than other treatment technologies.

Presently, the CWD is using the water from a sole-source aquifer and has no readily identifiable alternative water supply sources. Assuming that local surface waters are not available, the only feasible concept is to extend a long-distance transmission main to connect with the nearest regional water supplier. The Anacortes water transmission main is located approximately 36 miles to the north but Clinton (and any communities south of Oak Harbor) are not included within the Anacortes customer service area. The cost to extend such a pipeline would be prohibitively expensive and a project of this type is likely to have insurmountable permitting challenges. Another option is desalination of seawater to produce potable water. However, that method is not practiced on a community-wide scale in this region and thus is considered technically and economically infeasible for Clinton at this time.

The ability of CWD to utilize reclaimed water as a new water source, is expected to provide a valuable asset in comparison to other options. A more detailed assessment for using reclaimed water for groundwater recharge can be provided in the Capital Facilities Plan – subsequent to this study.

## **Marine Outfall**

The *Wastewater Facilities Plan, Clinton WA*, March 1995, R.W. Beck, presented a good summary of the marine outfall options and some excerpts are repeated in the following three paragraphs. The design development and recommendations developed in that report are still considered reasonable and consistent with potential wastewater treatment technology to sewer the Clinton area however this report presents updated construction cost information.

*(From the R.W. Beck Report):*

An outfall is considered a point discharge and therefore under Washington State law must not degrade the water quality of the receiving body. An outfall pipe with a diffuser section at the end typically extends from a wastewater treatment plant into the receiving waters to effectively dilute and disperse the effluent without adversely impacting water quality.

Design of an outfall is based on wastewater flow, degree of treatment, and physical conditions in the receiving water such as depth, current, and density. The jet effect provided by ports in the diffuser section induces mixing of the effluent with marine water. Because wastewater is less dense than the marine receiving waters, the effluent will form a “plume” and will rise due to buoyancy. As the plume rises it is further diluted with the marine water. Finally, the travel and dispersion of the plume is dependent upon currents. Mixing zones are established by Department of Ecology for all outfalls. Water quality standards can not be violated outside the mixing zone.

It is difficult to locate a new outfall in Puget Sound because of environmental considerations and the requirements of various regulatory agencies including the Washington State Department of Ecology, Department of Natural Resources, Department of Fisheries and Wildlife, and Department of Health.

## **Disinfection**

Recommended options for effluent disinfection methods include chlorine and UV irradiation. UV is a popular and effective disinfection method and would be appropriate for effluent disposal from an SBR plant to the marine outfall. However, UV equipment does not normally “modulate” to adjust irradiation output to match varying effluent flow rates. Consequently, an SBR plant would need an effluent flow equalization tank to operate in a cost effective manner. For effluent reclamation and reuse options, chlorine is recommended so that a residual disinfection capability is accomplished. Effluent reclamation and reuse options involving potential human contact should be disinfected with chlorine. However, high-quality effluent discharge to the natural environment (streams, wetlands etc.) with sensitive aquatic organisms, may be better accomplished with UV irradiation.

## **6.5 WASTEWATER SOLIDS**

The type of collection system chosen will affect the solids handling portions of the proposed treatment plant facility. If the sewage collection is done by septic tank effluent pumping (STEP), or small diameter gravity sewers, the sludge (sewage solids) will be mostly retained in the customer's septic tanks which would be periodically pumped out. Disposal of septage would likely be done elsewhere such as at the Island County Septage Handling Facility. Consequently, the Clinton treatment plant would receive and handle only a very small quantity of sewage solids. Conversely, if sewage collection is done by conventional gravity mains, grinder pumps etc. - without septic tanks on the customers site, then the treatment plant would need to receive, treat and dispose of all sewage solids generated in the service area. With this scenario it is possible to land-apply biosolids to local agricultural, pasture or forest lands or to make compost products that are suitable for public use or commercial sale.

Other options would transport treated, thickened sludge to other nearby wastewater treatment plants for further processing and disposal. Langley, Washington is the closest existing plant on the Island. However there is no surplus sludge processing capacity at Langley currently. Island County operates a sludge treatment facility and is expected to continue to receive septage from the existing number of residents and businesses. Collaboration with Island County is needed to assure capacity for additional future septage generation. Another option is to haul sludge to the City of Everett WWTP via the ferry. Subsequent research to establish the best option for sludge disposal can be done in the Capital Facilities Plan.

