ALTERNATIVE DEVELOPMENT AND EVALUATION

This chapter describes the process used to develop and evaluate potential solutions for meeting the combined sewer overflow control objective for the North Beach Basin. Alternatives were developed for several broad CSO control approaches: storage, convey-and-treat, end-of-pipe treatment, peak-flow reduction, and a combination of these.

Each alternative was evaluated for technical merit, ability to be implemented, and cost. The number of alternatives was reduced from a preliminary set of nine to a shortlist of three and, finally, to a recommendation of one proposed alternative for further environmental review.

5.1 EVALUATION METHODOLOGY

Alternative development and evaluation was conducted in two phases. Phase 1, which began in January 2007, focused on reviewing flow projections, assessing the viability of broad CSO control approaches, and developing initial criteria for evaluating CSO control approaches. The work included the following:

- Define evaluation criteria.
- Identify potentially viable control approaches.
- Develop initial conceptual alternatives.
- Evaluate initial conceptual alternatives.

Existing flow data was reviewed during Phase 1, which indicated that fieldwork was needed to better define the origin of peak flows. Flow monitoring was conducted in several sub-basins between December 2007 and June 2008. The flow monitoring helped define peak flow contributions from discrete sub-basin areas and confirmed flow modeling previously performed by the County. As a result of this effort, CSO control volumes were developed for several sub-basins, and overall control volumes for the basin were refined.

Phase 2 built upon the results of Phase 1 and flow monitoring work. Phase 2 included the following:

- Refine and re-evaluate preliminary CSO control alternatives.
- Screen preliminary alternatives.
- Refine short-listed alternatives to select a proposed project.

5.1.1 Phase 1

Phase 1 included a review of projected flows, identification of viable control approaches, development of initial criteria to screen control approaches, and identification of initial alternatives that responded to the criteria. During this phase, the project boundaries were established, as depicted in Figure 5.1. The project boundary was based upon the local

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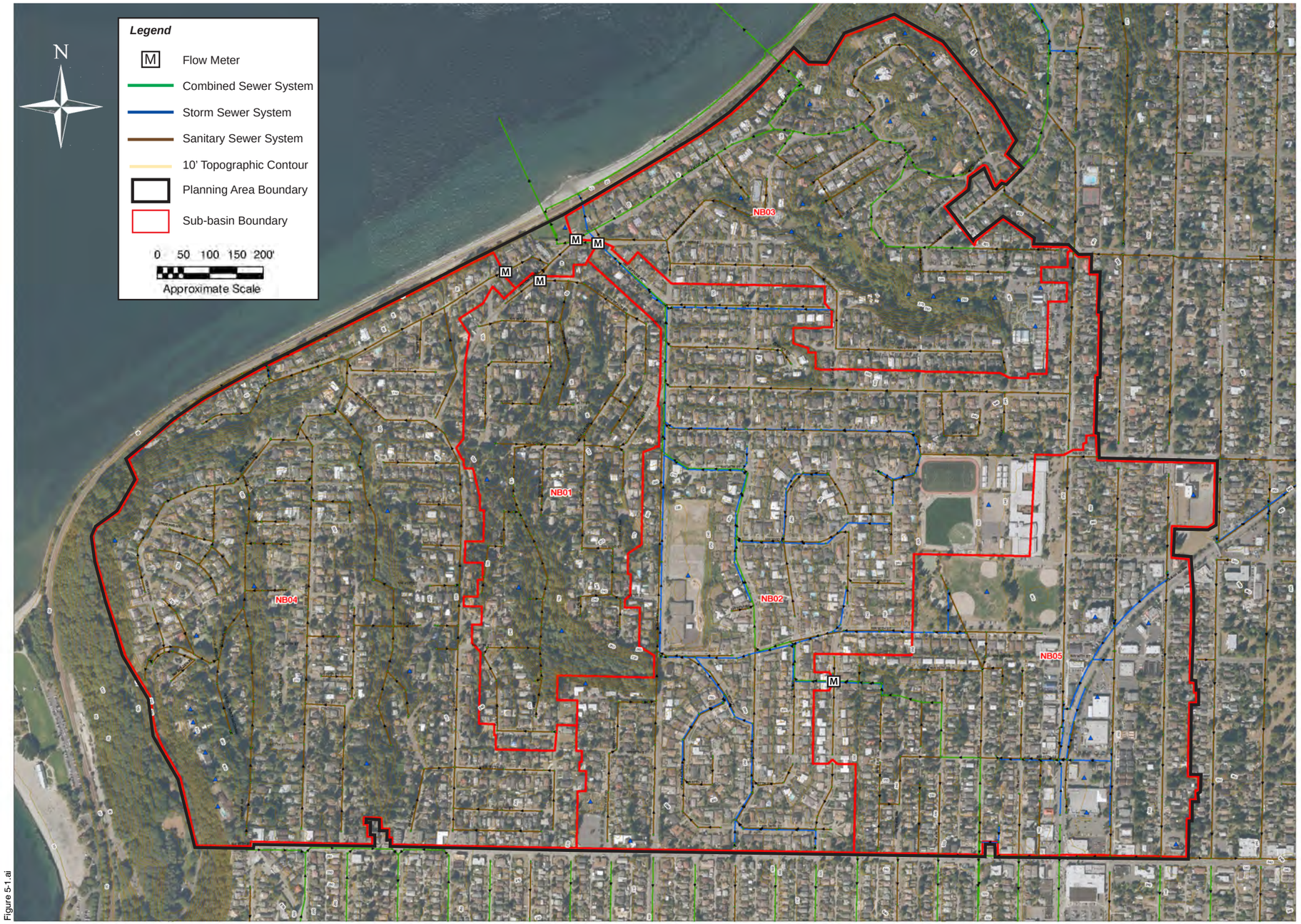

Figure 5-1.ai

Figure 5.1
NORTH BEACH BASIN OVERVIEW

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wastewater collection system, which is divided into five sub-basins that all flow to the North Beach Pump Station and outfalls. Phase 1 included the steps described below.

5.1.1.1 Step 1: Define Evaluation Criteria

This step began at project inception in January 2007. Criteria that were used to determine viability of CSO control approaches were defined by the project team. Seven criteria categories were selected, as illustrated in Table 5.1. The technical memorandum *CSO Control Approaches and Planning Boundaries* (Carollo Engineers, December 2007) describes the considerations for these categories in more detail.

5.1.1.2 Step 2: Identify Potentially Viable Control Approaches

The CSO control approaches evaluated in this project represent broad concepts for achieving CSO control. The following control approaches were considered:

- **Control Approach 1 – Peak-Flow Storage.** Store peak flows that exceed conveyance capacity in the basin during each storm event, and use existing pumping and piping facilities to convey stored flow downstream once the rainfall event has subsided.
- **Control Approach 2 – Convey-and-Treat Peak Flows.** Convey peak flows out of the basin by increasing pumping and force main capacity, or the capacity of the gravity sewer system. This approach may also require treatment upgrades at the point where the peak flows are discharged, as the capacity of existing treatment facilities may not be adequate for additional flows and loads.
- **Control Approach 3 – End-of-Pipe Treatment for Peak Flows.** Treat and discharge peak flows at or near the current CSO locations. The typical treatment process used for end-of-pipe treatment includes high-rate clarification (HRC) and ultraviolet (UV) disinfection.
- **Control Approach 4 – Peak-Flow Reduction.** Reduce the magnitude of the flow in the collection system through infiltration and inflow (I/I) reduction in separated systems, or by disconnecting impervious areas in combined systems.
- **Control Approach 5 – Combined Approach.** Reduce peak flows within the basin by implementing a combination of two or more of the previous four CSO approaches.

Table 5.1 Initial Evaluation Categories and Criteria

Cost Effectiveness	Operations and Maintenance Feasibility	Technical Feasibility	Public Health and Environmental Benefits	Flexibility	Community	Compatibility with Other Programs and Initiatives
– Capital cost – Life-cycle costs – Use of existing facilities – Grants/loan ranking	– Reliably meets CSO objectives – WTD automation – Ease of start-up/ shut-down – Ease of maintenance – No adverse impacts on County or City – Ease of regulatory reporting	– Compatible with existing system – Technically feasible – Can be permitted – Land is available – Minimizes federal & state permit constraints	– Meets CSO requirements – Minimizes public exposure – Minimal environmental footprint – Minimizes environmental risks – Minimizes or avoid contact with endangered species – Coordinates with Puget Sound goals	– Future regulations – Climate change – Implementation	– Neighborhood equity – Cost allocation – Minimal shoreline impacts – Minimal property disruption – Minimal implementation impacts – Minimal operations impacts – Minimal disturbance of archeological areas	– Coordinate with Seattle parks, SPU, and transportation – Sediment management plan – County-wide planning policies – Stormwater management responsibilities – Conveyance system improvement policies – WTD productivity initiative – WTD CSO Program

5.1.1.3 Step 3: Develop Initial Conceptual Alternatives

Initial alternatives were developed in order to assess each control approach, as described in the technical memorandum *CSO Control Approaches and Planning Boundaries*. Each initial alternative identified necessary infrastructure improvements and theoretical locations. The locations were chosen based on their proximity to the combined sewer overflow location and the feasibility of using gravity sewerage to convey flow into and out of the proposed infrastructure. Storage alternatives identified during this phase were limited to a single centralized storage location, either in the basin or out of the basin. Dispersed storage options were identified in Phase 2, after flow monitoring and modeling were completed.

5.1.1.4 Step 4: Evaluate Initial Conceptual Alternatives

Following the development of initial alternatives, an assessment of the viability of each control approach was completed considering the constraints of the North Beach Basin (topography, land use, downstream capacity, and peak-flow sources). The conclusions of the assessment were as follows:

- **Peak-Flow Storage Approach.** Peak-flow storage was determined to be technically feasible. The steep topography and built-out characteristics of the North Beach Basin results in very few suitable locations for storage except for sites near the North Beach Pump Station. Other storage-based alternatives would require pumping from the bottom of the basin to the CSO storage facility.
- **Convey-and-Treat Approach.** The convey-and-treat control approach was determined to be technically feasible, but would require increasing the capacity of the North Beach Pump Station, the North Beach Force Main, and the Carkeek CSO Treatment Facility (see Figure 2.1).
- **End-of-Pipe Treatment Approach.** End-of-pipe treatment was determined to be technically feasible. The steep topography and built-out characteristics of the North Beach Basin results in very few suitable locations for end-of-pipe treatment except for sites near the North Beach Pump Station. Other treatment-based alternatives would require pumping from the bottom of the basin to the CSO treatment facility.
- **Peak-Flow Reduction Approach.** Peak-flow reduction, including both inflow and infiltration reduction, appears to be technically feasible within the North Beach Basin. It would require an aggressive implementation plan to rehabilitate a significant portion of the infrastructure. It was recommended that the costs and feasibility (e.g., technical, inter-jurisdictional) associated with implementing peak-flow reduction within the North Beach Basin be more fully evaluated to determine the viability of this approach.

These were only initial assessments of the viability of the identified control approaches. Additional consideration of these control approaches was given in Phase 2.

These conceptual alternatives were reviewed with agency stakeholders at Agency Workshop No. 1 on May 7, 2009. Stakeholders included King County, Ecology, and Seattle Public Utilities. Input from the workshop was used to help refine the alternatives and criteria for Phase 2.

5.1.2 Phase 2

Phase 2 included refinement and re-evaluation of the feasible CSO control approaches and preliminary alternatives from Phase 1 following completion of flow monitoring. Community information meetings and briefings with citizens in the North Beach Basin in 2007, late 2009, and early 2010 elicited comments on community concerns about the approaches and alternatives under consideration. Community comments, such as the importance of Blue Ridge Park to maintaining open space and views, factored into refined criteria and ranking of alternatives. Phase 2 involved the following three steps.

5.1.2.1 Step 1: Refine and Re-evaluate Preliminary CSO Control Alternatives

The memoranda *Developing Criteria for Evaluating CSO Alternatives* (Carollo Engineers, August 2009) and *Selecting Candidate Sites for CSO Control Approaches* (Carollo Engineers, August 2009) describe the process used to refine and re-evaluate the preliminary alternatives. The process is summarized below.

5.1.2.1.1 Step 1A: Criteria Development

In order to develop criteria for evaluation of alternatives, the CSO Project Team appointed a “Category Lead,” team members designated as subject matter experts, for each of seven categories of selection criteria. The Category Leads developed selection criteria and applied them in three steps:

1. Select up to five criteria for each final category shown in Table 5.2. In the operations and maintenance (O&M) category, for example, one criterion might be “Reliability,” another might be “Site Access,” and so forth. As part of this process, the seven categories developed in Phase 1 were refined. During refinement, some categories were combined and renamed as shown in Table 5.2. Two initial categories, “Flexibility” and “Compatibility with other Programs and Initiatives,” were combined with other categories due to their interrelationship. The “Land Use/Acquisition/ Permitting” category was subdivided into two categories, “Land Use/Acquisition” and “Permitting,” in recognition of differences between land acquisition and project permitting.

2. Develop questions to be answered for each criterion. These questions were used to “test” the impact of a particular alternative on the criterion being considered. For example, one question for the “Reliability” criterion was, “Does the alternative rely on complex automation for successful operation?” Another question was “Has the alternative proven to be a reliable CSO control method in other installations?”

3. Develop a description of how the criterion will be measured using the rating scale (Low, Moderate, and High Impact). For the question, “Does the alternative rely on

Table 5.2 Initial and Final Evaluation Categories

Initial Category (June 2007)	Final Category (September 2009)
Cost Effectiveness	Cost
Ease of Operations and Maintenance	Operations and Maintenance (O&M)
Technical Feasibility and Compatibility	Technical
Public Health and Environmental	Environmental
Community Considerations	Community Impact
Flexibility[1]	Land Use/Acquisition[2]
Compatibility with Other Programs and Initiatives[1]	Permitting[2]

Notes:
1. Criteria combined with other categories in final criteria category list.
2. Category added following initial criteria category development.

complex automation for successful operation?" a "High" score would be described by, "The alternative requires substantial automation of mechanical equipment for performance." A "Low" score would be described by "The alternative is relatively simple and requires limited automation and equipment for performance."

A copy of the final criteria and evaluation questions are contained in the Alternative Evaluation Summary Documentation in Appendix C.

5.1.2.1.2 Step 1B: Alternatives Development

Site suitability criteria for the evaluation were developed and then used together with GIS data to identify potential preliminary sites.

Available land areas where new system components could be sited and constructed were identified based on the "technical feasibility" of the resulting alternative. "Technical feasibility" was defined as follows:

- Availability of Peak Flows. The resulting alternative must be sited in a location that allows sufficient peak flows to be captured and routed to the new facility.
- Constructability. The resulting alternative (and associated system components) must be constructible on site. In order for an alternative to be constructible, the site where components would be built must be sufficient size, with reasonable access provided for construction activities (e.g., staging, excavation, tank construction, etc.).
- Operational Performance. The resulting alternative (and system components) must be capable of meeting the intended performance within the existing hydraulic profile of the CSO outfall and (combined sewer system) CSS.

A hierarchy of technical considerations was used to judge "technical feasibility" and identify potential sites for the CSO control approaches; in the order of most to least favorable these were as follows:

1. Favor locations and facility configurations at the bottom of the basin near the existing CSO outfall.
   a. Provides ability to capture 100% of the flow in the basin and route it to the new facility.
   b. Reduces complexity of control system required to route flows to new facility; thereby, reducing risks of future overflows.
   c. Minimizes conveyance system construction requirements.
2. Favor locations along existing combined sewer trunk lines through which 50% or more of the total basin peak flow is conveyed.
   a. Helps ensure sufficient volumes are captured to adequately reduce peak flows and volumes at the bottom of the basin at the existing CSO outfall.
3. Favor locations and facility configurations that allow passive diversion of peak flows to the new facility (e.g., over a weir wall) over more complex control systems requiring telemetry or SCADA.
   a. Increases reliability by eliminating the need for a power and control system.
   b. Reduces the potential need to oversize the facility to limit overflows.
4. Favor locations and facility configurations where the bottom of new structures will not exceed a depth of 30 feet below the ground surface elevation.
   a. Minimizes shoring and dewatering requirements.
   b. Requires less area for construction and staging.
   c. Creates shallower facilities for easier access.
   d. Avoids excessive structural requirements for tanks and treatment facilities.
   e. Increases feasibility of cut-and-cover construction for storage pipes versus riskier and more expensive tunneled construction.

5.1.2.2 Step 2: Preliminary Alternative Screening

This step involved screening the full list of alternatives to develop a short-list of three for detailed evaluation. Step 2 was completed in a series of non-technical (community relations, land use and permitting, environmental) and technical (technical implementation, operations and maintenance, cost) meetings. The screening process for reducing the preliminary alternatives from nine to three is described in memoranda titled *CSO Control Alternative Review and Comment Procedure* (Carollo Engineers, September 2009) and *Alternative Narrowing Process* (Triangle Associates, November 2009). This process is summarized in Table 5.3.

