PROPOSED ALTERNATIVE

This chapter provides design details and environmental information to provide a complete description of the proposed alternatives for the Barton and Murray CSO basins.

8.1 BARTON CSO BASIN PROPOSED ALTERNATIVE OVERVIEW

Barton Alternative 4A (GSI) would establish a system of bioretention/bioinfiltration facilities between the sidewalks and streets in the Sunrise Heights and Westwood neighborhoods in Sub-basin 416 to reduce overflows at the Barton Pump Station. Bioretention/bioinfiltration facilities are dispersed small-scale landscape features using bioretention soil and vegetation designed to attenuate storm flows and treat stormwater. They are typically vegetation-filled depressions with a drainage function. They are often located in median strips, in parking lots, in planting strips along streets, or in other landscape areas. In this facilities plan, the term “rain garden” is used to describe these facilities.

The Sunrise Heights and Westwood neighborhoods are suited for this project because of their gentle topography and current connection of street drains to the combined sewer system. The rain gardens will be surface improvements constructed in City of Seattle public right of way. They will reduce CSO overflows by capturing and infiltrating rainwater that would otherwise enter the combined sewer system.

The project offers these benefits:

- Bioretention soil and vegetation allow stormwater runoff to infiltrate into the ground to reduce the volume of stormwater entering the combined sewer system.
- By maximizing the use of natural processes, the project supports the region's commitment to energy conservation and sustainability.
- King County will work with the neighborhoods to enhance the street’s landscape aesthetics, minimize parking impacts, and respond to applicable neighborhood preferences for the project.
- The project will not require major operating facilities however it may be desirable to install flow metering to monitor effectiveness during storm events.
- This approach reduces the risk of combined sewer overflows at Barton and reduces flows to the Murray CSO basin.

8.1.1 Overflow Frequency and Volume

Table 8.1 shows CSO frequency and volume from the Barton Basin both prior to project implementation and anticipated after implementation. The CSO frequency and volumes indicated in the table are shown for both modeled results over 30 years and actual monitored data collected at the outfall location between the years of 2000 and 2007.

Table 8.1 CSO Frequency and Volume from the Barton Basin

CSO Frequency and Volume	Monitored Prior To Project Implementation (2000 – 2007)	Model-Simulated Project Impacts	
		Prior To Project Implementation[1]	Anticipated After Project Implementation[2]
Annual Frequency	4 Overflows/year	4.9 Overflows/year	1 Overflow/year
Annual Volume	4.3 MG	1.8 MG	0.5 MG

Notes:

1. Based on a 30-yr King County Runoff simulation model and Barton Pump Station capacity of 22 MGD.
2. Based on a 30-yr King County Runoff simulation model and Barton Pump Station capacity of 33 MGD.

The annual frequency of overflows matches very closely for both the modeled and monitored results. Differences between modeled and monitored annual overflow volumes prior to project implementation can be due to a number of factors, including:

- Over-estimated overflow volumes due to limited sensitivities of level sensors and overflow calculations at the Barton Pump Station.
- Differing rainfall over the basin than that indicated by the rain gauges.
- Inaccuracies in the model.
- Monitoring period being different from the model period, with corresponding different rainfall events.

The 30-year simulation of the calibrated model provides the best engineering estimate of flow volumes to be expected, and is therefore used for sizing CSO facilities.

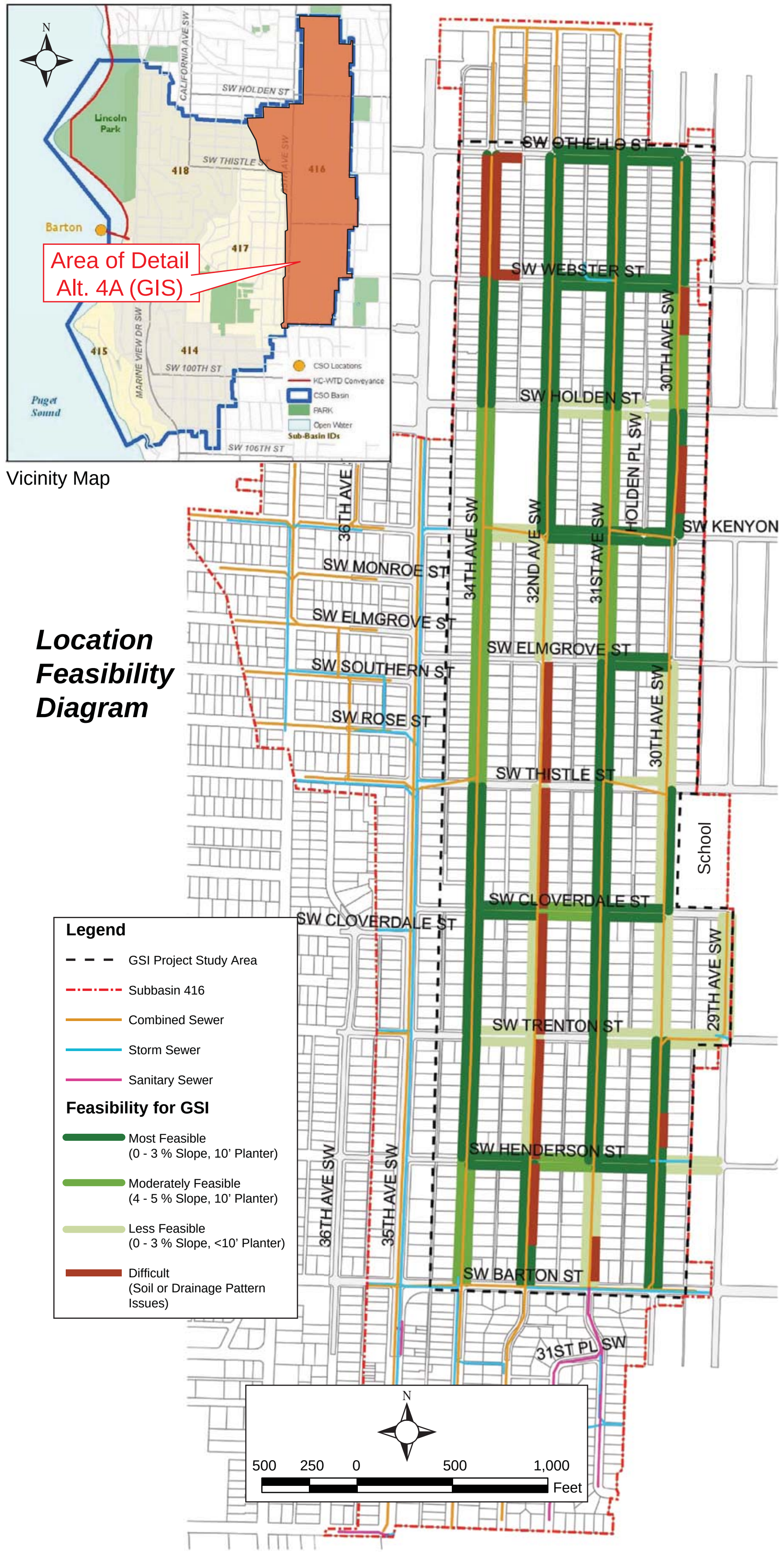
8.1.2 General Layout

The GSI alternative consists of rain gardens installed over multiple blocks (32 – 64 half blocks depending upon final design conditions) in planting strips or in new curb bulbs along the street. Figure 8.1 shows the key elements of the GSI alternative.

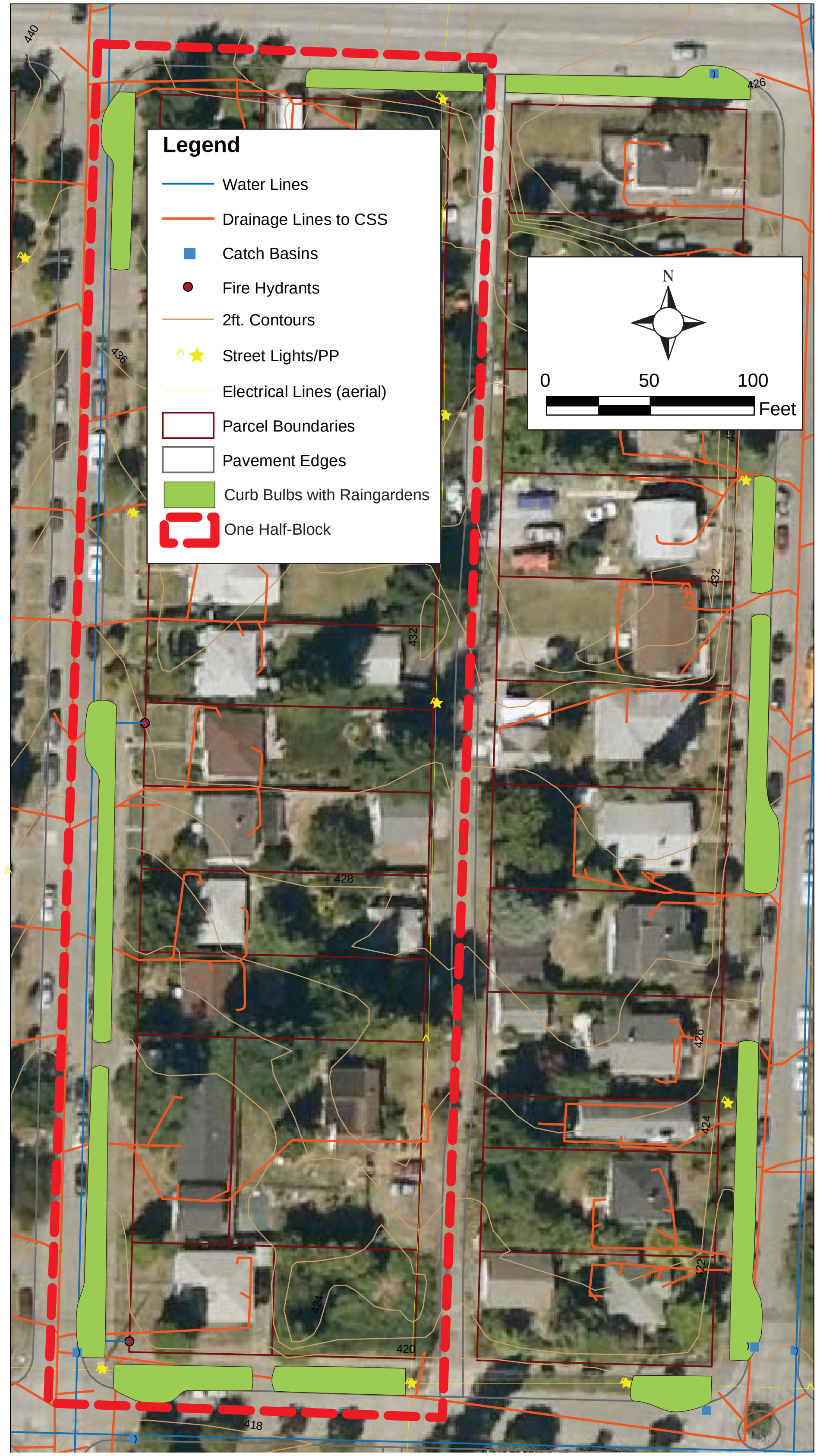
8.1.3 Wet-Weather Flow Description

Rain gardens along the street will be retrofitted within the existing right-of-way in Sub-basin 416 to intercept surface drainage that is currently routed to the combined sewer. The rain gardens will infiltrate and store some of the runoff, thereby reducing the volume and peak flow that enters the combined system and is conveyed to the downstream Barton Pump Station. The rain gardens will be used in areas with an existing curb and gutter system. Existing planter strips will be modified. In some locations this may include moving the curb out into the parking area of the roadway for a short distance. Figure 8.1 shows a sample image of an existing street in Sub-basin 416 before and after a hypothetical rain garden installation in the planting strip.

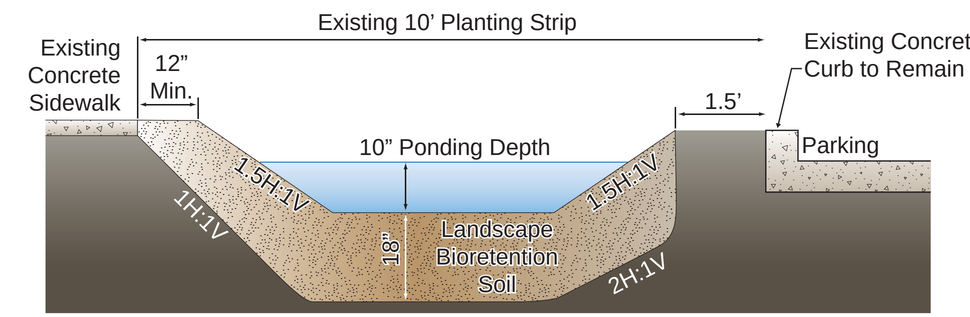
Location Feasibility Diagram



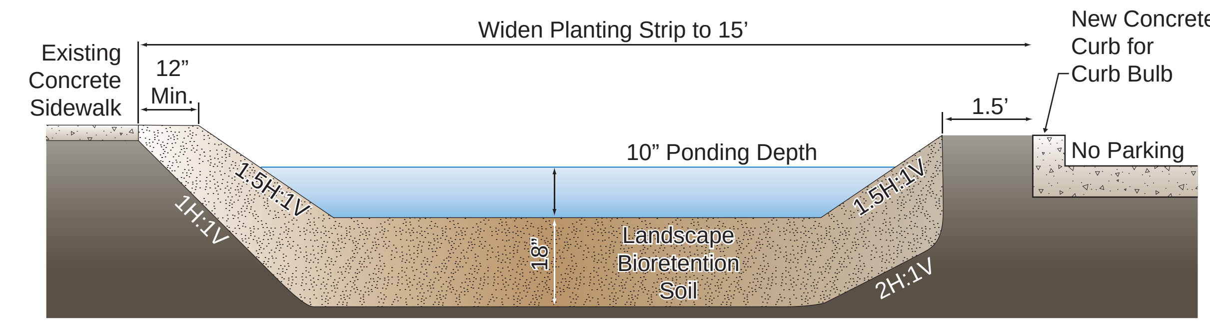
Layout of Rain Garden Cells on a Typical Block



Typical Cross-Sections



Section 2



Section 3

Typical Planting Strip

Before Rain Garden Installation

After

3630023/Fig8-01_Barton4A-GSI.ai

BARTON AND MURRAY COMBINED SEWER OVERFLOW CONTROL FACILITIES PLAN	Figure 8.1.
DRAFT – February 2011	BARTON CSO BASIN PROPOSED ALTERNATIVE 4A (GSI): GSI IN SUB-BASIN 416

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Surface runoff that is currently directed along the curb and gutter system will be routed to the rain gardens through curb cuts. Some runoff will infiltrate through the bottom of the rain garden. When the rate of runoff that is being routed to a rain garden exceeds the infiltration capacity of the facility, the water will begin ponding within the rain garden. Once the ponding depth exceeds 10 inches, runoff will begin to overflow back onto the gutter-line and into the catch basin connected to the combined system. Standard rain garden cross sections are shown in Figure 8.1. Section 2 shows a standard cross section for a rain garden that is installed within the existing 10-foot planting strip. Section 3 shows a widened cross section where the rain garden is extended into the street using a curb-bulb, increasing the facility's infiltration and storage capacity.

8.1.4 Facility Sizing

A Runoff/Transport model was used to determine the design storm events that would produce a combined sewer overflow (CSO) and to calculate the size of storage needed to control CSOs in the system. Details of the evaluation are included in Appendix A. The Runoff/Transport model allows for analysis in 10-minute time increments to account for different intensities of rain during the event. The results of the Runoff/Transport model design storm events were given in precipitation per 10 minute time increments. Rain garden sizing and distribution are related to soil infiltration rates and the volume of preceding rainfall during storms. These two factors affect the occurrence of sharp peaks during storm events.

