PREDESIGN REPORT

NORTH BEACH PUMP STATION
OVERFLOW CONTROL

ARMS No. A43301 Task No. W03

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SUMMARY

This predesign study was initiated to determine available options to control overflows at the North Beach Pump Station. The study had the following goals:

- Update estimates of existing overflows, station capacity, and system hydraulics, using recently acquired field data.
- Develop and evaluate potential facility improvements to reduce the frequency of overflows to one per year.
- Investigate potential phasing of the recommended improvements and explore interim measures to substantially reduce the frequency and volume of overflows in the near term.
- Recommend a course of action.

A hydrologic model was used to simulate basin conditions, using flow and level monitoring data collected between 1989 and 1992. The purpose of the modeling effort was to establish the current frequency and volume of overflows and to assess the effectiveness of potential facility improvements. The estimated frequency of overflows at the station is 18 events per year. The estimated annual volume of overflows is 1.9 million gallons (MG).

Staff also performed pump tests to verify the existing station's pumping capacity. The maximum capacity of the station is 3.4 million gallons per day (mgd), far less than the original station design of 4.2 mgd. The one-year peak inflow to the station is estimated at 6.8 mgd.

Engineering analysis of the existing pump station and transmission system identified three major constraints that limit the options to reduce overflows by upgrading the station's pumping capacity. These constraints include the design and condition of the North Beach force main, the piping configuration at the downstream portion of the force main, and the physical design of the existing pump station.

System assessment revealed that energy losses due to friction in the force main are the primary cause of the station's current reduced capacity. Potential energy losses in the force main also limit the upgrade options. If the station were upgraded without reducing energy losses in the force main through modifications such as replacing a portion of the main, unacceptably high working pressures would be required.

This working condition, coupled with potential peak surge pressures, would significantly increase the risk of a future catastrophic pipe failure.

The piping configuration at the downstream portion of the force main within Carkeek Park poses additional constraints on any potential pump station upgrade. Two City of Seattle gravity sewer lines discharge directly into this portion of Metro's force main. The liquid level in these steeply sloping gravity lines fluctuates as a direct result of pressure in the force main. Unacceptably high liquid levels would occur if Metro increased the pump station's capacity without replacing this portion of the force main to reduce pressures.

In addition to the force main improvements, upgrading the station's pumping capacity will require a structural modification to the station to house new electrical equipment necessitated by the increased horsepower.

Staff concurs with Brown and Caldwell's 1988 recommendation that overflows at the North Beach station be controlled by a combination of improvements including constructing a storage basin at the site, upgrading the pump station, and modifying piping in Carkeek Park. The recommended sizes and configurations of such improvements were revised, however, based on Metro's field data and analyses.

Alternative combinations of improvements that would ultimately reduce overflows to one per year were developed and evaluated, assuming that the improvements would be implemented in two phases. This phased approach was used at the client's request to minimize the budgetary impacts of any adopted modifications. A variety of potential interim measures to reduce overflows were also evaluated, but were not recommended for implementation for various reasons.

In Phase 1, staff recommends constructing a 140,000-gallon storage basin at the site of the North Beach station. Phase 1 would reduce the frequency of overflows from 18 to 4 per year, and would reduce the volume of overflows from 1.9 to 1.0 MG per year. The estimated total cost of implementing Phase 1 is $1,602,400.

In Phase 2, staff recommends upgrading the North Beach station capacity to 4.5 mgd, replacing 2,060 lineal feet of the North Beach force main within Carkeek Park, and making minor modifications to the City of Seattle pipelines. Phase 2 would reduce the frequency of overflows from 4 to 1 per year, and would reduce the overflow volume from 1.0 to 0.2 MG per year. The estimated total cost of implementing Phase 2 is $1,875,200.

The schedule for the recommended improvements will be determined as part of future Combined Sewer Overflow program planning. The schedule for Phase 2 should include a 3-year period, prior to final design, for monitoring flows in the two City of Seattle lines that discharge to the North Beach force main. This will allow Metro to estimate the liquid levels that would occur in these lines during large storms, which is necessary for Phase 2 design.

SECTION 1 -- BACKGROUND

The North Beach Pump Station was constructed in 1962 on the site of an existing City of Seattle primary sewage treatment plant. Parts of the treatment plant structure were incorporated into the construction of the pump station. The station is located at 2462 Triton Drive and is situated in a residential neighborhood. (See Figure 1.)

Flows from the North Beach Pump Station go north to the Carkeek Treatment Plant. The Carkeek plant is currently being converted from a primary treatment plant to a stormweather treatment plant. A new Carkeek Pump Station is being constructed to transfer sewage flows to the West Point Treatment Plant for secondary treatment.

Overflows have been recorded at the North Beach station since the 1970s. Brown and Caldwell Consultants, Inc., studied the North Beach system as part of the *Facility Plan for the Carkeek Transfer/CSO Facilities Project* (December 1988). The 1988 report presented estimates of existing station capacity and overflow frequency, and recommended improvements to reduce overflows at the station to a frequency of one per year.

The recommended improvements consisted of upgrading the pump station to increase its capacity, constructing a storage basin at the station site, and constructing a new pipeline in Carkeek Park to reroute flows from two City gravity sewer lines that discharge directly to Metro's force main.

The 1988 study considered a variety of alternative methods to control overflows at the station. Brown and Caldwell conducted an infiltration/inflow analysis for the basin and found that I/I control would be significantly more expensive than the recommended improvements. They also considered upgrading the system to handle the one-year peak flow by providing a higher-capacity pump station and constructing a new force main from the North Beach station to the Carkeek plant. This alternative was abandoned because of concerns about implementation in a shoreline zone.

The recommended improvements were prioritized along with other projects in Metro's Combined Sewer Overflow (CSO) program, based on cost-effectiveness and environmental considerations. The North Beach improvements were scheduled for delayed, rather than immediate, construction.

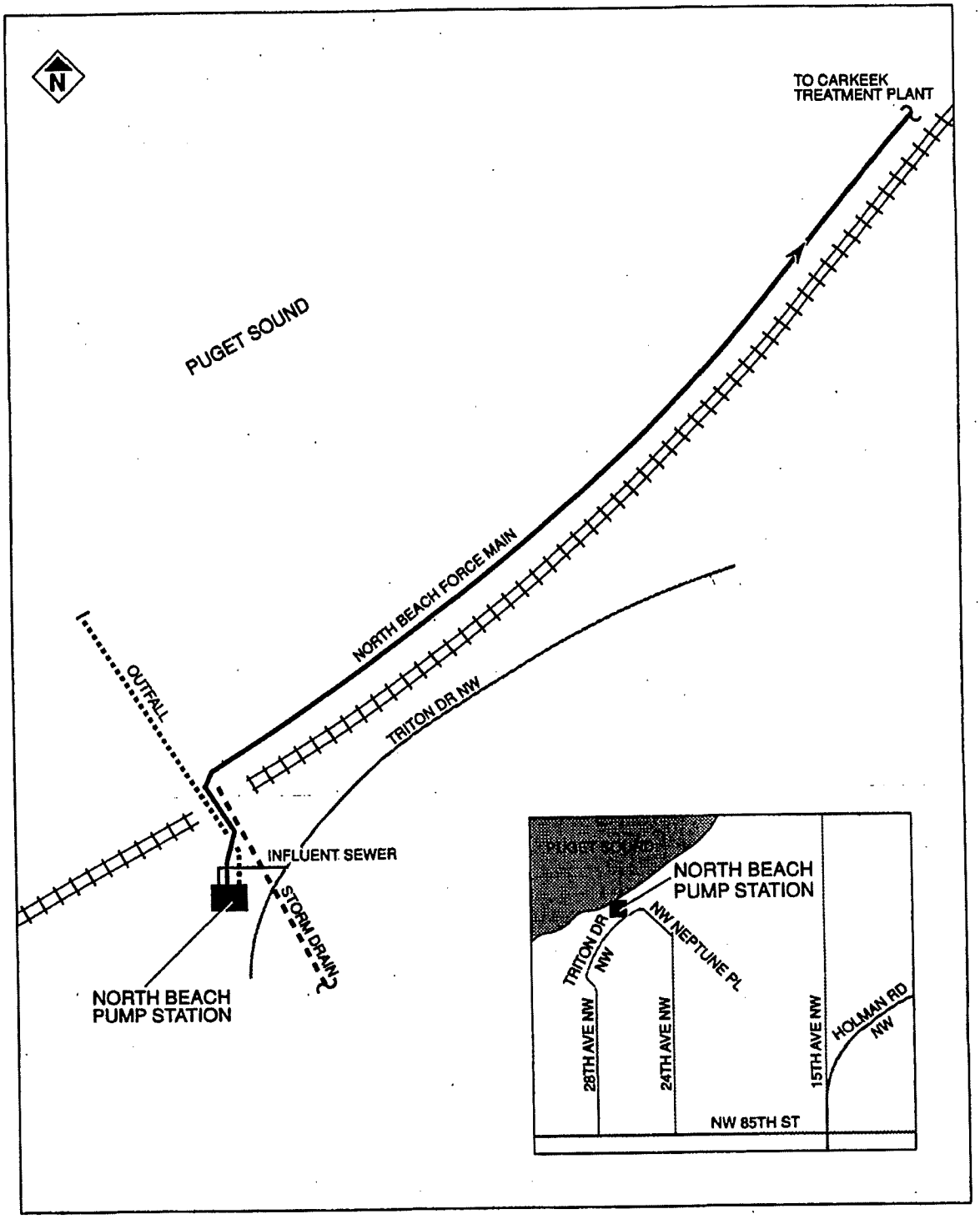


FIGURE 1. LOCATOR MAP

However, because the station is adjacent to a private bathing beach, Metro decided to conduct a predesign study to investigate interim or phased measures that could reduce the frequency of overflows in the short term, while delaying some costs.

After the Brown and Caldwell study, two flowmeters were installed at the North Beach station. Overflow volumes measured in 1989 and 1990 were substantially lower than the predicted volumes in the 1988 facility plan, and Metro decided to validate the inflow and overflow data as part of the predesign. In addition, Metro decided to install a flowmeter in the North Beach force main to allow for more accurate pump testing.

The predesign study, which was conducted by Metro's Engineering Services Division (ESD), had the following goals:

- Update Brown and Caldwell's estimates of existing overflows, existing station capacity, and system hydraulics, using recently acquired field data.
- Develop and evaluate potential facility improvements to reduce the frequency of overflows to one per year, based on the updated information.
- Investigate potential phasing of the recommended improvements and explore interim measures to substantially reduce the frequency and volume of overflows in the near term.
- Recommend a course of action.

This predesign report summarizes the results of Metro's monitoring, testing, and hydraulic analyses of the system; presents alternatives for phased facility improvements; and presents a recommended course of action.

A variety of potential interim and supplemental measures were also evaluated as part of the predesign study but were not recommended for implementation. A discussion of each of these measures has been included in the predesign report for reference.

The schedule for implementing the recommended improvements and reducing the North Beach overflows to one per year will be determined as part of future CSO program planning.

SECTION 2 -- EXISTING SYSTEM

This section describes the North Beach Pump Station system, including the site, service area, pipelines, and equipment.

SITE AND SERVICE AREA

Figure 2 shows a plan view of the North Beach Pump Station site. Figure 3 shows a section view of the station structure. The station is below ground, with access hatches and ventilation equipment located above ground. The walls and foundation of the structure were constructed as part of the original treatment plant on the site. The western half of the building houses a wet well with influent grit channels. The eastern half of the building houses a dry well pump room on the lower level and a motor room on the upper level. Most electrical and ancilliary equipment is located in the motor room.

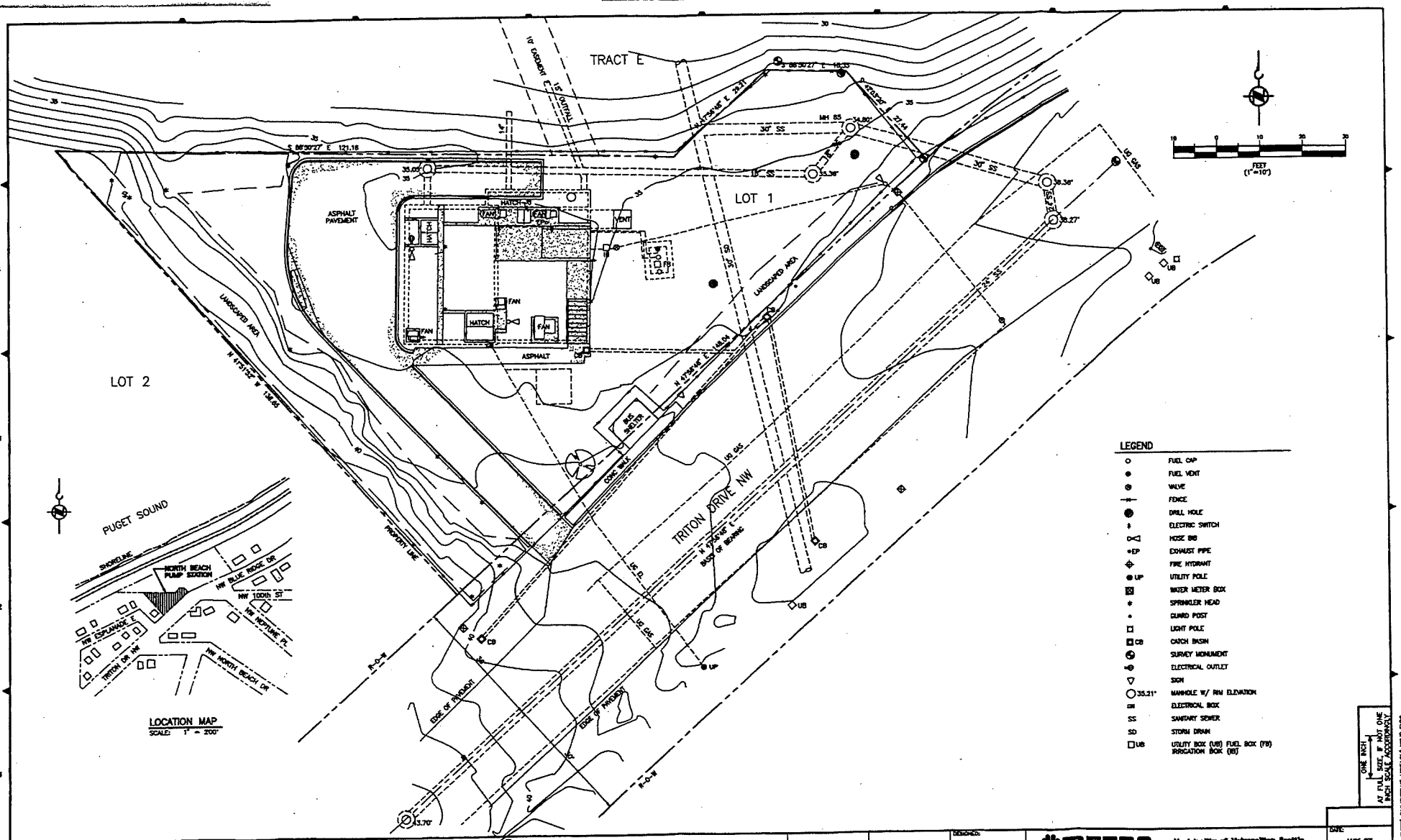
The station is located on a designated scenic view drive through a residential neighborhood. One single-family home is adjacent to the station site, on the southwest side. A private park for neighborhood recreational use is located on the station's north side. A street runs along the station's southeast side. Single-family homes located across the street have a view of Puget Sound over the pump station. The landscaping on the station site is well maintained to minimize any obstruction of views.

The topography of the area generally slopes to the northwest downward to Puget Sound. The high areas are east and south of the pump station. The area has been subjected to several continental glaciations. The major geological deposits in the area are Vashon till, Esperance sand, and Lawton silt.

The service area for the North Beach Pump Station is approximately 650 acres. The collection system tributary to the station is a separated system, operated and maintained by the City of Seattle. Pipe sizes in the tributary system range from 8 to 30 inches in diameter. Metro is responsible for operating and maintaining the pump station and force main only.

INFLUENT PIPING AND OVERFLOW LOCATIONS

The influent sewer to the station, which is shown in Figure 2, consists of 47 feet of 30-inch-diameter pipe and 103 feet of 18-inch-diameter pipe.