During the development of a short-list of three alternatives, potential sites were further refined so the project team could focus on the characteristics of specific sites and how they would affect the implementation of each alternative.

Table 5.3 Screening Steps and Schedule for Short-listing of Alternatives

Workshop/ Meeting Date	August 2009	September 2009	October 2009	November 2009	December 2009
Meeting Purpose	Basin Leads present preliminary alternatives for initial comment.	Non-technical focus meetings to identify information needed to complete alternative review matrices.	Technical focus meetings to add detail for O&M issues (e.g., layouts, configurations).	Team workshop to complete review matrices for each alternative.	Team workshops to select top 3 alternatives.
Screening Results	Preliminary cut of least-attractive alternatives by Consultant.	Revisions to preliminary alternative evaluations based on comments received from CSO Team (non-technical focus).	Revisions to preliminary alternative evaluations based on comments received from CSO Team (technical focus).	Revisions to preliminary alternative evaluations based on comments received from CSO Team (technical and non-technical focus).	Select 3 alternatives for further evaluation.

5.1.2.3 Step 3: Refinement of Short-listed Alternatives and Selection of a Proposed Alternative

Between February 2010 and August 2010, the three short-listed alternatives were further developed. Detailed information is provided in the *North Beach Alternatives Update Information Technical Memorandum* (Carollo Engineers, October 2010) in Appendix C. Step 3 was completed in a series of non-technical and technical meetings to identify the range of information needed to complete the alternative review and prepare evaluation matrices for each alternative.

5.2 NO ACTION ALTERNATIVE

RCW 90.48.480 and WAC 173-245-020 (22) require CSOs to be limited to an average of no more than one untreated discharge per year per outfall on a long-term average. In the North Beach Basin, there were an average of 10 combined sewer overflows annually from 1991 to 2009, with an average annual total overflow of 2.2 million gallons.

The No Action Alternative entails no changes to the sewer system in the North Beach Basin. This alternative would result in CSOs in the North Beach Basin in excess of one per year on a long-term average based on historical data. The Basin would not comply with RCW 90.48.480 and WAC 173-245-020 (22) or the West Point Treatment Plant NPDES Permit.

The risk to Puget Sound water quality (e.g., bacteria, nutrients, and metals) would remain at present levels. Decreased water quality could adversely affect biological resources and potentially result in decreased availability of the beach and/or public exposure.

5.3 PRELIMINARY ALTERNATIVES

This section provides a detailed description of the alternatives developed under Step 1B of Phase 2 (as described in Section 5.1.2.1.2). Development of alternatives began with identification of preliminary sites suitable for CSO facilities. Based on this information and design criteria resulting from flow monitoring and modeling, preliminary alternatives were developed using the identified viable CSO control approaches.

5.3.1 Basis of Design

5.3.1.1 Basis-of-Planning Requirements

Table 5.4 summarizes the basis-of-planning requirements for control of the North Beach Basin. This information was used to size facilities for each CSO control approach. Refer to Chapter 4 for details on the development of basis-of-planning requirements.

Table 5.4 North Beach Basin Basis-of-Planning Requirements

Required Storage Volume	0.23 MG
Required Conveyance Capacity	5.5 mgd[1]
Required End-of-Pipe Treatment Capacity	5.5 mgd[1]
Required Impervious Area Disconnection[2]	Varies

Notes:
1. Revised to 6.6 mgd following screening of preliminary alternatives to develop a short-list for further review. The increase in conveyance and end-of-pipe treatment capacity for final basis-of-planning requirements (see Section 4.3) would have had a negative impact on convey-and-treat and end-of-pipe treatment approaches. Since alternatives based on these approaches were not short-listed (see Section 5.4) the preliminary alternatives in this section were not revisited.
2. Impact of impervious area disconnection on the design criteria for each of the other approaches. For example, disconnection of 75% of the impervious area in the basin reduces the required storage volume to 0.02 MG.

5.3.1.2 Basis-of-Design Criteria

The basis-of-design criteria are key criteria established as a basis for sizing equipment and laying out facilities. Consistency of design criteria is important for evaluating alternatives. Documenting the design criteria also provides key input for final design of the improvements.

Figures 5.2 through 5.4 illustrate typical details for potential facilities common to many of the alternatives considered, including storage (rectangular and pipeline), conveyance (pump station), and end-of-pipe treatment. Table 5.5 highlights key design criteria used for preliminary screening.

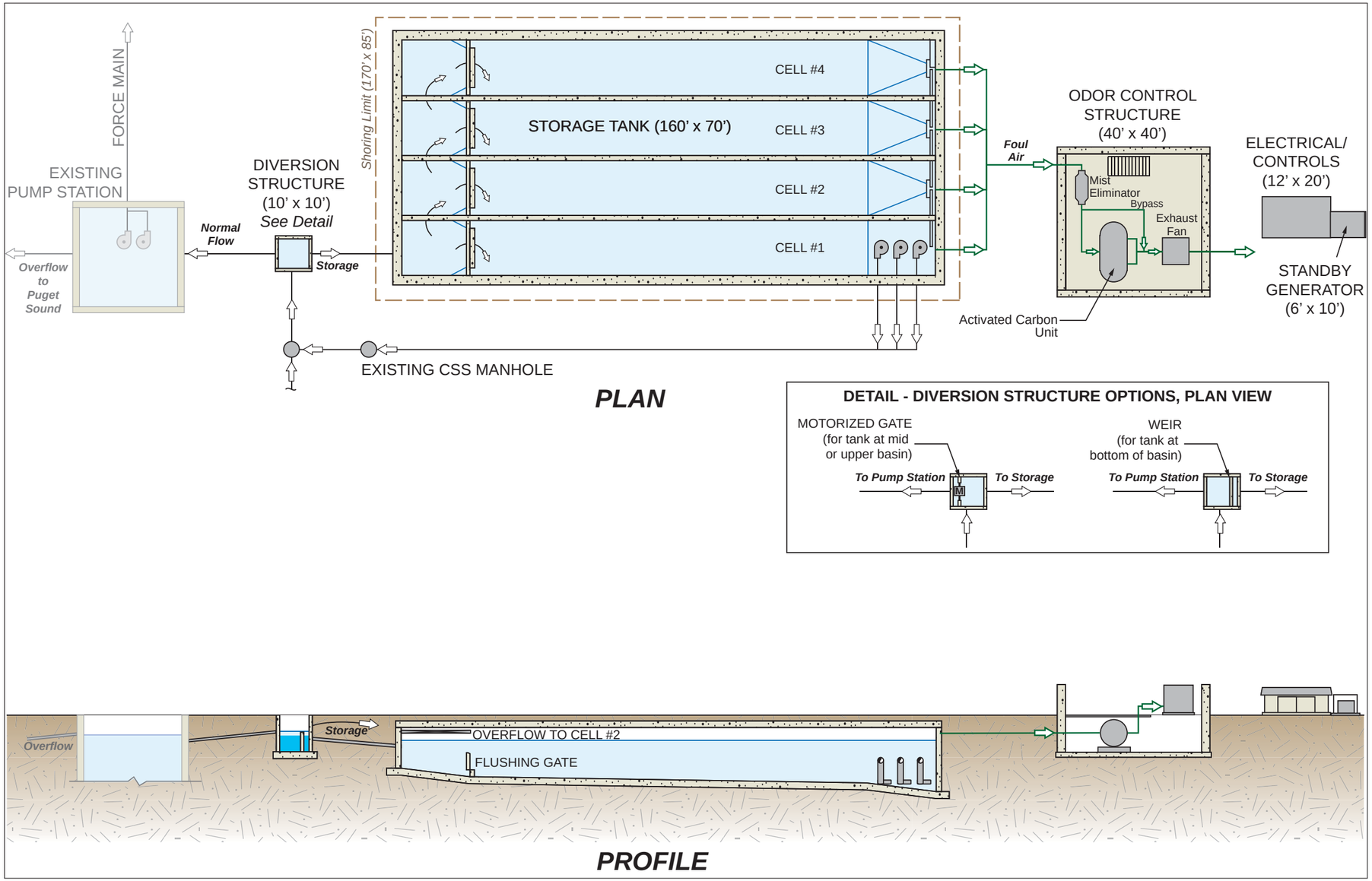

Figure 5.2
RECTANGULAR STORAGE
BASIS OF DESIGN TYPICAL DETAIL

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Figure 5-2.ai

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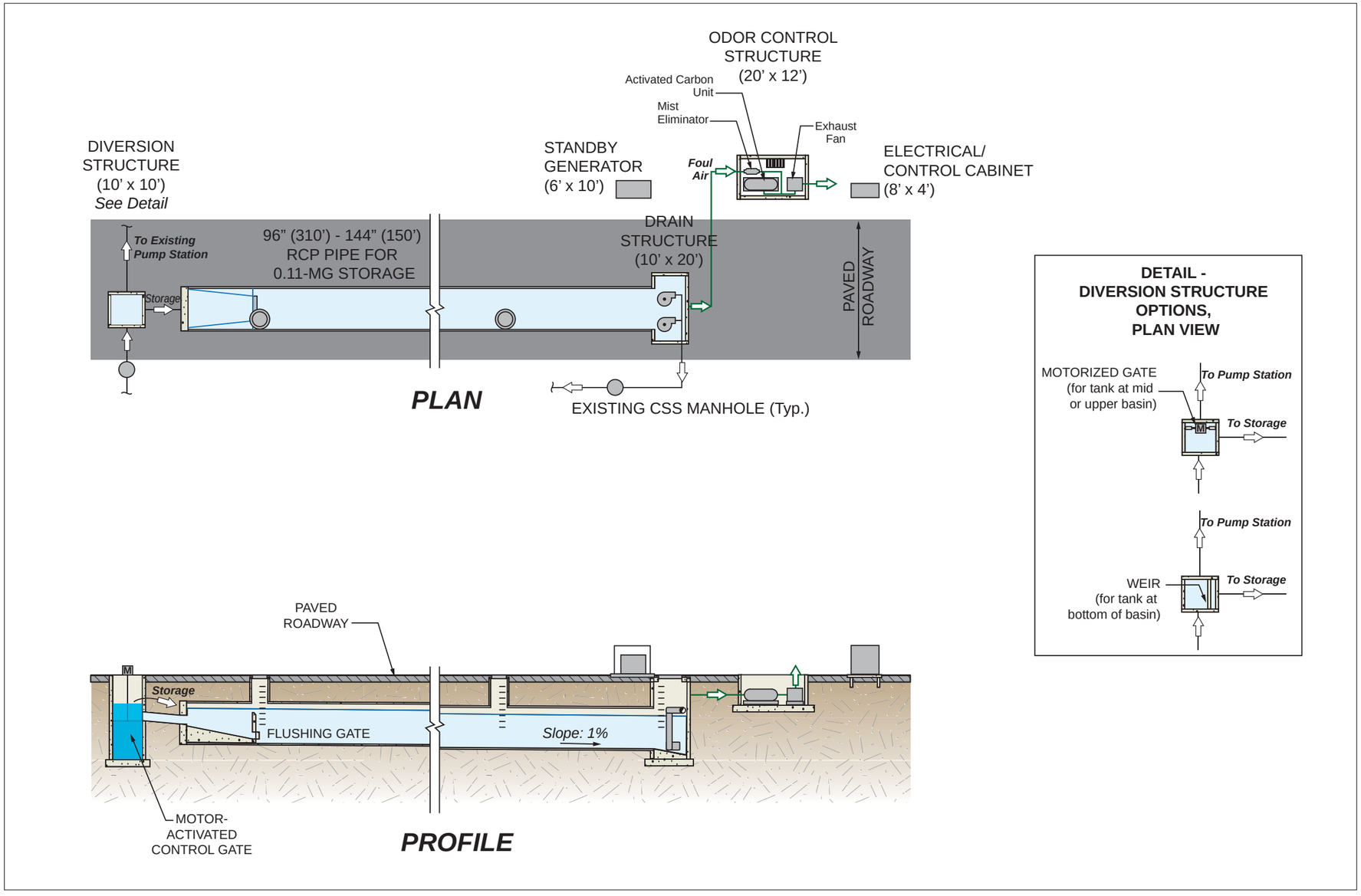

Figure 5.3
PIPELINE STORAGE
BASIS OF DESIGN TYPICAL DETAIL

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Figure 5-3.ai

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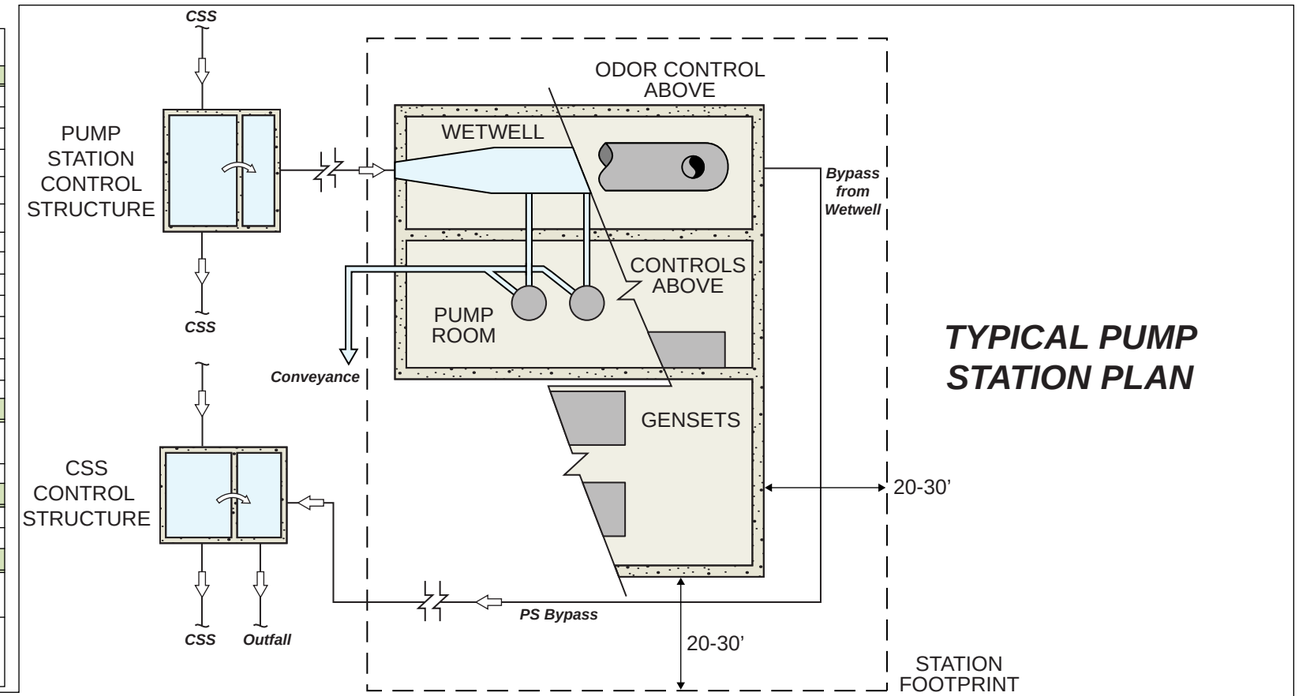
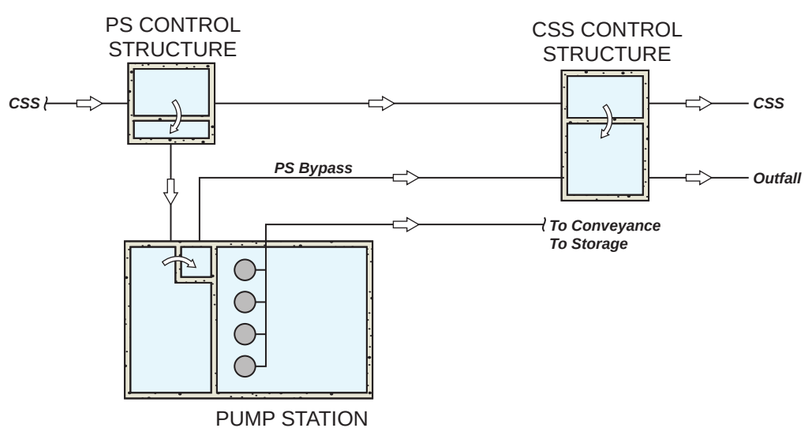
7 to 30 Mgd Pump Station Criteria and Assumptions