The proposed GSI alternative was evaluated and sized using the November 1-2, 1984 storm as the design storm event and targeting a peak flow reduction of 14.6 mgd. This storm is near a 1-year event and has a higher peak flow rate and higher CSO volume than the long-term 1-year storm event. This storm was selected as the design storm because it is more challenging to control and is near a 1-year CSO volume. The modeled event lasted from 10:00 a.m. on November 1 through 9:50 a.m. on November 2 (see Figure 8.2).

The November 1-2, 1984 storm was a long storm with a sudden peak. Two additional storms were also analyzed (See King County Technical Memorandum 600.5 in Appendix A for analysis):

- The November 21 – 22, 1988 storm was short, with an extended dry period before the heavy rain started.
- The March 1–2, 1987 storm included an extended period of rain before the peak of the storm.

The precipitation record of the rainfall event was entered into a mass balance model that was used to determine the amount of Sub-basin 416 that needs to be mitigated to control the CSO design storm event. Sub-basin 416 was modeled as individual half-block catchment areas rather than as a single catchment. Each half block consists of half a residential block, from the alley to the right-of-way. This includes half the right-of-way along one north/south street and one-quarter of the right-of-way along two east/west streets. The hydrograph for the half block catchment area was then routed through rain gardens to determine the peak flow reduction produced by the assumed rain garden cells (See TM 600.6 in Appendix A for further information).

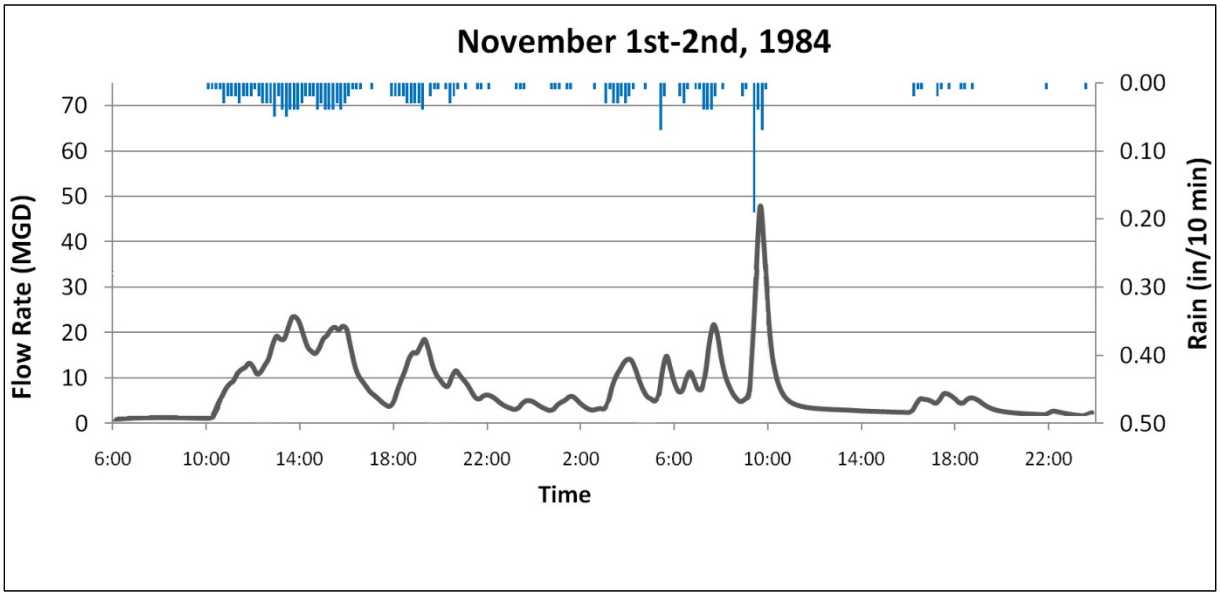


Figure 8.2 Modeled November 1-2, 1984 Design Storm Hydrograph at Barton Pump Station (See TM 600.5 in Appendix A)

The layout of rain garden cells on a typical block is shown in Figure 8.1 with a typical half-block delineated in red. This approach distributes runoff flows and rain gardens across the sub-basin and more closely defines how flows and storage will behave during a storm event. The model indicated that 32 half-blocks of rain gardens in Sub-basin 416 would achieve the peak flow reduction target of 14.6 mgd for the 1984 design storm event. Figure 8.3 shows the resulting flow hydrograph for the design storm event. See King County TM 600.5 in Appendix A for review of the 1987 and 1988 storm events.

The sub-basin was assessed for feasible rain garden locations. Locations were considered difficult for implementing rain gardens if they possessed any of the following conditions:

- Slopes greater than 5 percent.
- Poor soils as described in geotechnical evaluation by Shannon & Wilson dated March 26, 2010.
- Problematic drainage patterns (e.g. existing buildings are below adjacent street grade).
- Space constrained by planting strip width, road width and/or driveways.
- Location on an arterial street.

Feasible locations were ranked as most feasible, moderately feasible, or less feasible. The assessment indicates that there are approximately 57 feasible half-blocks within the GSI project study area, providing contingency if it is determined during final design that additional rain gardens are needed beyond the estimated 32 half-block requirement. Feasible rain garden locations are shown in Figure 8.1.

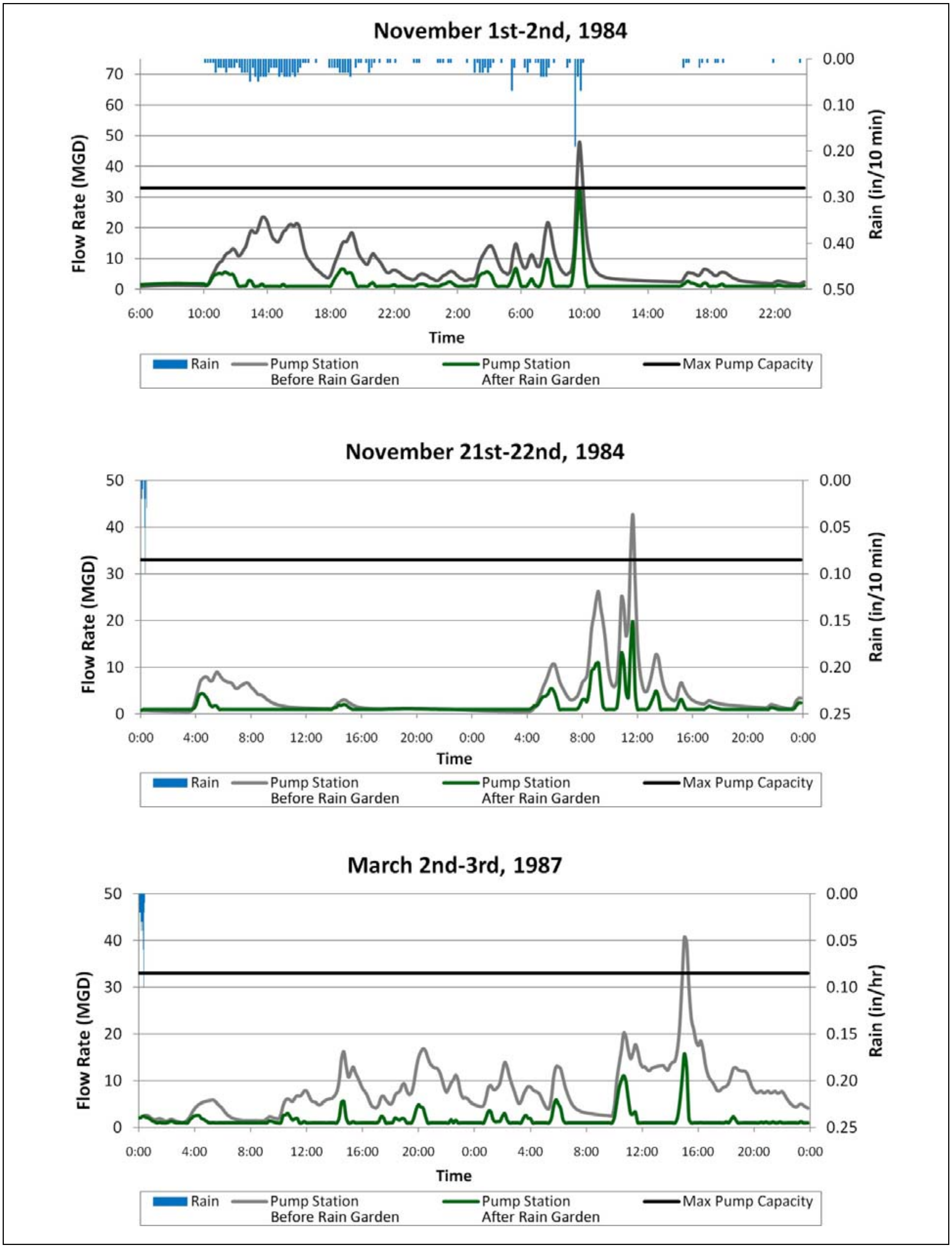


Figure 8.3 Estimated Flows Captured by Rain Gardens and Diverted from the Barton Pump Station During Design Storms (from King County TM 600.5, May 2010, Appendix A)

Table 8.2 presents major requirements and design assumptions for the GSI alternative.

Table 8.2 Barton Basin CSO Facility Sizing

Facility Component	Design Assumptions[1]
Rain Gardens	
Number of Half-Blocks of Rain Gardens Installed	32
Approximate Rain Garden Area per Half-Block	7,060 square feet
Ponding Depth	10 inches
Total Rain Garden Storage Volume Provided	2 million gallons
Design Infiltration Rate	0.5 inches/hour
Rain Garden Cross Section	See Figure 8.1 for soil depth and side slopes.
Planning Criteria	
Disconnected Area	52 acres
Peak Flow Reduction	14.6 mgd[2]

Notes:
1. Design assumptions are preliminary and may be revised during final design.
2. Peak flow reduction criterion assumes the existing Barton Pump Station will be upgraded from 26 mgd to 33 mgd as part of the upgrade project currently under design.

8.2 MURRAY CSO BASIN PROPOSED ALTERNATIVE OVERVIEW

Murray Alternative 1F includes a 1-MG underground storage tank on property that is currently in private ownership across Beach Drive SW from the existing Murray Pump Station. Ancillary facilities would be located on the same site. This alternative offers these advantages:

- There may be opportunities to enhance the surface of the site following construction in a way that benefits the neighborhood (for example, additional green space).
- Surface components of the project and related improvements will be constructed outside of Lowman Beach Park.
- The alternative provides for a single, reliable, facility near the existing pump station.
- The County has been planning upgrades to the Murray Pump Station’s electrical and odor control facilities for several years. The proximity of the proposed site to the Murray Pump Station provides an opportunity to serve both the CSO tank and the pump station from a single odor control facility and electrical standby generator at the storage tank site. Combining service functions would reduce the impact on Lowman Beach Park.

facilities. Opportunities to combine service functions would reduce the impact on Lowman Beach Park.

8.2.1 Overflow Frequency and Volume

Table 8.3 shows CSO frequency and volume from the Murray Basin both prior to project implementation and anticipated after implementation.

Table 8.3 CSO Frequency and Volume from the Murray Basin

CSO Frequency and Volume	Monitored Prior To Project Implementation (2000 – 2007)	Model-Simulated Project Impacts	
		Prior To Project Implementation[1]	Anticipated After Project Implementation[2]
Annual Frequency	5 Overflows/year	6.2 Overflows/year	1 Overflow/year
Annual Volume	5.2 MG	2.7 MG	2.0 MG

Notes:

1. Based on King County Runoff model and Barton Pump Station capacity of 22 MGD, 30-yr simulation.
2. Based on King County Runoff model, upgraded Barton Pump Station capacity of 33 MGD, and Murray Pump Station capacity of 31.5 MGD, 30-yr simulation.

The CSO frequency and volumes indicated in the table are shown for both modeled results and actual monitored results at the outfall location between the years of 2000 and 2007. The annual frequency of overflows matches very closely for both the modeled and monitored results. Differences between modeled and monitored annual overflow volumes prior to project implementation can be due to a number of factors, including:

- Over-estimated overflow volumes due to limited sensitivities of level sensors and overflow calculations at the Murray Pump Station.
- Differing rainfall over the basin than that indicated by the rain gauges.
- Inaccuracies in the model.
- The overflow record covered a time period of 8 years while the modeling covered a time period of 30 years, which included 22 years of additional and different rainfall data.

The 30-year simulation of the calibrated model provides the best engineering estimate of flow volumes to be expected, and is therefore used for sizing CSO storage facilities.

8.2.2 General Layout

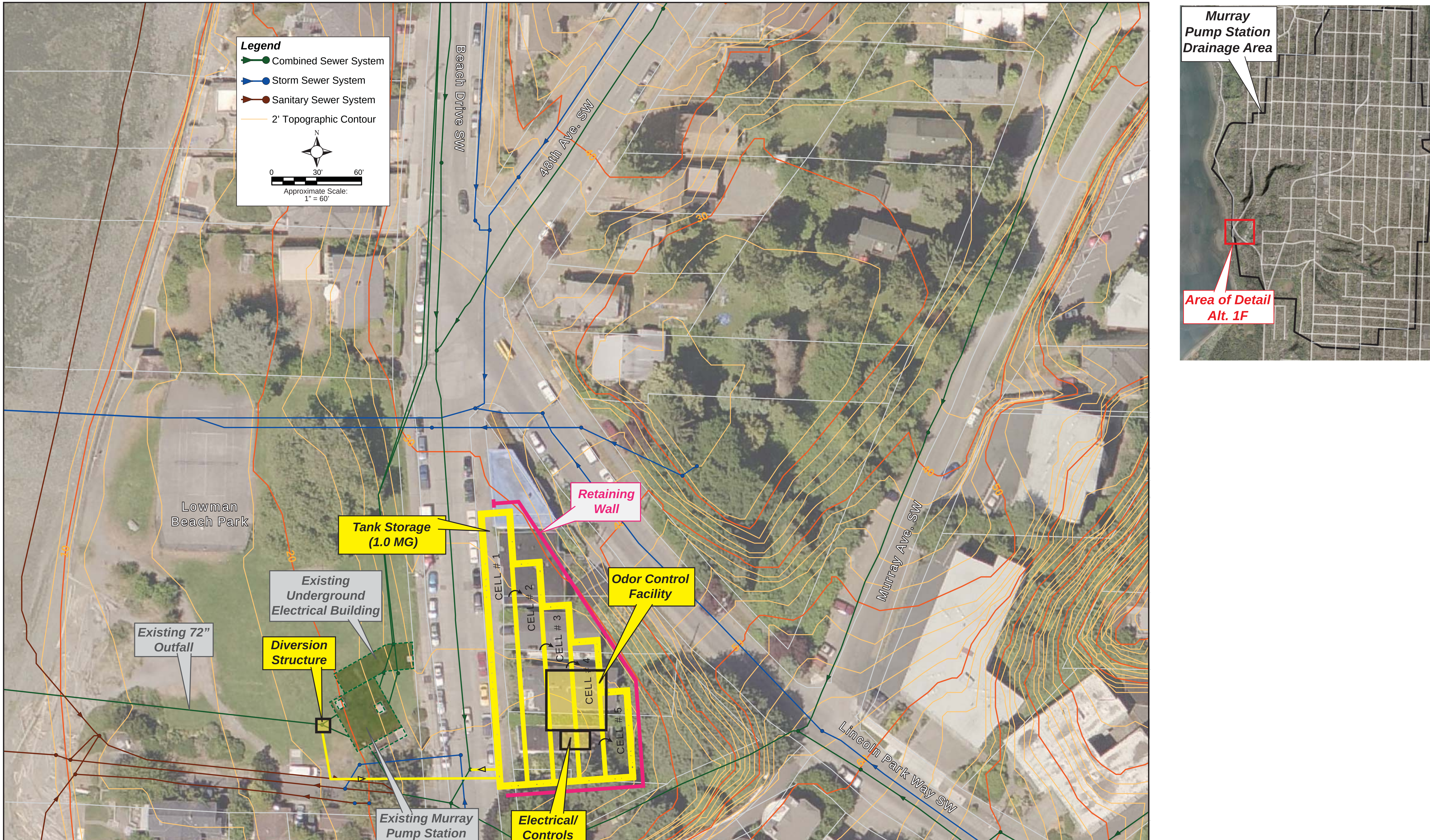
A general layout of Murray Alternative 1F location is shown in Figure 8.4. This alternative includes the following elements:

- A new diversion structure in Lowman Beach Park west of the existing Murray Pump Station to redirect peak flows from the sewer to storage.
- A new 1.0-MG buried, self-cleaning storage facility with the following features:
  - A 48-inch gravity influent sewer and isolation gate.
  - Five cells that will fill sequentially.
  - Drain pumps to empty the tank contents over a 12-hour period following a wet-weather event.
  - A flushing system to facilitate tank cleaning.
  - Access features for routine and long-term operation and maintenance (O&M).
  - A 12-inch effluent line to the local combined sewers.
  - Variable cell lengths
- Secant pile shoring on all sides of the tank
- Piles below the structure for uplift resistance and to prevent liquefaction-induced settlement
- A retaining wall to protect the existing hillside along the east side edge of the property.
- An ancillary equipment facility for odor control, mechanical, and electrical equipment including:
  - Control panels and motor control centers.
  - Standby power generator.
  - Odor control system including mist eliminator, carbon scrubbers, and fans.
  - Ventilation system.
  - Utility water system including backflow preventer, air gap tank, pumps, and hydropneumatic tank.