No.	REVISION	BY	APP'D	DATE

DESIGNED:
DRAWN: DJB CHECKED:
RECOMMENDED:
APPROVED:

METRO Municipality of Metropolitan Seattle

SCALE: NOTED
CONTRACT NO:

NORTH BEACH PUMP STATION
CSO CONTROL

EXISTING SITE PLAN
FIGURE 2

DATE: MAY 93
FILE NO: W03
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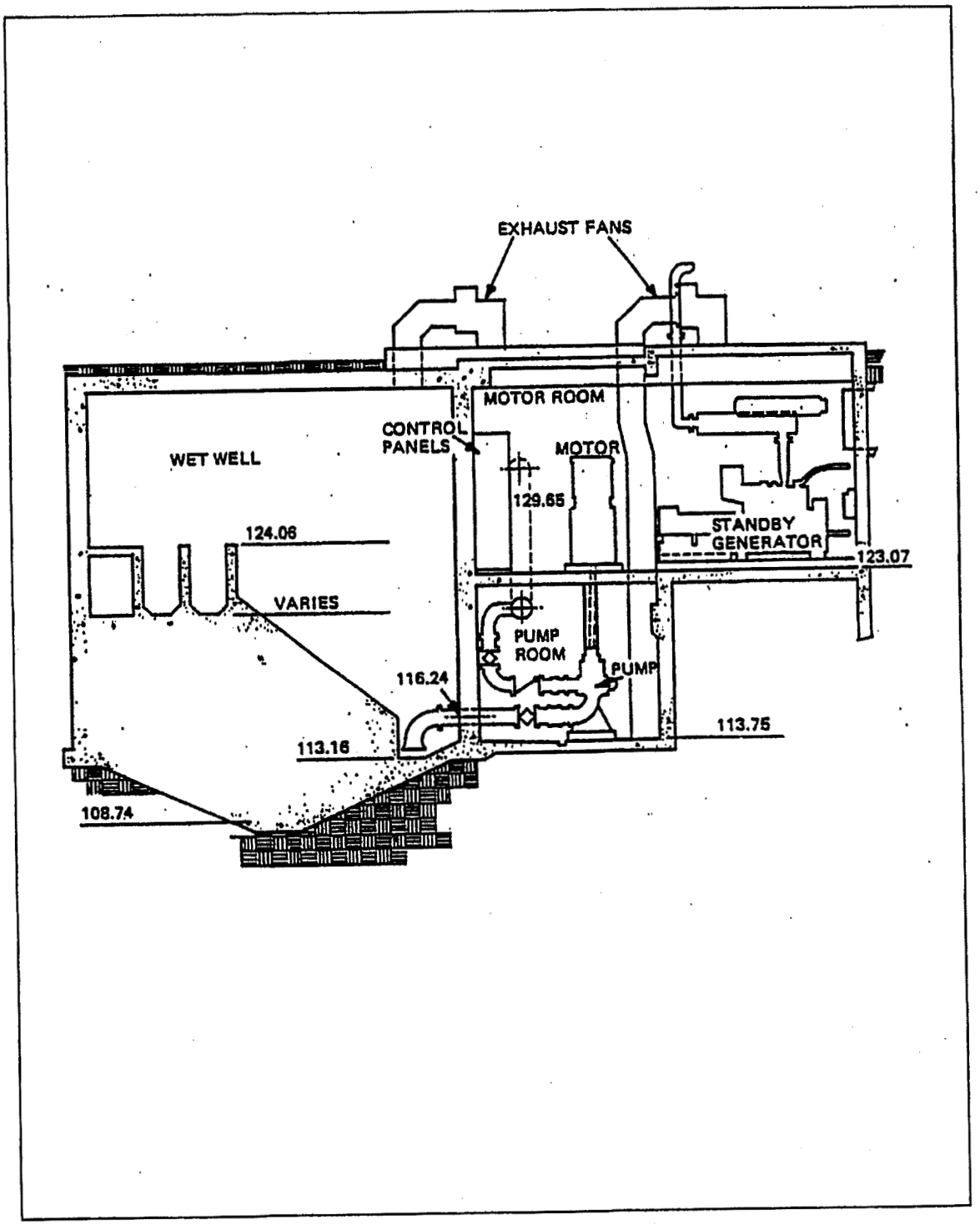


FIGURE 3. STATION CROSS SECTION

There are two overflow locations on the site. The pump station wet well has an overflow weir set at elevation 122.83. A 15-inch-diameter pipe carries these overflows to a 16-inch-diameter outfall, which discharges into Puget Sound at a distance of 900 feet from the shoreline bulkhead. This outfall, which is a remnant of the original treatment plant on the site, was repaired and upgraded in the 1970s.

Manhole (MH) No. 65, in the northeast corner of the site, has an overflow weir set at elevation 124.92. Overflows at this point pass through a 30-inch-diameter storm drain to the Puget Sound shoreline.

FORCE MAIN

The North Beach Pump Station pumps raw sewage to the Carkeek Treatment Plant through a 14-inch-diameter, 7,490-foot-long force main. The force main alignment runs parallel to the Burlington Northern Railroad tracks for approximately 4,700 feet within the tidal zone of Puget Sound.

In 1989, as part of the Carkeek Transfer/CSO Facilities Project, Specialty Consultants Group excavated and evaluated the condition of the force main at three locations (*North Beach Force Main Inspection Report*, Specialty Consultants Group, Inc., May 1989). The consultants determined that the force main was in good condition. This determination was based on the examination of three coupons removed from the pipe. Two of the coupons did not show significant pitting or corrosion. The third coupon did show deep pitting. The consultant estimated a "worst case" corrosion rate, based on the deep pitting in the third coupon. If this corrosion rate were to continue, the remaining pipe wall of the force main would be penetrated at the pit location in 32 years. If graphitization slowed the corrosion rate, as typically happens, the time-to-failure at the pit would be considerably greater than 32 years.

The force main was constructed in 1962. The specifications for the force main contract called for bituminous-coated, cement-mortar-lined cast iron pipe. The 1989 evaluation found that the cast iron pipe was coated internally with cement mortar but did not have any exterior coating.

Most of the force main (7,094 feet) was installed under the force main contract. The portions of the force main within the boundaries of the North Beach Pump Station site and the Carkeek Treatment Plant site were constructed separately, under the contracts for those two facilities. The discharge structure on the Carkeek site is currently being relocated as part of the Carkeek Transfer/CSO Facilities Project. About

70 feet of existing pipe is being removed and replaced with 165 feet of new force main.

GRAVITY LINE CONNECTIONS

Two active City of Seattle gravity sewers connect directly to the North Beach force main within Carkeek Park. These pipelines are shown in Figures 4 and 5.

One of the active gravity lines, which is shown in Figure 4 and is referred to as the "NW 117th Street line," connects to the force main about 650 feet west of the Carkeek Treatment Plant site. The tee from this 8-inch-diameter line to the force main is enclosed in a manhole structure (City MH No. 156). This line was constructed in 1964 and currently serves 28 houses.

The other active line, which is shown in Figure 5 and is referred to as the "Woodbine Way line," connects to the North Beach force main with an underground tee about 1,700 feet west of the plant site. The basin served by this 12-inch-diameter line was sewered in 1930. The force main connection was constructed in 1968.

Another City gravity sewer connects to the North Beach force main along the shoreline, 3,850 feet downstream of the North Beach Pump Station. This 10-inch-diameter line, which is shown in Figure 5, dates to 1930. Much of its service area was rerouted to the Woodbine Way line in 1968, but three houses remained connected until 1989. Flow from these houses was rerouted in 1989 and the line was abandoned, but the tee from this line to Metro's force main was not plugged.

In the original (1930) system, raw sewage from the Woodbine Way line's service area flowed westward and was discharged to Puget Sound via two outfalls. By connecting to Metro's force main, the City was able to route these flows eastward to Metro's Carkeek plant. The force main slopes upward toward the plant, and the flow from the City's lines is carried uphill to the plant by the pumped sewage from the North Beach station.

City of Seattle staff reported that prior to 1986, the Woodbine Way line experienced overflows at MH No. 002, uphill from the tee. The City had difficulty keeping the manhole sealed, because of the upward pressure on the lid. In 1986, the City completed a stormwater separation project in the Woodbine Way basin. No problems have been reported since then.

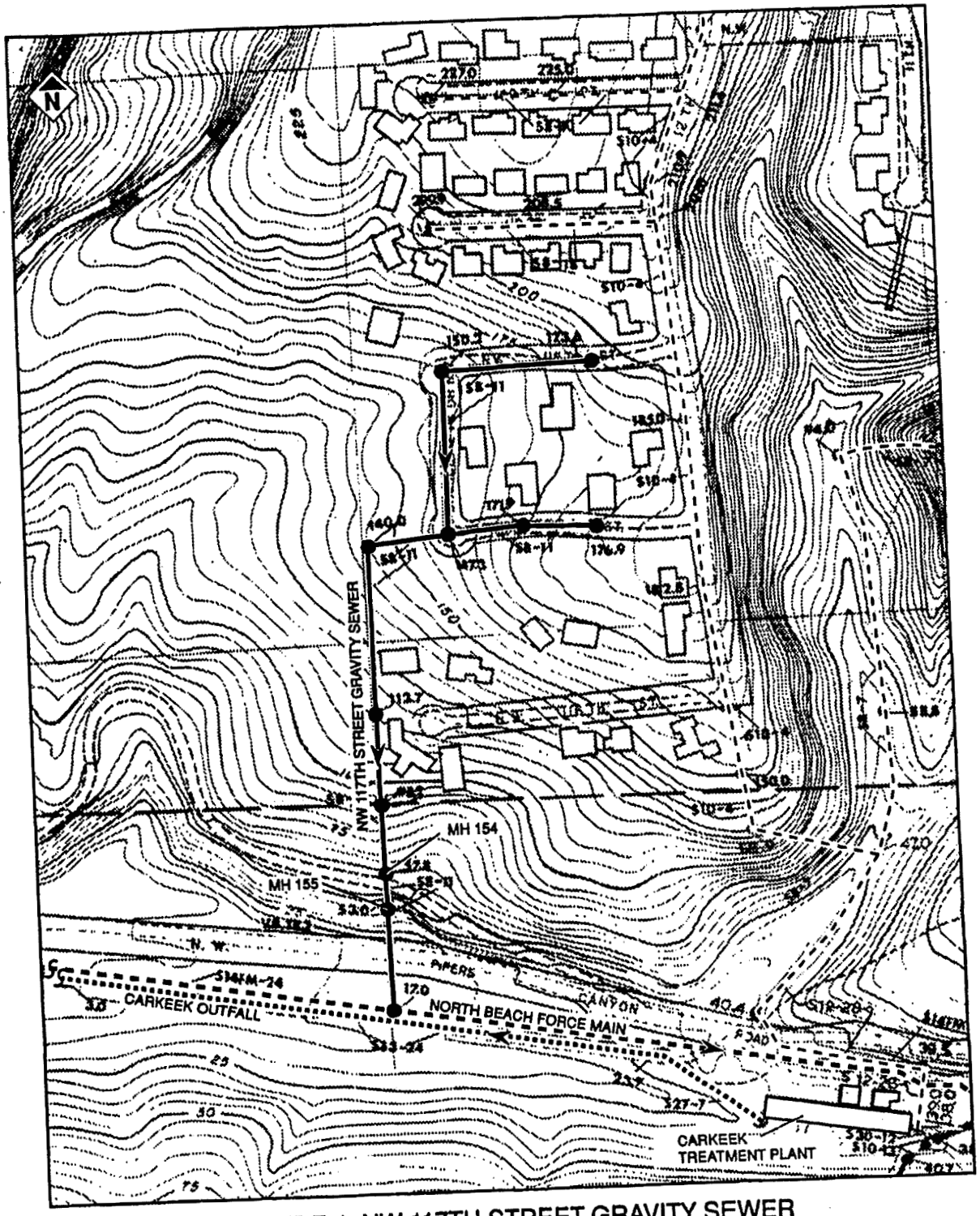


FIGURE 4. NW 117TH STREET GRAVITY SEWER

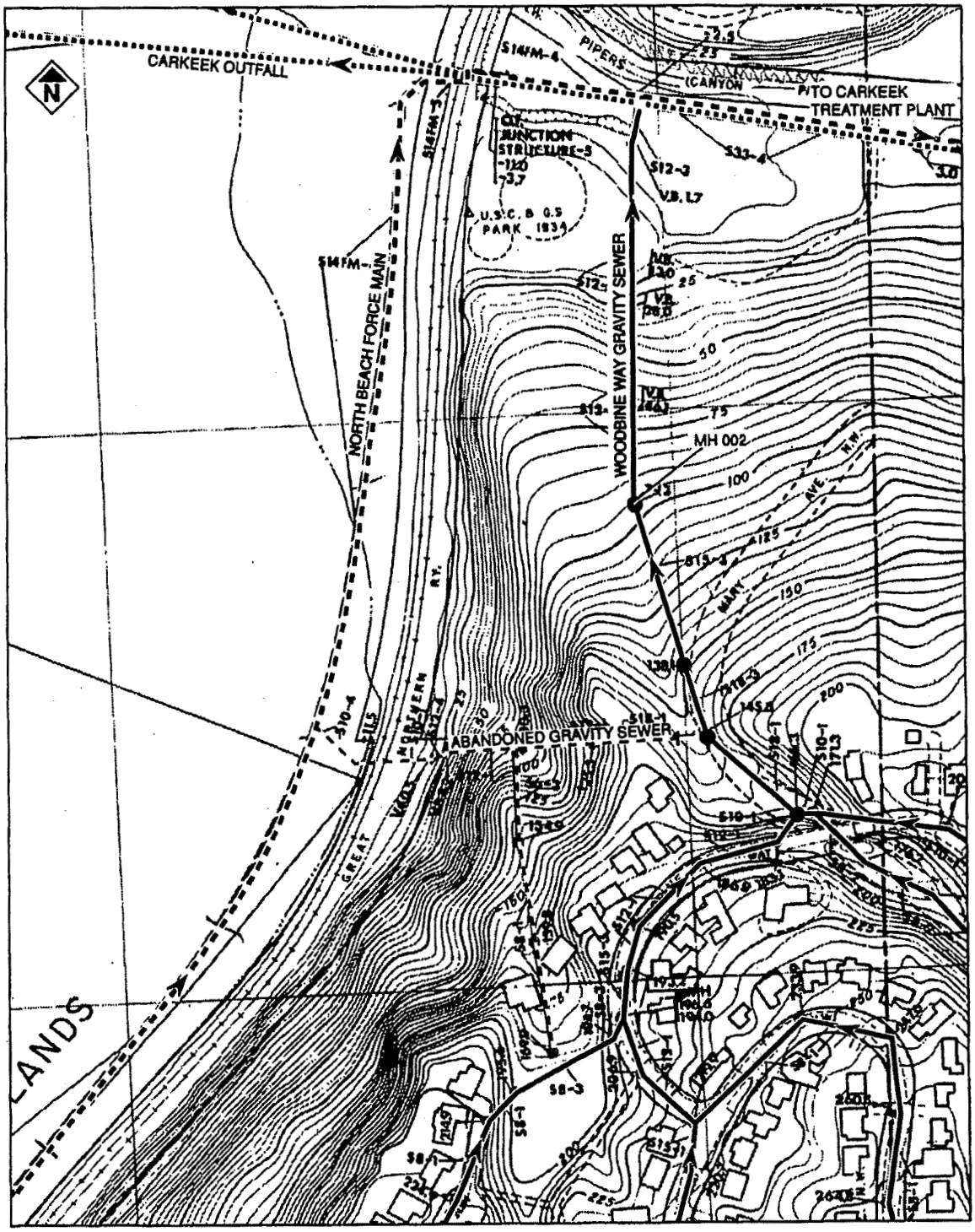


FIGURE 5. WOODBINE WAY GRAVITY SEWER

City staff also reported overflows in the 1970s at two manholes uphill from the tee on the NW 117th Street line. According to City staff, these manholes (No. 155 and 154) were sealed for some time after the overflows. The manholes are no longer sealed, however, and no problems have been reported recently.

In the 1988 facility plan, Brown and Caldwell noted that the flows from the Woodbine Way line could have a significant impact on North Beach system hydraulics, reducing the output of the North Beach Pump Station during periods of peak flow. (The flow from the NW 117th Street line was considered insignificant.)