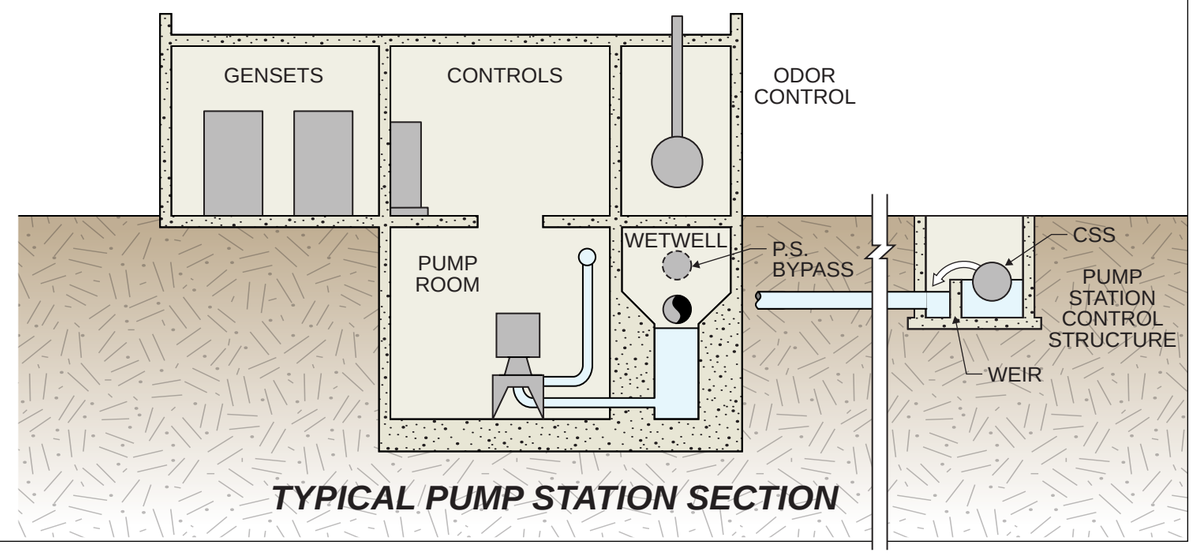
General				
Firm Capacity mgd		7	20	30
Hydraullic Conditions		70 - 200 ft head	70 - 200 ft head	Over 200 ft Head
		single stage	single stage	series, two stage
Number pumps installed		4	4	8
Motor Size, Hp		50 - 125 at 7mgd	125 - 325 at 20mgd	200 - 700 at 30mgd
Standby power, kW		1@200 - 400	2@250 - 650	2@600-1250
		Station Footprint, with setbacks		
Wetwell		Circular, rectangular	Rectangular	Rectangular
Pump types, installation	Submersible wet pit	90 x 90	110 x 105	NA
	Centrifugal dry pit	110 x 90	110 x 90	115 x 100
	VTSH dry pit	90 x 90	NA	NA
Average depth, ft		25	25	25
Outer Walls, ft		2	2	2
Shoring		5ft beyond walls		
Mechanical				
Ventilation	12 air changes per hour in occupied space when operational.			
Odor Control	Carbon scrubber and fan, 2AC/hr for wetwell. Operates when pump station on line.			
Ancillary Eqpmt.	Typical service air, water, gates, valves for ww pump station			
Electrical				
Pump drives	Close coupled motors, VFD			
Emergency Power	Permanent generator(s), diesel, sound attenuated. 36-hour fuel capacity in buried tank			
Flow Control Strategy				
Diversion Structure	Divert peak flows using a weir and/or gate structure on the sewer upstream of the CSO control structure.			
Control Strategy	Peak flows are diverted over a weir when water elevation exceeds capacity of sewer or existing dry wet weather pump station. Flows exceeding pump station capacity overflow to outfall.			



TYPICAL PUMP STATION PLAN

GENERAL ARRANGEMENT PLAN





TYPICAL PUMP STATION SECTION

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Figure 5.4
PUMP STATION
BASIS OF DESIGN TYPICAL DETAIL

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Table 5.5 North Beach Basin Basis-of-Design Criteria

Facility	Design Criteria
Peak-Flow Storage (Rectangular or Pipeline)	
Number of Cells	Rectangular - 2 to 4; Pipeline - 1
Floor Slope	1%
Minimum Freeboard	2 feet
Number of Drain Pumps	3 duty
Type of Pumps	Submersible
Maximum Time to Drain Storage	24 hours
Odor Control	Peak air displacement rate (peak flow to storage) or 2 air changes per hour (whichever is greater)
Air Treatment	Activated carbon; 1 pass; 50 fpm; constant speed fan/blower
Occupied Space Ventilation	12 air changes per hour
Standby Generator	Total estimated load; diesel w/ 24 hour capacity
Access	Every 200 feet (maximum); outside right-of-way
Equipment Materials	Corrosion-resistant (304/316 SS or FRP)
Conveyance (Convey-and-Treat)	
Number of Pumps	3 duty + 1 standby (per stage[1])
Type of Pumps	Centrifugal, dry-pit
Firm Capacity	Required conveyance capacity[2]
Wet well	Self-cleaning
Odor Control	2 air changes per hour (wet well)
Air Treatment	Activated carbon; 1 pass; 50 fpm; constant speed fan/blower
Occupied Space Ventilation	12 air changes per hour
Standby Generator	Total estimated load; diesel w/ 36 hour capacity
Force Main	2 @ Firm Capacity; 8 feet per second (maximum)
Equipment Materials	Corrosion resistant (304/316 SS or FRP)
Treatment (End-of-Pipe or Convey-and-Treat)	
Influent Screening	
Type	Perforated plate
Number of Screens	2
Screen Spacing	6 mm
High-Rate Clarification	
Number of Trains	2
TSS Removal	85% or 10 mg/L (maximum)
BOD Removal	50% or 10 mg/L (maximum)
Chemical Feed Systems	Coagulant and Polymer

Table 5.5 North Beach Basin Basis-of-Design Criteria

Facility	Design Criteria
UV Disinfection	
Number of Channels	1
Transmittance @ 254 nm	70%
Minimum Dose	40 mJ/cm^2
Odor Control	2 air changes per hour (process basins)
Air Treatment	Activated carbon; 1 pass; 50 fpm; constant speed fan/blower
Occupied Space Ventilation	12 air changes per hour
Standby Generator	Total estimated load; diesel w/ 36 hour capacity
Equipment Materials	Corrosion-resistant (304/316 SS or FRP)

Notes:
1 Total head above 200 feet requires 2-stage pumping for solids pumps.
2 See Table 5.4.

5.3.2 Identification of Preliminary Sites

Potential facility sites were evaluated using the criteria provided in Table 5.6 and GIS data from King County and the City of Seattle. The initial screening identified several parcels meeting the criteria. A survey and review of the site characteristics resulted in nine candidate sites, excluding public right-of-way and occupied properties. Figure 5.5 illustrates parcels in the North Beach Basin that could be suitable for siting CSO alternatives.

The viable control approaches were matched with the preliminary sites based on the results of flow monitoring and modeling, and on basin reconnaissance. Potential areas were defined roughly by the ability to route flow to the CSO facility location, topography, and distance from the existing CSO control facility. An important project assumption is that existing CSO outfalls would not be modified due to environmental and permitting impacts on the required CSO implementation schedule. Therefore, it was important that no new control points were created by the alternatives.

Table 5.6 Site Suitability Analysis

CSO Control Approach	Configuration	Minimum Requirements for Potential Sites
1. Peak-Flow Storage		
Bottom of Basin	Rectangular.	• Flat (< 5%)area near existing CSO. • Outside public right-of-way. • Greater than 1 acre. • Less than Elevation 60.
Bottom of Basin / "Up-Basin"	Rectangular, conveyance to Carkeek Pump Station.	• Flat (< 5%) area for pump station and storage. • Outside public right-of-way. • Pump station sized for peak flow. • Approximately 1 acre for storage; greater than 1/4 acre for pump station. • Pump station less than Elevation 50.
	Rectangular, conveyance to 8th Ave. Interceptor.	• Flat (< 5%) area for pump station and storage. • Outside public right-of-way. • Sized for peak flow pump station. • Approximately 1 acre for storage; greater than 1/4 acre for pump station. • Storage greater than Elevation 350. • Pump station less than Elevation 50.
	Deep Tunnel.	• Flat (< 5%) area for tunnel access portals. • Outside public right-of-way. • Approximately 2,600 feet at 14-feet diameter • Greater than 1/4 acre for downstream access; less than Elevation 50. • Greater than 1/2 acre for upstream access.

Table 5.6 Site Suitability Analysis

CSO Control Approach	Configuration	Minimum Requirements for Potential Sites
2. Convey-and-Treat		
Bottom of Basin	Peak flow pump station, pipeline to Carkeek CSO TP through Beach Alignment.	• Flat (< 5%) area for pump station. • Outside public right-of-way. • Sized for peak flow pump station. • Greater than 1/4 Acre for pump station. • Pump Station less than Elevation 50. • Carkeek CSO TP modifications.
	Peak flow pump station, pipeline to Carkeek CSO TP through Neighborhood Alignment.	• Flat (< 5%) area for pump station. • Outside public right-of-way. • Sized for peak flow pump station. • Greater than 1/4 Acre for pump station. • Pump station less than Elevation 50. • Carkeek CSO TP modifications.
3. End-of-Pipe Treatment		
Bottom of Basin	New high-rate clarification and UV disinfection treatment facility.	• Flat (< 5%) area for treatment facility. • Outside public right-of-way. • Greater than 1 acre. • Less than Elevation 50.
Bottom of Basin / ”Up-Basin”	Peak flow pump station, pipeline to new high rate clarification and UV disinfection treatment facility.	• Flat (< 5%) area for pump station and treatment facility. • Both sites outside public right-of-way. • Greater than 1/4 Acre for pump station. • Pump station less than Elevation 50. • Greater than 1 acre for treatment facility.

Table 5.6 Site Suitability Analysis

CSO Control Approach	Configuration	Minimum Requirements for Potential Sites
4. Peak-Flow Reduction		
Rooftop Separation	Disconnection of impervious areas (roof drains and catch basins) with stormwater re-routed to new or existing MS4.	• Available impervious area for disconnection. • Inside or outside public right-of-way.
Green Stormwater Infrastructure (GSI)	Implementation of GSI techniques to limit stormwater response to rainfall.	• See GSI findings for constraints.
MS4 Construction	Disconnection of impervious areas in the right-of-way (catch basins) with stormwater re-routed to new or existing MS4.	• Combined system inside public right-of-way. • See GSI findings for constraints.
5. Combined Approach		
I/I Control	Rehabilitation of sewers and laterals and disconnection of impervious areas (roof drains and catch basins). May require MS4 construction to prevent localized flooding.	• I/I assessment of sewers. • Available impervious area for disconnection. • Inside and outside public right-of-way.

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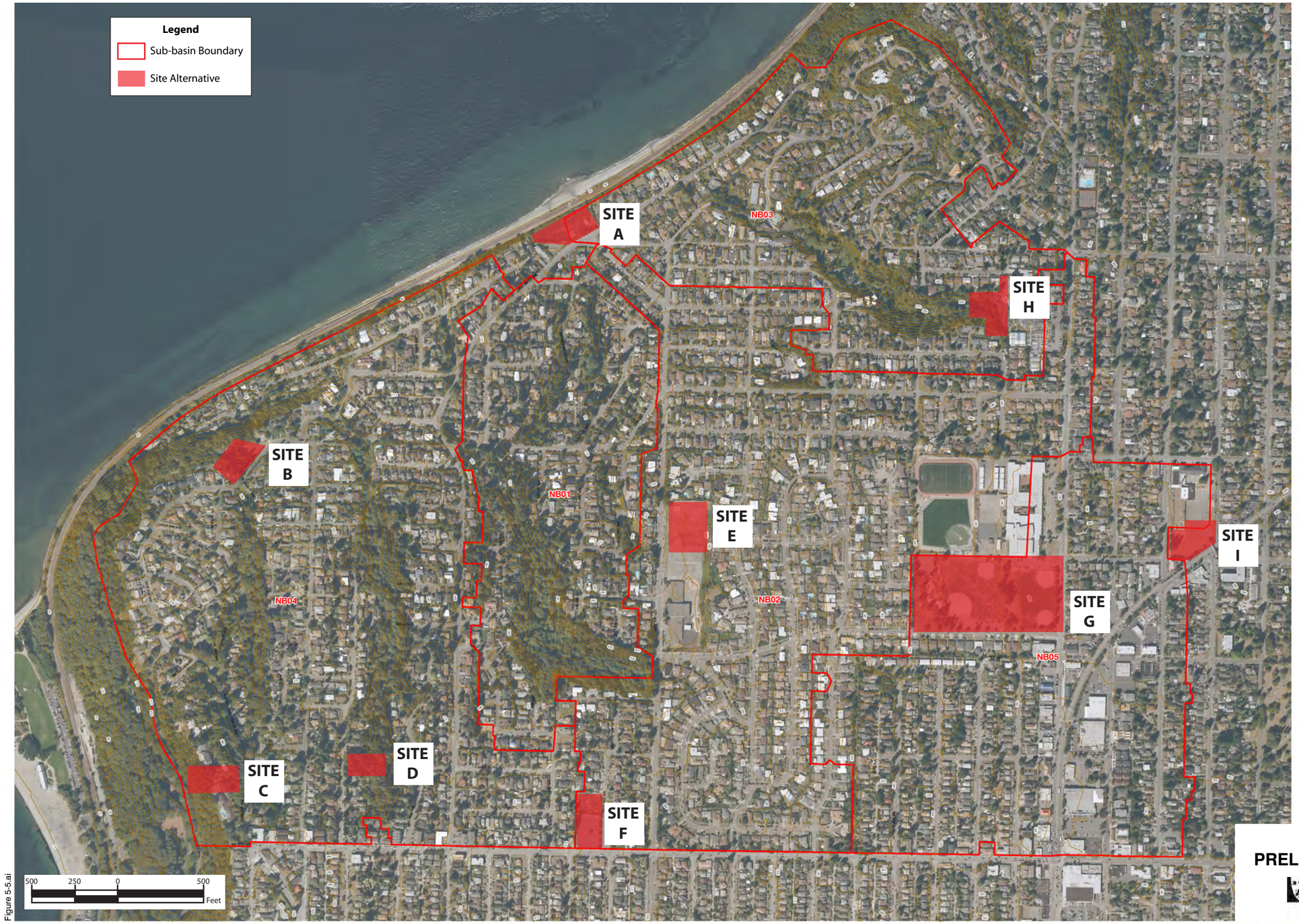

Figure 5.5
NORTH BEACH BASIN
PRELIMINARY SITE ALTERNATIVES

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5.3.3 Preliminary Alternatives Overview

Development of preliminary alternatives is described in detail in the memoranda *Planning Confirmation* (Carollo Engineers, March 2010) and *Siting Report* (Carollo Engineers, June 2010). The following alternatives were developed for the North Beach Basin:

Control Approach 1 - Peak-Flow Storage:

- Alternative 1A - Rectangular Bottom-of-Basin Storage
- Alternative 1B - Pipeline Bottom-of-Basin Storage
- Alternative 1C - Rectangular Storage Up in the Basin with Conveyance to 8th Avenue Interceptor
- Alternative 1D - Rectangular Bottom-of-Basin Storage with Conveyance to 8th Avenue Interceptor

Control Approach 2 - Convey-and-Treat:

- Alternative 2A - Conveyance to Carkeek CSO Treatment Plant through Beach Alignment
- Alternative 2B - Conveyance to Carkeek CSO Treatment Plant through Neighborhood Alignment

Control Approach 3 - End-of-Pipe Treatment:

- Alternative 3A - End-of-Pipe Treatment at the Bottom of the Basin
- Alternative 3B - End-of-Pipe Treatment Up in the Basin

Control Approach 5 - Combined Approach:

- Alternative 5A - Inflow Improvements with Storage, Infiltration Improvements or Green Stormwater Infrastructure (GSI)

Control Approach 4, Peak-Flow Reduction by separation, was not adequate as a standalone option and therefore was included in a combined approach (see Section 5.3.7).

The preliminary alternatives are described below and summarized in Table 5.7. Conceptual layouts for improvement facilities were developed and drawn at representative sites within the feasible areas, as shown in Figures 5.6 through 5.13.