8.2.2.1 Diversion Structure

Peak flow in excess of the Murray Pump Station's capacity will be routed through a new diversion structure and sent to storage. Figure 8.5 shows a conceptual plan and section view of diversion structure. During wet-weather, the water level in the Murray Pump Station wet well will rise when flows to the pump station exceed the station's peak capacity of 31.5 mgd. The rising water level will overtop the existing overflow weirs in the pump station (at Elevation 108.05 feet (Metro Datum)) and will be channeled through an overflow pipe outside the pump station and into the new diversion structure. Flows will then be diverted from this structure, through a 48-inch pipeline, to the inlet of the storage tank on the other side of Beach Drive.

When the maximum water surface elevation in the storage tank is reached (Elevation 107.2 feet (Metro Datum)), the water will back up within the conveyance pipe and diversion structure and overtop a weir (Elevation 107.2 feet (Metro Datum)). Excess flows will then go through the existing 72-inch diameter CSO outfall to Puget Sound.



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BARTON AND MURRAY COMBINED SEWER OVERFLOW CONTROL FACILITIES PLAN

DRAFT – February 2011

Figure 8.4.
MURRAY CSO BASIN PROPOSED ALTERNATIVE 1F: BEACH DRIVE AREA UNDERGROUND STORAGE

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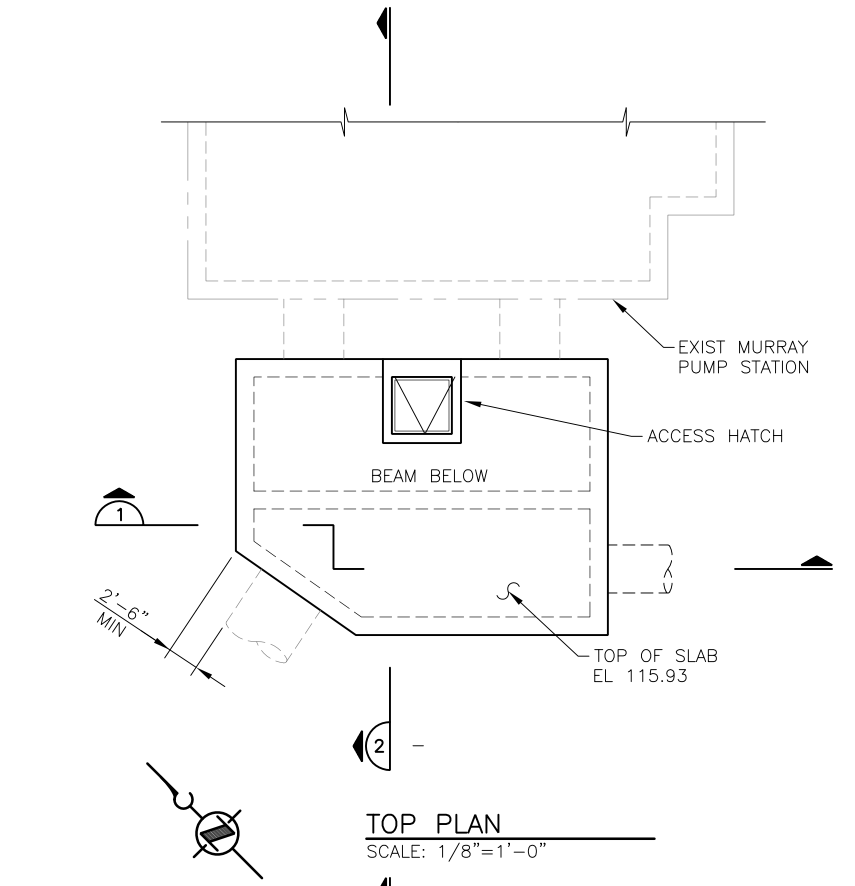
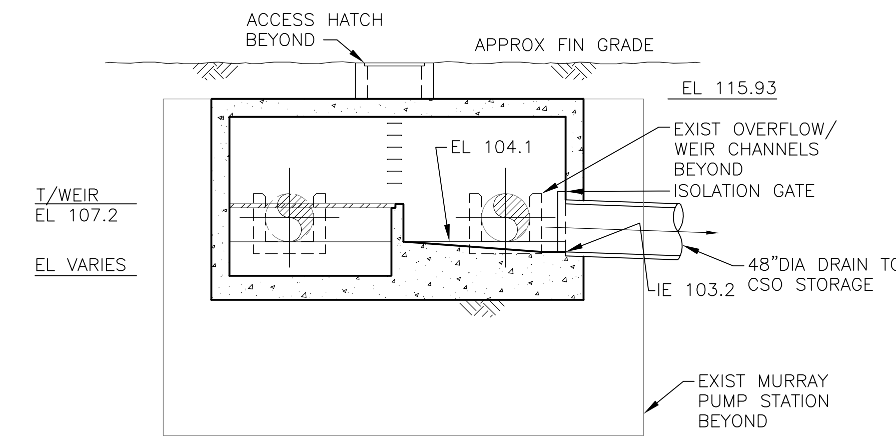


TOP PLAN
SCALE: 1/8"=1'-0"



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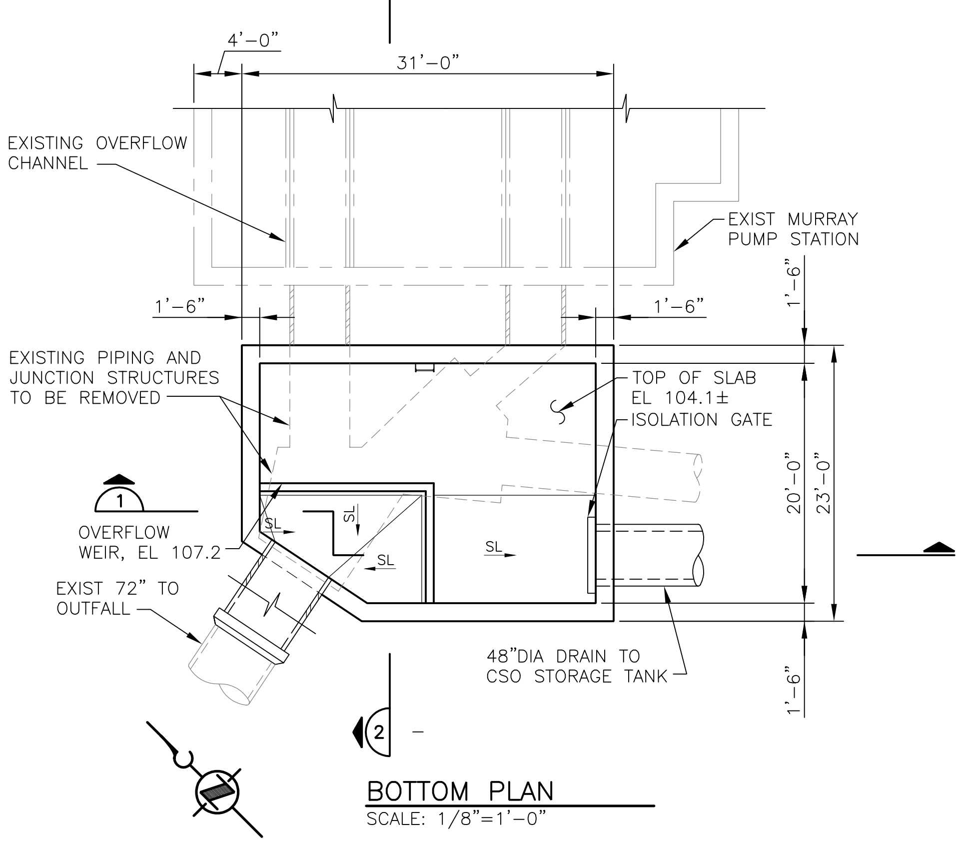

BOTTOM PLAN
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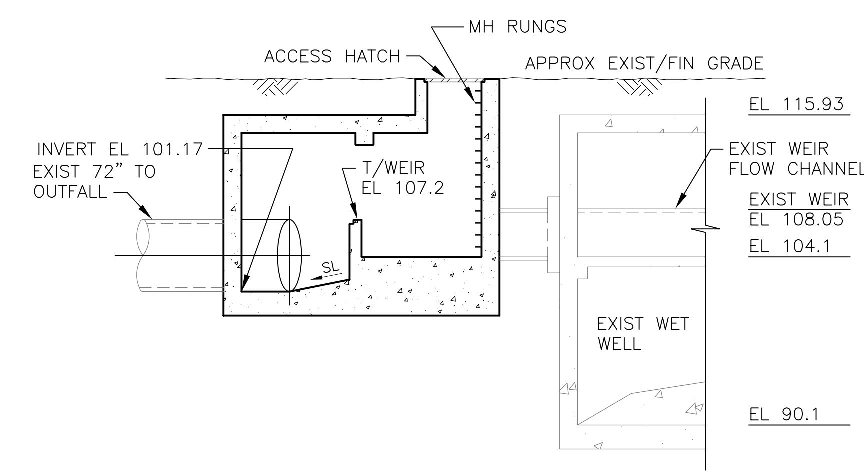

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SCALE: 1/8"=1'-0"

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PROJECT ACCEPTANCE: PROJECT MANAGER	CONTRACT NO: CONTRACT NUMBER

King County

DEPARTMENT OF NATURAL RESOURCES & PARKS
WASTEWATER TREATMENT DIVISION
MURRAY STORAGE TANK
BEACH DRIVE AREA UNDERGROUND STORAGE

FIGURE 8.5
DIVERSION STRUCTURE
PLAN AND SECTIONS

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The diversion structure will be below grade and include access hatches for visual inspection and maintenance. Utility water will be provided from within the pump station for washdown of the weir and flow channels within the diversion structure. The structure will also house a level sensor for remote monitoring of water levels.

8.2.2.2 Storage Tank

The proposed CSO storage facility is a buried five-cell tank, with each cell 15 feet wide and ranging in length from 60 feet to 180 feet. Figure 8.6 shows a conceptual plan and Figures 8.7 and 8.8 show section views of this storage tank. The tank will be equipped with carbon scrubber odor control, electrical equipment, and a backup generator, housed in a separate structure on the ground surface above the tank. The tank will be accessed from the top for maintenance at entry structures and access hatches over both ends of each cell. Equipment at the entry structures includes level sensors, tipping buckets (or flushing gates, as to be determined in final design), utility water valving for cleaning, and submersible pumps and valving to drain the tank.

The tank will begin to fill by gravity once CSOs overtop the weir at the diversion structure and are conveyed through the 48-inch influent pipe, which will discharge to the sump at the low end of Cell 1. Water will then fill Cell 1 until it reaches the elevation of the overflow opening to Cell 2. At that point, additional flow will fill Cell 2 until the Cell 2 water elevation reaches the overflow to Cell 3. The same process will then fill Cells 3, 4 and 5. When all cells are full, water will back up in the influent line and the diversion structure, ultimately overflowing through the CSO outfall.

When system flows drop below the capacity of the Murray Pump Station, the storage tank drain pumps will be activated. Three submersible pumps located in the sump of Cell 1 will lift stored flows back into the sewer system via a 12-inch force main to a local manhole in Beach Drive. The maximum pumping rate will be 1,400 gpm to drain the tank in 12 hours. Drain pump flows will be metered and monitored to ensure that the peak flow capacity of the Murray Pump Station is not exceeded during the tank draining process. After Cell 1 is drained, a drainage gate in Cell 2 will be opened to allow the stored water in that cell to flow to the sump of Cell 1 and be pumped to the sewer system. Cells 3, 4 and 5 similarly will be drained in sequence by opening the gates to allow their stored flow to drain to Cell 1.

For Cells 2, 3, 4 and 5, the automated flushing system using a flushing gate or tipping bucket will be activated to remove solids after each cell is drained. Flushing water will be sent through the cell, scouring the solids on the cell floor. After each flush, the water will be collected in the sump of Cell 1 and pumped by the submersible drain pumps. The same force main used to pump stored flows will convey the flush water from the tank to the sewer system. Cell 1 will be flushed after all cells in the tank have been drained and flushed.

Access to the storage tank will be through lift slabs and hatches. The accesses will have ladders, stairways or additional access equipment for routine maintenance. The entry structures will be isolated from the storage tank and ventilated as required to allow for routine O&M, such as level sensor calibration and pump exercising. The access hatches would be embedded into large, concrete removable panels that could be lifted by boom truck or crane to allow for infrequent repairs or manual cleaning.

8.2.2.3 Ancillary Equipment Facility

The ancillary equipment facility, shown in Figure 8.9, contains the odor control system, mechanical equipment, and electrical equipment to support the storage tank. The exterior dimensions of the facility will be 70 feet long by 44 feet wide. The facility will be no more than one story, as allowed by Seattle Municipal Code. It will be located on the site such that it will provide adequate access and to minimize its visual presence.

The odor control system will consist primarily of a carbon adsorption scrubber vessel, mist eliminator, and fan. Additional instruments and smaller components would also be required, but are not considered major equipment. The tank ventilation rate would be 2 air changes per hour (ac/hr) or maximum fill rate (43 mgd), whichever is greater, to control odors. There are also provisions, including a variable speed drive for the odor control fan and bypass ductwork, for 6 ac/hr to bypass the carbon scrubber and to facilitate manned entry into the storage tank.

The odor control system will be directly connected to the storage tank with buried corrosion-resistant ductwork or piping. Treated-air discharge ductwork would be routed to a location and height on the site as determined during final design.

The building also will house HVAC equipment for the ancillary equipment facility and the storage tank entry structures. The ventilation rate for the occupied spaces would be 12 air changes per hour (ac/hr) continuously.

To provide water for the flushing system and other facility needs, water drawn from a new service water line will be routed through an above-grade backflow preventer and air break tank as required by health codes. The air break tank will be a 1,500-gallon reservoir inside the ancillary equipment facility. Utility water pumps would draw from the reservoir and pump the water into a hydropneumatic tank to pressurize the utility water system.