PUMP STATION MECHANICAL EQUIPMENT

Raw Sewage Pumps

There are four raw sewage pumps at the station, all are the vertical non-clog type. Pumps 1 and 2 are larger than Pumps 3 and 4. The four pump motors are mounted on the floor above the pumps and drive the pumps via open propeller shafts with lubricatable universal joints. The motors for Pumps 1 and 2 are directly connected to Electric Machinery eddy-current clutches that provide variable speed drive capability. The motors for Pumps 3 and 4 are constant speed without eddy-current clutches. Table 1 gives the nameplate data for each pump.

Interviews with maintenance personnel indicate that the pumps are typically overhauled every 3 to 4 years, and the motors and clutches are overhauled every 6 to 8 years. Pumps 1 and 2 were last overhauled in December 1991.

Ventilation

The pump station wet and dry wells are ventilated using above-ground supply and exhaust fans. These fans operate continuously. Both the supply and exhaust fans were installed during the conversion from a treatment plant to a pump station in 1962. The fan assemblies are corroded from exposure to weather and salty ambient air. These units, therefore, may require replacement within the next 5 years.

The wet well supply fan and the wet well exhaust fan have a rated capacity of 3,760 cfm at 0 inches of water guage static pressure. Assuming that 3,760 cfm is the actual volume flow rate being produced by the fans, the continuous air change rate is approximately 28 per hour. This air change rate appears adequate, because corrosion and odor in the wet well are minimal.

Table 1
Pumping Equipment Nameplate Data

Pumps 1 and 2

Pump	
Manufacturer	Worthington
Model	8FLV16
Rated Capacity	2,450 gpm
TDH @ Rated Capacity	86 feet
Speed	1,145 rpm
Impeller Diameter	16 inches
Suction Size	10-inch
Discharge Size	8-inch
Motor	
Manufacturer	Electric Machinery
Frame Size	C445UP
Rating	75 hp
Speed	1,180 rpm
Electric Clutch	
Manufacturer	Electric Machinery
Model	MDM-18
Rating	75 hp
Speed	1,130 rpm

Pumps 3 and 4

Pump	
Manufacturer	Worthington
Model	5FLV16
Rated Capacity	900 gpm
TDH @ Rated Capacity	50 feet
Speed	1,170 rpm
Impeller Diameter	12-3/4 inches
Suction Size	8-inch
Discharge Size	6-inch
Motor	
Manufacturer	Electric Machinery
Frame Size	326UP
Rating	20 hp
Speed	1,160 rpm

The dry well supply fan has a rated capacity of 2,000 cfm at 1/8 inch of water gauge static pressure. The dry well exhaust fan has a 2,000-cfm volume flow rate capacity at 1/4 inch of water gauge static pressure. Assuming that 2,000 cfm is the actual volume flow rate being produced by the fans, the continuous air change rate is approximately 9 per hour. This air change rate appears adequate, because the condition, odor dilution, and heat dissipation in the dry well are good.

Ancillary Mechanical Equipment

Standby generator. An engine-generator set was installed in 1985 to provide standby power. It is in good condition. Modifications were made to the building to accommodate the additional ventilation needed during engine operation.

Instrument air system. The original instrument air system provides compressed air for instrumentation operation. The compressor is a 3/4-inch Bell and Gossett oil-less compressor. The system has adequate capacity and is in reasonably good condition, but is aging and will probably need replacement in a few years.

Sump pump. The original sump pump is still in use, although it has been rebuilt and repaired on occasion. It operates well but will also need replacement in the near future.

Seal water system. The seal water pumps are the original equipment, but have been overhauled and still function well. The C2 air break tank, however, is badly corroded and should be replaced in the very near future. The corrosion has created problems getting an adequate supply of seal water to the raw sewage pumps.

Access hatch. The access hatch located above the engine-generator set leaks water when it is raining, creating dangerous wet areas on the pump room floor.

Hoist. The existing monorail hoist and rail are difficult to use because they are poorly arranged. The equipment is in good condition, but the arrangement is undesirable.

CONTROL SYSTEM

The raw sewage pump control system is a semi-redundant type. Speed and start signals are derived from a bubbler in the wet well. The bubbler measures wet well level and provides level data to the Foxboro controller. Pumps may be started normally by the Texas Instruments PM550 programmable logic controller (PLC) or by the Foxboro controller. Speed references for the clutch drives are derived exclusively from the Foxboro level loop.

The pump station has two variable-speed 75-hp pumps and two fixed-speed 20-hp pumps. The 20-hp pumps alternate so that only one of them is operating at any given time. At no time does a 20-hp pump operate at the same time as a 75-hp pump.

The pumps operate in the following manner under low-flow conditions: One 20-hp pump starts when the wet well level rises to elevation 119.26. If the wet well level remains below 119.76, the 20-hp pump continues to operate until the wet well level drops to elevation 116.76.

The pumps operate in the following manner under high-flow conditions: One 20-hp pump starts at elevation 119.26. At elevation 119.76, the lead 75-hp pump starts and the 20-hp pump shuts down. If the wet well level rises to elevation 120.76, the follow 75-hp pump starts and both 75-hp pumps continue to operate until the wet well level drops to elevation 120.76 again.

As the the wet well level drops, the follow 75-hp pump shuts down at elevation 120.76, while the lead 75-hp pump continues to pump down to elevation 117.76.

ELECTRICAL POWER

Existing Service

Seattle City Light provides electrical power to the North Beach Pump Station. The service is 480Y/277 VAC, 3 phase, 400 amps. The power cable consists of three 500-kcmil wires. The ampacity of this cable is 430 amps (THHW, Cu -- based on table 310-16, 90°C column). The Seattle City Light transformer that serves the pump station has a power capacity of 500 kW.

The incoming motor control center (MCC) main breaker is 400 amps. The main panel supplies 332.4 kW at 480 VAC. The 480 VAC feeds the existing MCC bus system, which is rated at 600 amps. The station has three subpanels: Panel A (120 VAC), Panel PPM (480 VAC), and Panel PPC (120/208 VAC).

The standby generator system has a capacity of 250 kW continuous (300 amps), or 300 kW standby (361 amps).

Table 2 lists electrical service to various pump station equipment.

Raw Sewage Pump Wiring and Capacities

As shown in Table 2, the full load amperage of existing Pumps 1 and 2 is 88.5 amps each (111 amps at 125 percent). The full load amperage of existing Pumps 3 and 4 is 26.4 amps each (33 amps at 125 percent).

The breakers for Pumps 1 and 2 are 150 amps, 3 pole. The breakers for Pumps 3 and 4 are 50 amps, 3 pole.

The wiring to Pumps 1 and 2 is 4-1/0 in a 2-inch conduit. The rated ampacity of 1/0 copper wire is 125 amps (NEC Table 310-16, 60°C column). The age of the existing equipment would indicate that the lugs on the existing equipment are rated for only 60°C. This cable could handle a motor that used 100 amps. The existing 75-hp pump motor is the largest motor that could be used, per the requirements of the 1993 NEC and Table 430-150.

The wiring to Pumps 3 and 4 is 4-8 in a 1-1/4-inch conduit. The ampacity of No. 8 wire is 40 amps (NEC Table 310-16, 60°C column). The age of the existing equipment would indicate that the lugs on the existing equipment are rated for only 60°C. This wiring could handle a motor rated at 32 amps. The existing 20-hp motor is rated for 27 amps; therefore, 20 hp is the largest motor that could be used with the existing conductors.

Available Capacity for Future Use

With a current worst-case load requirement of 243.63 kW, the station uses about 73 percent of available power (or 80 percent of available kVA). This leaves 88.77 kW available for future use.

Approximately 62 hp would be available for a new raw sewage pump and motor, assuming that a fully loaded electrical system were allowable. However, the entire power available cannot be added to one pump/motor location because the existing wiring and breakers cannot accommodate an increase in pump motor size.

Moreover, the existing pump station is cramped for space. A field inspection revealed no space in which to mount any additional equipment.

According to the Square D Company, the existing MCC is outdated, parts for it are no longer manufactured, and the

current generation of MCC inserts do not fit into the existing type of MCC.

Panel PPM has three 100-amp spaces. Panel PPC has two 20-amp and two 15-amp spare breakers and 12 spaces. Panel A has no spares or spaces available.

Table 2
Existing Electrical Systems for Pump Station Equipment

Item	Circuit Breaker (amps)*	Wiring	hp	Current (amps)
Sewage Pump 1	150	4-1/0	75	88.5
Sewage Pump 2	150	4-1/0	75	88.5
Sewage Pump 3	50	4-8	20	26.4
Sewage Pump 4	50	4-8	20	26.4
Inst. Air 1	15	4-12	0.75	1.7
Inst. Air 2	15	4-12	0.75	1.7
Seal Water 1	15	4-12	1	3.6
Seal Water 2	15	4-12	1	3.6
Sump Pump	15	4-12	0.75	1.7
Flush Pump	15	4-12	1	3.6
HVAC Supply	15	4-12	5	--
HVAC EF-1	15	4-12	0.75	--
HVAC EF-2	15	4-12	3	--
Hoist Motor	--	--	--	--
Heaters	30	--	15 kW	18.1

* 3 pole

SECTION 3 -- INVESTIGATION OF SYSTEM HYDRAULICS

Metro staff conducted pump testing to determine the actual operating capacity of the North Beach Pump Station and the system head curve for the force main. Metro staff also studied the hydraulics of the City's gravity sewers in Carkeek Park. This section describes these investigations and discusses the implications of each with regard to upgrading the pump station.

STATION DESIGN CAPACITY

Each 75-hp pump was designed to provide 2,450 gpm (3.53 mgd) at a total dynamic head (TDH) of 86 feet when operating alone at rated speed (1,145 rpm). Each pump was to provide 1,450 gpm (2.09 mgd) at a TDH of 96 feet when operating in parallel with the other pump at rated speed. The design capacity of the station was therefore 4.2 mgd.

BROWN AND CALDWELL PUMP TESTING (1988)

Brown and Caldwell performed pump capacity tests at the station as part of the Carkeek Transfer/CSO Facilities Project. A first test was done in August 1988. A sonic flowmeter was clamped on the 14-inch discharge header inside the station, and pressure gauges were connected to taps in the header pipes. These flow and pressure data were not used because the flowmeter was installed relatively close to the pumps and the pressure gauges appeared to have clogged.

A second test was performed in September 1988. The time required for the wet well to empty and fill was noted and used to estimate flow. The test indicated that Pumps 1 and 2 have peak capacities of 2.81 mgd and 3.24 mgd, respectively. The two pumps produced 3.46 mgd when operating in parallel at maximum speed.

The rpm meters for the pumps indicated about 1,050 rpm at maximum speed during the pump test. Brown and Caldwell suggested that the eddy-current clutches might be limiting the speed of the pumps. They also suggested that Pump 1 might have lower output because of its condition. They estimated the system head curve graphically, using the flow data for Pump 2 and the manufacturer's pump curves at 1,050 rpm. They computed a maximum potential station capacity of 3.7 mgd, assuming that Pump 1 could operate like Pump 2.

METRO PUMP TESTING (1991)

Metro conducted additional pump tests to confirm the station capacity using better flow measurement and to provide a system head curve based on force main pressure and flow measurements.

Metro installed a flowmeter in the North Beach force main in 1990. The meter is a Marsh-McBirney probe-type Magmeter and is located in a vault near the Carkeek Treatment Plant. A strip chart recorder was installed at the plant to record flowmeter output. The flow measured at this location represents the total of North Beach Pump Station discharge and inflow from the City's gravity sewer lines that are connected to the force main.

The flowmeter was calibrated by the factory for the 14-inch-diameter force main. The manufacturer's representative and a Metro employee also checked the meter after installation, using a portable Marsh-McBirney Model 260 flowmeter.

Table 3 shows the results of a pump test conducted on April 2, 1991. The raw sewage pumps were run individually and together to gather data at different flows and pressure head conditions. The flow in the force main was measured with the flowmeter. The force main discharge pressure was indicated by a pressure gauge located on the discharge header at the pump station. The wet well level and pump speed were also recorded.

During the test, flows were recorded at City MH No. 003 in the Woodbine Way gravity line to determine whether that flow had any effect on the test data. The gravity line flow averaged only 100 gpm (0.14 mgd) during the test. Therefore, the test results represent station performance when the gravity lines are not affecting system hydraulics.

The rpm meters for the 75-hp pumps showed maximum readings of 920 to 950 rpm during the test. In March 1992, a Metro technician checked the maximum rpm of these pumps with different equipment and found it was approximately 1,100 rpm. At that time, the rpm meters on the pumps indicated about 900 rpm. The rpm meters were therefore determined to be incorrect.

Table 3
Metro Pump Test Data
April 2, 1991

Time, a.m.	Pump Number	Wet Well Elevation (ft)	Discharge Gauge (psi)	Flowmeter Flow (gpm)	Pump Speed (%)
10:33	3	120.7	16	944	100
10:40	3&4	120.7	20	1,200	100
11:00	1	120.7	13.6	720	60
11:06	1	120.7	35	2,040	100
11:17	1&2	120.8	41	2,360	100

*Discharge gauge reading at zero flow = 8.9 psi; gauge elevation = 128.

Station Capacity

The maximum capacity of Pump 1 was found to be 2.9 mgd. The maximum capacity of the station with the two 75-hp pumps operating together was 3.4 mgd. This station capacity was used in Metro's hydrologic modeling study, which is discussed in Section 4.

System Head Curve

The April 1991 test data were used to determine the system head curve for the existing force main. This was accomplished by recording discharge gauge pressures corresponding to various station flows.

The April 1991 pressure measurements at 100 percent pump speed closely replicated several earlier Metro tests. The flow data from the earlier Metro tests could not be used, however, due to a flowmeter calibration error.

System head data are shown in Table 4. The data represent the pressure in the discharge header pipe inside the station (at elevation 121) and indicate how much friction loss occurs in the force main downstream of that point. Theoretical system head curves for the existing force main at various Hazen-Williams friction ("C") factors were computed and compared to the measured system head curve. The existing force main has an effective "C" factor of 105.

ANALYSIS OF METRO TEST RESULTS

The two 75-hp pumps in the station were designed to pump a total of 4.2 mgd at 96 feet of TDH. This equates to a design "C" factor (friction factor) higher than 140 in the 13.5-inch-inside-diameter force main. The original designers apparently assumed that a "C" factor above 140 could be maintained in the pipe long-term. Metro's pump tests, however, indicated that the actual "C" factor is now 105. Under these conditions, a flow of 4.2 mgd would create a TDH higher than 150 feet.

Effects of Upgrading the Station Without Modifying the Force Main

If Metro were to upgrade the pump station to its original capacity of 4.2 mgd while making no changes to the existing force main, these increased friction losses would have several ramifications. First, the force main would be subjected to higher working pressures than were assumed during design. Second, higher horsepower motors and an upgraded electrical system would be required. The pump

Table 4
System Head Curve for the Force Main
Based on April 2, 1991, Pump Test Data

Flow (gpm)	Flow (mgd)	Discharge Gauge (psi)	System Head (ft)*
720	1.0	13.6	38
944	1.4	16	44
1,200	1.7	20	53
2,040	2.9	35	88
2,360	3.4	41	102

*System head datum = elevation 121; static head = 26.5 ft.

station structure would need to be modified to house new electrical equipment.

The 1988 facility plan assumed that the upgraded station would pump 5.0 mgd at 130 feet of TDH. Based on Metro's pump tests, however, a flow of 5.0 mgd in the existing force main would create a TDH of 205 feet. If the station were pumping 5.0 mgd and the Woodbine Way gravity line were experiencing its one-year peak flow, the TDH would be 215 feet. (The gravity lines would have to be sealed and pressurized to allow such heads to develop.)

INVESTIGATION OF PUMP REPAIR CONCEPT

A key concept that ESD was asked to investigate during predesign was whether the desired pump station upgrade could be achieved through equipment modifications alone, without modifying the structure or the force main. For example, if Metro had found that the 75-hp pumps were in poor condition or operating at reduced speeds as Brown and Caldwell had suggested, then Metro might have been able to increase the station's capacity through equipment repair or replacement.

After the 1988 study, Metro Operations staff had the 75-hp pumps overhauled and checked. The impellers were checked for cavitation, and no serious problem was found.

Moreover, after testing the pumps and checking the rpm meters, Metro concluded that the pumps are operating at approximately full speed. A comparison of Metro's new pump test data and the original pump curves indicates that the pumps are functioning similarly to when they were installed but are operating against a system head curve quite different from the design system head curve.