Table 5.7 Summary of North Beach Basin Preliminary Alternatives

Approach	Alternative	Description	Potential Site(s)[1]
Peak-Flow Storage	1A	0.23 MG rectangular storage at bottom of basin	A
	1B	0.23 MG pipeline storage at bottom of basin in public right-of-way	Right-of-Way
	1C	8.5 mgd pump station with 0.15 MG storage at top of basin and conveyance to 8th Avenue Interceptor	A, I
	1D	3.5 mgd pump station with 0.15 MG storage at bottom of basin and conveyance to 8th Avenue Interceptor	A, I
Convey-and-Treat	2A	8.5 mgd pump station and force main through beach alignment to Carkeek; 5.5 mgd additional treatment at Carkeek	A
	2B	8.5 mgd pump station and force main through neighborhood alignment to Carkeek; 5.5 mgd additional treatment at Carkeek	A
End-of-Pipe Treatment	3A	5.5 mgd treatment plant at bottom of basin	A
	3B	5.5 mgd pump station at bottom of basin and 5.5-mgd treatment plant at top of basin	A, B, C, D, E, F, G, H, and I
Combined	5A	Inflow Improvements with storage, infiltration improvements or GSI	N/A

Notes:

1. See Figure 5.5 - North Beach Basin Preliminary Site Alternatives.

Figure 5.6
NORTH BEACH BASIN
ALTERNATIVE 1A

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Figure 5-6.ai

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Figure 5.7
NORTH BEACH BASIN
ALTERNATIVE 1B

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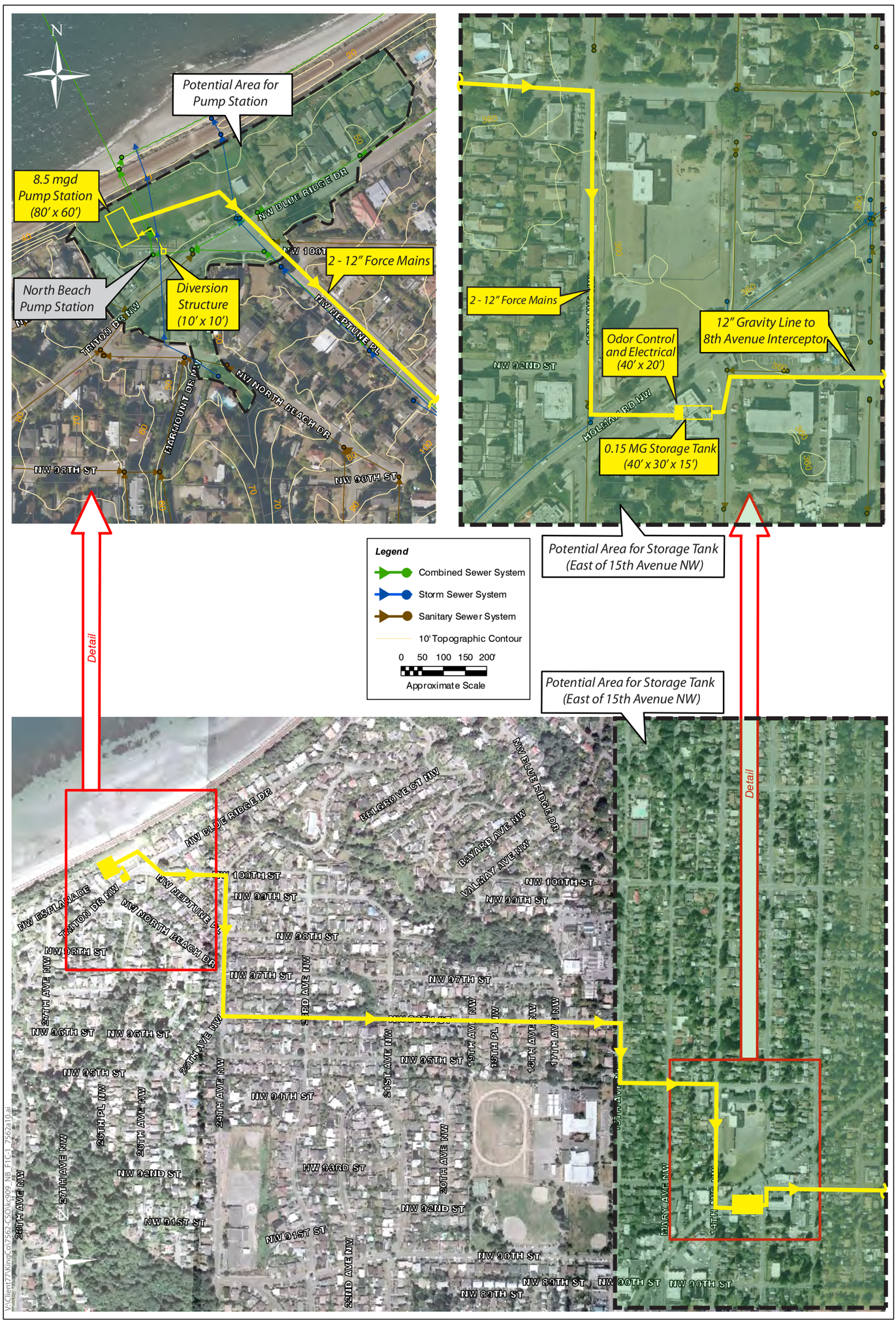

Figure 5.8
NORTH BEACH BASIN
ALTERNATIVE 1C

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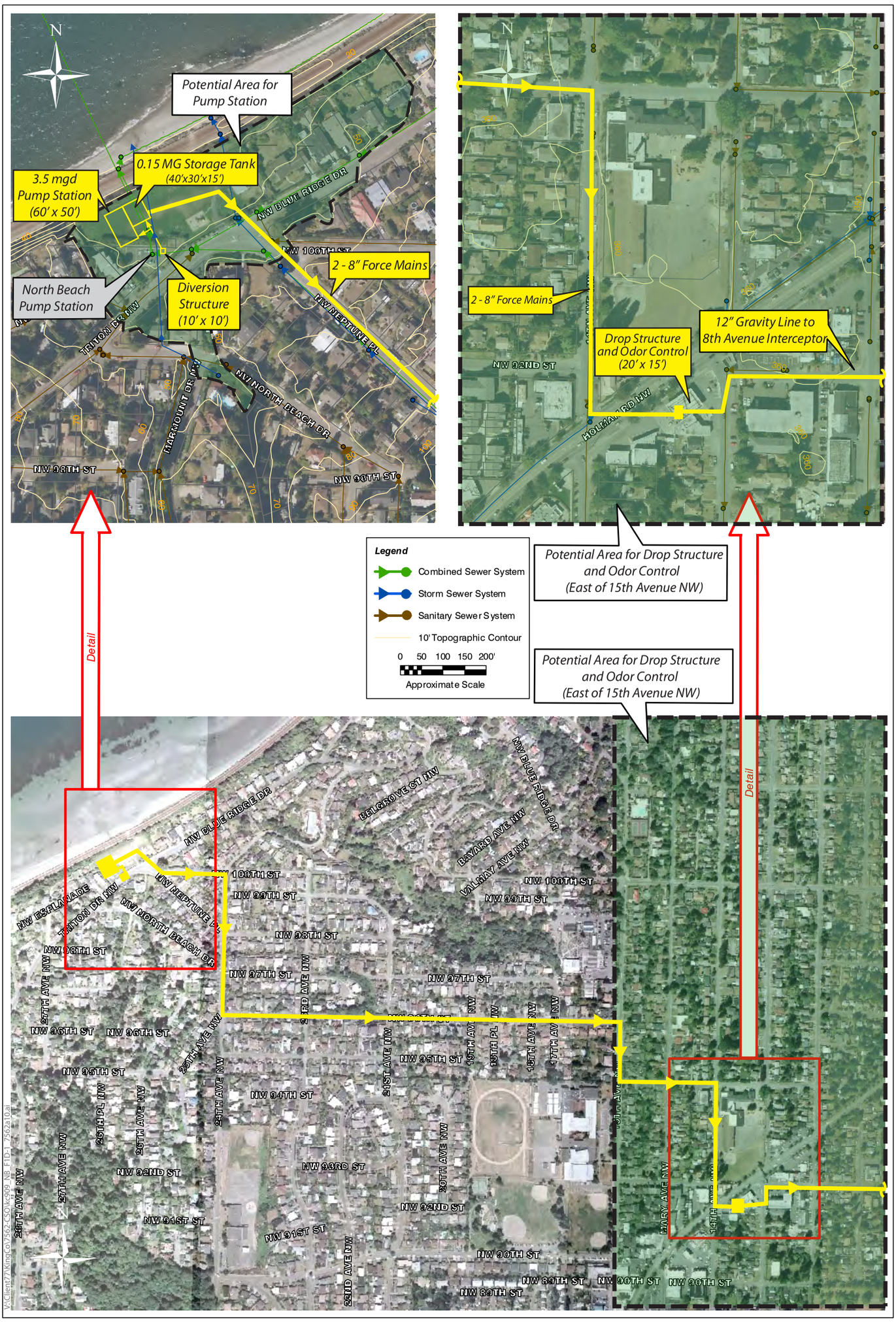

Figure 5.9
NORTH BEACH BASIN
ALTERNATIVE 1D

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Figure 5-10.ai

Figure 5.10
NORTH BEACH BASIN
ALTERNATIVE 2A

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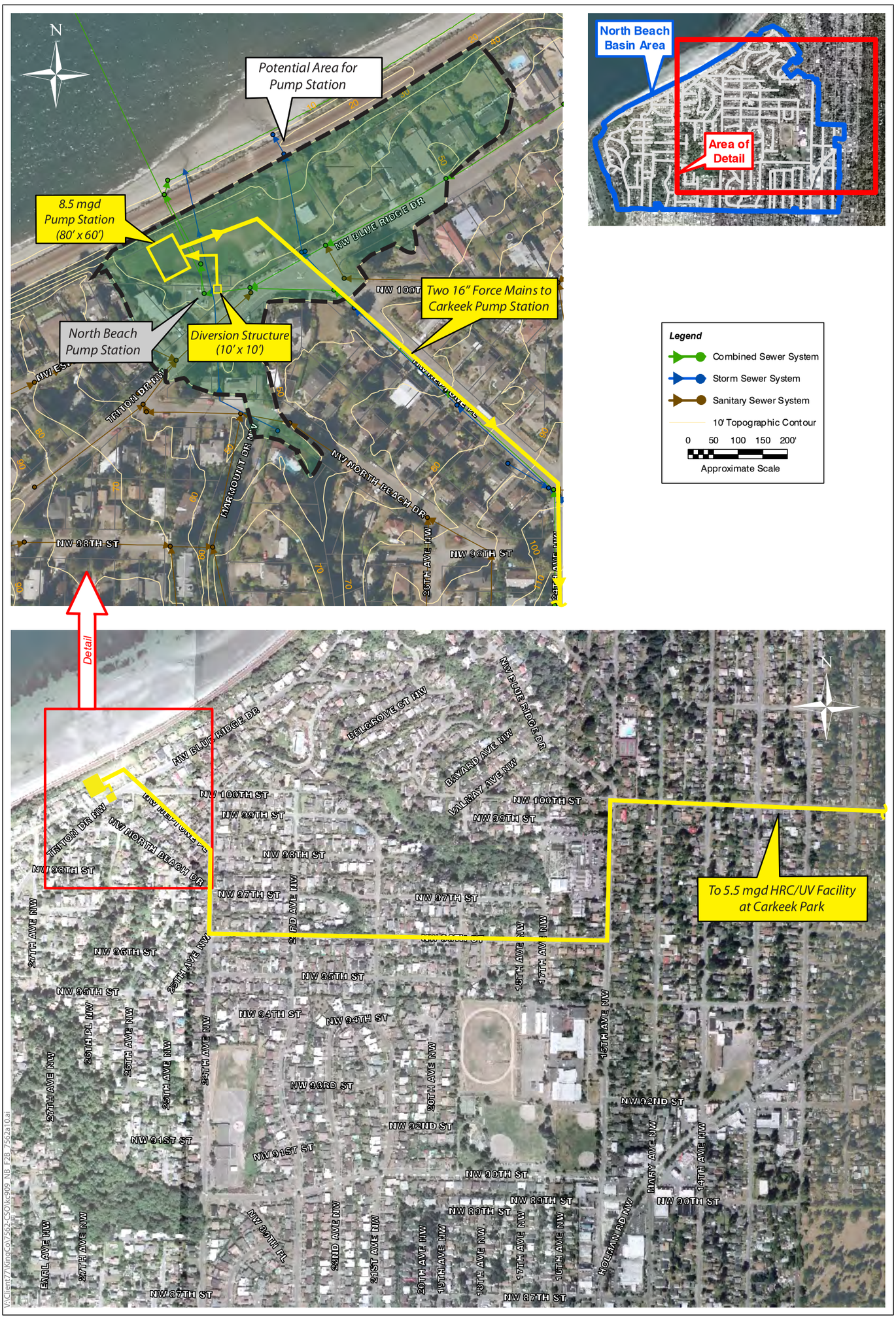

Figure 5.11
NORTH BEACH BASIN
ALTERNATIVE 2B

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Figure 5-12.ai

Figure 5.12
NORTH BEACH BASIN
ALTERNATIVE 3A

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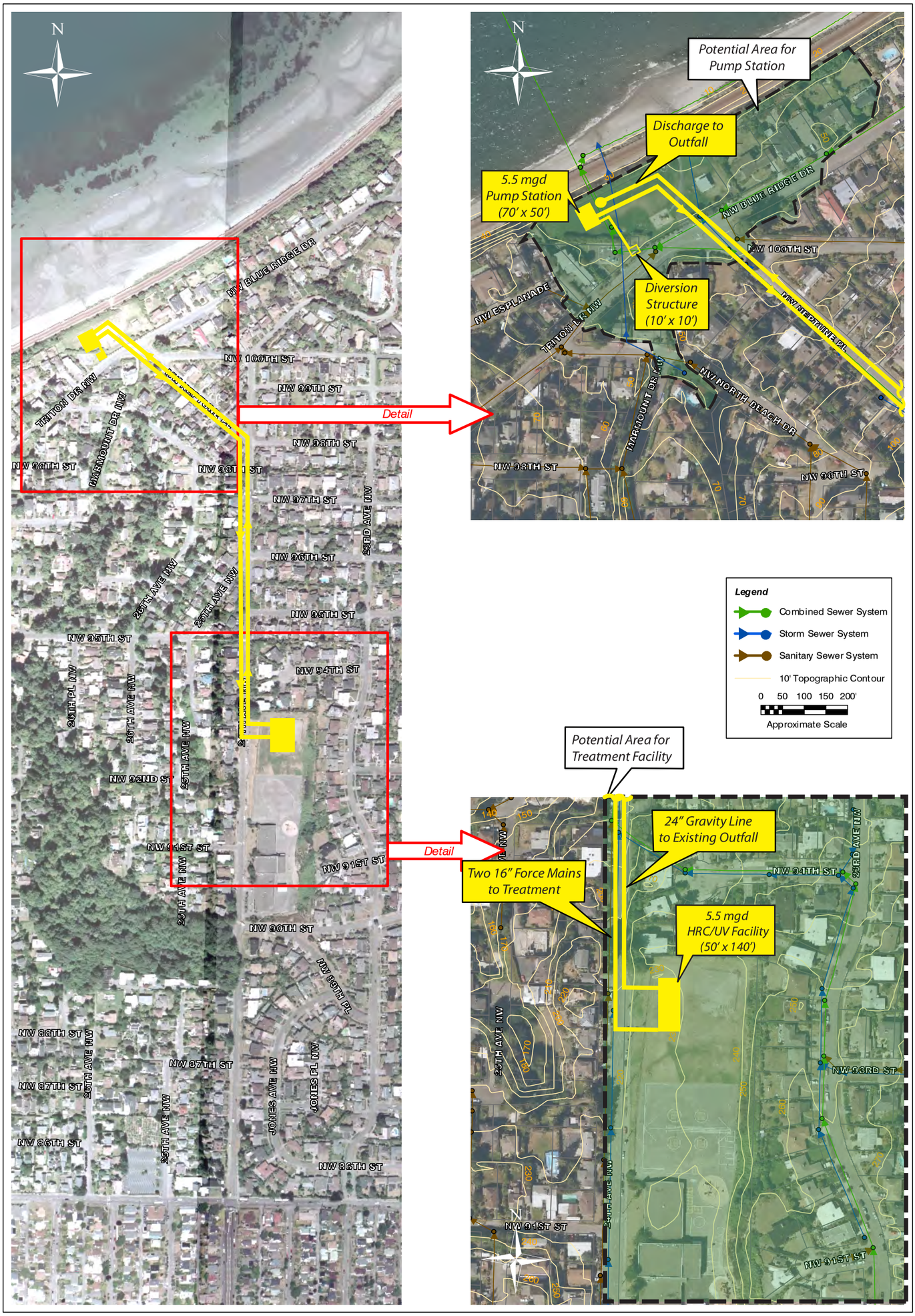

Figure 5.13
NORTH BEACH BASIN
ALTERNATIVE 3B

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Figure 5-13.ai

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5.3.4 Alternatives Using Control Approach 1 – Peak-Flow Storage

This control approach requires rectangular or pipeline storage tanks large enough to achieve the control objective. Alternatives with one tank, tunnel, or pipe are termed "centralized storage" and alternatives with more than one location for storage are termed "distributed storage."

Figure 5.14 shows the approximate flow from each sub-basin in North Beach. The maximum flow ranges from 17- to 30-percent of the total flow. Approximately 65 percent of the flow during a peak event (5.5 mgd out of the total 8.5 mgd) needs to be captured to provide adequate control. Therefore, distributed storage requires a minimum of three storage tanks. In addition, due to the branching of the collection system immediately upstream of the North Beach Pump Station, these storage tanks need to be near the bottom of the basin. Based on this information, distributed storage was deemed impractical in the North Beach Basin.