## **6.6 WASTEWATER TREATMENT PLANT SITE (SINGLE, CENTRAL)**

The usual location for a wastewater treatment plant is at the lowest elevation of the service area so that most sewage is conveyed by gravity and a receiving water body for effluent discharge is also close by. However, at Clinton, the lowest point is essentially somewhere along the shoreline. Disadvantages of the shoreline treatment plant sites are parcel size is very small requiring special design and construction measures for a compact facility and close proximity to existing residences. Due to those factors, it would be necessary to consider aesthetic measures including visual screening, noise abatement and special odor control equipment. Consequently, there are other factors that will be important in defining the most appropriate site for a wastewater treatment plant.

Presently, there are two potential sites identified for the options involving single, centralized wastewater treatment plants (Options 3, 4, and 5) and they are shown in Figure 5.1. The following is a discussion of the advantages and disadvantages for each of the sites:

The site identified as "Site #2" is actually three separate, cleared, unimproved land parcels under single, private ownership located on the west side of Conrad Street, south of Berg Road. The advantages of this site are: it is centrally located within the service

area and is at an elevation that is low enough (75') to be reached by pumps at the waterfront and by gravity from most of the upland service area. The site has adequate land area (2.8 acres) for a standard plant footprint with additional area for buffer and future expansion. Shortcomings of this site are that it is a relatively long distance away from the preferred marine outfall location and that the property is otherwise very desirable for residential development.

The site identified as "Site #6" is a large forested parcel of approximately 40 acres, owned by the Washington Department of Natural Resources (DNR) and is located at Humphrey Road, west of both Tiffany Drive and Marshall Road. Advantages of this site are several:

- Close to the recommended marine outfall site,
- Sewage can be conveyed by gravity from much of the upland service area,
- Large forested land area could be used for land application of treated effluent rather than the marine outfall,
- Land is zoned Rural and would not otherwise be used for residential.

Shortcomings of this site include:

- Purchase of the entire parcel from DNR would be required initially, however the District may subsequently sell the remaining land not needed.
- Site is at an elevation of 120 feet which would preclude the opportunity for individual grinder pumps along the waterfront to pump directly to the plant.

Chapter 7 provides a technical summary of Options 3, 4, and 5 and a comparison to other options.

## **6.7 WASTEWATER TREATMENT PLANT SITES (MULTIPLE, DE-CENTRALIZED)**

The R.W. Beck report attempted to present a plan for wastewater treatment at Clinton using a decentralized treatment plant approach (6.1.3 Alternative 3 – Small Community Collection and Treatment Systems). The sewer service area was divided into three separate small areas: North, Central and South, with each area having its own sewage collection network and treatment plant. R.W. Beck was unable to demonstrate that the de-centralized treatment approach was feasible because the proposed treatment process technologies were risky, inferior or otherwise too costly, effluent discharge to multiple marine outfall pipes was prohibited and effluent reuse and reclamation opportunities were not well defined.

This report attempts to revisit that option and to present a more promising strategy for de-centralized treatment plants (Option 2). Refer to Figure 5-2 – De-Centralized Collection System, for a map showing the plant site locations. Advantages and reasons for using de-centralized sewage collection and treatment are summarized as follows:

- Topography: the proposed service area ranges from waterfront (elevation = sea level) to upland (elevation = 360'). In addition there are three separate drainage basins. Topographical conditions significantly influence the layout of traditional sewage collection and treatment systems. With a de-centralized system it is generally less complicated to extend collection pipes because it is not necessary to cross over the dividing crest of drainage basins.
- Patterns of land development result in distinctly different areas ranging from dense beachfront homes, active commercial and business district to sparse rural residential neighborhoods. There are distinctly different levels of need and relative urgency with respect to wastewater collection, treatment and disposal for the proposed service area. A de-centralized system makes it easier for a given area (small segment of the District) to independently build and operate sewage collection and treatment facilities if desired.
- Utilization of reclaimed wastewater effluent can be implemented easier if the (de-centralized) wastewater treatment plants are located near the reuse sites. This minimizes the amount of conveyance pipe and costs for pumping.

Chapter 7 provides a technical summary of Option 2 and comparison to other Options.