DOWNSTREAM EFFECTS OF A STATION UPGRADE

If Metro were to upgrade the North Beach station, the increased flows and pressures would affect the two City of Seattle gravity sewer lines that discharge directly to the force main in Carkeek Park. The liquid level in each of these pipelines rises when the force main flows under pressure. Each line was designed to handle backups to a certain elevation. The lower portion of each City line is made of cast iron pressure pipe and slopes steeply uphill away from the force main.

The City has reported no recent overflow problems in the gravity lines. Friction losses in Metro's force main are higher now than they were when the gravity lines were constructed, but the North Beach station sends less flow to

the force main than it did at that time. The liquid levels in the gravity lines have not been measured. Based on a theoretical analysis, the estimated one-year flow from the Woodbine Way line and the peak flow that the existing North Beach pumps would produce under current conditions could be carried by the existing force main without causing overflows at the City's manholes.

Based on the same theoretical analysis, however, if Metro increased the flow from the North Beach station without disconnecting the City lines or altering the force main downstream of those lines, overflows would begin to occur at MH No. 154 and 155 on the NW 117th Street line during large storms.

CONCLUSION

The North Beach station should not be upgraded until Metro determines the flows in the City gravity lines and modifies Metro or City pipelines in Carkeek Park so that the system can accommodate the increased flows. *Equipment modifications at the North Beach station will not provide the advantages of quick implementation or low impact that were envisioned by the Water Pollution Control Department (WPCD) at the beginning of ESD's predesign.*

Brown and Caldwell recommended, based on a brief analysis of the issue, that flows from the City lines be rerouted. In addition, Metro's pump tests revealed that friction losses in the force main are higher than was assumed in 1988. Because force main friction loss and the presence of the attached City lines both limit Metro's ability to upgrade the North Beach Pump Station, ESD concluded that the analysis of North Beach system improvements should include a more thorough analysis of force main and gravity line modifications (see Section 5).

SECTION 4 -- HYDROLOGIC MODELING

Metro used recent flow data to calibrate a hydrologic model of the North Beach basin. The model was used to estimate existing flows and overflows at the North Beach station and to analyze the sizing and effectiveness of potential facility improvements.

BROWN AND CALDWELL MODELING STUDIES (1988)

Brown and Caldwell developed a flow simulation model for the North Beach system as part of the 1988 Carkeek facility planning. In its chapter on existing facilities, the report stated that with a station capacity of 3.7 to 3.8 mgd, there would be 25 overflows per year with a total annual discharge volume of 12.5 MG. This estimate became established as the existing frequency and volume of overflows at the pump station.

However, in a more detailed chapter on flows and waste loadings, the 1988 report stated that with a station capacity of 3.8 mgd there would be 18 overflows per year with a total annual volume of 4.6 MG. Brown and Caldwell staff have since indicated that the 18-overflow-per-year estimate is more accurate.

METRO'S HYDROLOGIC MODELING ANALYSIS (1992)

Metro has been using Marsh-McBirney Model 260 flowmeters to monitor overflows at two locations at the North Beach Pump Station. One location is in the 18-inch-diameter influent pipe entering the wet well. This monitor, which was installed in March 1989, is used to monitor influent flows as well as wet well overflows. The overflow elevation at the wet well is 122.83. The other location is in the 18-inch-diameter influent sewer exiting MH No. 65. This monitor, which was installed in October 1988, is used to measure overflows only. The overflow elevation at this location is 124.92.

Metro's Information Systems Division developed a hydrologic model of the North Beach system and calibrated the model using influent flow data from March 1989 to July 1992. They used the calibrated model and 13 years of rainfall data (1978 to 1990) to generate 13 years of simulated flow data. The data were used to perform the following tasks:

- Estimate the current number of overflows per year and the total overflow volume per year at the North Beach Pump Station.

- Estimate peak flows entering the station.
- Estimate peak flows entering the North Beach force main from the Woodbine Way gravity sewer line in Carkeek Park.
- Determine combinations of pump station capacity and storage volume that would reduce overflows at the station to one per year.
- Estimate the interim overflow reduction resulting from the first phase of two-phased facility improvements.

The one-per-year condition was determined using simulated flow frequencies rather than a one-year design storm, because the North Beach basin is a separated basin. This approach is consistent with the 1988 Carkeek facility plan.

A report detailing the hydrologic modeling analysis and results is included as Appendix A.

SUMMARY OF RESULTS OF METRO'S ANALYSIS

Existing Overflows

Based on 13 years of simulated flow data, the estimated frequency of overflows is 18 events per year. The estimated total volume of overflows is 1.9 MG per year.

North Beach Pump Station Influent Peak Flow

The peak flow recorded by the flowmeter between March 1989 and July 1992 was 6.2 mgd, during the large storm on January 9, 1990. Based on 13 years of simulated flow data, the 10-minute peak flow with a return period of one year at the North Beach Pump Station is 6.8 mgd.

The highest simulated peak generated from the 13 years of record averaged 13.9 mgd during the maximum 10 minutes and 7.9 mgd during the maximum hour. This peak was caused by a very high-intensity rainfall of 1.03 inches in one hour, after several days of lighter rain.

Woodbine Way Gravity Line Peak Flow

Flows entering the North Beach force main from the Woodbine Way gravity line were estimated by assuming that the basin served by this line has the same characteristics as an adjacent North Beach subbasin. The adjacent systems were constructed at the same time and have similar land uses. According to City staff, the Woodbine Way line experienced problems in the early 1980s from unexpectedly high inflow. A rehabilitation project to reduce inflow was successfully

completed in the Woodbine basin in 1986. No metering data since then are available to validate the peak flow estimates.

The 10-minute peak flow with a return period of one year is estimated to be 1.0 mgd.

Preliminary estimates of less frequent peaks were generated for use in the force main hydraulics analysis. The 10-year peak is estimated to be 1.7 mgd. The 25-year peak is estimated to be 2.4 mgd.

Facility Sizing

Overflows at the North Beach station could potentially be reduced by increasing the pumping capacity of the station, by adding storage at the station site, or by a combination of these two measures. The 1988 Carkeek facility plan recommended upgrading the station to 5.0 mgd and constructing 280,000 gallons of storage. Metro's hydrologic model was used to update these facility sizing calculations. First, the model was used to determine combinations of pump station capacity and storage volume that would reduce overflows at the station to one per year. Then the model was used to estimate the interim overflow reduction resulting from the first phase of two-phased facility improvements.

The sizing analysis studied potential design flows in the range of 3.4 mgd (existing) to 5.0 mgd. The maximum value of 5.0 mgd corresponds to a maximum allowable force main velocity of 8 feet per second (fps), as recommended in the 1988 report. In addition, the new Carkeek plant facilities were sized assuming the transfer of up to 5.0 mgd from North Beach.

The computations incorporated the rate for pumping out the storage basin after storms. This pumpout rate affects the emptying time, which, in turn, affects the available volume of storage for subsequent storms. The model approximated the storage pumpout rate as a constant flow rate. The model assumed that pumpout would not begin until the inflow to the pump station fell below the station capacity minus the storage pump flow rate.

The storage volumes required to reduce overflows to one per year for a 3.4, 4.0, 4.5, and 5.0 mgd station and the resulting average annual overflow volumes are listed in Table 5. The interim benefits of upgrading the pump station (while delaying the construction of storage) are shown in Table 6. The interim benefits of constructing storage (while delaying upgrade of the pump station) are shown in Table 7.

Table 5
Pump Station Capacity/Storage Relationships to Achieve One Overflow Per Year

Pump Station Capacity (mgd)	Storage Pumpout Rate* (mgd)	Storage Volume** Required (gal)	Remaining Overflow Volume/Yr (MG)
3.4 (existing)	0.36	474,000	0.39
	0.72	460,000	0.40
	1.08	466,000	0.39
	1.44	466,000	0.39
4.0	0.36	248,000	0.29
	0.72	252,000	0.28
	1.08	252,000	0.27
	1.44	252,000	0.28
4.5	0.36	142,000	0.19
	0.72	133,000	0.20
	1.08	128,000	0.20
	1.44	119,000	0.21
5.0	0.36	70,000	0.12
	0.72	67,000	0.13
	1.08	67,000	0.13
	1.44	67,000	0.13

* Constant flow rate was assumed for preliminary calculation.

** Preliminary values are based on constant pump-out rate

Table 6
Interim Overflow Frequency and Volume with Pump Station Upgrade and No Storage

Pump Station Capacity (mgd)	Number of Overflows/Yr	Overflow Volume/Yr (MG)
3.4 (existing)	18	1.91
4.0	12	0.96
4.5	8.5	0.51
5.0	5.0	0.27

Table 7
Interim Overflow Frequency and Volume with Storage and No Pump Station Upgrade
(Pump station capacity: 3.4 mgd)

Storage Volume Provided* (gal)	Storage Pumpout Rate** (mgd)	Number of Overflows Per Year	Overflow Volume/Yr (MG)
70,000	0.36	6.0	1.30
67,000	0.72	5.9	1.31
67,000	1.08	5.8	1.32
67,000	1.44	6.1	1.33
133,000	0.72	3.8	1.01
128,000	1.08	3.9	1.03
119,000	1.44	4.2	1.08
252,000	1.08	2.0	0.68
252,000	1.44	2.1	0.69

* Preliminary values are based on constant pump-out rate.

** Constant flow rate was assumed for preliminary calculation.

The estimated storage volume and overflow values for various combinations were then refined further to reflect approximate variations in pumpout rate. In these calculations, the model assumed that pumpout would not begin until the available capacity equalled the maximum pumpout rate. The refined results are shown in Tables 8 and 9.

The storage volume corresponding to a station capacity of 4.0 mgd was not refined further, because that combination was eliminated as an alternative before the second round of calculations (see Section 6).

Table 8
Station Capacity/Storage Combinations to Achieve One Overflow Per Year Incorporating Variations in Pumpout Rate

Station Capacity (mgd)	Avg/Max Pumpout Rate (mgd)	Storage Volume (gal)	Overflow Volume/Yr (MG)
4.5	1.2/1.7	140,000	0.21
5.0	0.9/1.3	75,000	0.14

Table 9
Interim Overflow Reduction With Storage and No Pump Station Upgrade Incorporating Variations in Pumpout Rate

Storage Volume (gal)	Avg/Max Pumpout Rate (mgd)	Overflow Events Per Year	Overflow Volume/Yr (MG)
140,000	1.2/1.7	4	1.0
75,000	0.9/1.3	6	1.3

SECTION 5 -- EVALUATION OF CARKEEK PARK PIPING ALTERNATIVES

Metro's pump testing and hydraulic analyses confirmed that the North Beach station should not be upgraded until the effects of the upgrade on force main headlosses and the City's gravity sewer lines is addressed (see Section 3). ESD investigated several approaches.

CONNECTING CITY GRAVITY LINES TO A NEW GRAVITY PRESSURE MAIN

The 1988 Carkeek facility plan included an estimated construction cost of $472,700 for "collection system improvements," which was the estimated cost of disconnecting the Woodbine Way and NW 117th Street lines.

ESD reviewed the design concept that formed the basis for this estimate. The concept was to connect the gravity lines to a new gravity pressure main that would run parallel to Metro's force main. The pressure main would slope uphill to the new Carkeek Pump Station. Liquid would back up in the gravity lines to push the flow uphill. An 8-inch-diameter pressure main was proposed, based on velocity criteria of 2 fps at the design average dry weather flow (ADWF) and 8 fps at the estimated one-year peak flow.

Metro compared the measured ADWF at the North Beach station to the ADWF assumed in the 1988 plan. The actual ADWF for the North Beach basin is only 50 percent of the ADWF assumed in the 1988 plan. Metro's estimated ADWF for the Woodbine basin is about 15 percent of the Woodbine ADWF that was assumed in the 1988 calculations.

ESD does not recommend this concept for several reasons:

- If the actual ADWF in the Woodbine basin is indeed less than that assumed in the 1988 calculation, the average velocity in an 8-inch-diameter pressure main would be less than 2 fps.

- Even if ADWF in the Woodbine basin were higher than Metro estimates, the minimum velocity on a summer day could still be extremely low and the maximum velocity on a summer day might not be enough to resuspend solids.

- An analysis of hydraulic grade lines indicates that at the estimated 10-year flow of 1.7 mgd, liquid would have to back up above the level of the existing manhole lids to pass through an 8-inch-diameter pipe. This concept would therefore have to include pressurization of both

gravity lines and construction of a new manhole on the NW 117th Street line to protect hilltop homes.

- Placing an 8-inch-diameter line downstream from a 12-inch-diameter line and a 10-inch-diameter line introduces some risk of blockage.

- It would be difficult to construct a pipeline parallel to the easternmost 350 feet of the force main.

- This method would have no effect on the high working pressures that would occur in the force main and pump station under regular conditions (when branch flows were low). This problem would still have to be addressed in some other way.

PRESSURIZING CITY LINES

The City's gravity lines were constructed of pressure pipe materials in their lower reaches and gravity pipe materials in their upper reaches. The pipes slope steeply uphill through the park, and the houses served by the lines are located along the hilltop. The City pipelines could be modified to accommodate higher liquid levels by replacing uphill portions of the lines with pressure pipe and installing pressure manholes. The sealed system would be installed to an elevation high enough to prevent overflows.

Replacement of these gravity pipelines is feasible from a construction standpoint. The Woodbine Way line is located under a dirt road. The pipe between MH 154 and MH 155 (on the NW 117th Street line), which is the lowest piece of gravity pipe in the system, is located underneath the park entrance road. The pipe above these manholes is underneath a hill covered with light trees and brush.

ESD computed hydraulic grade lines for various combinations of station capacity and gravity line flow. The existing lines could potentially be reconstructed to handle flow from a 4.5-mgd pump station. ESD does not recommend this approach, however, for the following reasons:

- The 10-year Woodbine Way line flow would cause pressures of 20 to 30 feet on the manhole lids.

- The 25-year Woodbine flow would cause the liquid level in the NW 117th Street line to rise near the level of households at the hilltop.

- Feasibility strongly depends on accurate estimates of gravity line flow.

- This method would have no effect on the high pressures in the North Beach station and force main. This problem would still have to be addressed in some other way.

OTHER MODIFICATIONS TO ACCOMODATE GRAVITY LINE FLOWS

ESD identified several other concepts for modifying the City's piping to reroute or reduce peak flows from the City's gravity lines. Identified concepts included building a small pump station within Carkeek Park; constructing new pipelines across the steep, tree-lined slopes in the park between the higher reaches of the gravity lines and the Carkeek plant; and constructing an underground storage tank in the park for storing peak flows in the Woodbine Way line. None of these concepts were investigated in detail, because they would most likely not be accepted by the City and the community.

REDUCING HEAD LOSS IN THE FORCE MAIN

Metro could reduce the liquid levels that occur in the City gravity lines by reducing head losses in the portion of the North Beach force main that is downstream from the City connections. ESD computed pipeline velocities and hydraulic grade lines for several potential methods of reducing head loss in the system.

The analysis assumed that the force main should be able to accommodate the flow from a 4.5-mgd station and 25-year flows from the Woodbine Way gravity line. In addition, the minimum force main velocity (the velocity with Pump 3 or 4 operating) should be at least 2.0 fps.

The City of Seattle requires storm drains and combined sewers to carry the 10-year flow without surcharging and the 25-year flow without overflowing. Three parallel criteria were assumed for this location: (1) no pressurization of manholes or non-pressure pipe at the 10-year flow, (2) no overflows at the 25-year flow, and (3) minimal pressurization at the 25-year flow to avoid replacement of existing pipe.

The analysis showed the following:

- Pigging the existing force main to produce a "C" factor of 120 would not meet the criteria (nor replicate the original system conditions).

- Replacing the portion of the force main that is downstream of the Woodbine Way tee using 24-inch-diameter ductile iron pipe would reduce head losses enough to meet the criteria but would result in a minimum force main velocity below 1.0 fps.

- Replacing a portion of force main using HDPE pipe with an inside diameter of 14.7 inches (a nominal "18-inch-diameter" HDPE pipe) would reduce head losses enough to meet the criteria while allowing a minimum velocity of 2.0 fps to be maintained. In this case, the length of force main replaced could be limited to 2,060 feet, the distance from the Woodbine Way tee to the new section of force main being installed in the Carkeek Transfer/CSO Facilities Project. This is the recommended alternative.