Storage could be located anywhere in the basin or out of the basin. However, the pump station required to convey the flows would be larger than a storage tank at the bottom of the basin. Therefore, centralized storage up in the basin was deemed to be impractical in the North Beach Basin.

Alternative 1A - Rectangular Bottom-of-Basin Storage (see Figure 5.6). This alternative includes a rectangular storage tank at the bottom of the basin adjacent to the North Beach Pump Station on private property. It includes the following elements:

- A 0.23 MG buried storage tank with dimensions of 55 x 40 x 15 feet deep.
- The tank includes a pump station to empty the tank contents over a 24-hour period after a storm.
- A new diversion structure to divert flows from the sewer to storage during a peak event.
- Ancillary facilities including:
  - Standby power.
  - Odor control.
  - Electrical room.
- The site includes surface access, fencing, and off-street parking.

Alternative 1B - Pipeline Bottom-of-Basin Storage (see Figure 5.7). This alternative includes pipeline storage located at the bottom of the basin adjacent to the North Beach Pump Station within the public right-of-way (NW Blue Ridge Drive and Triton Drive NW). Ancillary facilities would be located on the North Beach Pump Station site. It includes the following elements:

- A 0.23 MG buried storage pipeline with dimensions of approximately 250 feet (subsequently revised to 325 feet to allow for additional freeboard and one percent slope) by 12 feet diameter.

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Figure 5.14
NORTH BEACH BASIN
SUB-BASIN FLOW PERCENTAGES

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Figure 5-14.ai

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- The tank includes a pump station to empty the tank contents over a 24-hour period after a storm.
- A new diversion structure to divert flows from the sewer to storage during a peak event.
- Ancillary facilities including:
  - Standby power.
  - Odor control.
  - Electrical room.
- The site includes surface access, fencing, and off-street parking.

Alternative 1C - Centralized Storage Up in the Basin with Conveyance to 8th Avenue Interceptor (see Figure 5.8). This alternative includes a pump station at the bottom of the basin, a force main to the top of the basin, and a gravity line from the top of the basin to the 8th Avenue Interceptor. In addition, it includes a storage tank located at the top of the basin. Ancillary facilities would also be located at the top of the basin. This alternative replaces the existing North Beach Pump Station and Force Main to the Carkeek Pump Station. It includes the following elements:

- An 8.5 mgd pump station with approximate dimensions of 80 x 60 feet.
- Two 12-inch diameter force mains of approximately 5,000 linear-feet.
- One 12-inch diameter gravity sewer of approximately 3,000 linear-feet.
- A new diversion structure to divert flows from the sewer to the new pump station.
- A 0.15 MG buried storage tank with dimensions of 40 x 30 x 15 feet deep.
  - The tank includes a pump station to empty the tank contents over a 24-hour period after a storm.
- Ancillary facilities including:
  - Standby power.
  - Odor control.
  - Electrical room.
- The sites include surface access, fencing, and off-street parking.

Alternative 1D - Rectangular Bottom-of-Basin Storage with Conveyance to 8th Avenue Interceptor (see Figure 5.9). This alternative includes a pump station at the bottom of the basin, a force main to the top of the basin, and a gravity line from the top of the basin to the 8th Avenue Interceptor. In addition, it includes a storage tank located at the bottom of the basin. Ancillary facilities would be located both at the top of the basin (drop structure, odor control, and electrical) and at the bottom of the basin (standby power and electrical). This alternative replaces the existing North Beach Pump Station and force main to the Carkeek Pump Station. It includes the following elements:

- A 3.5 mgd pump station with approximate dimensions of 60 x 50 feet.
- Two 8-inch diameter force mains of approximately 5,000 linear-feet.
- One 12-inch diameter gravity sewer of approximately 3,000 linear-feet.
- A new diversion structure to divert flows from the sewer to the new pump station.
- A 0.15 MG buried storage tank with dimensions of 40 x 30 x 15 feet deep.
- The tank includes a pump station to empty the tank contents over a 24-hour period after a storm.
- Ancillary facilities including:
  - Standby power.
  - Odor control.
  - Electrical room.
- The sites include surface access, fencing, and off-street parking.

5.3.5 Alternatives Using Control Approach 2 - Convey-and-Treat

This control approach includes conveyance capacity increases to convey peak flows out of the basin to downstream facilities. A constraint of this approach is that the treatment capacity at the Carkeek CSO Treatment Plant would need to be increased by 5.5 mgd.

Alternative 2A - Conveyance to Carkeek CSO Treatment Plant through Beach Alignment (see Figure 5.10). This alternative includes a pump station and force main to Carkeek Pump Station. In addition, it includes a high-rate clarification treatment facility adjacent to the Carkeek Pump Station and CSO Treatment Facility. This alternative replaces the existing North Beach Pump Station and Force Main to the Carkeek Pump Station. It includes the following elements:

- An 8.5 mgd pump station with approximate dimensions of 80 x 60 feet.
- A 16-inch diameter force main of approximately 3,000 linear feet within the Puget Sound tidelands and Carkeek Park.
- A new diversion structure to redirect flows from the sewer to the new pump station.
- A 5.5 mgd high-rate clarification treatment facility adjacent to the Carkeek Pump Station.
- Ancillary facilities including:
  - Standby power.
  - Odor control.
  - Electrical room.
- The sites include surface access, fencing, and off-street parking.

Alternative 2B - Conveyance to Carkeek CSO Treatment Plant through Neighborhood Alignment (see Figure 5.11). This alternative includes a pump station and force main to the Carkeek Pump Station. In addition, it includes a high-rate clarification treatment facility adjacent to the Carkeek Pump Station and CSO Treatment Facility. This alternative replaces the existing North Beach Pump Station and Force Main to the Carkeek Pump Station. It includes the following elements:

- An 8.5 mgd pump station with approximate dimensions of 80 x 60 feet.
- A 24-inch diameter force main of approximately 7,000 linear-feet within the public right-of-way.
- A new diversion structure to redirect flows from the sewer to the new pump station.
- A 5.5 mgd high-rate clarification treatment facility adjacent to the Carkeek Pump Station.
- Ancillary facilities including:
  - Standby power.
  - Odor control.
  - Electrical room.
- The sites include surface access, fencing, and off-street parking.

5.3.6 Alternatives Using Control Approach 3 – End-of-Pipe Treatment

This control approach includes treatment of peak flows through a high-rate clarification facility within the North Beach Basin. The treated effluent would be discharged through the existing North Beach outfall.

Alternative 3A - Bottom-of-Basin Treatment Facility (see Figure 5.12). This alternative requires a high-rate clarification wet-weather treatment plant located at the bottom of the basin near the North Beach Pump Station. It includes the following elements.

- A new diversion structure to redirect flows from the sewer to the new treatment plant.
- A 5.5-mgd high-rate clarification plant with approximate dimensions of 50 x 140 feet.
- A 20-inch discharge pipe to connect the plant to the existing outfall.

Alternative 3B - Treatment Facility Up in the Basin (see Figure 5.13). This alternative requires a high-rate clarification wet-weather treatment plant located up in the basin. This alternative also requires a pump station near the North Beach Pump Station and conveyance piping to and from the treatment facility. It includes the following elements:

- A new diversion structure to redirect flows from the sewer to the new pump station.
- A new 5.5 mgd pump station of approximately 70 x 50 feet to convey flows from the bottom of the basin to the treatment plant.
- A 16-inch force main to convey flows to the treatment plant.

- A 5.5 mgd high-rate clarification plant with approximate dimensions of 50 x 140 feet.
- A 24-inch discharge pipe to connect to the existing outfall.

5.3.7 Alternatives Using Control Approach 5 - Combined Approach

This approach combines peak-flow reduction by disconnecting rooftops that are currently connected to the CSS with peak-flow reduction through infiltration improvements or peak-flow storage. A detailed analysis of this approach is provided in the *North Beach Inflow and Infiltration Alternative Analysis Project Memorandum* (Carollo Engineers, May 2010).

Alternative 5A - Inflow and Infiltration (I/I) Control. Table 5.8 summarizes the assumptions used in the North Beach I/I analysis. More detailed investigations (sewer system evaluation survey (SSES)) would be conducted to refine these assumptions and gain pre-design level information if this alternative is pursued. However, these assumptions are consistent with the County's I/I Program.

Table 5.8 I/I Analysis Assumptions

Number of Homes in Sub-basin	NB01-274; NB02-676; NB03-310; NB04-667; NB05-461	
	Inflow	**Infiltration**
Percent of Homes Repaired	10%[2]	63%[1]
Repair Effectiveness	100%	75%
I/I Reduction Cost	$3,300/home[3]	Easy - $10,000/home[4] Medium - $12,000/home[4] Hard - $17,000/home[4]
Percent of Homes per Repair Category	N/A	Easy - 33% Medium - 33% Hard - 33%

Notes:
1. Based on 95% of "easy" and "medium" homes consistent with the *Initial Infiltration and Inflow Reduction Project Alternative Analysis Report* (King County, April 2009).
2. Based on 13% of homes connected as cited in the *CSO Beach Project GIS Analysis* (King County, September 2008) and disconnection of 75% of these homes.
3. Based on *North Beach I/I Reduction Benefit/Cost Analysis* (King County, July 2007).
4. From *Initial Infiltration and Inflow Reduction Project Alternatives Analysis Report* (King County, April 2009).

The *North Beach I/I Reduction Benefit/Cost Analysis* (King County, July 2007) report estimated 4% of the homes had roof drains connected to the sewer system. The *CSO Beach Project GIS Analysis* (King County, September 2008) indicated 13% of the homes had roof drains connected. The I/I analysis for North Beach assumed 13% of houses are connected. Disconnecting a maximum of 75% of those connected homes is assumed to account for

potential issues associated with disconnection such as technical feasibility and homeowner willingness.

The cost to disconnect roof drains was $3,000 per roof in 2003 dollars (*North Beach I/I Reduction Benefit/Cost Analysis;* King County, July 2007). Using the Engineering New Record Construction Cost Indices (ENR CCI) the cost has been escalated to $3,300 per roof in 2010 dollars. These costs do not include contingency, project costs, or other miscellaneous expenses associated with construction. This estimate does not include conveyance or treatment of roof runoff, which would increase the costs substantially.

It was assumed that 63 percent of side sewers are repaired for infiltration. In the *Initial Infiltration and Inflow Reduction Project Alternative Analysis Report* (King County, April 2009) the County estimated they could repair side sewers on the “easy” and “medium” homes (67 percent). The “hard” homes would have significant landscaping, challenging topography, or other issues that would make side sewer repair infeasible or cost prohibitive. Of the “easy” and -“medium” homes, it was assumed the County could obtain right-of entry agreements with 95 percent of the homeowners.

Any repairs made to the side sewers/laterals would not completely eliminate infiltration in that location. The *I/I Reduction Feasibility Evaluation for Alternatives Analysis* (King County, November 2009) estimated a range for side sewer/lateral repair effectiveness; it was assumed that between 60 and 75 percent of the infiltration would be eliminated in that particular location by the repair efforts. The I/I analysis for North Beach assumed 75 percent repair effectiveness.

The cost to repair a side sewer/lateral varies depending upon how easy or difficult it is to access the pipe. The *Initial Infiltration and Inflow Reduction Project Alternative Analysis Report* (King County, April 2009) for Eastgate, Issaquah, and Skyway divided the ease-of-access and construction into three categories: “Easy”, “Medium”, and “Hard.” The I/I analysis for North Beach assumed an equal split between these categories, similar to Eastgate.

Inflow Improvements

To eliminate development of infrastructure such as storage or end-of-pipe treatment for North Beach CSOs, inflow and infiltration need to be reduced by 5.5 mgd. This is the flow rate over and above the capacity of the North Beach Pump Station (3.0 mgd).

The North Beach hydraulic model was used to determine the amount of infiltration and inflow in each sub-basin. A 1-year storm from October 2007, identified by King County as a design storm, was used to generate the storm flow volumes. The total peak storm inflow rate was estimated to be 5.9 mgd.

The calculations averaged the inflow rate over the 310 connected homes and assumed disconnection of 233 of these homes (10 percent of the total homes). Based on the number of homes repaired and the repair effectiveness, inflow reduction for the entire basin is estimated to be 4.42 mgd. This is 80 percent of the required peak-flow reduction (4.42 mgd divided by 5.50 mgd). Therefore, even with inflow reduction throughout the basin, approximately 45,000 gallons of storage (20 percent of the total volume required), green stormwater infrastructure, or infiltration improvements would be required.

The average unit cost (not including project costs and contingencies) for inflow reduction is $4.16 per gallon removed from the peak flow. This is lower than the unit cost (not including project costs and contingency) of $10.00 per gallon of storage. However, the unit costs for inflow reduction do not include potential requirements for stormwater collection and treatment.

Considering the steep slopes and high groundwater table in certain areas, additional water percolating into the ground may exacerbate landslide issues and localized flooding within the basin. Stormwater collection and treatment impacts the costs significantly and adds to the risk and cost variability of inflow improvements.

Inflow Improvements with Bottom-of-Basin Storage

A 45,000 gallon storage tank would be required to supplement inflow improvements. The construction cost for inflow improvements and storage facilities is approximately $5.7 million not including stormwater collection infrastructure. If stormwater collection were required, the total construction costs could be as high as $46.6 million to include storm sewers and street upgrades throughout the basin. While the scope of stormwater collection requirements may be reduced during detailed design, the range of costs indicates a high degree of variability and risk associated with this option.

Inflow Improvements with Infiltration Improvements

The total peak storm inflow rate is estimated to be 3.2 mgd. Assuming 63 percent of homes in the basin/sub-basin can be repaired and 75 percent of the infiltration from those homes is eliminated, the infiltration reduction for the entire basin (1,504 homes) is estimated to be 1.51 mgd. This is approximately 27 percent of the required peak-flow reduction (1.51 mgd divided by 5.50 mgd). Only 1.1 mgd of the total potential infiltration reduction would be required to eliminate storage since inflow would be the first priority. Therefore, approximately 1,100 homes (out of 2,388 total within the North Beach Basin) would need to be repaired to supplement inflow improvements.

Infiltration reduction project costs are based on the unit costs in Table 5.8 with an average cost of $12,000 per home repaired. The average unit cost (not including project costs and contingency) for infiltration repairs is $315 per gallon removed from the peak flow. This is significantly higher than the unit cost (not including project costs and contingency) of $10.00 per gallon of storage. In addition, the unit costs for infiltration reduction do not include potential requirements for stormwater collection and treatment.

The construction cost for the inflow and infiltration improvements is approximately $32.4 million, not including stormwater collection infrastructure. If stormwater collection were required, the total construction costs could be as high as $73.3 million to include storm sewers and street upgrades throughout the basin. While the scope of stormwater collection requirements may be reduced during detailed design, the range of costs indicates a high degree of variability and risk associated with this option.

Inflow Improvements with Green Stormwater Infrastructure (GSI)

Green Stormwater Infrastructure (GSI) was evaluated in the memorandum *CSO Beach Projects Demand Management Analysis* (King County, May 2010) to determine whether GSI, either alone or in combination with other methods, can achieve CSO control. GSI was not recommended for the North Beach Basin. The following is a summary of the analysis and findings.

King County performed a GIS analysis in 2008. The analysis identified sources of stormwater to the CSS and the separate municipal storm sewer system (MS4) and the characteristics of the basin as they relate to these sources. Impervious, pervious, and rooftop areas were identified, along with the destination of any flows originating from these locations, on both assessed property and the street ROW. The analysis built on flow monitoring and modeling in the CSS conducted in 2006. The results of this analysis indicated that less than 10 percent of the impervious area in the basin is connected to the sewer system.

Results of the GIS analyses were used to conduct a GIS spatial analysis to assess the feasibility of GSI implementation in the study area. King County based its feasibility analysis of the potential for GSI on a white paper titled *Low Impact Development: San Francisco's Green Approach to Stormwater Management* (Carollo Engineers, October 2007). The steps in King County's analysis were as follows:

- Develop criteria to identify types of areas suitable for application of the GSI techniques, starting with the San Francisco criteria and modifying them to accommodate data available for Seattle.
- For each GSI technique, identify the number of acres connected to the CSS in each sub-basin where stormwater could potentially be diverted or attenuated.

Final criteria used to identify suitable areas for each of the GSI techniques are shown in Table 5.9.

All of the criteria for a given scenario and source of flow - rooftop, impervious, or pervious - had to be met for that area to be considered for a GSI technique. Acreages identified for one GSI technique could also be included for another technique. For example, the acres under green roofs for a sub-basin are also included in acres under roof disconnection for the same sub-basin.

The results of the GSI feasibility analysis indicates that the North Beach Basin has little potential for GSI implementation. Depending on the GSI technique, only 4 to 13 acres connected to the CSS shows potential for GSI. In addition, the steep slopes, inflow/infiltration issues, and lack of public-right-of-way connections to the sewer system make this basin less favorable for GSI. See Figure 5.15.