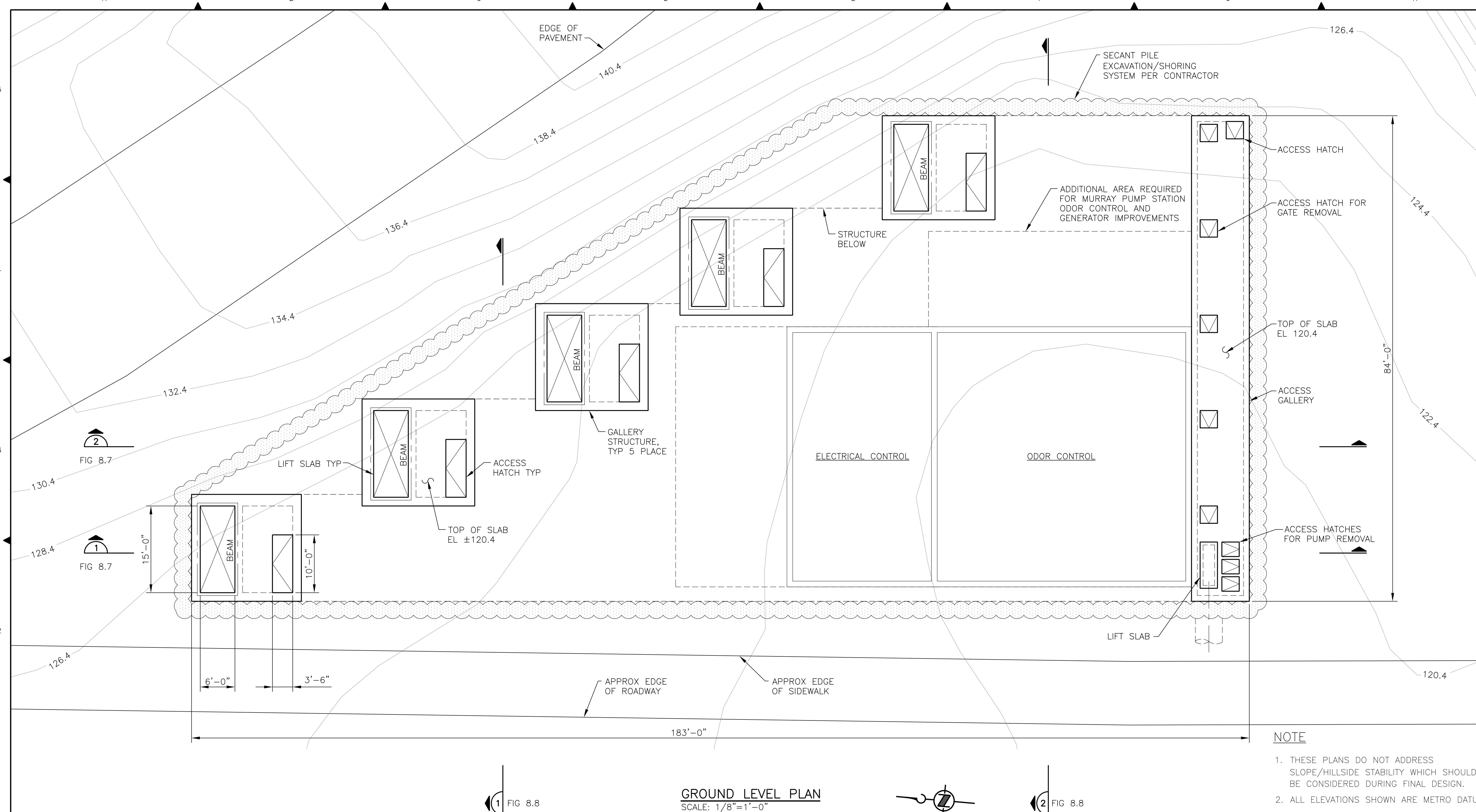
King County has also been planning upgrades to the electrical and odor control facilities for the Murray Pump Station for several years. They may choose to co-locate these improvements with the storage tank odor control and electrical systems to reduce construction impacts in Lowman Beach Park. The area of the ancillary equipment facility would need to expand by roughly 50% as shown on Figure 8.6 to accommodate these additional improvements.

8.2.2.4 Site Improvements

8.2.2.4.1 Access to Proposed Facilities

Access to the storage facility site will be from Beach Drive SW. It is anticipated that the site will be partially or entirely fenced for security purposes. All access hatches would be rated for HS20 loading. Removable lifting slabs will be configured over the tipping buckets and access gallery to provide a larger opening for less frequent maintenance activities.

The Murray Pump Station has access from Beach Drive and Pump Station Road. The pump station is accessed from the surface through hatches and a stairway. The proposed diversion structure would be below grade and would have access hatches at the ground surface for maintenance.



GROUND LEVEL PLAN
SCALE: 1/8"=1'-0"

NOTE

1. THESE PLANS DO NOT ADDRESS SLOPE/HILLSIDE STABILITY WHICH SHOULD BE CONSIDERED DURING FINAL DESIGN.
2. ALL ELEVATIONS SHOWN ARE METRO DATUM.

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King County

DEPARTMENT OF NATURAL RESOURCES & PARKS
WASTEWATER TREATMENT DIVISION
MURRAY STORAGE TANK
BEACH DRIVE AREA UNDERGROUND STORAGE

FIGURE 8.6
STORAGE TANK CONCEPTUAL PLAN

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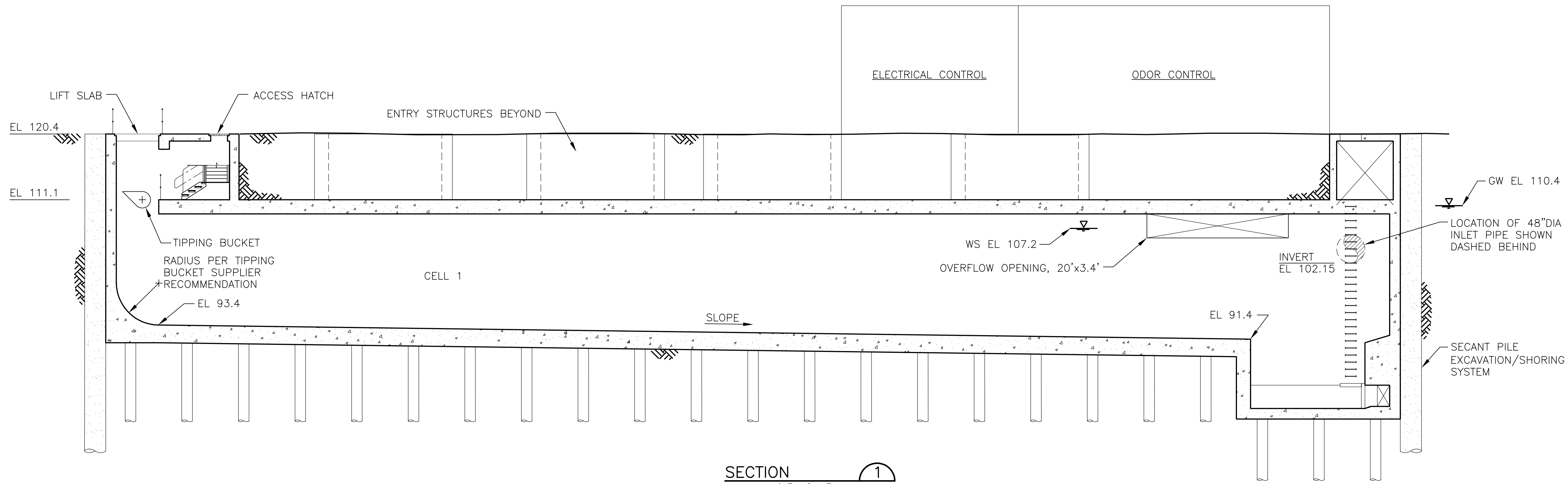
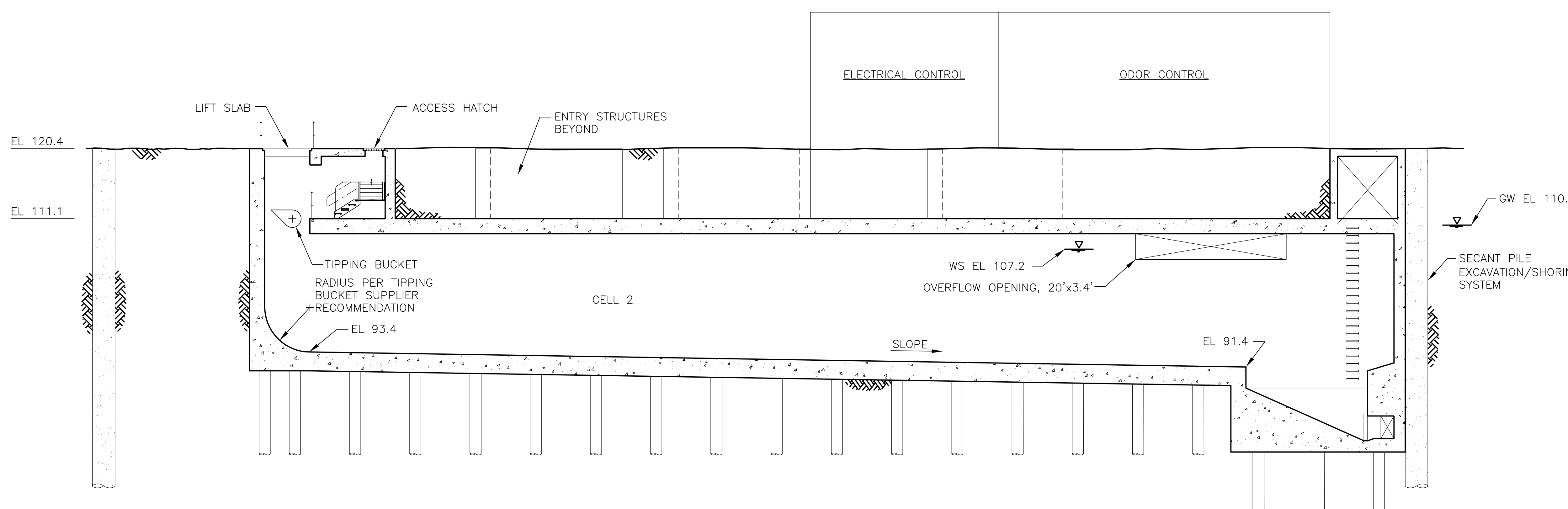


SECTION 1
SCALE: 1/8"=1'-0" FIG 8.6



SECTION 2
SCALE: 1/8"=1'-0" FIG 8.6

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DEPARTMENT OF NATURAL RESOURCES & PARKS
WASTEWATER TREATMENT DIVISION
MURRAY STORAGE TANK
BEACH DRIVE AREA UNDERGROUND STORAGE

FIGURE 8.7
STORAGE TANK SECTIONS

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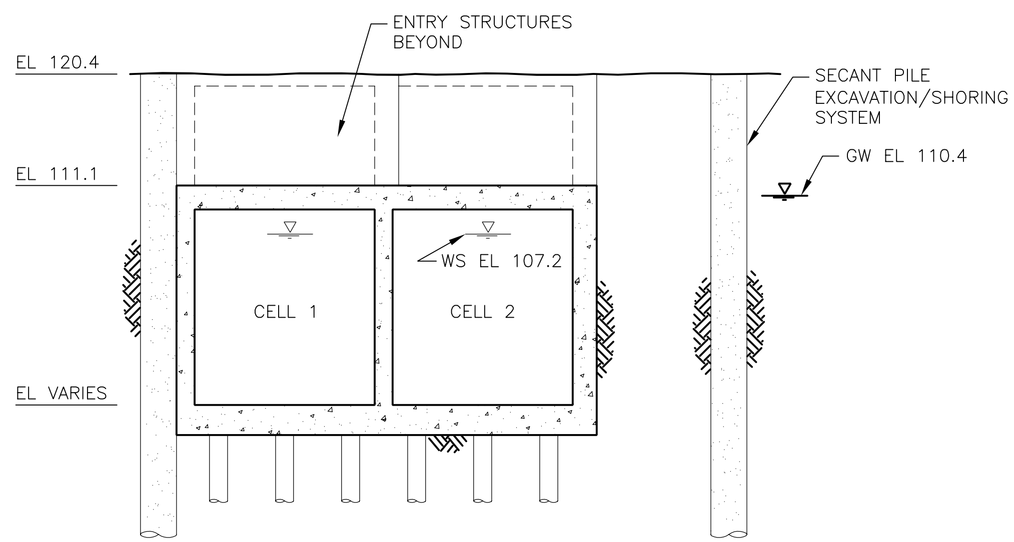
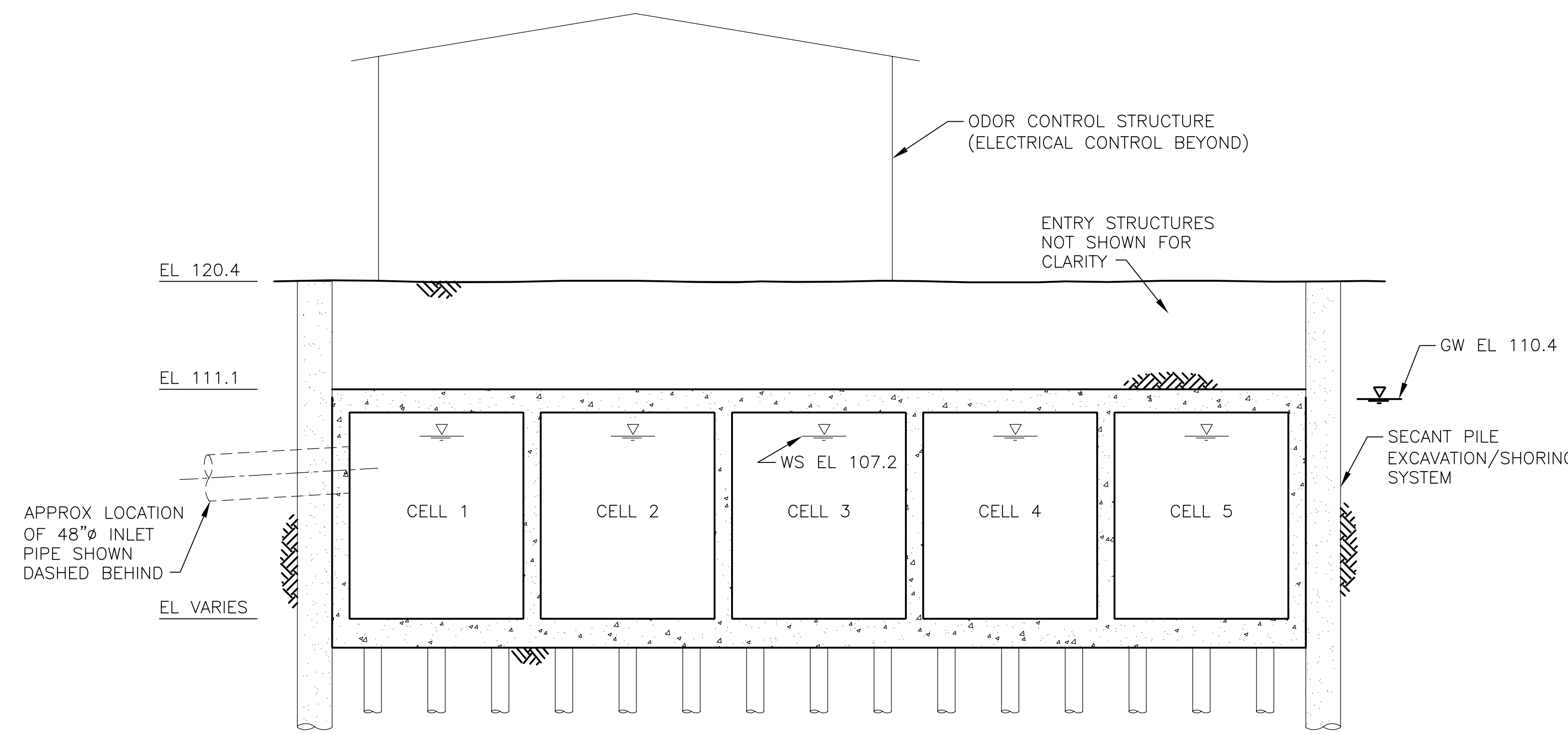