RECOMMENDATION -- PARTIAL FORCE MAIN REPLACEMENT

ESD recommends that Metro reduce head losses in the system by replacing 2,060 lineal feet of its own force main downstream from the Woodbine Way connection. This portion of force main is located in a flat open area of the park near the treatment plant. Partial force main replacement using HDPE pipe or a pipe with similar friction characteristics would do the following:

- Reduce liquid levels in the City lines rather than merely accommodating them.
- Create hydraulic conditions in the park similar to the original condition of the system.
- Decrease the sensitivity of the system to variations in flow.
- Provide an acceptable option for the City.
- Reduce working pressures at the North Beach Pump Station to more reasonable levels.

If this portion of the force main were replaced, the system could accommodate the 10-year peak flow without reaching the City manhole lids. MH No. 002 on the Woodbine Way line would have to be sealed to accommodate the 25-year peak flow, allowing a pressure head of about 4 feet to develop. Sealing this manhole would create no risk to upstream homes, because there is another manhole 60 feet higher (vertically) upstream. MH No. 154 and MH No. 155 on the NW 117th Street line would also have to be sealed to accommodate the 25-year flow, allowing a pressure head of about 2 feet to develop. A new manhole should be installed a short distance up the hill from the sealed manholes to protect hilltop homes during emergency conditions.

To maintain a minimum velocity of 2.0 fps in the force main, the new Pumps 3 and 4 in the North Beach station would have a capacity of 1,050 gpm rather than 900 gpm. The motors would

be sized to allow a 13-minute cycling time in the existing wet well control scheme.

The estimated construction cost of a partial force main replacement is $505,057. Construction issues are summarized in Section 7.

RECOMMENDED FLOW MONITORING

Metro should monitor flows in the City's gravity lines prior to final design of the partial force main replacement and the pump station upgrade. This would allow Metro to estimate the liquid levels that would occur in these lines during large storms, including the 25-year event. Metro should also consider the effects of the one-year gravity line flow on the upgraded pump station, because the upgraded station must control overflows to one per year.

Metro's flow estimates for these lines have not been validated by any actual flow data. The City's only gauging data for the Woodbine Way line were recorded in 1983, before the stormwater separation project was initiated. The data indicated peak flows exceeding 3 mgd, prior to separation.

Three years of new gravity line data will be required in order to estimate the 25-year gravity line flow. This data could be correlated with the longer gauging record from the North Beach Pump Station to aid in estimating the recurrence intervals of events.

SECTION 6 -- EVALUATION OF SYSTEM ALTERNATIVES

After ESD determined feasible combinations of storage volume and pump station capacity that would reduce overflows at the North Beach station to one per year, it grouped these combinations into alternatives and compared them to determine how best to control overflows at the station. The comparison assumed that the improvements would be constructed in two phases and that head losses in the system would be reduced via partial force main replacement before the station is upgraded (see Section 5).

The 1988 Carkeek facility plan considered reducing overflows to one per year by upgrading the North Beach station and force main to handle the estimated one-year peak flow without storage, but did not recommend this alternative. ESD briefly reviewed this concept, given Metro's revised one-year peak flow estimate and system head curve, to verify that constructing storage and upgrading the station is still the best approach.

DEVELOPMENT OF SYSTEM ALTERNATIVES

Four alternative approaches to overflow reduction at the station were developed, assuming that improvements would be constructed in two phases and that the effectiveness and impacts of Phase 1 would be taken into account.

Alternatives were developed for two pump station capacities: 4.5 mgd and 5.0 mgd. Alternatives involving a station capacity of 4.0 mgd were eliminated when preliminary calculations indicated that more than 252,000 gallons of storage would be required. This represents an excessive reliance on storage rather than pumping. It would also be difficult to construct a basin this size at this North Beach site. The 1988 study proposed construction of a 280,000-gallon storage basin with extensive rerouting of existing utilites, but a field survey conducted in 1989 revealed that the sewer main in Triton Drive is closer to Metro's site than was assumed in the 1988 layout. The 4.0 mgd option would also be less economical. The larger storage basin would be more expensive and disruptive to construct than a 140,000-gallon basin, while a 4.0 mgd station would require comparable facilites to a 4.5 mgd station.

The maximum pump station capacity considered was 5.0 mgd, based on a maximum allowable velocity of 8 fps in the North Beach force main. The TDH for each alternative was computed assuming partial force main replacement.

Definition of Station Capacity

The output of the pump station is affected by the branch flow from the City's gravity lines. ESD computed hydraulic grade lines and system head values for various combinations of pump station flow and branch flow. The pump curves for Worthington Type MF solids-handling pumps were used to estimate the effects of the gravity line flow on pump station output.

Because the upgraded station must control overflows to one per year, ESD equated the pump station "capacity" values from the hydrologic study to the capacity of the station at the moment when the Woodbine Way line is experiencing a one-year peak flow. This report defines a "4.5 mgd-capacity station" as one that produces 4.5 mgd when the gravity line is flowing at 1.0 mgd. This station would have a capacity of approximately 4.6 mgd when gravity line flows are negligible. Actual conditions would vary between these two limits throughout the wet season. The resulting variation in TDH would be minor for the type of new pump that was assumed in predesign.

Summary of System Alternatives

Table 10 summarizes the alternatives that were compared and the effectivness of each in reducing the number of overflows at the station.

DISCUSSION OF EVALUATION CRITERIA

This subsection provides background detail on several of the factors that were included in the comparison of alternatives.

Phase 1 Costs and Effectiveness

WPCD indicated that the selected alternative should achieve a significant reduction in overflows in Phase 1. The evaluation of alternatives considered the costs, impacts, and effectiveness of the Phase 1 improvements, as well as the costs, impacts, and effectiveness of the ultimate combination of improvements.

The Washington State Department of Ecology (Ecology) regulates CSO's based on the number of events per year, with an ultimate goal of one event per year. Metro's interim agreement with Ecology, which is based on CSO volumes, does not include the North Beach Pump Station. Reducing the number of overflow events per year is therefore the critical goal in Phase 1 as well as Phase 2.

Table 10
Summary of System Alternatives

Alternative A

Phase 1 -- Upgrade pump station to 4.5 mgd capacity, with partial force main replacement.

Reduce overflows from 18 to 9 per year.

Phase 2 -- Construct a 140,000-gallon storage basin.

Reduce overflows from 9 to 1 per year.

Alternative B

Phase 1 -- Construct a 140,000-gallon storage basin.

Reduce overflows from 18 to 4 per year.

Phase 2 -- Upgrade pump station to 4.5 mgd capacity, with partial force main replacement.

Reduce overflows from 4 to 1 per year.

Alternative C

Phase 1 -- Upgrade pump station to 5.0 mgd capacity, with partial force main replacement.

Reduce overflows from 18 to 5 per year.

Phase 2 -- Construct a 75,000-gallon storage basin.

Reduce overflows from 5 to 1 per year.

Alternative D

Phase 1 -- Construct a 75,000-gallon storage basin.

Reduce overflows from 18 to 6 per year.

Phase 2 -- Upgrade pump station to 5.0 mgd capacity, with partial force main replacement.

Reduce overflows from 6 to 1 per year.

With regard to overflow control, a pump station upgrade is more effective in reducing annual overflow volumes, but a storage basin is more effective in reducing the number of overflow events per year. This occurs because a station upgrade and a storage basin control overflows in different ways. Constructing storage would be the more cost-effective way to reduce the number of overflows in Phase 1.

Operations Issues

WPCD indicated that the ultimate combination of improvements should emphasize pumping rather than storage, if costs and other factors are similar.

Station and Force Main Pressures

If the North Beach Pump Station were upgraded to pump 4.0 mgd or more, the force main would be subjected to higher working pressures than it was designed for (see Section 3). This may be acceptable, because force main piping is typically constructed to withstand pressures much higher than the working pressure. However, corrosion may have reduced the effective strength of the 31-year-old force main. The 1989 inspection examined the pipeline at three locations. In one location, pitting from corrosion had occurred, reducing the pipe wall thickness.

There is some uncertainty regarding the original thickness of the pipeline. The contract documents for the force main contract called for Class 100 (psi) or Class 150 (psi) pipe, depending on pipe elevation and depth. The force main inspection conducted in 1989 revealed that the installed pipe did not exactly match specifications, however. The portions studied appeared to have an original wall thickness greater than specified. The portion of force main on the pump station site may have been designed for a working pressure of 80 psi (185 feet) and a test pressure of 315 psi, according to the specifications for that contract.

Table 11 shows the estimated system head and TDH for upgraded station capacities of 4.0 mgd, 4.5 mgd, and 5.0 mgd, assuming partial force main replacement.

Table 11
Pressure Head Comparison

	Station Capacity (mgd)	Branch Flow (mgd)	System Head (ft)	Estimated TDH (ft)
Station Design	4.2	0.0	--	96
Existing Station Test	3.4	0.0	102	--
Upgraded Station*	4.0/4.1	0.0/1.0	126	132
Upgraded Station*	4.5/4.6	0.0/1.0	146	153
Upgraded Station*	5.0/5.1	0.0/1.0	176	185

* With partial force main replacement completed.

As shown in Table 11, if the pump station were upgraded to 5.0 mgd, the resulting system head and TDH would exceed 175 feet. The force main would be operating under a working pressure almost twice as great as the design working pressure. The force main velocity of 8 fps would introduce additional risk, because the maximum pressures that occur in a force main during a hydraulic transient event are directly related to the velocity of flow.

ESD recommends limiting the capacity of the North Beach station to 4.5 mgd. This will limit the working pressure in the force main to about 150 feet.

During final design of the pump station upgrade, Metro should conduct a detailed hydraulic transient analysis to determine the maximum pressures that will occur in the force main and to design measures that will minimize this risk. In addition, Metro should conduct some additional field inspection of the force main, and perform a theoretical strength analysis of the existing pipe, to assess the risk associated with a pump station upgrade.

COMPARISON OF SYSTEM ALTERNATIVES

This subsection describes the advantages and disadvantages of the four system alternatives.

Alternative A

Phase 1 -- Upgrade station to 4.5 mgd capacity, with partial force main replacement.
Phase 2 -- Construct a 140,000-gallon storage basin.

Advantages

- This combination maximizes the use of pumping to achieve 1 overflow per year, while keeping force main pressures within the recommended limits.
- The aging equipment in the station would be replaced in Phase 1. (Some ancilliary equipment in the station may require replacement in the near future.)
- The need for storage basin maintenance would be postponed.

Disadvantages

- This alternative is the least effective in Phase 1, reducing the number of overflows to 9 per year.
- Phase 1 cost is greater than for Alternative B (see Section 7).

Alternative B

Phase 1 -- Construct a 140,000-gallon storage basin.
Phase 2 -- Upgrade station to 4.5 mgd capacity, with partial force main replacement.

Advantages

- This combination maximizes the use of pumping to achieve 1 overflow per year, while keeping force main pressures within the recommended limits.
- This alternative is the most effective in Phase 1, reducing overflows to 4 per year.
- Phase 1 cost and cost-per-overflow are lower than for Alternative A (see Section 7).
- Phase 1 construction would be limited to Metro's property and adjacent street right-of-way. Construction in Carkeek Park would be postponed.

- The risk associated with operating the force main at higher working pressures would be postponed.

- Use of the storage basin could eliminate the need for bypassing flow during construction at the station and could prevent emergency overflows during Phase 2 construction.

Alternative C

Phase 1 -- Upgrade station to 5.0 mgd capacity, with partial force main replacement.
Phase 2 -- Construct a 75,000-gallon storage basin.

Advantages
- This combination would maximize the use of pumping.

- The aging equipment in the station would be replaced in Phase 1. (Some ancilliary equipment may require replacement in the near future.)

- The need for storage basin maintenance would be postponed.

Disadvantages
- This alternative has the highest cost in Phase 1.

- A flow of 5.0 mgd represents a limiting acceptable velocity of 8 fps. Head losses begin to increase significantly in this flow range.

- A flow of 5.0 mgd would create working pressures in the force main that exceed the recommended limits.

- The design velocities in the station's suction and discharge piping are slightly higher than current guidelines recommend, but have proved acceptable through operation. A flow of 5.0 mgd would introduce risk by increasing these velocities.

Alternative D

Phase 1 -- Construct a 75,000-gallon storage basin.
Phase 2 -- Upgrade station to 5.0 mgd capacity, with partial force main replacement.

Advantages
- This combination would maximize the use of pumping.

- This alternative has the lowest cost in Phase 1 of all the alternatives.

- Phase 1 construction would be limited to Metro's property and adjacent street right-of-way. Construction in Carkeek Park would be postponed.

- The risk associated with operating the force main at higher working pressures would be postponed.

- Use of the storage basin could eliminate the need for bypassing flow during construction at the station and could prevent emergency overflows during construction at the station and the force main.

Disadvantages

- If a 75,000-gallon storage basin is constructed now, assuming a future upgrade to 5.0 mgd, little flexibility remains for changing conditions in the future. This may introduce some risk of not achieving 1 overflow per year.

- A flow of 5.0 mgd represents a limiting acceptable velocity of 8 fps. Head losses begin to increase significantly in this flow range.

- A flow of 5.0 mgd would create working pressures in the force main that exceed the recommended limits.

- The design velocities in the station's suction and discharge piping are slightly higher than current guidelines recommend, but have proved acceptable through operation. A flow of 5.0 mgd would introduce risk by increasing these velocities.

RECOMMENDED ALTERNATIVE

ESD recommends Alternative B as the best approach to controlling overflows at the North Beach station. Phase 1 provides a cost-effective, substantial reduction in the number of overflows. The ultimate combination provides the best balance of storage volume and pumping capacity.

INVESTIGATION OF PEAK FLOW PUMPING ALTERNATIVES

This subsection describes ESD's review of two alternatives to upgrade the station and force main to handle the estimated one-year peak flow. The review was conducted to make sure that the selected alternative is the most feasible approach, given that peak flow and system head curve estimates were revised since peak flow pumping was last considered.

New North Beach Pump Station and Force Main

In addition to considering alternatives for station upgrade and storage, the 1988 facility plan considered construction of a new North Beach station and force main sized for an estimated one-year peak flow of 9.0 mgd. This alternative was abandoned in the 1988 study because of concerns about implementation in a shoreline zone. To construct a new force main with a greater capacity within the shoreline zone, Metro would have to demonstrate that no reasonable alternative exists. The proposed storage basin and station upgrade represents a reasonable alternative.

Moreover, the 1989 force main investigation (see Section 1) concluded that the force main along the shoreline is in good condition and that there is no need to replace it (at its existing capacity) at this time.

The 1988 study recommended constructing storage and upgrading the North Beach station to 5.0 mgd. The Carkeek plant was subsequently designed for a maximum input of 5.0 mgd from North Beach.

Brown and Caldwell updated cost data from the 1988 study to develop a 1992 cost estimate for a 9.0 mgd station and force main. The cost is substantially higher than the cost of the proposed approach.

When considering construction of a new station and force main to handle the revised one-year flow of 7.0 mgd, the same concerns about implementation in the shoreline zone still apply.

Rerouting Excess Flows to the 8th Avenue Force Main Through a New Pump Station and Force Main

ESD briefly investigated another concept for peak flow pumping that was suggested by Metro staff after the 1988 study. This concept involves two elements: (1) continued operation of the existing force main to carry 3.0 to 4.5 mgd and the City gravity line flows to the Carkeek plant, and (2) a new force main to carry peak flows of up to 4.0 mgd east over the hill to the 8th Avenue force main, which will carry

secondary-transfer flows from the new Carkeek Pump Station to the West Point plant.

The 8th Avenue force main is sized to carry 4.0 mgd more than its design flow, but doing this may have CSO implications for the City collection system. The North Beach input would be accommodated by operating the Carkeek Pump Station and new North Beach pump station in a coordinated manner to reduce Carkeek transfers when the North Beach station is operating; by modeling flows in the system in detail and negotiating with the City regarding CSO implications; or by a combination of these two approaches.

This concept has potential advantages. Assuming a peak flow of 7.0 mgd and depending on the exact flows that may be transferred in each direction, this concept would eliminate the need for a storage basin, and might eliminate the need to modify the existing force main.

This concept has potential disadvantages as well. It would require either a new station adjacent to the existing one, which would operate only during times of peak flow, or, more likely, a new station at the North Beach site that would pump to both force mains. The new force main would be at least 6,100 feet long and would operate only during times of peak flow. The static lift (hill height) for a shallow force main over the hill would be greater than 300 feet. The last portion of the main would drop back down about 100 feet to discharge into the 8th Avenue force main. Eliminating the 100-foot drop would require about 4,000 feet of tunnel construction. (The hydraulics at the point of discharge to the 8th Avenue force main were not investigated.)