Table 5.9 Used to Identify Areas Suitable for GSI Techniques

GSI Technique	Criteria
Green Roofs	• Roofs connected to CSS. • Roofs over 5,000 ft^2. • Roofs with slopes between 5 and 20 degrees. • Buildings and garages selected from City of Seattle building footprint dataset (does not include decks, patios, etc.).
Roof Disconnection	• Roofs connected to the CSS
Street Trees	• Areas identified in LIDAR as less than 5 ft higher than ground elevation. • Areas in the right-of-way. • Areas connected to the CSS. • Pervious areas.
Bioretention	• Non-rooftop areas in the right-of-way or on private property. • Impervious areas. • Areas connected to the CSS. • Ground slope less than 5%.
Permeable Pavement	• Impervious areas of low-traffic streets, alleys, and parking lots greater than 10,000 ft^2. • Areas connected to the CSS. • Ground slope less than 5%.

5.4 SCREENING OF PRELIMINARY ALTERNATIVES

This section describes the alternatives screening performed under Step 2 of Phase 2 (as described in Section 5.1.2.2). The screening process is described in detail in memoranda titled *CSO Control Alternative Review and Comment Procedure* (Carollo Engineers, September 2009) and *Alternative Narrowing Process* (Triangle Associates, November 2009).

5.4.1 Refined Preliminary Alternatives

The preliminary alternatives were refined and evaluated between August 2009 and February 2010. Team workshops held each month focused on technical and non-technical aspects of the alternatives. Engineering schematics of each of the CSO control approaches were developed in order to estimate site-specific costs as a result of county operations and maintenance input. The schematics were used to develop a basis of costs for the alternatives. A planning-level cost estimate for each of the alternatives was developed and included in this evaluation.

5.4.2 Short-List Development

The refined preliminary alternatives were reviewed in a team workshop on February 11, 2010, at which they were reduced to the following three alternatives for further evaluation:

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Shaun O'Neil 20100611

Figure 5.15
RESULTS OF GSI FEASIBILITY ANALYSIS

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- Alternative 1A – A buried, rectangular 0.23 MG concrete storage tank within Blue Ridge Park adjacent to the existing North Beach Pump Station. A below-grade odor control and electrical support facility would be required.
- Alternative 1B – A buried, 0.23 MG storage pipeline located adjacent to the North Beach Pump Station within the public right-of-way (Triton Drive NW and NW Blue Ridge Drive). An above-grade odor control and electrical support facility would be required and is assumed to be on county property.
- Alternative 1D – A buried, rectangular 0.15 MG concrete storage tank within Blue Ridge Park adjacent to the North Beach Pump Station. In addition, this alternative includes a 3.5-mgd high-head pump station and above-grade odor control and electrical support facility adjacent to the storage tank. This pump station would replace the existing North Beach Pump Station and convey base flows through two small-diameter (~8-inch) force mains, drop structure, and gravity sewer (~12-inch) to the 8th Avenue Interceptor.

Meeting notes for this workshop (Alternative Screening Workshop for North Beach Basin, February 11 and 17, 2010) are included as Appendix C.

5.4.3 Refinement of Short-Listed Alternatives

Between February 2010 and August 2010, the three short-listed alternatives were further developed by the Category Leaders, Basin Leads, and project team at large.

Appendix C includes a detailed description of the short-listed alternatives (*North Beach Alternatives Update Information Technical Memorandum*, Carollo Engineers, September 2010). It includes detailed operational descriptions and control narratives. Summaries of the short-listed alternatives are given below. Table 5.10 summarizes pertinent data for the alternatives. These options are illustrated in Figures 5.16 through 5.18.

5.4.3.1 Alternative 1A – Rectangular Bottom of Basin Storage

This alternative includes a buried, rectangular concrete storage tank, located adjacent to the North Beach Pump Station on Triton Drive NW. The tank provides 0.23 MG of combined sewage storage volume. Below-grade odor control and electrical facilities are included.

The existing 15-inch outfall line would be re-routed from the North Beach Pump Station to the upstream end of the storage tank. Any flows during a peak wet-weather event that exceed the capacity of the pump station (approximately 3 mgd) would overtop the weir at the North Beach Pump Station and flow to the storage tank via the outfall line. Once the capacity of the storage tank had been reached, flow would overtop the outfall weir (approximate elevation 123.00) in the storage tank and flow to the existing 15-inch outfall line. A schematic of this flow pattern is shown in Figure 5.19.

Table 5.10 North Beach Basin Short-Listed Alternative Data

	Alternative 1A	Alternative 1B	Alternative 1D
Type of Vessel, Dims., ft.	Buried, Rectangular Tank, 85 x 40 x 15	Buried, Pipeline Storage, 12 (diameter) x 325	Buried, Rectangular Tank 55 x 40 x 15 High Head PS 85 x 35 x 35 (15 above grade)
# Internal Channels	2	1	2
Sewer, Dia, in./length, ft/ construction	N/A	N/A	2@8/ 5,000 LF / Cut-and-Cover 12/ 3,000 LF/Cut-and-Cover
Excavation Limits to Shoring, L x W x H (depth), ft	90 x 50 x 35	335 x 25 x 25	65 x 50 x 40 High Head PS 60 x 40 x 30
Diversion Control Structure Dims L x W x H (depth), ft	N/A	10 x 10 x 10	N/A
Odor Control / Electrical Footprint, L x W x H (height),ft	40 x 20 x 15	40 x 20 x 15	35 x 35 x 15 Attached to High Head Pump Station
Drop Structure DimsL x W x H (depth), ft	N/A	N/A	20 x 15 x 5
Land Acquisition, SF	10,000	N/A	18,000
Construction Limits, Staging, SF	20,000	20,000 (in addition to 60-ft temporary construction easement along storage pipeline)	20,000

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North Beach Alternative 1A: Rectangular Bottom of the Basin Storage

Project Elements:

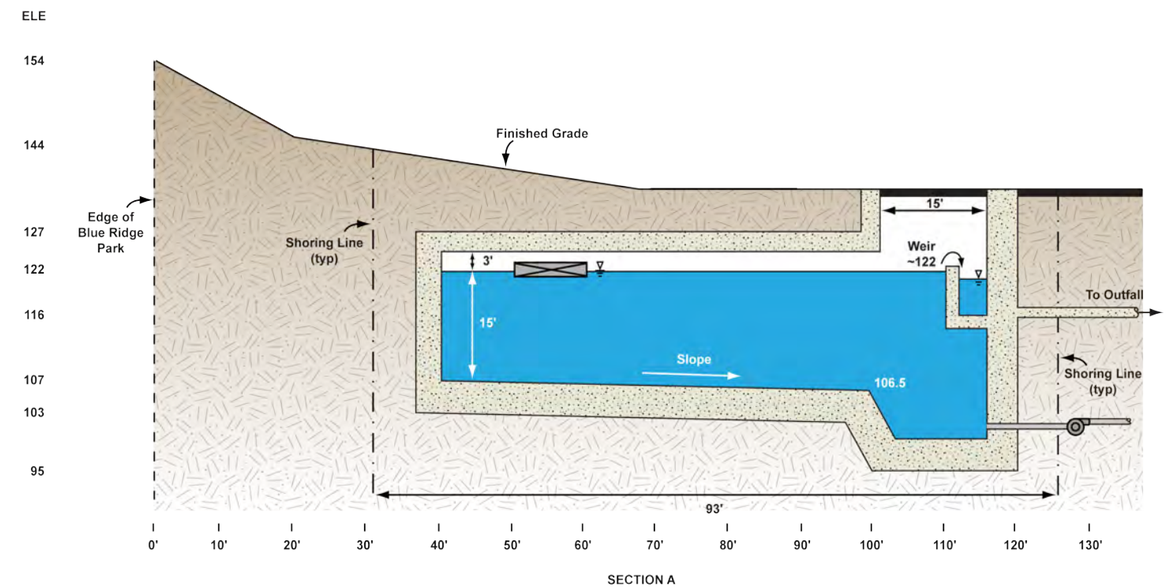
- 0.23 MG underground storage tank
- Underground pumping equipment to drain stored flows
- Underground odor control and electrical facilities

Benefits:

- Facility located where peak flows can be captured passively
- Similar to other King County operating facilities
- Efficient, safe access for operations and maintenance staff

Challenges:

- Easement or acquisition of private park required
- Requires shoreline permit
- Access to Blue Ridge Park restricted during construction
- Shoreline zone is Conservancy Recreation



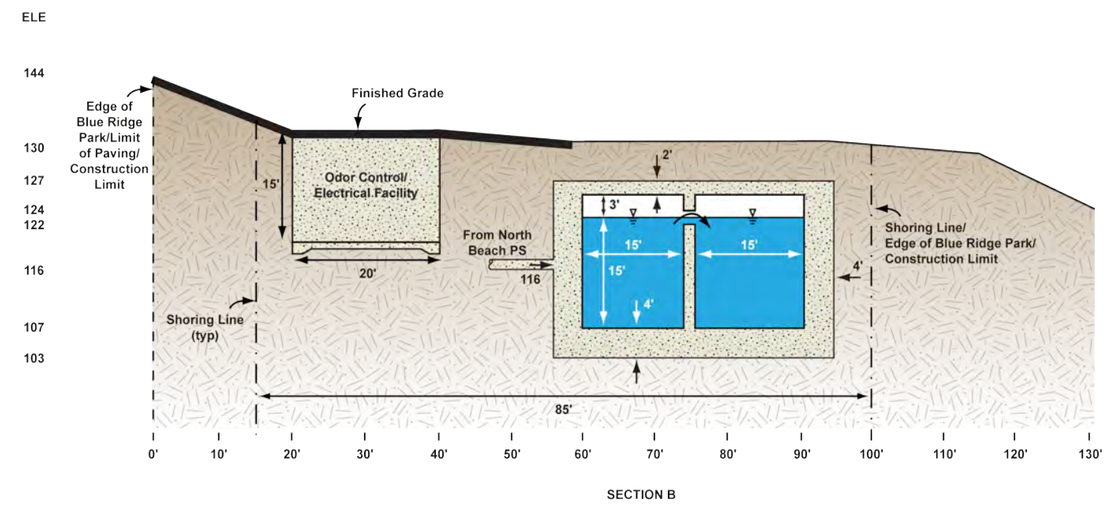


Figure 5.16
NORTH BEACH BASIN ALTERNATIVE 1A - RECTANGULAR BOTTOM OF BASIN STORAGE SITE PLAN AND SECTIONS

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Figure 5-16.ai

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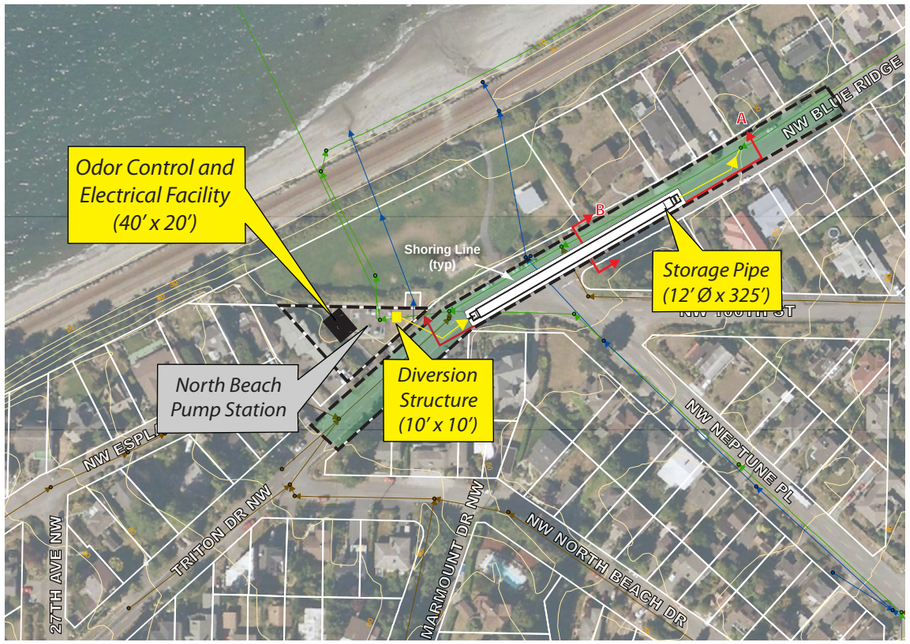
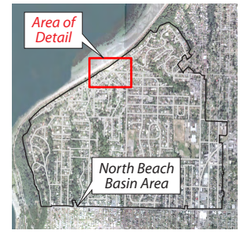
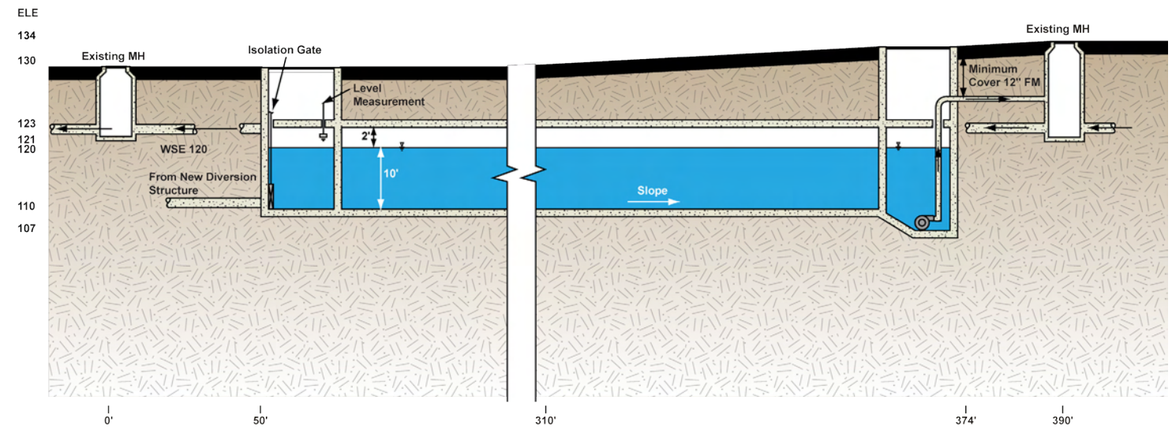




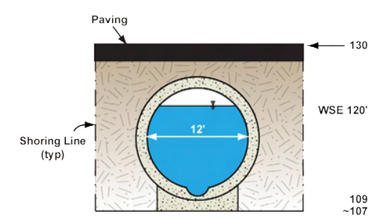
0 50 100 150'
Approximate Scale

Legend

- Combined Sewer System
- Storm Sewer System
- Sanitary Sewer System
- 10' Topographic Contour



SECTION A



SECTION B

North Beach Alternative 1B: Pipeline Bottom of the Basin Storage

Project Elements:

- Underground diversion structure to direct flows to storage
- 0.23 MG underground storage pipeline in right-of-way
- Underground pumping equipment to drain stored flows in the in-line storage pipe
- Odor control and electrical facilities located on King County property

Benefits:

- Facility located where peak flows can be captured passively
- Similar to other King County operating facilities
- No apparent need to use or acquire private property

Challenges:

- Location in narrow street will result in access limitations to residences during extended construction period
- Periodic long-term street access is needed for operations & maintenance activities

Figure 5.17
NORTH BEACH BASIN ALTERNATIVE 1B - PIPELINE BOTTOM OF BASIN STORAGE SITE PLAN AND SECTIONS

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Figure 5-17.ai

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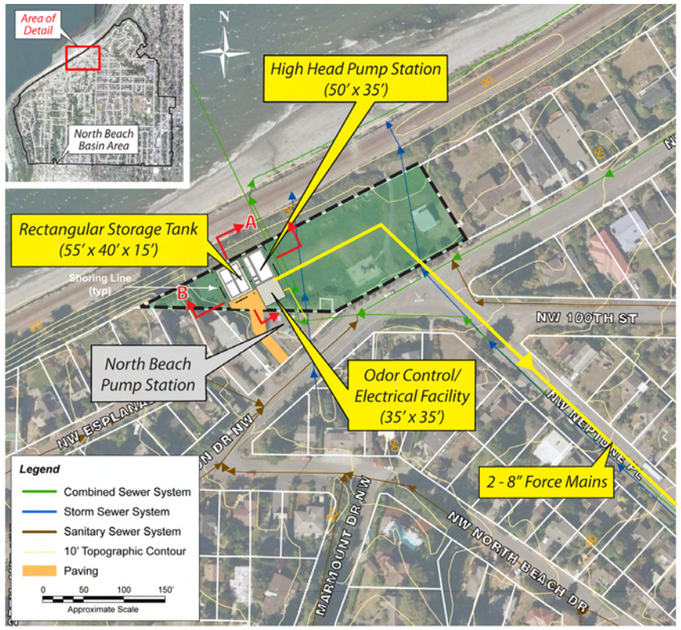