SECTION 1
SCALE: 1/8"=1'-0" FIG 8.6



SECTION 2
SCALE: 1/8"=1'-0" FIG 8.6

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PROJECT ACCEPTANCE: PROJECT MANAGER	CONTRACT NO: CONTRACT NUMBER

King County

DEPARTMENT OF NATURAL RESOURCES & PARKS
WASTEWATER TREATMENT DIVISION

MURRAY STORAGE TANK
BEACH DRIVE AREA UNDERGROUND STORAGE

FIGURE 8.8
STORAGE TANK SECTIONS

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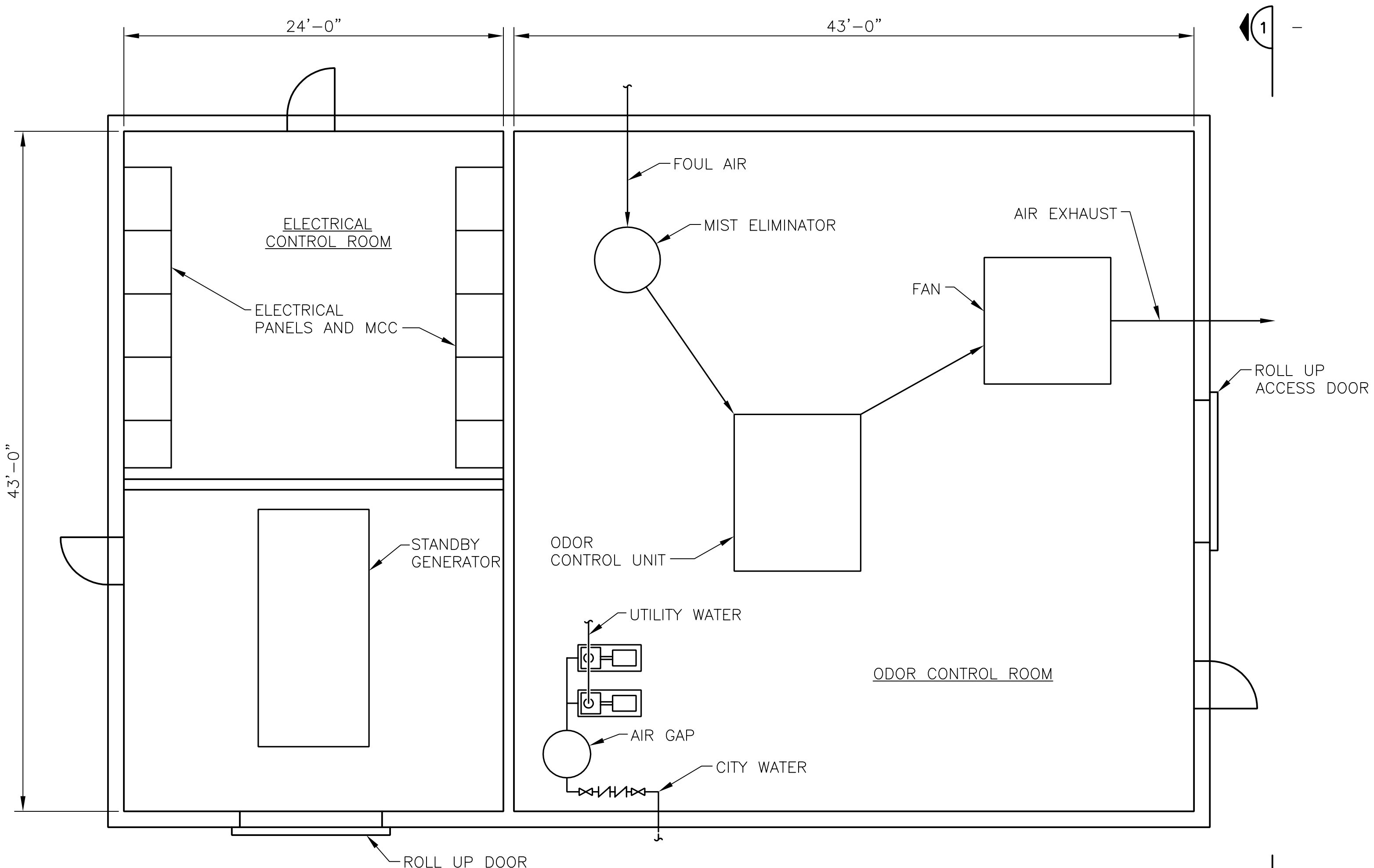

PLAN
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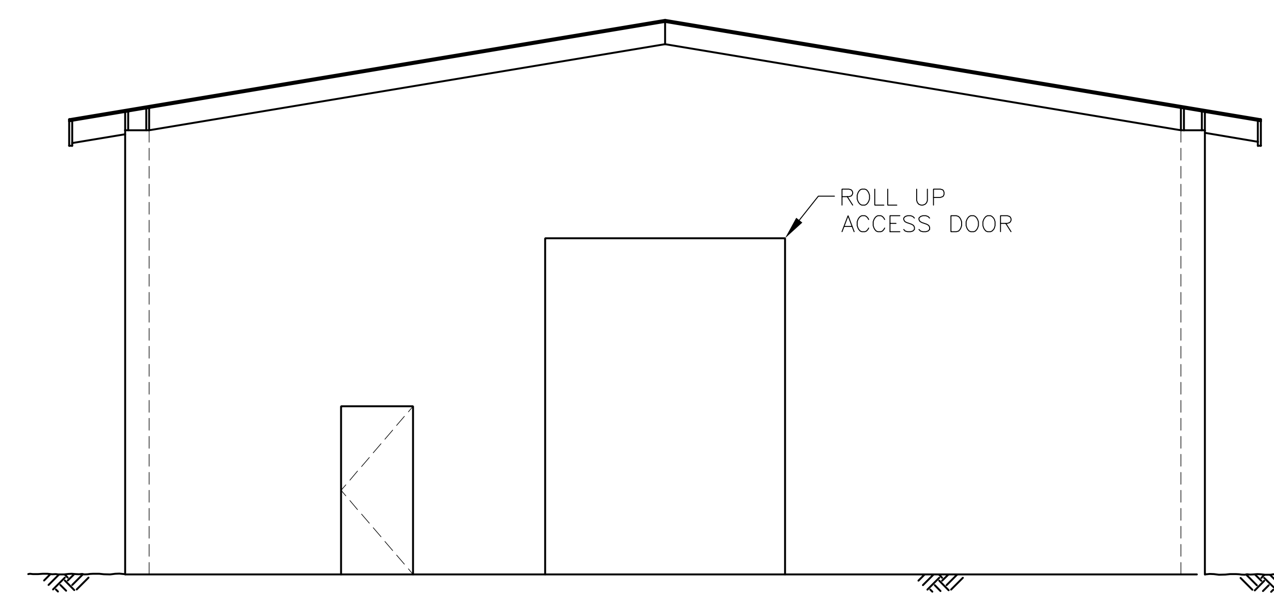

SECTION 1 –
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King County

DEPARTMENT OF NATURAL RESOURCES & PARKS
WASTEWATER TREATMENT DIVISION
MURRAY STORAGE TANK
BEACH DRIVE AREA UNDERGROUND STORAGE
FIGURE 8.9
STORAGE TANK EQUIPMENT FACILITY
PLAN AND SECTIONS

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8.2.2.4.2 Revisions to the Existing Site

Six private residential multifamily properties would be acquired in order to construct the storage facility. Six structures would be demolished and the site prepared for excavation and construction of the underground concrete tank and ancillary facilities.

Stormwater control and treatment will be required per the Seattle Municipal Code. If feasible, stormwater bioretention will be placed around the site adjacent to paved surfaces, and runoff will be directed to these locations for treatment prior to discharge to the storm drain system.

In Lowman Beach Park, part of the existing lawn will be disturbed for excavation and construction of the diversion structure and conveyance pipeline to the storage facility. The pipe will cross Beach Drive SW and will require cutting of a pipe trench. The grass area will be restored and there will be an access hatch at the surface for the diversion structure. Roadway will be restored as described below.

8.2.2.4.3 Right-of-Way Improvements

In this scenario, the right-of-way in the project area will be repaved following construction to meet current SDOT pavement and street restoration requirements. Applicability of the following codes would be verified during final design:

- Development projects must provide full street improvements (Ordinance 122615 Sidewalks Improvement Initiative).
- Pavement removal and restoration in the right-of-way must conform to SDOT Director’s Rule 2004-02.
- Any new landscaping must be in accordance with City of Seattle standards.
- Stormwater requirements must conform to Seattle Department of Planning and Development Director’s Rule 17-2009 (SMC Chapters 22.800 – 22.808).

8.2.2.4.4 Stormwater Requirements

Due to improvements both within the right-of-way and on a parcel, if implemented this alternative would be classified as a "Joint Project" under Seattle Municipal Code, requiring that both parcel-based and roadway stormwater requirements be met (SMC 22.805.070). The area of impact for the proposed alternative includes more than 13,000 square feet of new or replaced impervious surface. Therefore, for site stormwater control, according to the November 2009 Directors' Rules for the Seattle Stormwater Code (SMC Chapters 22.800-22.808), runoff from the site will require water quality treatment. The design water quality treatment volume is equal to 91 percent of the total volume of the simulation period using an approved continuous model (SMC 22.805.090.B1.a).

The site discharges to a storm system that drains to Puget Sound, which is classified as a designated receiving water and will not require the project to implement flow control.

This location is not designated as "capacity-constrained,” which would require peak flow control (SMC 22.805.080.B4). However, as a "large" project (replacing 5,000 square feet or more of impervious surface), this project would require an analysis of the downstream system within 1/4-mile of the site to ensure sufficient capacity of the drainage system (SMC

22.805.020.I). Should the downstream system be determined to have insufficient capacity for the peak flow with a 4-percent annual probability (a 25-year recurrence interval), peak flow control or improvements to the drainage system may be necessary.

This alternative will implement green stormwater infrastructure best management practices (BMPs) as much as feasible (SMC 22.805.020.F), including, but not limited to, permeable surfacing and bioretention for water quality treatment. Under the City's current standards for design of low impact development (LID) concepts, the size of the treatment facility will be based on the percent of existing impervious surface and on the technology used.

8.2.2.4.5 Landscaping

Areas disturbed in Lowman Beach Park for construction of the diversion structure and conveyance pipeline will be restored with lawn and pavement to original conditions.

The tank site will be restored with landscaping and hard surfaces where needed for maintenance equipment access and to reduce congestion in the right-of-way. Landscape areas will be planted with drought-tolerant or native plantings, or both, as developed during final design. Landscaping will be in accordance with City of Seattle standards. The County will work with the community to develop the landscaping plan, as this area is adjacent to Lowman Beach Park, which is a local community amenity. Temporary irrigation systems would be employed during the plant establishment period (typically 1 to 2 years) to reduce plant mortality.

8.2.3 Process Flow

This section describes how the proposed Murray CSO control facilities would operate during dry-weather flow and wet-weather events.

8.2.3.1 Dry- and Moderately Wet-Weather Flow Description

Figure 8.10 is a schematic of average dry-weather and moderately wet-weather flow operation (defined as flow up to 31.5 mgd, which is the capacity of the Murray Pump Station). These flows will pass through the Murray Pump Station and no flows will be diverted to storage. All flow will be conveyed to the 63rd Avenue Pump Station and, ultimately, the West Point Treatment Plant.

8.2.3.2 High Wet-Weather Flow Description

Figure 8.11 is a schematic of high wet-weather flow operation. High wet-weather flow is defined as flow greater than 31.5 mgd, which exceeds the capacity of the Murray Pump Station. Under high wet-weather flow conditions, flows exceeding the pump station's capacity will enter the diversion structure and be sent to storage. The Murray Pump Station will continue to send flows up to 31.5 mgd to the 63rd Avenue Pump Station.

Flow exceeding the pump station capacity will overflow a weir in the pump station wet well, enter the diversion structure, and flow by gravity to the storage tank. If the capacity of the influent pipe (up to 100 mgd) or tank storage (1 MG) is exceeded, flows will back up in the diversion structure, overtop a weir and flow through the 72-inch CSO outfall to Puget Sound.

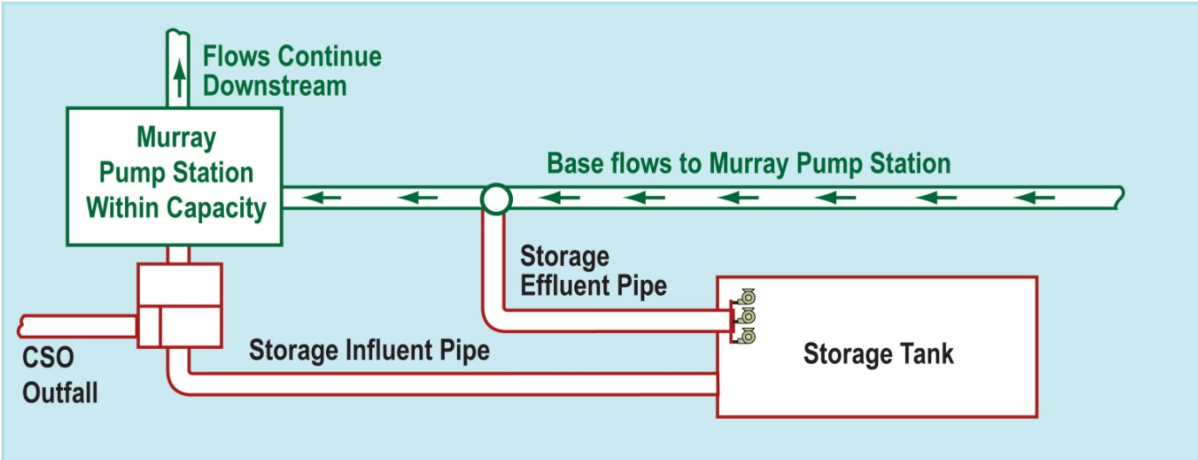


Figure 8.10 Murray Storage Tank Dry-Weather and Moderately Wet-Weather Flow Operation

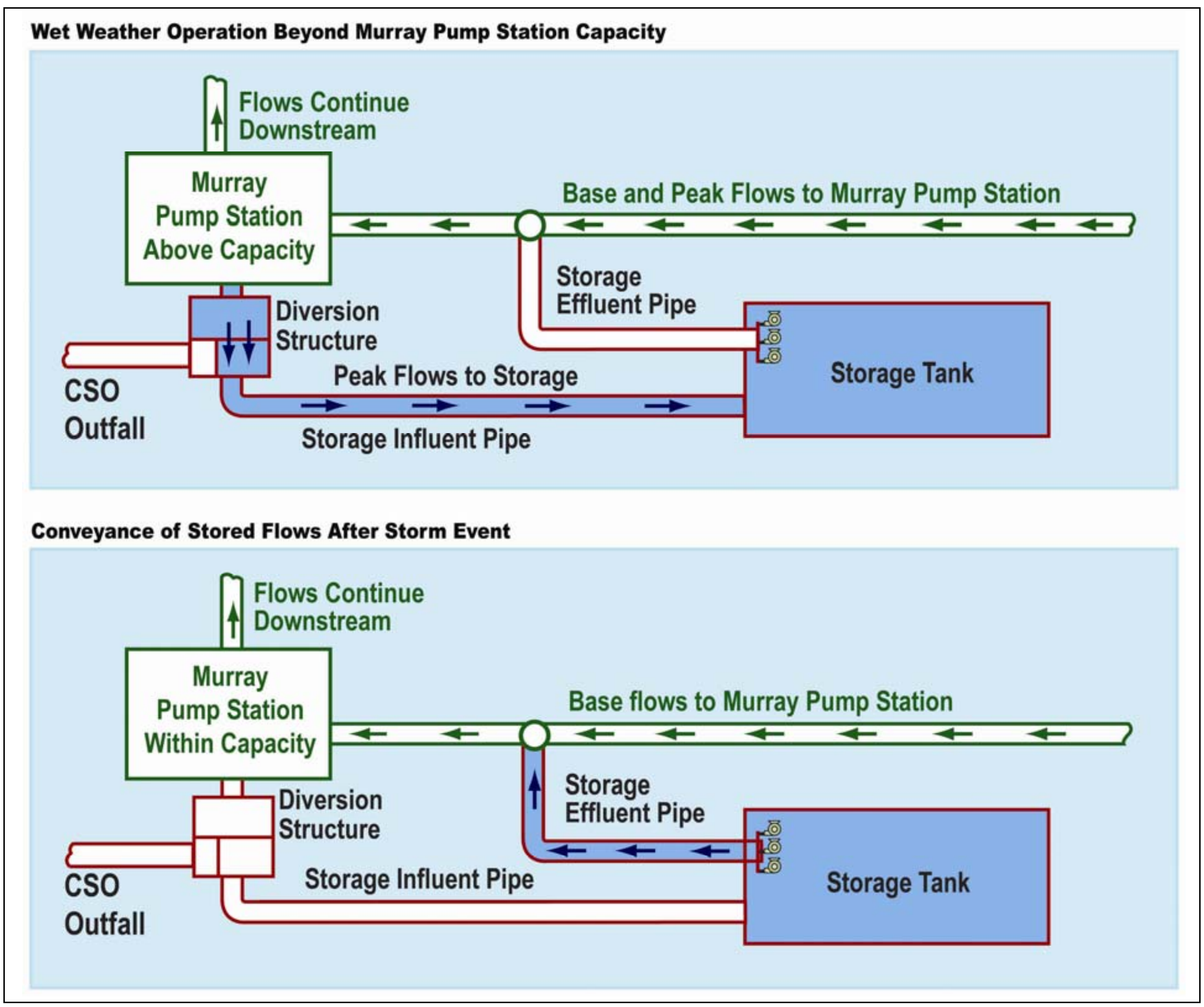


Figure 8.11 Murray Storage Tank High Wet-Weather Flow Operation

At the conclusion of the high wet-weather event, when system flows subside to less than 31.5 mgd, drain pumps will empty the storage tank. The pumps will be sized to drain the storage tank in 12 hours (capacity). The flow rate of the drain pumps will be regulated so that the peak flow capacity of the Murray Pump Station is not exceeded during tank draining.