This concept would involve construction of new pumping facilities in a very constrained location in a single-family zone. Moreover, the concept involves a total dynamic lift of well over 300 feet. An additional booster pump station would probably be required to carry flows over the hill. ESD did not prepare a detailed cost estimate for this concept, but believes it would be significantly more expensive and more difficult to implement than the proposed alternative.

Conclusion

ESD concurs with Brown and Caldwell that increasing pump station capacity and constructing a storage basin is the best approach to controlling overflows at the North Beach station. Metro's revised one-year peak flow estimate does not alter this conclusion.

SECTION 7 -- DESCRIPTION OF RECOMMENDED FACILITIES

In Phase 1, Metro will construct a 140,000-gallon storage basin at the site of the North Beach station (Figure 6). The estimated construction cost of Phase 1 is $1,180,400. The estimated total cost of Phase 1 is $1,602,400.

Phase 1 will reduce the frequency of overflows from 18 to 4 per year, and will reduce the volume of overflows from 1.9 to 1.0 MG per year.

In Phase 2, Metro will upgrade the North Beach station to a capacity of 4.5 mgd (Figure 7) and will install new pipe to replace 2,060 lineal feet of the North Beach force main within Carkeek Park. The estimated construction cost of Phase 2 is $1,391,500. The estimated total cost of Phase 2 is $1,875,200.

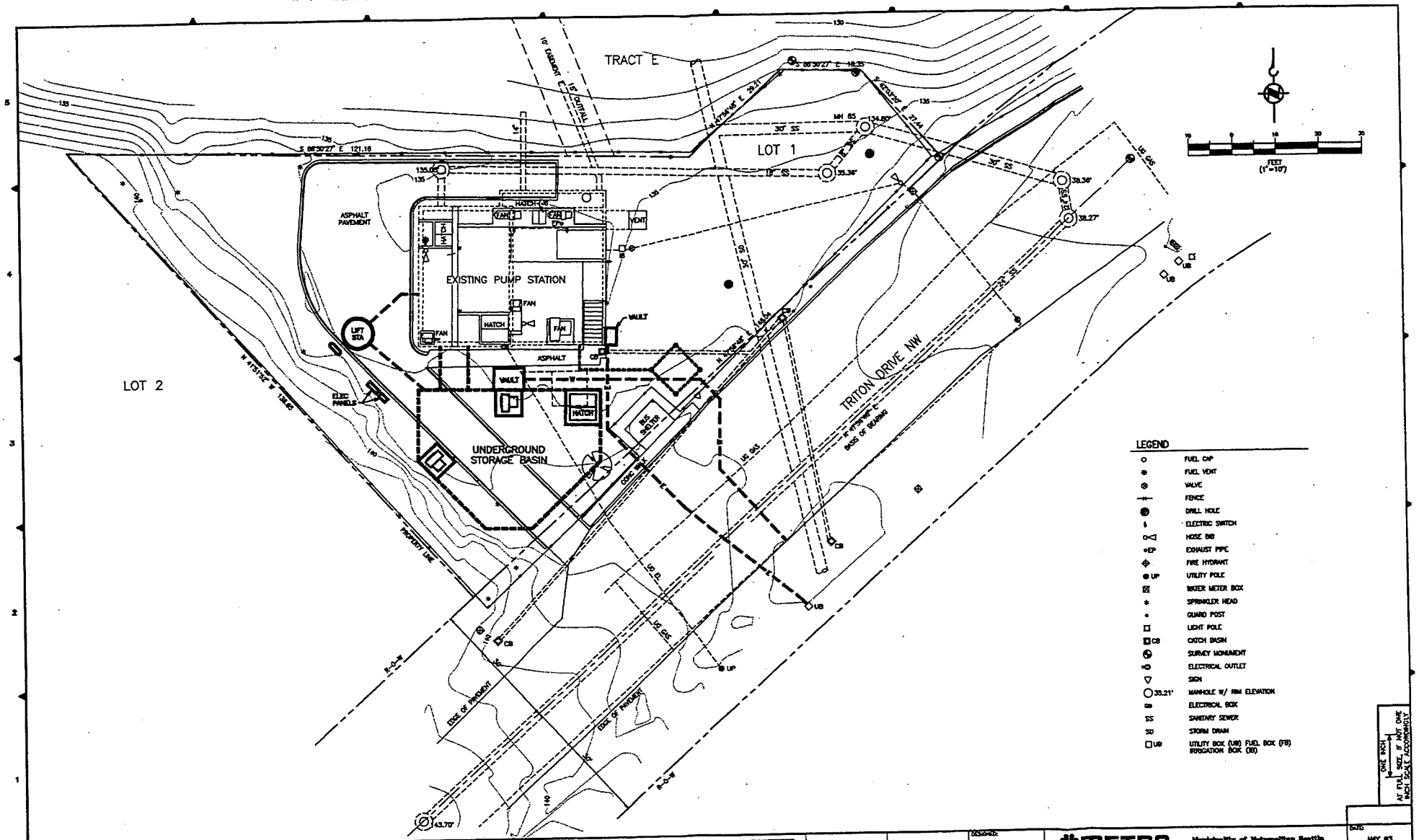
Phase 2 will reduce the frequency of overflows from 4 to 1 per year, and will reduce the overflow volume from 1.0 to 0.2 MG per year.

The cost of Phase 2 includes a total cost of $661,600 for partial force main replacement and a total cost of $1,213,600 for the pump station upgrade. The cost of force main replacement includes the cost of site restoration, but does not include the cost of any special mitigation measures that the City might require. The cost of the pump station upgrade does not include the cost of replacing/relocating the underground fuel tank on the site; this tank is scheduled for replacement in 1993 as part of a separately funded capital program.

Detailed cost estimate summaries are provided in Appendices B and C. All costs are shown in 1993 dollars. Total costs include construction costs and allied costs. (Allied costs do not include predesign costs or WPCD staff costs.)

PHASE 1 -- DESCRIPTION

The proposed storage basin, which is shown in Figures 6 and 8, has a storage volume of 140,000 gallons at a maximum liquid depth of 20 feet. A rectangular weir opening will be constructed in the wall of the existing station to allow liquid to overflow to the storage basin from the existing wet well. Overflows from the wet well will enter the storage basin through a concrete overflow duct. The basin will initially be used an average of 18 times per year. After Phase 2, the basin will be used about 9 times per year.



PRELIMINARY - FOR INFORMATION ONLY

No.	REVISION	BY	APP'D	DATE

DESIGNED:
DRAWN: DJB CHECKED:
RECOMMENDED:
APPROVED:

METRO Municipality of Metropolitan Seattle

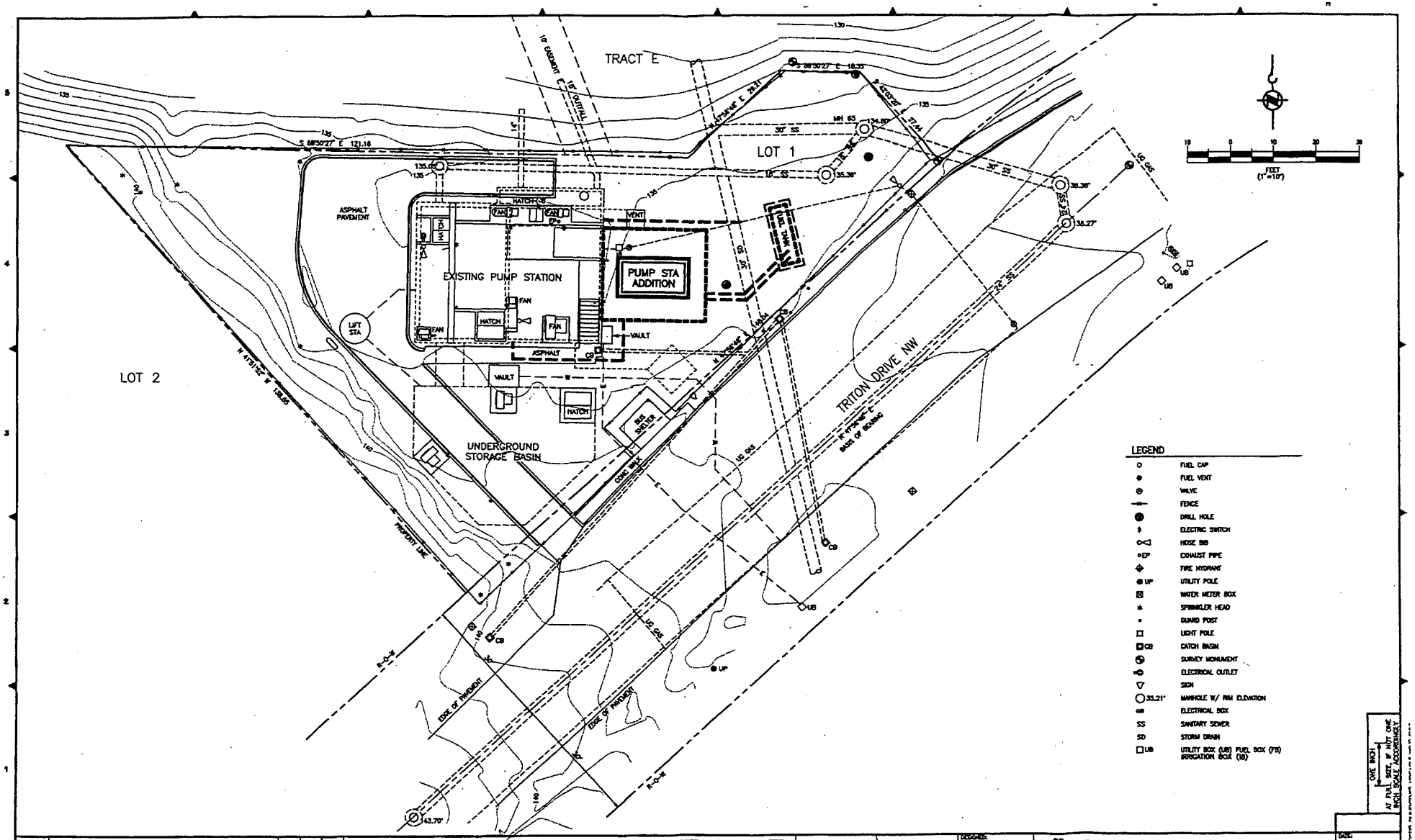
SCALE: NOTED
CONTRACT NO:

NORTH BEACH PUMP STATION
CSO CONTROL

SITE PLAN – PHASE 1
FIGURE 6

DATE: MAY 85
FILE NO: W03
DRAWING NO: —
SHEET NO: OF

ONE INCH
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY



PRELIMINARY - FOR INFORMATION ONLY

No.	REVISION	BY	APP'D	DATE

METRO Municipality of Metropolitan Seattle

NORTH BEACH PUMP STATION
CSO CONTROL

SITE PLAN – PHASE 2
FIGURE 7

DATE: MAY 93
FILE NO: 1403
DRAWING NO: —
SHEET NO: OF

DESIGNED:
DRAWN: DJB
CHECKED:
RECOMMENDED:
APPROVED:
SCALE: NOTED
CONTRACT NO:

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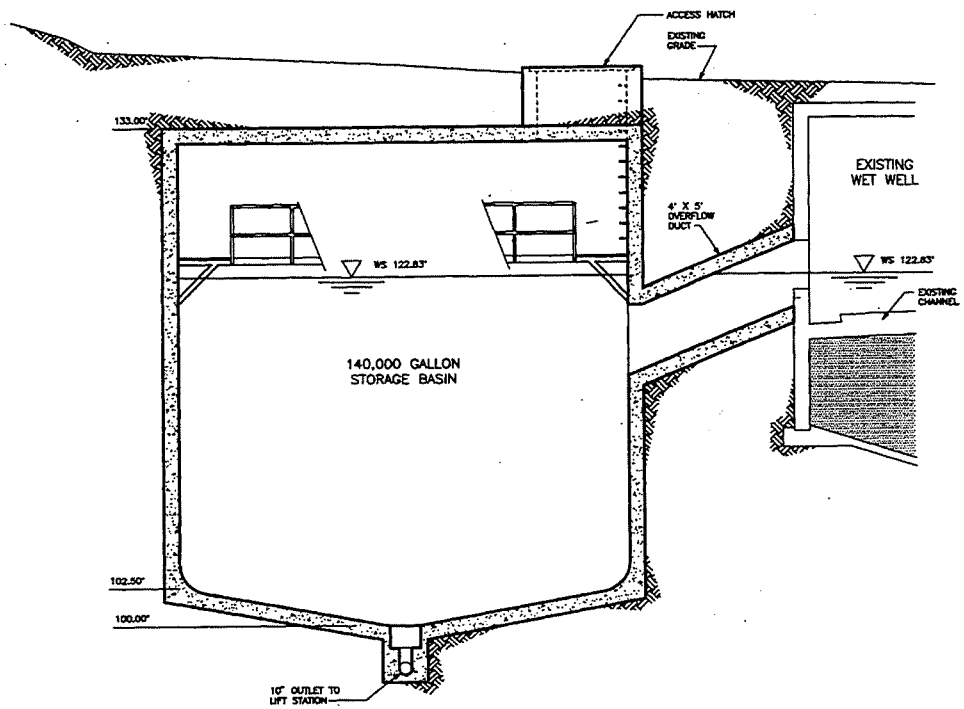
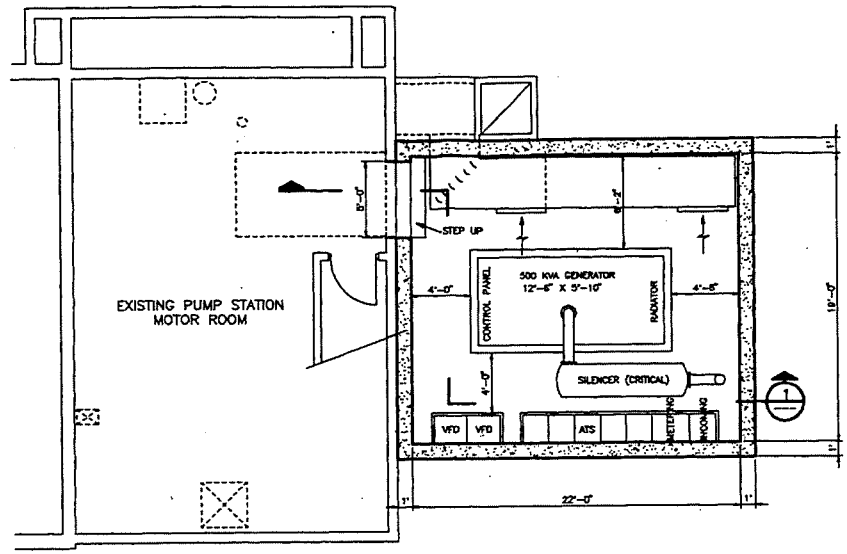
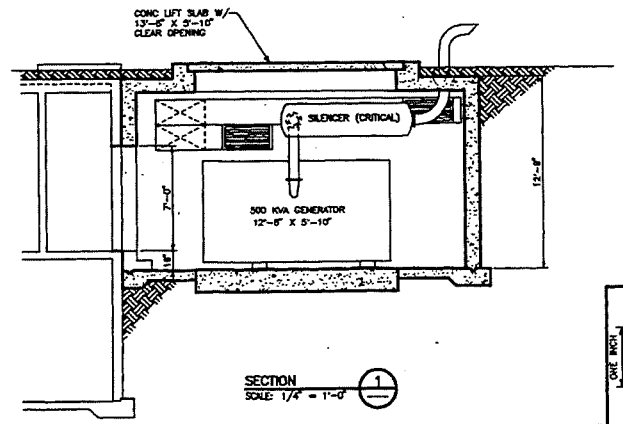


SECTION THROUGH UNDERGROUND STORAGE BASIN
SCALE: 1/4" = 1'-0"



PLAN OF PUMP STATION ADDITION
SCALE: 1/4" = 1'-0"



SECTION 1
SCALE: 1/4" = 1'-0"

ONE INCH
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

No.	REVISION	BY	APP'D	DATE

PRELIMINARY - FOR INFORMATION ONLY

DESIGNED:
DRAWN: DJB CHECKED:
RECOMMENDED:
APPROVED:

METRO Municipality of Metropolitan Seattle

SCALE: 1/4" = 1'-0"
CONTRACT NO.