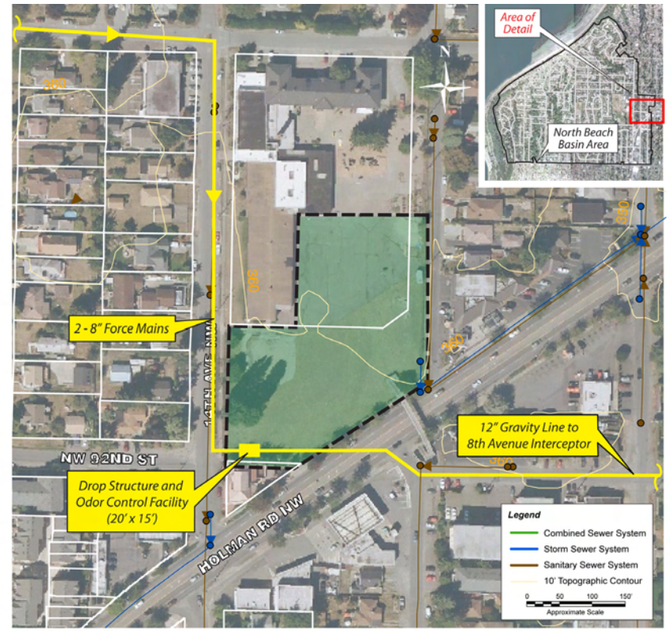

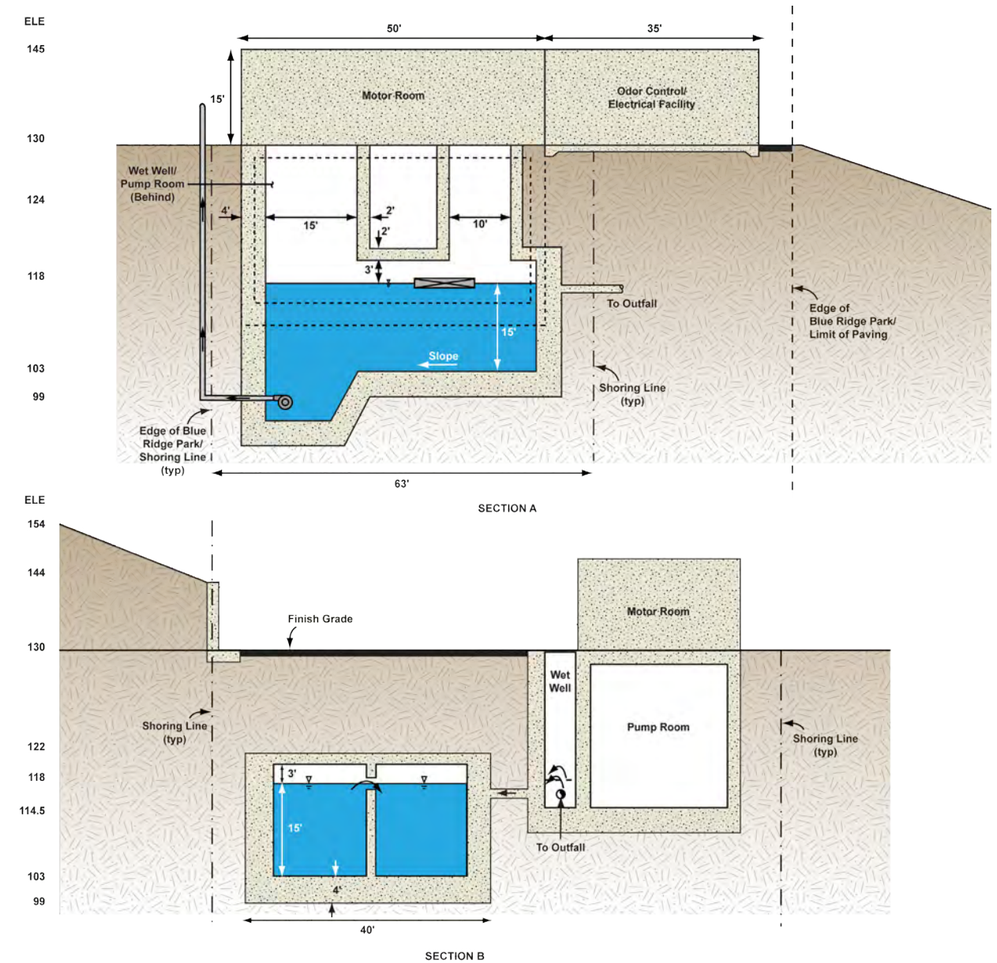

North Beach Alternative 1D: Centralized Storage at Bottom of Basin with Conveyance to 8th Avenue Interceptor

Project Elements:

- 3.5 mgd Pump Station at bottom of basin (300+ feet of head)
- 0.15 MG underground storage tank at bottom of basin
- Above ground odor control and electrical facilities adjacent to pump station
- 2 - 8" Force Mains from bottom of basin to Holman Rd NW (~5000 linear feet)
- Drop structure and odor control in utility easement
- 12" gravity sewer to 8th Avenue Interceptor (~3000 linear feet)

Benefits:

- Replaces existing force main in tidelands
- Facility located where peak flows can be captured passively
- Similar to other King County operating facilities
- Efficient, safe access for operations and maintenance staff

Challenges:

- Private property acquisition required for this alternative
- Increased O&M costs
- Requires shoreline permit
- Access to Blue Ridge Park restricted during construction
- Shoreline zone is Conservancy Recreation

Figure 5.18
NORTH BEACH BASIN ALTERNATIVE 1D - RECTANGULAR BOTTOM OF BASIN STORAGE WITH CONVEYANCE TO 8TH AVENUE INTERCEPTOR SITE PLAN AND SECTIONS

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Figure 5-18.ai

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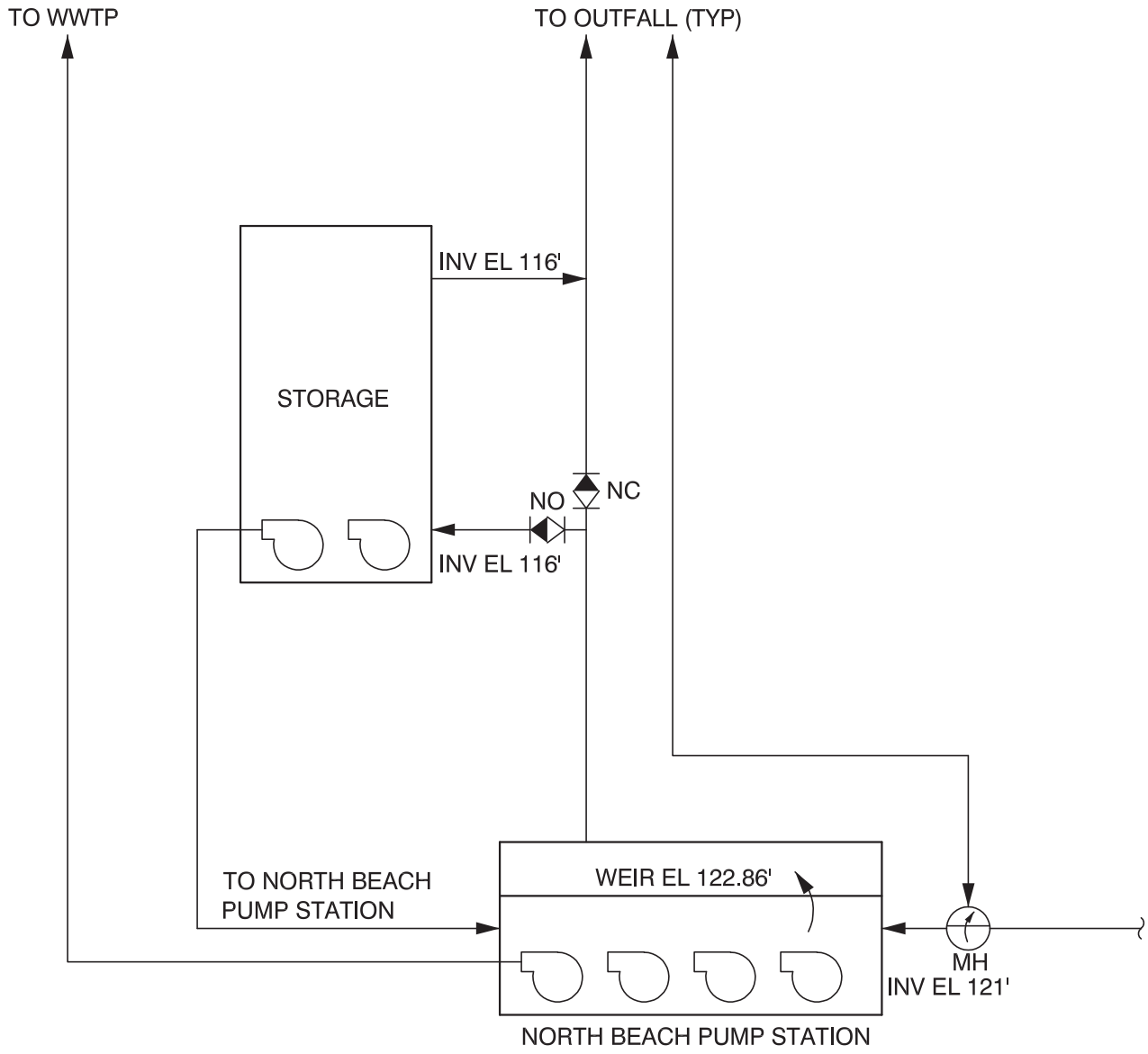

Figure 5.19
NORTH BEACH BASIN ALTERNATIVE 1A - RECTANGULAR BOTTOM-OF-BASIN STORAGE FLOW SCHEMATIC

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Figure 5-19.ai

The tank would retain the required volume until rainfall had ceased and a preset time had elapsed. Automatic cleaning cycles would empty each of the tank channels in turn, and the contents would be pumped back into the North Beach Pump Station over a 24-hour period using submersible pumps in the tank.

The tank would be equipped with carbon scrubber odor control, electrical equipment, and a backup generator, all housed in a separate below-grade structure. The tank would be accessed from the top at either end for maintenance. Cleaning equipment would consist of either flushing gates or tipping buckets as determined during detailed design.

The County evaluated this alternative using the evaluation criteria listed in Appendix C. Detailed results of this evaluation are also provided in Appendix C. The sections below summarize evaluation considerations for this alternative.

5.4.3.1.1 Land Use and Permitting

The site for Alternative 1A is located in residentially zoned open space owned by the Blue Ridge Homeowners Association. The site is known as “Blue Ridge Park.” Partial acquisition or an easement would be required. The park is designated "Conservancy Recreation" (CR) in Seattle's Shoreline Master Program. Storage is considered a "Utility Service Use" and is prohibited. This would require a code amendment or rezone. This alternative would also require a Shoreline Permit.

5.4.3.1.2 Environmental

The site is a relatively flat, clear space. There are no known environmental issues of concern associated with the site.

5.4.3.1.3 Technical

Alternative 1A is the simplest to operate of the three alternatives because it would allow for passive inflow during peak events and the tank’s rectangular geometry would facilitate cleaning. Because of the site’s location and size extensive shoring would be required during construction and would limit the ability to expand the tank in the future.

5.4.3.1.4 Operations and Maintenance

The storage tank concept is familiar to county operations staff. The concept is simple to operate and maintain. There is safe access to the site.

5.4.3.1.5 Costs

This alternative is the second least costly of the short-listed alternatives. At this level of estimating, the cost is essentially equal to that of Alternative 1B. However, since the parcel is privately owned, the schedule and cost risk for this alternative is significant.

5.4.3.1.6 Community

Construction at this site would have short-term and long-term impacts on the community. Construction would create noise, dust, and construction traffic impacts on local traffic and neighboring residences. Blue Ridge Park would be inaccessible during construction and

would be impacted by periodic maintenance activities. The community has a strong opposition to use of any portion of Blue Ridge Park.

5.4.3.2 Alternative 1B – Pipeline Bottom of Basin Storage

This alternative includes buried pipeline storage located in Triton Drive NW and NW Blue Ridge Drive public right-of-way. The tank provides 0.23 MG of combined sewage storage volume. Odor control and electrical facilities would be included on the existing North Beach Pump Station property.

Flow to the North Beach Pump Station would be routed through a new diversion structure. During wet-weather events, the water level in the wet-well of the pump station would back-up and overflow the weir (approximate elevation 123.00) at the diversion structure. A new 15-inch overflow pipeline would run from the diversion structure to the head of the 12-foot diameter storage pipeline. When the maximum water surface elevation (approximately 121.00) was reached in the storage pipe, the rising water level would overtop the existing outfall weir(s) and peak flows would be conveyed through the existing outfall(s) to Puget Sound. A schematic of this flow pattern is shown in Figure 5.20.

The tank would retain the required volume until rainfall had ceased and not occurred for a preset time. Automatic cleaning cycles would empty the tank and the contents would be pumped back into the North Beach Pump Station over a 24-hour period using submersible pumps in the tank.

The facility would include carbon scrubber odor control, electrical equipment, and a backup generator on the North Beach Pump Station site. The storage pipeline would be accessed from the top at either end for maintenance. Cleaning equipment would include either flushing gates or tipping buckets as determined during detailed design.

The County evaluated this alternative using the evaluation criteria listed in Appendix C. Detailed results of this evaluation are also provided in Appendix C. The sections below summarize the evaluation considerations for this alternative.

5.4.3.2.1 Land Use and Permitting

The site for Alternative 1B is in a public right-of-way and is on county-owned property. Site acquisition would not be required. Zoning for the North Beach Pump Station site is Single Family Residential. Utility service use is permitted as a City Council conditional use. This alternative would not require a Shoreline Permit. This alternative would require either a Street Improvement Permit or Major Utility Permit

5.4.3.2.2 Environmental

The site is a relatively flat, clear space. There are no known environmental issues of concern associated with the site.

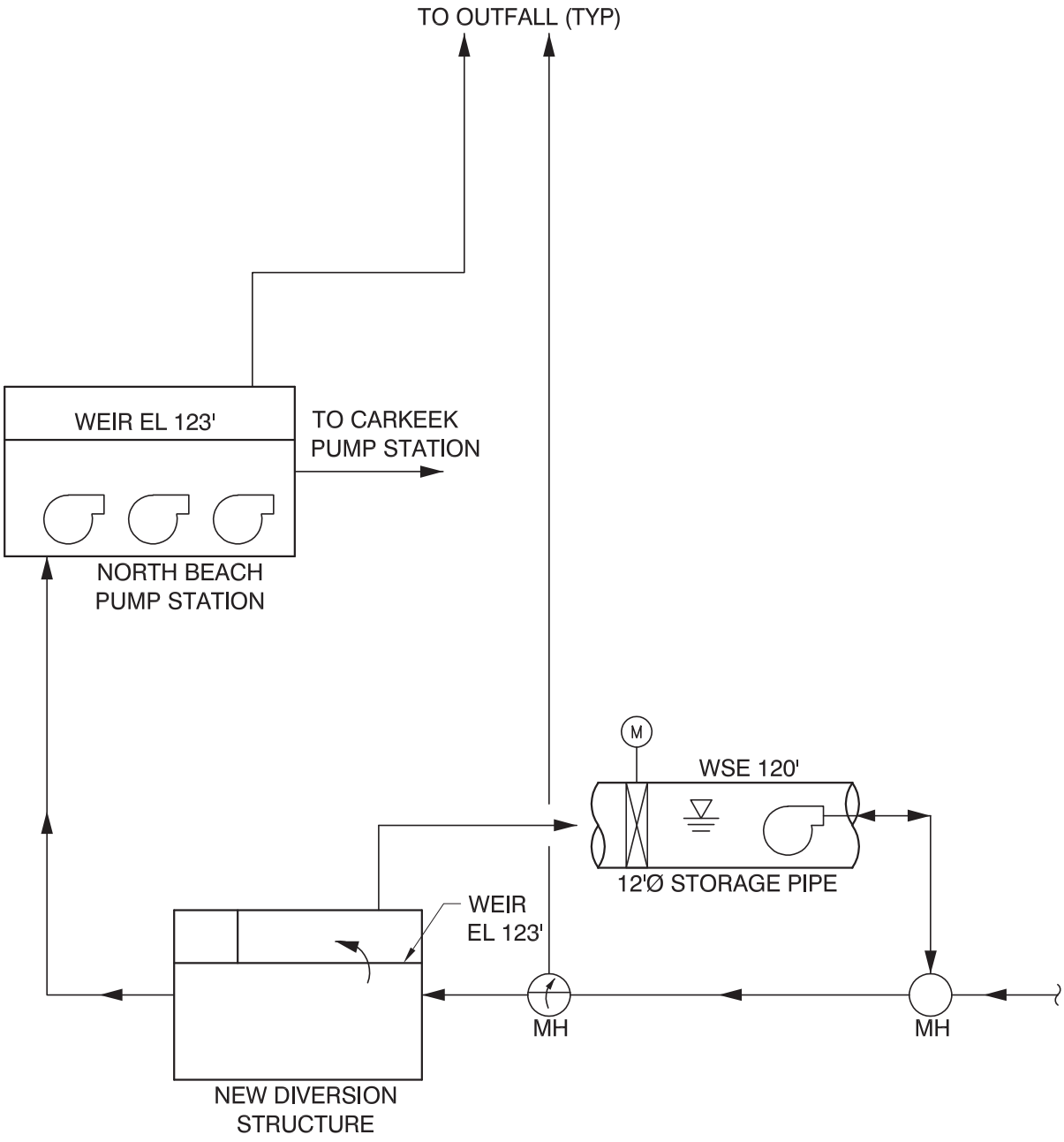

Figure 5.20
NORTH BEACH ALTERNATIVE 1B - PIPELINE BOTTOM-OF-BASIN STORAGE FLOW SCHEMATIC

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Figure 5-20.ai

5.4.3.2.3 Technical

Alternative 1B would be relatively simple to operate because it would allow for passive inflow during peak events and only has one cell. However, pipeline storage may be more difficult to clean than rectangular storage due to the shape and length. Site location and size would require extensive shoring during construction and limit the ability to expand the tank in the future.