8.2.3.3 Process Flow Diagram

Figure 8.12 shows a process flow diagram of the Murray CSO control system. Instrumentation and control strategies will be developed during final design. The SCADA system will provide the operator with applicable control set points and will generate level alarms when the storage facility approaches and reaches its fill level and when flows overtop weirs. Appropriate control actions will be implemented for the following situations:

- Power failure and restore.
- Communications failure and restore.
- PLC self-diagnostics alarms and restore.
- Level measure calibration, out of range (high and low), and restore.
- Set point entry range checking.

8.2.4 Hydraulic Profile

The hydraulic profile of the Murray CSO control system is shown in Figure 8.13.

8.2.5 Facility Sizing

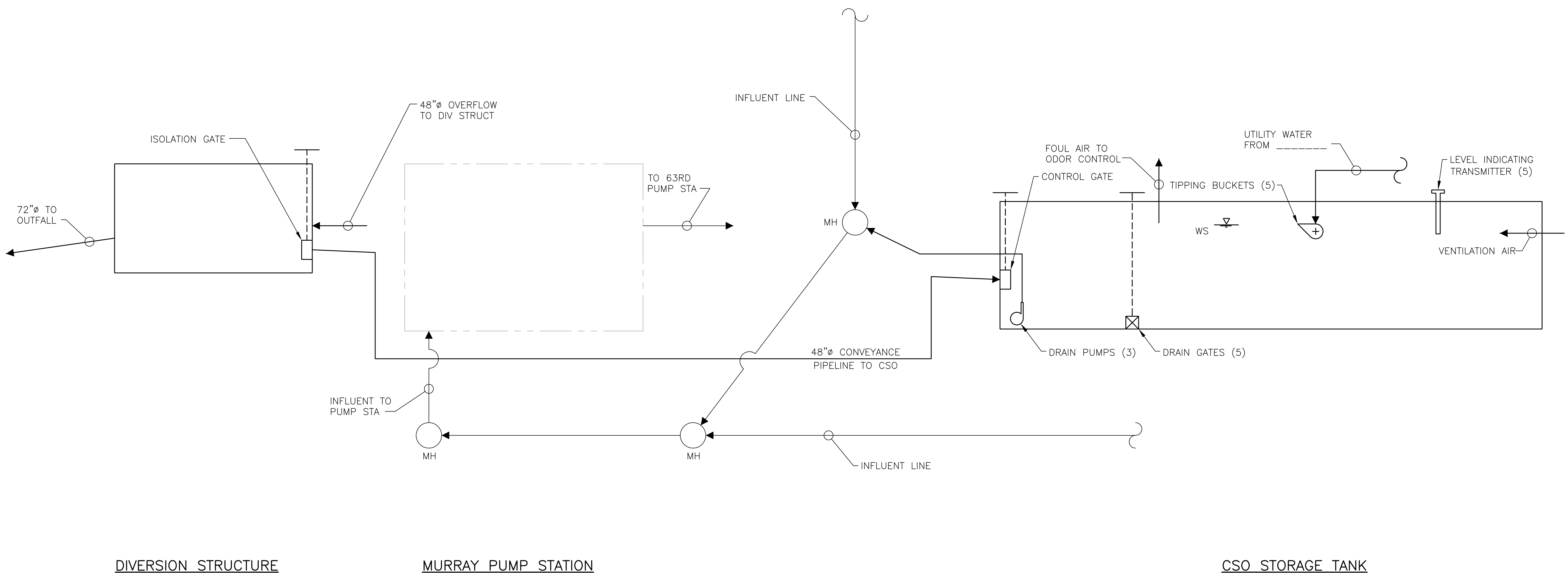
Major project dimensions and sizes are provided in Table 8.4.

8.3 ENVIRONMENTAL IMPACTS

The proposed alternatives would reduce the volume and frequency of untreated overflows to Puget Sound, enhancing water quality and wildlife habitat. The County is preparing a SEPA Environmental Checklist in accordance with WAC 197-11 and plans to issue a threshold determination in April 2011. A copy of the Environmental Checklist and threshold determination will be provided in Appendix D when available.

8.3.1 Barton GSI Alternative

The primary project area for the GSI alternative consists of street rights of way within approximately 200 developed residential acres between 29th and 34th Avenues SW and SW Barton and Othello Streets. Documentation provided in Appendix E describes existing environmental conditions in the project area. A preliminary geologic/geotechnical evaluation (Shannon & Wilson, Inc., March 26 2010) of the Barton CSO basin alternatives also is provided in Appendix E. The evaluation included an assessment of geologic conditions and geotechnical limitations in the project area. A detailed geotechnical evaluation will be conducted during final design.



PROCESS FLOW DIAGRAM

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WASTEWATER TREATMENT DIVISION
MURRAY STORAGE TANK
BEACH DRIVE AREA UNDERGROUND STORAGE

FIGURE 8.12
CSO CONTROL SYSTEM
PROCESS FLOW DIAGRAM

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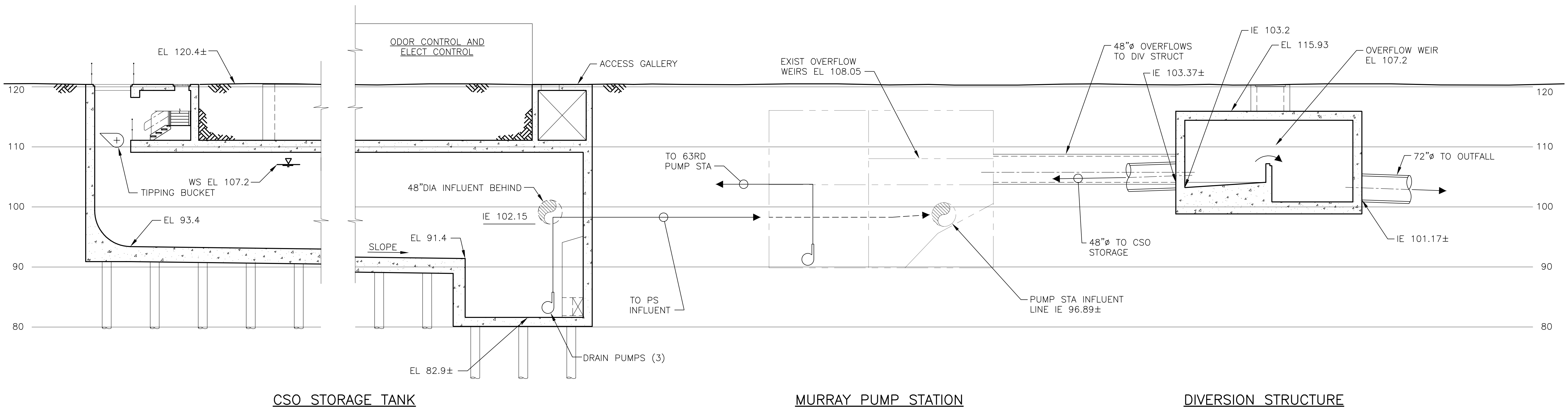

HYDRAULIC PROFILE

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WASTEWATER TREATMENT DIVISION

MURRAY STORAGE TANK
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FIGURE 8.13
CSO CONTROL SYSTEM
HYDRAULIC PROFILE

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Table 8.4 Murray CSO Basin CSO Facility Sizing

Facility Component	Design Criteria[1]
Diversion Structure	
Structure Dimensions	31 feet by 23 feet
Structure Depth	20 feet
Weir Length	26 feet
Storage Tank	
Number of Cells	Five
Width of Cells	15 feet
Length of Cells	180 feet to 64 feet
Total Volume	1 MG
Floor Slope	3%
Minimum Freeboard	1 foot
Number of Drain Pumps	2 duty + 1 standby
Drain Pump Type	Submersible
Drain Pump Capacity	700 gpm each
Diameter of Effluent Pipe	12 inch
Maximum Time to Drain Storage	12 hours
Access	Two per cell plus one hatch for each of three drain pumps
Equipment Materials	Corrosion resistant (316 SS or FRP)
Ancillary Equipment Facility	
Odor Control	Peak air displacement rate (43-mgd peak-flow to storage) or 2 air changes/hr (whichever is greater)
Air Treatment	Activated carbon; 1 pass; 50 fpm; variable speed fan/blower
Occupied Space Ventilation	12 air changes /hr
Standby Generator	Total estimated load; diesel w/ 24 hr capacity
Backflow Preventer	4 inch
Air Gap Tank	1,500 gal
Number of Utility Water Pumps	1 duty + 1 standby
Utility Water Pump Type	End-suction centrifugal
Utility Water Pump Capacity	100 - 250 gpm
Facility Footprint	63 feet by 42.5 feet

Notes:

1. Design criteria are preliminary and may be revised during final design.

8.3.1.1 Existing Ecosystems

8.3.1.1.1 Wetlands

According to the City of Seattle Critical Areas Map (Figure 3.9), there are no wetlands on or immediately adjacent to the project area.

8.3.1.1.2 Streams and Ditches

The City of Seattle Critical Areas Map (Figure 3.9) shows no streams or ditches in the project area.

8.3.1.1.3 Fish Resources

There are no fish bearing streams in the vicinity of the proposed project. This project would limit combined sewer overflows to Puget Sound, which should enhance water quality and wildlife habitat. Therefore, no negative impact on fish resources is expected.

8.3.1.2 Groundwater and Surface Water

Because of spotty distribution and variable thickness of weathered till and overlying recessional outwash on top of the relatively impermeable till in the proposed project area, increased groundwater levels due to infiltration at rain gardens could result in changes to moisture levels in residential yards, basements, and crawl spaces on the subject and adjacent properties.

To reduce the potential risk, sites noted in the geotechnical evaluation or in the field as having poor soils and/or poor drainage patterns were classified as infeasible locations for GSI and eliminated from the analysis. Further, all proposed rain gardens are located so that the basements of adjacent properties will be outside of the zone of influence. This zone of influence is a rough estimate of how the infiltrating water from the proposed facilities will travel. For this analysis it was assumed that if the adjacent basement bottom elevation was above the zone of influence of the bioretention soil, which is measured by a 45-degree angle downward from the bottom edge of the bioretention soil, then the basement is outside the zone of groundwater influence.

Puget Sound lies to the west of the project area. However, no impact on the Sound is expected. The project will have a long-term beneficial impact on water resources since it will achieve the CSO control objective of allowing no more than one untreated event per year on average.

8.3.1.3 Earth Resources

8.3.1.3.1 Soils

The long, broad ridge on which the GSI alternative is proposed to be constructed is underlain by Vashon till and advance outwash. These very dense soils are overlain by a relatively thin layer (typically 0 to 2 feet thick) of loose to medium dense recessional outwash or weathered and topsoil zones. In the southeastern comer of the project area near SW Barton Street and 29th Avenue SW, post-glacial depression deposits consist of a mixture of soft peat and loose

to medium dense silt and sand. The advance and recessional outwash deposits are relatively pervious, whereas the Vashon till is relatively impervious. Permeability of the postglacial depression deposits is highly variable.

Impacts on soils during construction of the rain gardens will include minor erosion from excavation activities, which will be mitigated using construction best management practices (BMPs).

8.3.1.3.2 Geologic Hazards

According to a review of a Department of Ecology database, there are no geologic hazards on or near the proposed project area.

8.3.1.3.3 Soil and Groundwater Contamination

There are no known contaminated areas in the vicinity of the project.

8.3.1.4 Land Use

The 200-acre neighborhood identified for the GSI alternative is a single-family area with a regular street grid pattern near the upper reaches of the Barton CSO basin. The rain gardens associated with the alternative would be constructed in public street right of way (typically the landscape strips between the curb and the sidewalk). Some loss of parking where curb bulbs will be installed is the only permanent land use impact anticipated.

8.3.1.5 Recreational Resources

There are no recreational resources within the proposed project area; although the project boundary does border E.C. Hughes Playground. Roxhill playground is located outside the project area near the intersection of Barton and 25th Avenue SW, There would be no long-term impact anticipated on recreational resources.

8.3.1.6 Utilities

Existing public utilities are not expected to be significantly impacted. Service lines from the right of way to homes may need to be relocated or replaced as part of the installation of rain gardens in the planter strips. Existing residential services for sewer, drainage, power, gas, water and telecommunications services would be maintained through temporary and/or permanent relocation of utility services, as required by the final design.

8.3.1.7 Transportation

There will be temporary local impacts on traffic and access during construction of rain gardens. It is not anticipated that any streets will be closed during construction, but traffic may be restricted to one lane, requiring traffic control measures and street parking restrictions during some of the construction activities. Longer traffic queuing times are not anticipated. Access restrictions to residences are anticipated to be minimal and temporary.

Rain gardens will be installed in residential streets on a progressive schedule. The peak number of daily construction vehicle trips during construction would be about 10 trips per

day. There may be additional traffic in the area during peak shopping seasons because the Westwood Village Shopping Center is east of the project area.

During construction, the contractor would be required to submit a traffic control plan detailing the haul route for construction traffic. Additional traffic control measures, such as warning signs and flaggers, may be a requirement of the haul route approval.

Measures to reduce or control transportation impacts by the completed project would not be required.

On-street parking removals will vary dependent on the final design. The final design will adhere to traffic regulations and City of Seattle parking requirements. The loss of on-street parking could range from about 3 parking stalls per street to approximately 20 (roughly 50-percent of the on-street parking).

8.3.1.8 Odor and Air Quality

Air quality impacts from earth-moving activities during construction are typical for large construction projects. BMPs would be implemented for dust control, including street sweeping, watering exposed soil surfaces, and covering soil stockpiles to help minimize the amount of fugitive dust and particulate pollution to the surrounding areas. Similar BMPs might be employed by the contractor to minimize dust. Construction activities often concentrate heavy equipment powered by gas or diesel engines in a particular location. Air pollution from engines could increase during certain activities, such as queuing trucks for loading and offloading of materials, or during excavation. Provisions to limit idling of mechanical equipment typically are included in King County projects and would be employed during construction to minimize the amount of air pollution generated from gas- and diesel-engine-driven machinery, as well as to limit greenhouse gas effects.