NORTH BEACH PUMP STATION
CSO CONTROL

UNDERGROUND STORAGE BASIN AND NEW BUILDING ADDITION

DATE: 11-82
FILE NO: W33
DRAWING NO: FIG 8
SHEET NO. OF

The weir elevation and width will be set to balance several design factors. The weir should be as high as possible above elevation 120.76, where the follow 75-hp pump comes on, to allow maximum use of the pumps and to minimize unecessary overflows. Existing wet well level data should be examined during final design to estimate the frequency of various wet well levels. The weir should also be low enough and wide enough to allow liquid to overflow without reaching the level of the existing wet well overflow weir at elevation 122.83. The weir will be located at the discharge end of the existing grit channel, where the wall thickness is at a minimum. The practical width of the weir will be limited by the concrete shelves on either side of the weir location.

The storage basin is expected to fill to its maximum level four times per year with a 3.4-mgd pump station (Phase 1), and once per year with a 4.5-mgd pump station (Phase 2). The liquid level would rise above the storage basin influent weir when the basin is full. Excess liquid will flow over the existing wet well weir and discharge through the existing pump station outfall.

A return-flow lift station will be constructed next to the storage basin. The lift station will pump stored liquid out of the storage basin and into the pump station wet well after each storm. The predesign cost estimate is based on a duplex station with Flygt CP-3127 submersible pumps and a return-flow rate varying from 600 to 1,200 gpm during pumpout. Level measurements in the pump station and lift station wet wells will control the operation of the lift station pumps. To minimize variations in return flow rate, one lift station pump will operate at high liquid levels and the second pump will be activated after the liquid level has dropped.

The control panel for the return-flow lift station will be located above ground in Phase 1, because there is no space available in the existing station. The control panel will be approximately 42 inches high and 36 inches wide, and could be located as shown in Figure 6. The panel will be relocated to the new pump station electrical room in Phase 2. A smaller power panel will serve the storage basin supply and exhaust fans, the storage basin lighting, and the lift station controls (duplex starter and electronic controls). This panel would also be located above ground in Phase 1 and relocated to the new electrical room in Phase 2.

Metro operations staff have indicated that manual cleaning of the basin would be appropriate. The predesign cost estimate assumes the use of two Stang AA Series water monitors for cleaning. The water monitors, which will be mounted on the grating walkway shown in Figure 8, will each discharge 350 gpm at 80 psi through a 1-1/2-inch nozzle. Pressure information from the Seattle Water Department indicates that

the desired discharge pressure can be provided at the basin without booster pumps.

Some other features of the proposed storage basin are as follows:

- Rounded fillets at wall and floor corners, to facilitate cleaning
- A walkway grating around the perimeter
- Good lighting, to facilitate cleaning
- Constant ventilation at a rate of 12 air changes per hour (per NFPA 820)
- Two above-ground fans located more than 20 feet from Metro's south ("front yard") property line

ESD does not propose to install odor control at the North Beach facility. The existing station does not experience odor problems. The proposed storage basin will be used intermittently, for dilute winter stormweather flows. And, after Phase 2, the basin will be used only 9 times a year.

PHASE 1 -- CONSTRUCTION ISSUES

Protection of the existing pump station structure, portions of which were constructed in 1948, will be crucial during construction of the storage basin. In addition, the lot southwest of the pump station has an existing house in the northeast corner (near the pump station's parking lot) and a garage that is located only several feet from Metro's property line (near the location of Phase 1 construction).

Geotechnical and structural investigations should be conducted at an early stage of final design to define dewatering and excavation shoring requirements and to define, if necessary, any recommended alterations in the shape or location of the storage basin.

Construction of the storage basin will require temporary relocation of Metro's existing bus stop and temporary closure of the "bus lane" on Triton Drive NW.

The northwest portion of Metro's site is classified as Urban Residential Shoreline Environment, but this would not preclude the use of this area for contractor staging.

PHASE 2 -- PARTIAL FORCE MAIN REPLACEMENT

The proposed Phase 2 improvements include the following pipeline modifications:

- Replacing 2,060 feet of existing force main with new pipe. The predesign cost estimate is based on the use of HDPE pipe.
- Modifying City MH No. 002 (Woodbine Way line), MH No. 155, and MH No. 154 (NW 117th Street line) to allow pressure flow during large storms.
- Installing a new manhole upstream of City MH 154.
- Plugging the abandoned City pipeline that connects to Metro's force main along the shoreline 3,850 feet downstream of the North Beach station.

The exact alignment of the new force main will be determined in final design. West of the Carkeek Treatment Plant site, the new pipeline will likely be installed parallel to and north of the existing force main. Inside the treatment plant site, the new main will likely be located south of the existing main. The easternmost 200 feet of new pipe will have to be installed in the same alignment as the existing pipe, requiring bypass pumping during construction.

A steep road bank is located north of the Woodbine Way tee. If ground conditions necessitate, a new tee may need to be located east of the existing tee. At the existing NW 117th Street tee, a replacement valve structure will be installed. Crossing Pipers Creek, the new main will be placed in a bored or jacked casing to avoid disturbing the creek. At the west entrance to the treatment plant, the new main will likely be routed through the entry drive, or placed in a bored or jacked casing to avoid disturbing the wall that is being constructed as part of the Carkeek plant upgrade. Existing plant utilities and limited construction space will make the easternmost 200 feet of new pipe the most difficult to install.

PHASE 2 -- PUMP STATION UPGRADE

In Phase 2, the existing pump station will be upgraded to provide a capacity of 4.5 mgd. A site plan for Phase 2 construction is shown in Figure 7; a detailed plan and section view are shown in Figure 8. A new electrical room will be required to house a larger standby generator and other new electrical equipment.

The predesign cost estimate assumes the following new raw sewage pumps:

Pumps 1 and 2:	Worthington Model 6MFV-14 1,560 gpm at 155 feet TDH 1,770 rpm 100-hp motor
Pumps 3 and 4:	Worthington Model 4MFV-11 1,050 gpm at 50 feet TDH 1,770 rpm 30-hp motor

Although 100-hp motors are sufficient for the conditions assumed in predesign, altered conditions in final design might require the use of 125-hp motors for Pumps 1 and 2. The size of the pump station electrical room addition shown in Figures 7 and 8 will be the same if 125-hp pumps were required.

The shoreline portion of the North Beach force main could require replacement due to age during the useful life of the new pumps. In this case, operating the pumps at a lower speed could accommodate a significant drop in head.

The predesign estimate for Phase 2 also includes new seal water pumps for higher-head operation; a new air break tank, washdown pump, instrument air system, and sump pump to replace aging equipment; and a new access hatch and monorail for safer operation.

PHASE 2 -- CONTROL AND ELECTRICAL SYSTEMS

Control System

The control system will be modified to modernize the system. The new control scheme will be based on the new system head curve. The existing Foxboro controller system will be replaced with a Moore controller.

The new control system will be constructed around the PLC. The PLC will supply all pump start/stop commands and speed reference signals. A relay will be added to switch the drive speed reference input to the Moore controller in the event of a PLC failure.

Drives

Variable frequency drives (VFDs) will be used to control the 100-hp raw sewage pump motors. VFDs will provide improved pump control and will use less energy than new eddy-current clutches. In addition, there is minimum clearance between the existing clutches and the motor control center (MCC). If

new larger clutches were used, the existing MCC would have to be removed.

Motor Control Center

The existing power to the station is based on a 400-amp feeder circuit breaker/incoming section; load calculations indicate that the power will need to be increased to 600 amps to meet the requirements of the station when the pump motors are upgraded. This increase requires a new service entrance (incoming) section, a new automatic transfer switch, and voltage and current monitoring equipment rated for the increased amperage. The existing MCC cannot accommodate this equipment.

The smaller constant-speed pump motors will each increase from 20-hp to 30-hp; the starter sizes will also increase, from size 2 to size 3. The size 3 starter requires 6 inches more vertical space than the size 2 starter. There is no space available in the existing MCC for the larger starter.

A new MCC will be installed to accommodate these changes and provide space for other miscellaneous starters and feeders.

Standby Generator

Section 700 of the NEC requires an emergency system (generator) to have "adequate capacity and rating for all loads on the emergency system to be operated simultaneously." The existing generator is rated at 300-kW standby, or 361 amps at 480 VAC. This capacity would fall short of the full load requirements of the upgraded pump station (469 amps/390 kW).

Currently, the entire electrical load of the pump station is connected to the standby generator. To reduce the size of a new generator for the station, less critical equipment may be removed from the power system during emergencies. This load shedding could be done via MCC arrangement or via controls. These less critical items would have to be identified during final design. The total connected load assumed in predesign is shown in Table 11.

The size of the new generator also depends on the amount of reactive power reflected back onto the power system by the equipment at the pump station. Historically, VFDs and other electronic equipment have been sources of reactive power. A generator manufacturer's representative recommends that the generator be oversized to accommodate the needs of the VFDs within the system.

Table 11
Proposed Load Connected to Standby Generator

Item	Breaker (amps)*	Wiring	HP	Starter Size	Current (amps)
Sewage Pump 1	200	4-2/0	100	4	155**
Sewage Pump 2	200	4-2/0	100	4	124
Sewage Pump 3	70	4-6	30	3 ***	40
Sewage Pump 4	70	4-6	30	3 ***	40
Inst. Air 1	15	4-12	0.75	00	1.7
Inst. Air 2	15	4-12	0.75	00	1.7
Seal Water 1	15	4-12	1	00	3.6
Seal Water 2	15	4-12	1	00	3.6
Sump Pump	15	4-12	0.75	00	1.7
Flush Pump	15	4-12	1	00	3.6
HVAC Supply	15	4-12	5	0	7.6
HVAC EF-1	15	4-12	0.75	00	1.4
HVAC EF-2	15	4-12	3	0	4.8
Hoist Motor	--	--	--	--	--
Heaters	30	--	15 kW	--	18.1
Storage and Return Panel	100	4-2	55kVA	--	62.2

Note: Total Connected Load = 469 amps (390 kW).

* 3 pole.
** Largest motor rated continuous @ 125%.
*** Starter size increased from size 2 (@ 20 hp) to size 3 (@ 30 hp).

PHASE 2 -- ELECTRICAL ROOM

A new room will be constructed adjacent to the motor room to house the new electrical equipment. The new electrical room is shown in Figures 7 and 8.

The new room is needed because the existing pump station motor room is full. The new MCC and standby generator will not fit into the existing space. Addition of any new equipment in the motor room would seriously endanger the safety of the personnel who maintain the station.

In addition, the space between the existing MCC and the pump motors is at the limits of the working space requirements. The 75-hp motor and eddy-current clutch are located 36 inches from the MCC with a 2-inch conduit located 33 inches away from the MCC. The NEC (Section 110-16) states that the minimum working clearance is 36 inches. When there are exposed live parts (an open MCC compartment) and any grounded device (the motor, controller, or metal conduit) the minimum working clearance required is 42 inches. Therefore, any modification or installation within these boundaries would be a violation of the NEC. The new, higher horsepower motors would likely be larger than the existing motors. Depending on the size and space requirements of the new motors, the clearances required by the NEC could be violated.

SECTION 8 -- SCHEDULING ISSUES

This section describes the additional studies and permitting activities that should be completed, and the time that should be allowed in the project schedule to complete these tasks.

PERMITTING

Single-Family Zone

The schedules for Phase 1 and Phase 2 should each allow at least one year for a City Council land use decision and for acquisition of building and utility permits.

Pump stations are defined both as a "Utility Service Use" and as a "Public Project" under the City of Seattle land use code. The zoning for the North Beach Pump Station property is SF7200 (single-family). Utility service uses require City Council approval under the single-family provisions of the Land Use Code for Public Projects (23.44.036 A.4). "The proponent...shall demonstrate the existence of a public necessity for location or expansion of the use in a single-family zone."

Metro should evaluate, in subsequent design and discussion with the City of Seattle, whether a proposal to build a storage basin on the pump station site could be considered under the land use code as an "Accessory Use" (23.44.040 B.), customarily incidental to pump stations, rather than an expansion of the facility. If not, then a City Council land use decision will be required.

If a Type IV Council land use decision is required, the Director of the Department of Construction and Land Use (DCLU) must complete a report and issue a recommendation to approve or deny the proposal; a hearing examiner must hold a hearing and issue a recommendation to the Council; and the Council must consider the hearing examiner's recommendation and make a decision. This process could take at least 12 months to complete.

Shoreline Environment

The northwest portion of the North Beach Pump Station site falls within the shoreline district as defined under the City of Seattle's Shoreline Master Program. The shoreline environment on the pump station property is UR (Urban Residential). A shoreline permit would be required for construction of any facilities on this portion of the site. Utility lines are permitted outright in UR zones, if no reasonable alternative exists. Pump stations are defined as

a Utility Service Use under the Shoreline Master Program. Utility Service Uses are permitted outright only if their "operations require a shoreline location." Therefore, modifications to the pump station within the shoreline district would require Metro to demonstrate one of the following:

- The operations require a shoreline location.
- The modifications are considered as renovation or do not involve expansion of the facility.
- The modifications are necessary to comply with other laws.

Based on available information, the shoreline district appears to include only the area northwest of the pump station's northwest corner. The Phase 1 and Phase 2 site layouts shown in Figures 6 and 7 are designed to avoid any construction in the shoreline district. A shoreline permit would therefore not be required for Phase 1 construction.

Metro must determine the exact boundary of the shoreline district by field survey before finalizing the Phase 1 site layout or applying for any permits.

PHASE 2 -- FLOW MONITORING

Metro should monitor flows in the City's gravity lines before upgrading the North Beach station. Metro's flow estimates for these lines have not been validated by any actual flow data. Accurate flow and liquid level estimates are important for the design of facility improvements in Carkeek Park, the design of the pump station upgrade, and for City and community acceptance of Metro's proposal.

Planning should assume that 3 full years of data will be required. The data have to be collected and analyzed before final design of the pump station upgrade and partial force main replacement begins.

SECTION 9 -- EVALUATION OF INTERIM AND SUPPLEMENTAL MEASURES

The predesign effort included investigation of several construction measures that seemed to have potential value as interim solutions, cost-saving measures, or as supplemental measures to further reduce overflows at the North Beach Pump Station. This section summarizes construction measures that ESD considered but does not recommend for implementation at this time.

PIGGING THE FORCE MAIN

The slime layer in pipelines can be a significant factor influencing roughness (friction loss). Pushing one or more "pigs" through a pipeline may increase its "C" factor to about 120 by scraping off the slime layer. Under low flow conditions, sewage in the existing North Beach force main moves at 2 fps when the 20-hp pump is pumping and the sewage sits still in the force main while the wet well is filling. Pigging is therefore a reasonable option to consider at this location.

If pigging could increase the "C" factor of the existing force main to 120, the capacity of the existing pump station would increase from 3.4 mgd to about 3.6 mgd. The increased capacity would reduce overflows from 18 per year to about 16 per year. Pigging would have to be done on a regular basis to be effective.

A pigging program is not easy to implement at this force main. The length of underground force main between the wall of the station and Metro's property line is only 7 feet, and the pipeline is 6 feet deep. The pig would have to be pushed into the line at a right angle, which typically requires that a separate source of pressurized liquid be applied behind the pig. The pig launcher would be quite visible on the station site. Moreover, it is possible that the installation of a pig launcher may require construction within the shoreline zone.

A 14-inch pig could potentially turn and go up into the 12-inch-diameter Woodbine Way gravity line in Carkeek Park. The Woodbine line would, therefore, have to be plugged during each pigging operation. To facilitate regular pigging, the tee from the Woodbine line to the force main would likely have to be excavated, and a bar installed across the Woodbine line. This bar would introduce some risk of blockages in the City's line. A structure with a valve might also be installed. This structure might be expensive, because the tee is fairly near a steep roadbank.

Before pigging, it might also be necessary to permanently plug the abandoned 10-inch-diameter gravity line that connects to the force main 3,850 feet downstream from the pump station. (The NW 117th Street gravity line has an existing gate valve at the point of connection.)

ESD does not recommend installing pigging facilities as an interim measure or as part of Phase 1 (storage basin) construction. Metro may still want to consider adding pigging facilities to the station in Phase 2, when the pump station is upgraded.

PARTIAL FORCE MAIN REPLACEMENT AS AN INTERIM MEASURE

Partial force main replacement would not be cost-effective as an interim solution. Unaccompanied by other improvements, it would only increase the existing station capacity to about 3.5 mgd and would only reduce overflows from 18 per year to about 17 per year.