5.4.3.2.4 Operations and Maintenance

The storage tank concept is familiar to county operations staff. The concept is simple to operate and maintain. However, access is a concern and additional staffing (relative to Alternative 1A) is likely needed due to the location within the public right-of-way. Infrequent maintenance issues would require traffic control procedures and a street use/closure permit.

5.4.3.2.5 Costs

This alternative is the least costly of the short-listed alternatives. Furthermore, the schedule and cost risk is estimated to be significantly lower than the other alternatives since private property is not required and the facilities would not be within the Conservancy Recreation zone. Street use costs might be substantial if the work took longer than anticipated.

5.4.3.2.6 Community

Construction at this site has short-term and long-term impacts on the community. It would create noise, dust, and construction traffic impacts on local traffic and neighboring residences. Maintenance activities might require street closures. The community has indicated strong support for this alternative since it does not use any portion of Blue Ridge Park.

5.4.3.3 Alternative 1D – Rectangular Bottom-of-Basin with Conveyance to 8th Avenue Interceptor

This alternative includes a buried, rectangular concrete storage tank located adjacent to a new county pump station on Triton Drive NW. The tank would provide 0.15-MG of combined sewage storage. The new 3.5 mgd pump station would replace the existing North Beach Pump Station and convey base wastewater flows through two 8-inch diameter force mains to a drop structure at the top of the basin. The drop structure would provide a transition from the force mains to a 12-inch gravity sewer that conveys the flows to the 8th Avenue Interceptor. The drop structure includes odor control equipment. Odor control and electrical facilities would also be included within the new pump station at the bottom of the basin.

Alternative 1D would include construction of a new 3.5 mgd high-head pump station. Flow would be routed directly from the collection system via the existing 18-inch line to the wet-well of the new pump station. Flows exceeding 3.5 mgd would overtop the first weir (approximate elevation 120.00) in the wet well. From there flows would be conveyed via a short pipeline to the underground storage tank. When the level in the tank reached its maximum water surface elevation, flow in the wet-well would overtop the overflow weir

(approximate elevation 118.00). The overflow would flow by gravity to the existing outfall and Puget Sound. A schematic of this flow pattern is shown in Figure 5.21.

The tank would retain the required volume until rainfall had ceased and a preset time had elapsed. Automatic cleaning cycles would empty each tank and the contents would be pumped back into the North Beach Pump Station over a 24-hour period using submersible pumps in the tank.

The pump station and tank would be equipped with carbon scrubber odor control, electrical equipment, and a backup generator. The tank would be accessed from the top at either end for maintenance. Cleaning equipment would consist of either flushing gates or tipping buckets as determined during detailed design.

The County evaluated this alternative using the evaluation criteria listed in Appendix C. Detailed results of this evaluation are also provided in Appendix C. The sections below summarize the evaluation considerations for this alternative. Land Use and Permitting

The site for Alternative 1D is located in a residentially zoned open-space owned by the Blue Ridge Homeowners Association. The site is known as “Blue Ridge Park.” Partial acquisition would be required. The park is designated "Conservancy Recreation" (CR) in Seattle's Shoreline Master Program. Storage is considered a "Utility Service Use" and is prohibited. This would require a code amendment or rezone. This alternative would also require a Shoreline Permit. This alternative requires a Street Utility Permit, but construction of the drop structure near Crown Hill Park would be within an existing 30-foot wide utility easement.

5.4.3.3.1 Environmental

The site is a relatively flat, clear space. There are no known environmental issues of concern associated with this site. There are known contaminated sites and there is potential that contaminated soils could be encountered in the vicinity of the drop structure and odor control facility site and pipeline alignment.

5.4.3.3.2 Technical

The pump station would require two-stage pumping, which is more costly and requires more maintenance than the existing North Beach Pump Station design. Flows from the Carkeek Pump Station would need to be limited so that the capacity of the 8th Avenue Interceptor would not be exceeded. Site location and size would require extensive shoring during construction and limit the ability to expand the tank in the future. In addition, gravity lines that connect to the North Beach Force Main upstream of the Carkeek Pump Station would need to be modified since the force main would no longer carry flows from North Beach.

5.4.3.3.3 Operations and Maintenance

The pump station and storage tank concept is familiar to county operations staff. The alternative would require more maintenance relative to Alternatives 1A and 1B due to the need for a two-stage pump station. There is safe access to the site.

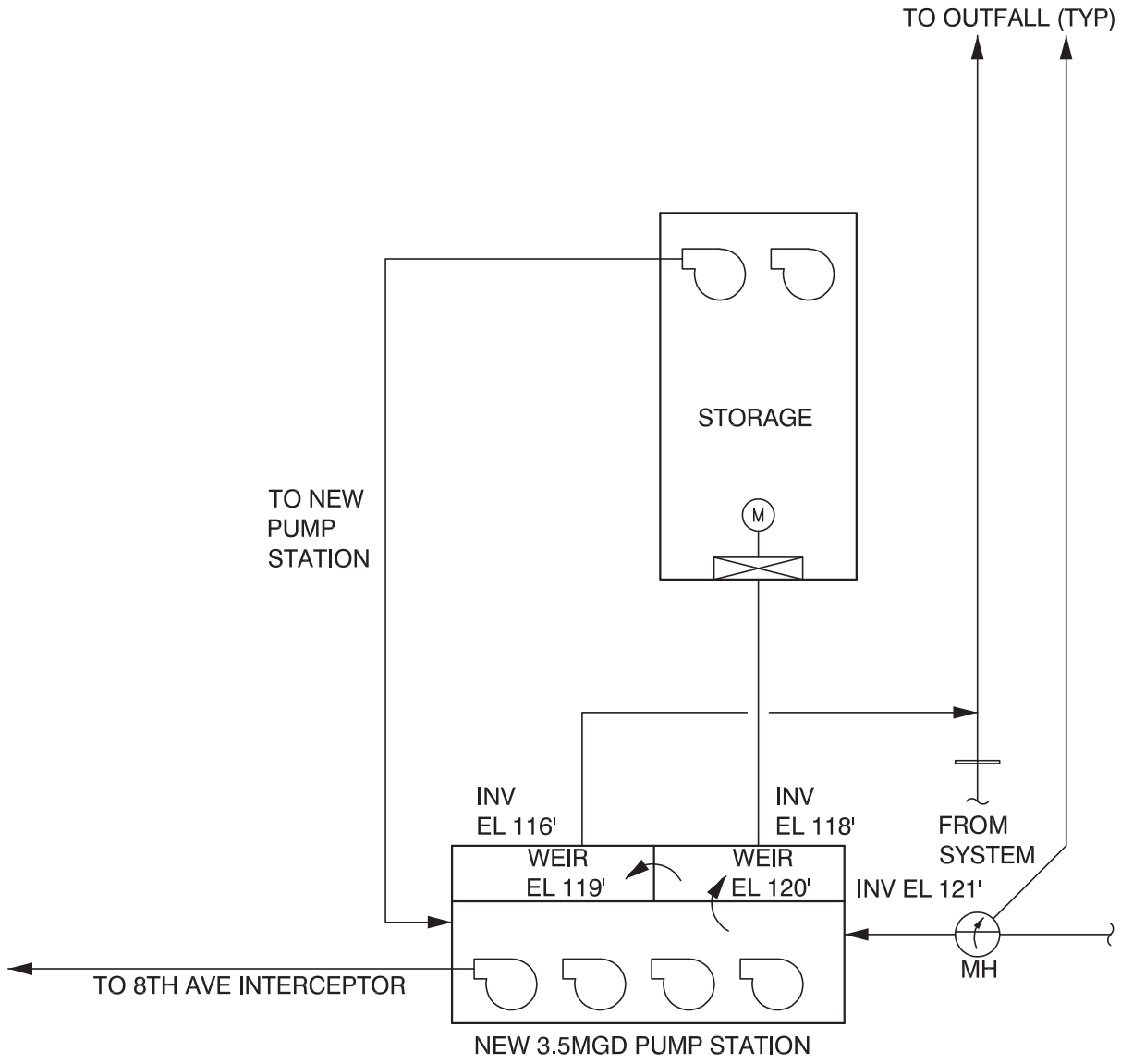

Figure 5.21
NORTH BEACH ALTERNATIVE 1D - RECTANGULAR BOTTOM-OF-BASIN STORAGE WITH CONVEYANCE TO 8TH AVENUE INTERCEPTOR FLOW SCHEMATIC

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Figure 5-21.ai

5.4.3.3.4 Costs

This alternative would be three to four times more costly than Alternative 1A or 1B and would significantly change the operating characteristics of the North Beach infrastructure by bypassing the Carkeek Pump Station. Since the wastewater would need to be pumped over a ridge to 8th Avenue, the operating costs would also be significantly higher than the existing system.

5.4.3.3.5 Community

Construction at this site would have short-term and long-term impacts on the community. Construction would create noise, dust, and construction traffic impacts on local traffic and neighboring residences. Because pipeline and facility construction would occur at two sites, this work would impact multiple areas of the basin. Blue Ridge Park would be inaccessible during construction and would be impacted by periodic maintenance activities. The community has a strong opposition to use of any portion of Blue Ridge Park. Construction of the Drop Structure might impact Crown Hill Park.

The alternative would eliminate the need for a future potential project to upgrade the existing force main and/or pump station.

5.5 SELECTION OF A PROPOSED ALTERNATIVE

This section describes the selection of a proposed project approach from among the three short-listed alternative under Step 3 of Phase 2 (as described in Section 5.1.3.3). Detailed information is provided in the *North Beach Alternatives Update Information Technical Memorandum* (Carollo Engineers, June 2010) in Appendix C.

5.5.1 Refinement of the Evaluation Criteria

The evaluation template used by the project team to evaluate these alternatives is included in Appendix C. It describes the team's comments on the various factors affecting review and recommendation of a proposed alternative.

5.5.2 Evaluation Process

5.5.2.1 <u>Screening Analysis</u>

The project team convened several focus group meetings between March 2010 and August 2010. The team reviewed updated and new information about the alternatives . The team refined the criteria questions and evaluation ratings using the results of each of these meetings.

The team compiled evaluation results from the focus group meetings and convened a workshop in August 2010 to make a recommendation for a proposed alternative to carry forward for further environmental review. Meeting notes from this workshop are in Appendix C. Table 5.11 summarizes the project team's analysis of the three shortlisted alternatives.

Table 5.11 Evaluation Summary of Short-Listed Alternative Data

	Alternative 1A: Rectangular Bottom-of-Basin Storage	**Alternative 1B: Pipeline Bottom-of-Basin Storage**	**Alternative 1D: Centralized Storage at Bottom of Basin with Conveyance to 8th Avenue Interceptor.**
Evaluation Ratings	This alternative was in the middle for low-impact scores and tied with Alternative 1D for the most high-impact ratings.	This alternative had the most low-impact ratings and had the fewest high-impact ratings.	This alternative had the fewest low-impact scores and tied with Alternative 1A for the most high-impact ratings.
Technical Considerations	Passive diversion of flows and infrastructure similar to other county facilities. Shoring, groundwater, and physical space concerns for constructability. No street access required. Minimum staffing and maintenance requirements.	Passive diversion of flows and infrastructure similar to other county facilities. Shoring, groundwater, and physical space concerns for constructability. Street access may be required - concern about staff safety and street closure requirements. Increased staffing and maintenance requirements due to facilities in the right-of-way.	Passive diversion of flows and infrastructure similar to other county facilities. Shoring, groundwater and physical space concerns for constructability. Increased maintenance due to two-stage pumping. No street access required and minimum staffing and maintenance requirements.
Preliminary Cost Estimates[1]			
Project Costs	$10,350,000	$9,080,000	$33,610,000
Land Acquisition (including easements)	$600,000	$400,000	$785,000
Street Use Permits	$0	$350,000	$480,000
Life Cycle Costs (annual)	$560,000	$550,000	$1,780,000
Community Input	Not as much support as Alternative 1B.	Support for this alternative.	Not as much support as Alternative 1B.
Real Estate	Opposition to acquisition of portion of Blue Ridge Park (private park owned by the Blue Ridge community).	No property acquisition required. Facilities within right-of-way or county property.	Opposition to acquisition of portion of Blue Ridge Park (private park owned by the Blue Ridge community).
Land Use Permits (in addition to the typical construction permits)	Shoreline Permit Council Conditional Use Permit – The storage tank would be located in a privately-owned park designated "Conservancy Recreation" (CR) in Seattle's Shoreline Master Program. Storage is considered a "Utility Service Use." Utility Service Uses are prohibited.	Council Conditional Use Permit - Would be straight forward because Seattle Municipal code says this is permitted and there is community support for this alternative.	Shoreline Permit Council Conditional Use Permit – The storage tank would be located in a privately-owned park designated "Conservancy Recreation" (CR) in Seattle's Shoreline Master Program. Storage is considered a "Utility Service Use." Utility Service Uses are prohibited.
Environmental Considerations	No known environmental issues of concern.	No known environmental issues of concern.	Known contaminated sites and potential to encounter contaminated soils in the vicinity of the drop structure and odor control facility site and pipeline alignment near Holman Road.
Risk Analysis High Impact and High Probability Risks	• Challenge to Shoreline Permit application; appeal successful. Cost: $900,000; Schedule: 11 months. • City would not issue permit for storage in "Conservancy Recreation" Shoreline Designation; rezone or code amendment required. Cost: $N/A; schedule: 9 months. • County procured construction permits delayed. Cost: $N/A; schedule: 9 months. • Significant portion of park closed for intermittent maintenance. Cost: $3,000,000; schedule: N/A. • Stakeholders request additional meetings to discuss the project. Cost: $N/A; schedule: 5 months. • Small Contractor Supplies (SCS) requirements change. Cost: $N/A; schedule: 4 months. • Blue Ridge Board agrees to grant an easement then changes mind. Cost: $2,400,000; schedule: 14 months. • Blue Ridge Board sued; all negotiations stopped with KC. Cost: $N/A; schedule: 16 months.	• Small Contractor Supplies (SCS) requirements change. Cost: $N/A; schedule: 4 months.	• Challenge to Shoreline Permit application; appeal successful. Cost: $900,000; schedule: 11 months. • City would not issue permit for storage in "Conservancy Recreation" Shoreline Designation; rezone or code amendment required. Cost: $N/A; schedule: 9 months. • County procured construction permits delayed. Cost: $N/A; schedule: 9 months. • Stakeholders request additional meetings to discuss the project. Cost: $N/A; schedule: 5 months. • Small Contractor Supplies (SCS) requirements change. Cost: $N/A; schedule: 4 months. • Existing building encroaches on easement in Crown Hill Park. Cost: $50,000; schedule: 11 months. • Blue Ridge Board agrees to grant an easement then changes mind. Cost: $2,400,000; schedule: 14 months. • Blue Ridge Board sued; all negotiations stopped with KC. Cost: $N/A; schedule: 16 months.

Notes:

1. Project costs include construction and non-construction capital costs except for specific itemized costs noted in the table.

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5.5.2.2 Project Risk Analysis

In July 2010, the project team conducted project implementation risk assessment workshops for the short-listed alternatives. The resulting risk assessment matrices are in Appendix C. Alternatives 1A and 1D had a number of potential high-impact and high-probability risks, as shown in Table 5.11. This resulted in higher cost and schedule risk for these alternatives which could impact meeting the compliance schedule and final project costs. Alternative 1B had only one potential high-probability and high-impact risk, resulting in much lower cost and schedule risk.

5.5.3 Proposed Alternative for Further Environmental Review

Pipeline Bottom-of-Basin Storage (Alternative 1B) is the alternative proposed for further environmental review for the following reasons:

- Straightforward approach, similar to other county facilities, with minimal technical complexity.
- Minimal permitting/zoning issues.
- Private property acquisition not required.
- Preferred by the community.
- No known environmental issues of concern.
- Lowest capital and life-cycle costs.
- Lowest schedule and cost risk.

Chapter 6 describes the proposed alternative in detail.