There would be no odor emissions from the rain gardens except related to initial landscape installation.

8.3.1.9 Noise

Noise impacts during construction would be mitigated by contract documents requiring compliance with noise regulations and the local jurisdictional codes. Variances may be obtained if the schedule requires working additional hours beyond current ordinance allowances.

Equipment operation after the rain gardens are in operation would produce little if any noticeable noise. This would include vehicles associated with landscape maintenance. Larger equipment may be used for major maintenance intervals where soil and related plantings are removed and replaced. For budgeting purposes this is estimated at every 15 years.

8.3.1.10 Cultural Resources

No known archaeological resources have been identified in the upper sub-basin location of the GSI Alternative, and the project area has a low probability of containing archaeological

resources due to shallow excavation anticipated at less than 4 feet deep. The sub-basin contains no known historic structures.

8.3.1.11 Endangered/Threatened Species or Habitats

There are no threatened or endangered species known to be on or immediately adjacent to the project site. Long-term effects of the project would be beneficial to listed species in Puget Sound, as water quality would be improved with a reduction in combined sewer overflow events.

8.3.1.12 Prime or Unique Farmland

There is no farmland within the project area, so there would be no impacts on prime or unique farmland.

8.3.2 Murray Alternative 1F

The primary project area for Murray Alternative 1F consists of currently privately-owned parcels south of the intersection of Beach Drive SW and Lincoln Park Way SW. Documentation provided in Appendix E describes existing environmental conditions in the project area. A preliminary geologic/geotechnical evaluation (Shannon & Wilson, Inc., March 26, 2010) of the Murray CSO basin alternatives also is provided in Appendix E. The evaluation included an assessment of the geologic conditions and geotechnical limitations in the project area. A detailed geotechnical evaluation will be conducted during final design.

8.3.2.1 Existing Ecosystems

8.3.2.1.1 Wetlands

According to the City of Seattle Critical Areas Map (Figure 3.10), there are no wetlands on or immediately adjacent to the project site.

8.3.2.1.2 Streams and Ditches

The City of Seattle Critical Areas Map (Figure 3.10) indicates that the proposed project area contains riparian corridor surrounding a piped portion of Pelly Creek, which would likely be moved during construction if necessary.

8.3.2.1.3 Fish Resources

There are no fish bearing streams in the vicinity of the project. This project would limit combined sewer overflows to Puget Sound, which should enhance water quality and wildlife habitat. Therefore, no negative impact on fish resources is expected.

8.3.2.2 Groundwater and Surface Water

The proposed storage tank would involve a 45-foot-deep excavation near the toe of an existing steep slope and would likely require the use of relatively impermeable shoring. Considerable dewatering and groundwater recharge requirements to control groundwater-drawdown induced settlements. Given the presence of very loose soils, the presence of

organic soils and peat, and the proximity of existing structures, utilities, and other improvements, a driven or vibrated sheet pile shoring system could result in unacceptable vibrations and settlements. The proposed secant pile system would reduce the likelihood of impacts on adjacent structures and reduce the dewatering requirements.

Available subsurface data does not indicate the presence of a suitable groundwater cutoff layer. Therefore, some dewatering and potentially some groundwater recharge will likely be required even if relatively impermeable shoring is used. The shoring could be assumed to extend to twice the excavation depth to help control groundwater. Caving soils may cause difficulties during excavation of the shoring.

Provisions to control uplift may also be required depending on the depth, size, and design of the structure. Given the proposed structure footprint size, uplift piles or anchors may be needed.

Puget Sound lies to the west of the project area and no impact on the Sound is expected. The project will have a long-term beneficial impact on water resources since it will achieve the CSO control objective of allowing no more than one untreated event per year on average.

8.3.2.3 Earth Resources

8.3.2.3.1 Soils

The original ground at the project site has been filled to depths ranging from 7 to 12 feet. The fill consists mostly of loose to dense, silty, slightly sandy gravel and gravelly sand; however, one boring encountered clayey soils. Many of these fill soils contain some organics, wood, boulders, and foreign debris. Underlying the fill are about 10 to 30 feet of very loose to medium dense sands and gravels with organic materials, and soft peat layers. In two recent borings, a 2- to 3-foot-thick layer of soft to medium stiff, organic silt was encountered at about sea level. The recent soils are underlain at depths of 21 to 40 feet by medium dense to very dense recessional outwash, consisting of slightly silty to silty, gravelly sand and sandy gravel.

Impacts on soils during construction of the CSO facilities will include erosion from excavation activities, which will be mitigated using construction BMPs. A majority of the soils excavated for the storage tank would be hauled off-site to approved locations.

8.3.2.3.2 Geologic Hazards

The City of Seattle Critical Areas Map (Figure 3.10) shows potential landslide hazard areas and slopes greater than 40 percent to the south and east of the proposed project site, and a liquefaction zone to the west. Uplift piles, if required, could limit liquefaction-induced settlement of the tanks; otherwise, deep foundation elements would likely be required. As an alternative, ground improvement could be performed, such as compaction grouting, creating confining cells of improved ground under the tank footprint, or installing stone columns or vertical drains.

8.3.2.3.3 Soil and Groundwater Contamination

There are no known contaminated areas in the vicinity of the project.

8.3.2.4 Land Use

The triangular parcel of land east of Lowman Beach Park where the proposed storage tank would be constructed, bounded by Beach Drive SW and Lincoln Park Way SW, is occupied by several low-rise multifamily buildings. These buildings would be acquired and removed.

8.3.2.5 Recreational Resources

The project site is immediately east of Lowman Beach Park, a 4.1-acre waterfront park. It includes lawn/open space, a tennis court, and a tidal beach area on Puget Sound. Construction of the facilities would impact access to the park by recreational users during construction. Parking immediately adjacent to the park will not be available and part of the park may be used for construction staging and material lay-down. These areas would be restored, and there would be no long-term impact on recreational resources.

8.3.2.6 Utilities

There are existing utilities within the Beach Drive SW right-of-way that may need to be relocated as part of project construction. Existing sewer, drainage, power, gas, and telecommunications services would be maintained through temporary and/or permanent relocation of utilities as required by the final design.

8.3.2.7 Transportation

There will be impacts on traffic, parking, and access during construction within Beach Drive SW and SW Lincoln Park Way. Potential delays and detours during construction could have temporary, indirect impacts. Longer traffic queuing times are not anticipated.

Temporary lane closures would occur on Beach Drive SW and SW Lincoln Park Way within the construction area for construction of the influent pipe, storage tank, effluent pipe and utilities required for the storage tank. There are nearby alternate routes available to SW Lincoln Park Way. However, there are no alternative routes for properties south of the construction site along Beach Drive SW. Access will need to be maintained throughout construction. The length of traffic disruption is anticipated to be 12 to 18 months.

In addition to lane closures and detours during construction, there will be increased construction traffic to and from the project site. The peak number of daily construction trips would occur during excavation and backfilling of the storage tank and asphalt paving and are estimated at 30 trips per day. During other phases of construction, the number of daily construction trips is likely to be less than 30 per day. It is likely that the general construction traffic would have little impact on the level of service in the area.

During construction, the contractor would be required to submit a traffic control plan detailing the haul route for construction traffic. Additional traffic control measures, such as warning signs and flaggers, may be a requirement of the haul route approval.

Measures to reduce or control transportation impacts by the completed project would not be required.

There may be a net permanent loss of up to two parking spaces on the east side of Beach Drive SW in front of the facility site. This would be associated with a driveway entrance on to the proposed site. There currently is one residential driveway entrance serving one of the residential properties

8.3.2.8 Odor and Air Quality

Air quality impacts from earth-moving activities during construction are typical for large construction projects. BMPs would be implemented for dust control, including street sweeping, watering exposed soil surfaces, and covering soil stockpiles to help minimize the amount of fugitive dust and particulate pollution to the surrounding areas. Other similar BMPs might be employed by the contractor to minimize dust. Construction activities often concentrate heavy equipment powered by gas or diesel engines in a particular location. Air pollution from engines could increase during certain activities, such as queuing trucks for loading and offloading of materials, or during heavy excavation. Provisions to limit idling of mechanical equipment typically are included in King County projects and would be employed during construction to minimize the amount of air pollution generated from gas- and diesel-engine-driven machinery, as well as to limit greenhouse gas effects.

Long-term impacts (continuous emissions) from odors associated with operation of the facilities would be minimized and mitigated through several design features. Odor generation in the new diversion structure would be minimized by limiting turbulence and keeping the hatches to the structure closed. Odors generated at the storage tank would be minimized through the automated flushing system installed to clean settled solids from the tank after each storage event. Periodic manual wash-down of the accessible portions of the tank walls could be used to minimize odorous gas formation in the tank further; however, the current design prioritizes the automated flushing system. Any odors generated within the tank from stored wastewater or solids not removed from the wash-down system would be mitigated through operation of the planned odor control facility.

Instrumentation to measure inlet and outlet gas concentrations at the odor control facility would help determine the functional performance and life remaining on the carbon filter media to more accurately schedule carbon replacement. Active monitoring ensures that foul odors are controlled to the extent possible by the installed system.

8.3.2.9 Noise

Noise impacts during construction would be mitigated by contract documents requiring compliance with noise regulations and the local jurisdictional codes. Variances may be obtained if the schedule requires working additional hours beyond current ordinance allowances.

Equipment operation after the facility is in operation would produce little if any noticeable noise. Pumps in the storage tank are submersible and would not produce noticeable noise. All functional noise controls, such as insulation under access hatches, would be implemented

so that noise levels at the property line would not exceed limits established for the site's current zoning.

In this alternative odor control equipment, pump motor starters and a standby generator are housed in a facility on the storage tank site. Additional noise mitigation measures such as louver baffles, acoustical shrouds, and exhaust stack silencers would be included as necessary to provide minimum noise conditions at the site's property line. Additional measures such as cabinet acoustical insulation or noise-suppressing insulation inside the structure may be required if noise levels at the site became unacceptable to the adjacent residents.

8.3.2.10 Vibration

Vibration during construction of the facilities would be monitored at nearby residences. Standards of care would be applied and specified in the contract documents.

During normal operation of the storage tank and completed facility equipment, vibrations would be localized to the degree that only those persons standing near the equipment enclosure or on hatches directly adjacent to equipment would notice vibrations. Pumps currently sized for this facility are not large enough to create vibration issues, particularly given the mass of the new storage facility. Odor control equipment and standby generator would be fitted with anti-vibration components in the equipment anchoring systems specified for the project.

8.3.2.11 Cultural Resources

There have been no archaeological or cultural resources identified in the proposed project area, but its location and site characteristics indicate a medium probability of containing archaeological resources.

8.3.2.12 Endangered/Threatened Species or Habitats

There are no threatened or endangered species known to be on or immediately adjacent to the project site. Construction related noise may impact marbled murrelets, but are not expected to adversely affect them. A biological assessment will be prepared for the proposed project. Project construction would be approximately 220 to 330 feet east of Puget Sound (diversion structure construction activities will be closer to Puget Sound). Long-term effects of the project would be beneficial to listed species in Puget Sound, as water quality would be improved with a reduction in combined sewer overflow events.

8.3.2.13 Prime or Unique Farmland

There is no farmland within the project area, so there would be no impacts on prime or unique farmland.

8.4 DESIGN LIFE

8.4.1 Barton GSI Alternative

GSI is a living system and therefore the definition of useful design life needs further clarification. Rain garden repair, such as plant replacement and isolated soil removals would be considered to be major maintenance. In general a residential rain garden facility under best management practices would be expected to exceed a 50-year design life.

8.4.2 Murray Alternative 1F

The design life of the storage facility is based on a 50-year life cycle, and the primary equipment design life is based on a 20-year life cycle. Routine maintenance of the facility and replacement of equipment would occur as needed to obtain the design life.

8.5 RESIDUALS MANAGEMENT

8.5.1 Barton GSI Alternative

Plant materials and soils will contain certain amounts of oils, metals, and roadway contaminants. Based on current data, removed plant materials and soils should be categorized as non-hazardous waste and will be disposed of accordingly.

8.5.2 Murray Alternative 1F

The proposed storage tank will include a flushing system so that solids can be cleaned out of the tank following a CSO event and will not accumulate in the tank. Utility water would also be provided at the diversion structure from the existing Murray Pump station to flush the influent pipeline to storage. Therefore, sludge management should not be a concern here. The storage tank will be designed to allow for access and cleaning by O&M staff, should additional cleaning be needed.

8.6 ABILITY TO EXPAND

It is not anticipated that the Barton or Murray CSO basin will experience any significant demographic or land use changes in the future. The area is considered built-out and population levels are anticipated to remain relatively constant. The need for the proposed projects is not due to anticipated population growth or increase in sewered areas (connecting on-site systems to sewer system); therefore, it is not anticipated that future demographics, land use, or population growth will increase the CSO control volume required to meet current Ecology requirements.

In the event that the proposed alternatives fail to provide sufficient CSO control, the primary option to provide additional CSO reduction is reduction of inflow and infiltration, including a focus on the City of Seattle’s Residential RainWise Program. Due to the age of the collection system in the Barton and Murray CSO basins, it is likely that many locations experience inflow and infiltration; the majority of the inflow and infiltration is likely occurring on private property. Key aspects of these additional CSO control measures would be as follows:

- The City's Residential RainWise Program aims to reduce the amount of stormwater runoff (inflow) from private properties into the sewer collection system. By removing residential stormwater connections from the combined system, the volume and flow rate of wet-weather peak flows are reduced. This reduction allows the existing facilities to convey a higher percentage of the flows from the basin.
- For the City-owned collection sewers, additional investigation would be required to identify and locate points of infiltration in the system. It is difficult to predict the level of reduction that could be achieved with infiltration reduction projects, and the projects are unreliable in achieving the reductions of flow required for CSO control. Other combined sewer agencies across the nation, including many in the Northwest, consider infiltration reduction a good asset management practice but do not rely upon it to achieve compliance with CSO reduction requirements. Infiltration reduction is usually a secondary benefit of rehabilitating the pipe.

8.7 O&M AND STAFFING NEEDS

8.7.1 Barton GSI Alternative

The proposed GSI alternative would require periodic maintenance to ensure that proper operation occurs and that the design life of the facility is met. Tables 8.5 and 8.6 show the likely types of operation and maintenance activities, respectively, the frequency of each activity, staffing requirements to perform those activities and equipment required. Key issues for O&M include the following:

- Exploration of partnership opportunities for GSI maintenance with public agencies or possible third party contractors.
- Definition of operational protocols.

8.7.2 Murray Alternative 1F

The proposed alternative would need regular maintenance to ensure that the design life of the facility is met and proper operation occurs. Table 8.7 shows the types of O&M activities that could occur, the frequency of each activity, and staffing requirements to perform those activities. Key issues for O&M include the following:

- Monitor the system remotely during a wet-weather event and for equipment condition during dry weather.
- Design the system for ease of operation and maintenance, including post-wet weather event cleaning.
- Design so that maintenance staff will not need to routinely enter the storage tank.
- Provide provisions for entry to storage tank and maintenance, if needed.
- Visually integrate the ancillary facility with the surrounding neighborhood.

Table 8.5 Operation Activities for Barton GSI Alternative

	Activity	Frequency	Staff Needed	Equipment Needed
Before Major Storm (Forecast of heavy downpour or approximately one inch of rainfall in 24 hours)	Inspection/maintenance to ensure gutter inlets/curb cuts are clear of litter, debris and built-up sediment	Varies. Estimate 4 times a year on average	1-2	Rakes/Gardening Tools, Truck to haul debris
After Major Storm (Heavy downpour or approximately one inch of rainfall in 24 hours)	Inspection/maintenance to ensure gutter inlets/curb cuts are clear of litter, debris and built-up sediment	Varies. Estimate 4 times a year on average	1-2	Rakes/Gardening Tools, Truck to haul debris

Table 8.6 Maintenance Activities for Barton GSI Alternative

	Activity	Frequency	Staff Needed	Equipment Needed
General Maintenance	Pruning, Weeding	2 times per year	2	Rakes/Gardening tools, Truck to haul material.
Irrigation	Watering of vegetation	Summer Months	none	Automated system
Minor Maintenance	Inspection of rain gardens	1/month	1	Rakes/Gardening tools
Maintenance	Removal of debris during wet weather/fall leaf drop	2 times a week for two months	1-2	Rakes/Gardening Tools
Maintenance	Replace Mulch	Every 3 years	2	Excavation equipment, Trucks, Rakes/Gardening tools
Repair Maintenance	Replace required plants and soils upon evaluation	every 15 years	3	Excavation equipment, Trucks, Rakes/Gardening tools

Table 8.7 Operation and Maintenance Activities for Murray Alternative 1F

Component	Activity	Frequency	Staff Needed	Special Equipment Needed
Diversion Structure				
Access Hatches	Inspect hatches for wear and tear from surface by opening access hatches and visually assess conditions; replace worn or damaged components.	Annually	2	Repair components from manufacturer/ supplier
Gates	Grease riser stems, adjust seats, etc. depending on type of gate.	Semi-annually or per manufacturer recommendations	2	None
	Exercise gates/actuators	Monthly	1	None
	Replace gates.	As needed	6	Confined space entry equipment
Operators/ Actuators	Grease riser stems, packing, seats, etc., depending on type of operator/actuator.	Semi-annually or per manufacturer recommendations	2	None
Level Gauges	Inspect and take readings.	Weekly	1	None
	Calibrate.	Annually	1	None
	Repair/Replace gauges.	Semi-annually	2	None
Storage Tank				
Access Hatches	Inspect hatches for wear and tear from surface by opening access hatches and visually assess conditions; replace worn or damaged components.	Semi-annually	2	Repair components from manufacturer/ supplier
Flushing Gate	Inspect flushing gate for wear and tear from surface by opening access hatches to view and visually assess conditions.	Semi-annually	2	None
Flushing Filling System	Inspect for damage to filling system; replace worn or damaged components.	Semi-annually	2	Repair components from manufacturer/ supplier
Storage Cells	Surface inspection – open hatches and inspect visible areas with surface-supplied lighting to monitor for debris accumulation.	After each event for first year. Thereafter, annually.	2	Surface direction lighting
	Manned structural inspection – perform manned entry into tank to inspect concrete structure.	10-year cycle/post-seismic event	5	Confined space entry equipment, fire department standby
	Survey of existing structure for settlement.	10-year cycle/post-seismic event	4	Survey crew and equipment

Table 8.7 Operation and Maintenance Activities for Murray Alternative 1F

Component	Activity	Frequency	Staff Needed	Special Equipment Needed
Pumps	Routine maintenance – bearings, sensors – can be done at surface.	Quarterly	3	None
	Pump Start/Stop cycling; operate pumps manually to ensure start/stop.	Weekly	2	None
	Clearing rags, blockages; can be done at surface.	As needed	3	None
	Slide rail/level controller – inspect for wear and tear.	Annually/when manned structural inspection is performed	5	Confined space entry equipment, fire department standby
Valves	Grease riser stems, packing, seats, etc., depending on type of valves.	Semi-annually or per manufacturer recommendations	3	None
	Replace valves.	As needed	3	None
Gates	Grease riser stems, adjust seats, etc., depending on type of gate.	Semi-annually or per manufacturer recommendations	3/5	None/confined space entry equipment
	Exercise gates/actuators	Monthly	1	None
	Replace gates.	As needed	6	Confined space entry equipment
Operators/ Actuators	Grease riser stems, packing, seats, etc., depending on type of operator/actuator.	Semi-annually or per manufacturer recommendations	3	None
Flow Meter	Inspect and take readings.	Post event	1	None
	Calibrate.	Semi-annually	1	None
	Repair/Replace gauges.	As needed	2	None
Level Gauges	Inspect and take readings.	Post event	1	None
	Calibrate.	Semi-annually	1	None
	Repair/Replace gauges.	As needed	2	None
Electrical Room				
Panels	Routine inspection and maintenance.	Semi-annually or per manufacturer	1	None
Variable Frequency Drives	Routine inspection and maintenance.	Semi-annually or per manufacturer	1	None
Programmable Logic Controller	Routine inspection and maintenance.	Semi-annually or per manufacturer	1	None
Motor Control Center	Routine inspection and maintenance.	Semi-annually or per manufacturer	1	None
Motor Starters	Routine inspection and maintenance.	Semi-annually or per manufacturer	1	None

Table 8.7 Operation and Maintenance Activities for Murray Alternative 1F

Component	Activity	Frequency	Staff Needed	Special Equipment Needed
Standby Generator	Routine inspection and maintenance.	Monthly or per manufacturer	2	None
	Routine testing under load.	Monthly	2	None
Mechanical Room				
Air Gap Tank	Visually inspect for leaks, corrosion and fouled contacts on instruments/floats.	Annually	1	None
Air Gap Tank Filling System	Visually inspect for leaks, manually operate valves or system by hand-adjusting floats/level controllers.	Weekly	1	None
HVAC	Belts and Bearings – Inspect and replace as needed.	Annually or per manufacturer	1	None
Carbon Filter Media	Sample carbon for saturation; collect analytical sample for analysis by vendor/laboratory.	Quarterly	1	None
	Inspect filter bed for crusting/fouling – use rake/hand tools to break up fouled surface (horizontal bed only).	Annually or as indicated by pressure gauges across filter bed	1	None
	Replace carbon media.	On 5-year intervals or as indicated by carbon testing results	3	Vacuum truck, boom truck or lifting equipment if facility not equipped
Fan – Odor Control Fan	Belts and Bearings - Inspect and replace as needed.	Semi-annually or per manufacturer	1	None
Fan – HVAC	Belts and Bearings - Inspect and replace as needed.	Semi-annually or per manufacturer	1	None
Grease/Mist Eliminator	Remove fouled media filters and replace with clean filters; clean fouled filters off-site and store.	Annually or as indicated by pressure gauges across filter bed	2	Flatbed truck to haul filters, lifting equipment if facility is not equipped
Pressure Gauges	Inspect all gauges and record readings.	Monthly based on visits to facility	1	None
	Repair/Replace gauges.	As needed	1	None
Fiberglass Ductwork	Visually inspect all ductwork for cracking or leaks.	Semi-annually and after seismic events	1	None
Dampers	Visually inspect all dampers and actuators for damage or wear and tear.	Semi-annually	1	None
Silencer	Visually inspect silencer for damage or wear and tear.	Annually	1	None

8.8 DESIGN GUIDELINES

8.8.1 Site Design

The finished design of the proposed projects must provide for adequate traffic movement and safety while providing adequate access, working space, and parking for maintenance of the facilities. Minimizing impact on existing land uses is an important design parameter.

8.8.2 Traffic

It is important to minimize lane closures and impacts on traffic during construction. Once the proposed projects are completed, King County O&M staff will periodically be required to visit the sites. Disruption to traffic will need to be minimized during O&M activities.

8.8.3 Structural/Geotechnical

Shoring for earthwork should be of a type appropriate for the available space and other site conditions. Shoring for earthwork must adequately support the sides of the excavation and protect adjacent areas and structures.

Anticipated groundwater levels at the Murray proposed alternative site would require dewatering during construction of the tank, piping and diversion structure. The structural design of the storage tank would also need to counteract buoyancy due to groundwater.

Rain gardens should be located where infiltrated water will not affect building foundations or slopes.

8.8.4 Stormwater Management

Stormwater design will follow the City of Seattle Stormwater Code for water quality treatment for runoff. The design water quality treatment volume will be equal to 91 percent of the total volume of the simulation period using an approved continuous model (SMC 22.805.090.B1.a). The stormwater design for the proposed Murray alternative also will incorporate GSI concepts to the extent feasible including, but not limited to, the use of permeable surfacing and bioretention.

8.8.5 Architecture/Landscaping

The ancillary equipment facility in the Murray proposed alternative will be architecturally designed to be visually integrated with the surrounding neighborhood. Architectural consideration will be given to retaining walls, exhaust stacks, intake and exhaust plenum vaults, and other exposed above-grade features to ensure compatibility with the existing site's aesthetic characteristics.

Landscape design in the Murray proposed alternative will be compatible with the surrounding neighborhood and park, will utilize native or drought-tolerant plants, and will minimize irrigation and maintenance requirements.

Landscaping of the proposed rain gardens for the Barton CSO basin will be compatible with the surrounding neighborhood and will meet the technical requirements for GSI and CSO control in the Barton basin.

8.8.6 O&M and Facility Inspections

An important objective in the design of the projects is to allow simple, reliable and safe operation and maintenance. This includes avoiding the need to routinely enter the storage tank to perform O&M activities by including a post-event flushing system and other design features.

The Murray Alternative storage tank would be maintainable from entry structures on the ground surface whenever possible, including the post-event solids removal activities. Entry structures would be located so that O&M crews can access the equipment and storage cells, if needed.

Provisions would be made for personnel and equipment to enter the tank. For example, removable concrete panels would be incorporated into the design to allow large equipment to be placed inside or removed. Smaller access hatches would also be provided to allow access for routine O&M. Furthermore, the overall facility would be remotely monitored during operation to verify that mechanical systems are working properly.

Pumps would be used to drain the storage facility rather than draining it by gravity. When downstream capacity is available, the storage facility would drain at the maximum flow rate possible without overloading the downstream conveyance system. The pumps would be rail-guided submersible pumps to minimize the need for entry for maintenance.

The odor control system can assist in ventilation for maintenance activities. The ventilation rate is 2 ac/hr to control odors, with provisions for 12 ac/hr with a bypass around the carbon scrubber prior to entry into the storage facility. Auxiliary portable ventilation equipment could be employed for infrequent entrance into the tank.

O&M of the proposed rain gardens for the Barton CSO basin will not involve any special provisions other than landscape and surface work along the roadside planting strip. Minimal traffic control would be required for routine maintenance activities. Lane closure and traffic control would be required during heavy maintenance intervals involving removal and replacement of soil and plant materials.

8.8.7 Reliability

The location of the proposed Murray alternative site allows for filling of storage by gravity. Existing outfalls provide a relief point in the event that flow rates or volumes exceed the capacity of the storage tank and influent piping.

The odor control equipment, drain pumps, and other items requiring power are not considered critical to storing flows to prevent CSOs, since the storage tank would fill by gravity. Loss of power would prevent the storage facility from being drained by the pumps after an event; however, this would not prevent the sewer collection system from continuing to operate. It is anticipated that the storage facility will only be used a few times a year and

that the likelihood of back-to-back uses is very low. However, the design does include on-site standby power. Final design will investigate the use of the standby generator at the proposed storage facility to provide emergency power to the existing Murray Pump Station in lieu of a installing a separate generator in Lowman Beach Park.

The GSI alternative is a decentralized facility located over multiple blocks of Barton Sub-basin 416. Since this removes stormwater from a large area, there is no single point of failure, which makes this alternative highly reliable. There are emergency overflows within the rain gardens to prevent localized flooding if the design storm is exceeded and the storage volume of the rain gardens has been reached.

8.8.8 Effects of Sea Level Rise

In March 2006, the King County Executive issued an executive order on Global Warming Preparedness directing all agencies to prepare for the effects of climate change, including adaptation, mitigation and sequestration. The Wastewater Treatment Division is evaluating the effects of rising sea levels associated with climate change. Sea level rise (SLR) scenarios were developed by combining prediction of future SLR and storm surge from statistical analysis. The three main sources for the scenarios came from the University of Washington's Climate Impacts Group, Department of Ecology Report *Sea Level Rise in the Coastal Waters of Washington State* (2008) and *Response of Extreme Storm Tide Levels to Long-Term Sea Level Change* (C.E. Zervas, 2005).

To give a broad array of possibilities 1-, 2-, 10-, and 100-year storm events were considered for each SLR scenario. Table 8.8 shows the values used for possible future sea-level conditions with storm events.

Table 8.8 Puget Sound Sea-Level Rise Scenarios with Storm Surge

		Storm Surge (Metro datum in feet)			
Sea-Level Rise Scenarios	**No Storm**	**1-Year (1.48')**	**2-Year (2.27')**	**10-Year (2.79')**	**100-Year (3.19')**
Current Conditions (MHHW)	105.36	106.84	107.63	108.15	108.55
Medium SLR 2050 (6")	105.86	107.34	108.13	108.65	109.05
Medium SLR 2100 (13")	106.44	107.92	108.71	109.23	109.63
Very High SLR 2050 (22")	107.19	108.67	109.46	109.98	110.38
Very High SLR 2100 (50")	109.53	111.01	111.8	112.32	112.72

8.8.8.1 Barton Basin Vulnerabilities

The proposed area for GSI is high in the basin. The Barton Pump Station was identified as being vulnerable to storm surge and sea level rise in the *Vulnerability of Major Wastewater Facilities to Flooding from Sea Level Rise* Report (July 2008). The overflow weir is at elevation 107.75 feet (Metro) and the facility is at elevation 109.3 feet (Metro). This facility has flooded during storm surges in the past.

The Barton Pump Station upgrade includes several measures that will improve the reliability of the pump station under flooded conditions that would result from tidal surges or sea level rise. Those measures include installing new raw sewage pumps that are submersible and able to operate in flooded conditions; replacing and relocating the pump station's electrical equipment to a higher elevation that is less likely to flood; and modifying the pump station structure so that key components for operating the pump station are at a higher elevation. The hatch on top of the dry well will be raised to a higher elevation, thereby reducing the likelihood of the drywell being inundated by a storm surge.

In April 2010, a flap gate was installed between the overflow weir and overflow pipe, greatly reducing saltwater entering the wet well from the overflow pipe.

The outfall flow rate could be diminished under future SLR scenarios. This is being evaluated for the entire combined sewer system, and adaptation plans will be evaluated under a separate project.

8.8.8.2 Murray Basin Vulnerabilities

Components of the CSO facilities would be vulnerable to sea level rise. The storage tank and ancillary facilities are located away from the shoreline at elevation 120.3 feet (Metro) and are not vulnerable to sea level rise or storm surge. The existing Murray Pump Station and new diversion structure are located at elevation 116.3 feet (Metro) and are not vulnerable to sea level rise or storm surge.

The pump station/wet well overflow weir is at elevation 108 feet (Metro) and the overflow weir in the new diversion structure would also be located at elevation 108 feet (Metro) to allow for gravity flow. The weir elevation makes the facility vulnerable to saltwater intrusion through the overflow pipe. The facility has had saltwater intrusion in the past. Due to the arrangement of the existing overflow weirs in the Murray Pump Station, there is not a feasible option to prevent this from occurring until an upstream assessment of influent sewer connections is assessed to determine if the weir elevations can be raised.

The outfall flow rate could be diminished under future SLR scenarios. This is being evaluated for the entire combined sewer system, and adaptation plans will be evaluated under a separate project.

It is recommended that the design for the new diversion structure to the CSO storage tank in the Murray Basin incorporate a flap gate on the outfall discharge side to reduce saltwater intrusion from storm surge and/or sea level rise.

8.9 FEASIBILITY OF IMPLEMENTATION

8.9.1 Barton GSI Alternative

Based on an evaluation of land use/permitting, environmental impacts, engineering, operation and maintenance, and community impacts, implementation of the proposed Barton GSI alternative appears to be feasible, with no identification of fatal flaws.

8.9.2 Murray Alternative 1F

Based on an evaluation of land use/permitting, environmental impacts, engineering, operation and maintenance, and community impacts, implementation of the proposed Murray storage tank alternative appears to be feasible, with no identification of fatal flaws.