PIPELINE STORAGE AS AN INTERIM MEASURE

Modifying the influent sewer to provide detention of sewage or constructing off-line storage facilities that would empty by gravity are cost-effective ways to add storage at a pump station site. However, the volume of storage that could be provided at the North Beach station by enlarging existing pipelines is very limited. The onsite piping is not very long, and the pipelines entering the site are on fairly steep slopes. Off-line storage in pipelines or a shallow basin adjacent to the influent pipe would be difficult to clean.

The resulting volumes would provide interim storage, but would not be as large as the ultimate storage facilities required. The interim facilities would require significant site area and would therefore be abandoned when permanent facilities were installed.

Metro's ability to provide gravity storage at the North Beach influent sewer is constrained by the allowable minimum and maximum liquid levels. The minimum level must be high enough to allow the stored liquid to drain to the pump station after the storm. The maximum level must be low enough to avoid flooding upstream residences. Critical elevations at the station are as follows:

Minimum wet well level	116.8
Lead 75-hp pump start	119.8
Influent sewer invert at wet well	121.1
MH No. 65 overflow weir	124.9
Lowest residential basement (approx.)	131.0

In 1977, Metro temporarily plugged the overflow at MH No. 65. Because the station's outfall was damaged at that time, sewage backed up in the system and flooded four residences. Metro staff compared liquid levels at the station and at the residences and found that levels at the residences were significantly higher. The overflow weir at MH No. 65 was then constructed at a low enough elevation so that future emergency overflows would not flood residences.

To install any significant volume of interim storage that could empty by gravity, Metro would have to raise the level of this emergency overflow. This would increase the risk of backups at residences and therefore would be an inappropriate interim solution.

OVERSPEEDING THE EXISTING PUMPS

Pumping substantially higher flows through the existing force main would result in substantially higher-head operation than the original design condition. The resulting working pressures at the existing pumps would exceed the working pressures that they were built to handle. The pump manufacturer does not recommend operating the pumps in this range of pressures.

If head losses were reduced via partial force main replacement, the existing pumps, if oversped to pump 4.5 mgd, would exceed their design working pressures by 8 feet. Higher horsepower would still be required, and all of the other costs associated with an upgrade would still apply. Partial force main replacement would preclude quick implementation. Considering the age of the existing pumps, new pumps should be used.

REPLACING ONE PUMP

Replacing just a single pump to produce the desired station capacity would produce excessive velocities and head losses in the suction and discharge piping of that pump, and would involve high head and high horsepower draw at that pump. This measure, therefore, is not recommended.

INFLUENT SEWER MODIFICATIONS

The influent sewer to the North Beach Pump Station has an emergency overflow weir, located in MH No. 65. Overflows at this point pass through a storm drain and are discharged at the Puget Sound shoreline.

The 1988 Carkeek facility plan recommended upgrading the influent sewer to carry the largest inflow event on record.

The storage basin location shown in the 1988 report required demolition of MH No. 65.

The capacity of the existing influent sewer is sufficient to carry the one-year flow event; this was confirmed by data measured during the actual one-year event at the station in 1990. The capacity of the influent sewer during larger storms is difficult to estimate, because of a short, mild-sloped run of pipe downstream of MH No. 65. In addition, during wet well overflows, the liquid level in the system is above the invert of the influent sewer.

Metro's Information Systems Division examined flow and level data measured from 1988 to 1992 to determine whether the occasional overflows at MH No. 65 could be linked to any particular combination of hydraulic conditions.

Liquid levels above the height of this overflow weir were recorded on three occasions. The data did not provide any conclusive evidence regarding the cause of the overflows. Station inflows were less than the one-year flow. The wet well level was measured during only one of the events, and it was not unusually high. The measured overflows may have been due to temporary pipe blockages, equipment malfunction, or erroneous data.

A brief examination of level data showed that high liquid levels in MH No. 65 typically occur when the wet well is overflowing and the inflow to the station exceeds 4 mgd. High liquid levels may be related to the backup of liquid in the sewer during wet well overflows. The proposed installation of a storage basin would decrease the frequency of high wet well levels, and should decrease the risk of overflows at MH No. 65.

ESD does not recommend any modifications to the influent sewer at this time. Metro may want to examine flow and level data measured after construction of the Phase 1 storage basin, to determine whether to add influent sewer improvements to the Phase 2 construction.

The elevation of the overflow weir in MH No. 65 is set at its current level to protect upstream properties. This weir should not be raised.

OUTFALL MODIFICATIONS

A hydraulic analysis of the existing outfall conducted in 1977 by Metro staff indicated that the existing outfall can accommodate wet well overflows of more than 4.5 mgd without causing a backup that would submerge the wet well weir.

This means that the existing pumps and outfall together can handle a station inflow greater than the one-year inflow of 6.8 mgd without this kind of a backup occurring. ESD does not recommend any modifications to the existing outfall.

If Metro considers upgrading the influent sewer in the future to accommodate very large storms, the ability of the outfall to handle the associated peak inflows should be evaluated concurrently.

Appendices

APPENDIX A

HYDROLOGIC MODELING ANALYSIS REPORT

NORTH BEACH PUMP STATION
HYDROLOGIC MODELING ANALYSIS

Prepared by: Bob Swarner
Mike Thompson
of the Application Development & Support Section of ISD

Date: September, 1992

Scope of This Hydrologic Analysis

The North Beach Pumping Station basin is a separated sewer area which has a significant volume of inflow and infiltration during storm events. A number of overflows occur at the pump station each year. Two flow meters were placed near the pump station in 1989 to record depths and flows. The purpose of this hydrologic analysis is to investigate the flow data and its relationship to the rainfall record, simulate thirteen years of flow using a computer program, and perform the following tasks for use in the pre-design of facilities to reduce the frequency and volume of overflows in the basin:

- Compute the Average Dry Weather Flow (ADWF) for the metered period;
- Compute the Average Wet Weather Flow (AWWF) for the metered period;
- Estimate the number of overflow events per year at North Beach Pump Station;
- Estimate the total overflow volume per year at North Beach Pump Station;
- Estimate the peak flow entering the North Beach Pump Station;
- Determine the volume of storage needed as a function of pumping capacity to reduce overflows at North Beach Pump Station to a one per year frequency;
- Estimate the overflow reduction achievable from interim facility improvements;
- Estimate the peak flow from the gravity line coming from Woodbine Ave. NW. and entering the North Beach force main in Carkeek Park.

Background

Brown & Caldwell Consultants completed the Carkeek Flow Analysis as part of Metro's Carkeek Facilities Plan in 1988. Flow estimates for the North Beach basin were derived during the analysis. There was limited flow data on which to base those estimates. The results from the Brown & Caldwell analysis are documented in the Carkeek Facilities Plan.

During the fall of 1988 and spring of 1989, two flow sensors were installed at the North Beach Pumping Station to obtain good flow data from the basin. The sensors are Marsh-McBirney Flo-Totes, which measure both depth and velocity in 5 minute increments and generate a flow rate based on the two measured values.

One meter was placed in the 18" pipe entering the wet well. A second meter was placed in an overflow manhole about 110 feet upstream from the entrance to the wet well. A 30" pipe transitions to an 18" pipe in this manhole and an overflow weir is about 2" above the crown of the 30" incoming line. The flow meter was placed in the 18" pipe exiting the manhole, just downstream of the overflow weir and transition from the 30" pipe.

Basin Characteristics

The North Beach basin is a fully developed, mostly residential, neighborhood. The impervious surfaces of rooftops and pavement account for about 25% of the basin area. Storm drainage is generally into unlined ditches which transport flow to the storm drains.

Average Dry and Average Wet Weather Flows

Measured flows were reviewed to determine the average dry weather flow (ADWF) and average wet weather flow (AWWF). ADWF is defined as the average flow during the months of April through August, including storm flows. AWWF is defined as the average flow during the months of September through March, including storm flows. These definitions are the same as used in the Carkeek Facilities Plan.

The measured flow data during the two years of data collection is summarized in Table A.

Table A
Average Flows at North Beach Pump Station

Dry Season	ADWF (mgd)	Wet Season	AWWF (mgd)
1989	0.36	1989-1990	0.49
1990	0.41	1990-1991	0.57

Overflow Frequency and Volume during Metering Period

The overflow weirs in the wet well and in the upstream overflow manhole were field-measured to verify the as-built information. It was discovered that the weir in the wet well is only 9.0 feet long, instead of the 10.5 feet shown on the as-built drawing. This correction was made to Metro's spreadsheet program which is used to compute overflow volumes. The corrected overflow occurrences and volumes are listed in Table B for the years when the meters were in place.

The upstream overflow weir was measured as 32.5 inches above the invert of the 18" pipe. A corrected estimation of the overflow occurrences and volumes using this new information is shown in Table C for the upstream manhole.

Table B
Wet Well Overflows

Year	Number of Overflows	Volume of Overflows (MG)
1989*	6	0.59
1990	15	2.76
1991	24	2.75
1992**	17	2.26

* Began on March 24, 1989
** Through July 15, 1992

Table C
Upstream Manhole Overflows

Year	Number of Overflows	Volume (mg)
1988*	2	0.224
1989	0	0
1990	0	0
1991	0	0
1992**	1	0.009

* Began Oct. 28, 1988
** Through July 15, 1992

Rainfall and Storm Information

Rainfall Data

The rain data from City of Seattle gauge #7, located at Whitman Jr. High was used for calibration and simulation of flows for the North Beach Pump Station. The gauge is in the North Beach Pump Station basin.

The rain gauge records rainfall in hundredths of an inch for each minute in which there has been rain.

One-year Storm Intensity

The storm intensity-duration curves for the North Beach area were investigated to determine the best measure of a one-year design event. The time to concentration for the area that is directly connected to the sewer system is about two hours. Only about 2% of the basin is directly connected, however. Half of the peak flow rate can consist of flow that enters in a delayed fashion from the groundwater. There is no definitive relationship between rainfall intensity and peak flows for any duration of storm because antecedent conditions contribute so much to any large flow.

The storm flows have been simulated for the 13 years, from 1978 through 1990, using the rain data from the city gauge in the basin. Flow rates and overflow volumes were computed from this 13 years of simulated record to obtain overflow statistics and impacts of storage and pump station upgrades.

Computer Modeling of North Beach Basin

Runoff Model

Metro's Runoff model was used to simulate sanitary and storm flows through the North Beach collection system. The Runoff model is a physically-based model which includes components of overland flow, dry-weather domestic flow, dry-weather infiltration and wet weather infiltration to the sewer system. The model uses a kinematic wave formulation in solving the St. Venant equations for overland flow.

Metro's Runoff Model was modified to simulate the excessive inflow and infiltration which is characteristic of the North Beach basin. The model now incorporates varying dry-weather flow and three components of

infiltration. The infiltration includes a constant dry-weather value, a decaying wet weather value, and a large flow factor which is assumed to enter the sewer pipes during substantial rain events through leaky connections or damaged pipes. The Runoff model computes flow in ten minute increments.

Model Calibration

Flow data from the entrance to the North Beach Pump Station wet well from October 14, 1989 through February 4, 1991 was used to calibrate Metro's Runoff model to simulate the flow to the pumping station based on rainfall at the city of Seattle rain gauge #7. (The rain data from gauge #7 is interrupted on February 5, 1991.)

The basin was broken down into 3 subbasins, as was done in the Carkeek Facilities Plan. The basin parameters used by B&C were used as a starting point in the calibration process. The basin parameters were adjusted until the best fit to the flow data was achieved. The outflow hydrographs from the three basins were added to estimate the flow at the pump station. The confluence of the three basins is only 170 feet upstream from the wet well.

Calibrating the model to the flow data revealed that a significant portion of the basin is directly connected to the sewer system. Values of 5 to 15% of the impervious basin areas were used (2 % of the entire basin). A large contribution of inflow enters the system only after significant rainfall has fallen over the basin. It is suspected that this portion of the inflow is due to rainwater that infiltrates into the ground, collects in the filled-in trenches in which the sewer pipes were laid, and enters the sewer pipes through leaky connections.

The Runoff model was modified to simulate this infiltration from the ground into the sewer pipes. Rainfall volume which infiltrated into the ground was used as the basis for the rate and volume of flow entering the pipes.

Table D contains the calibrated basin parameters for each of the sub-basins.

The final calibration results are shown on Figures 1-5 for the eight largest storms in the October, 1989 - Feb. 4, 1991 time frame. The Runoff model simulated 26 overflow events during the calibration time period compared to 23 overflow events indicated by the flow meter at the wet well. The total

Figure 1. Comparison of Simulated Data to Flow Data
Dec. 2-5, 1989

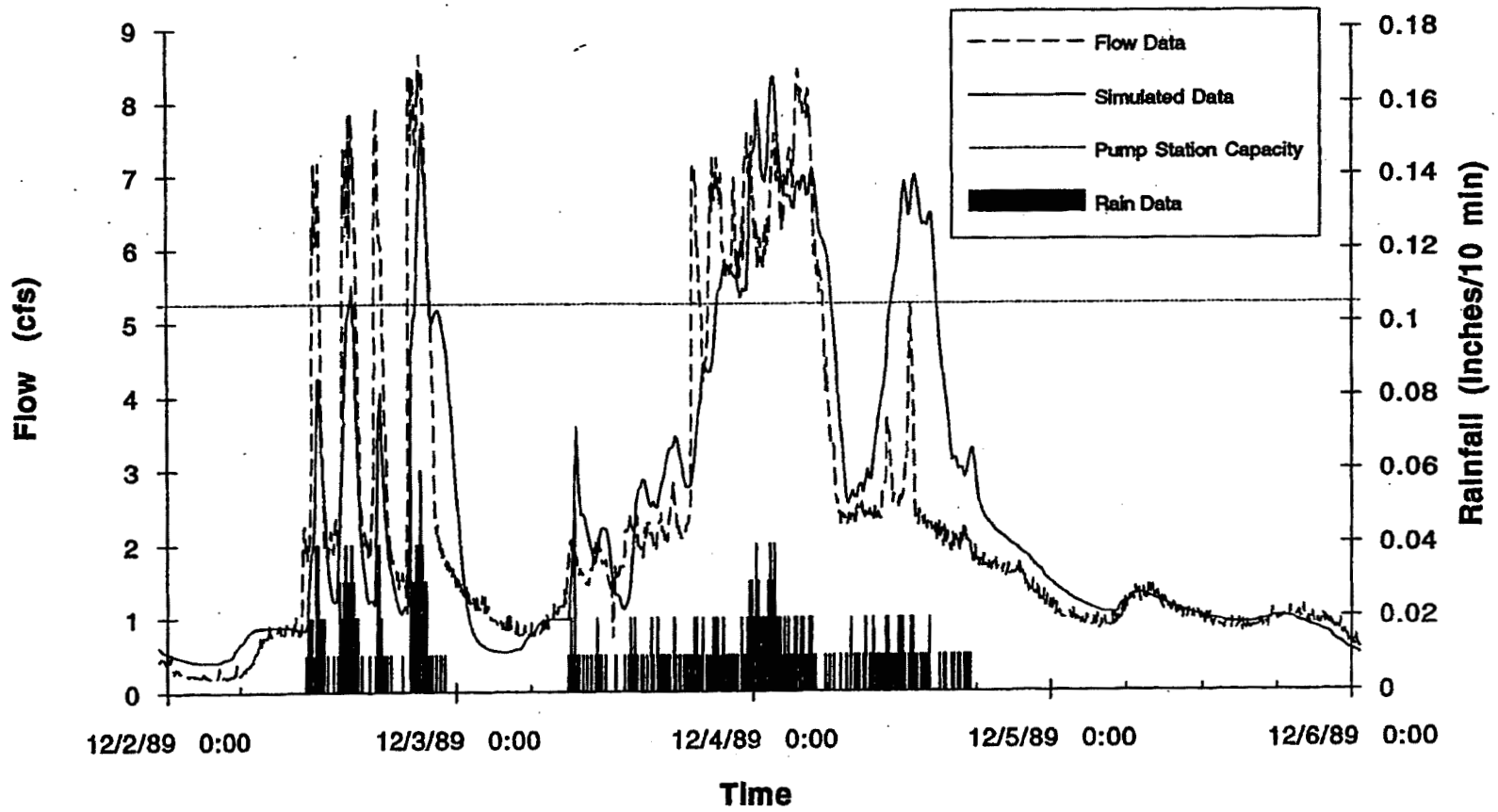


Figure 2. Comparison of Simulated Data to Flow Data
Jan. 5 - 10, 1990

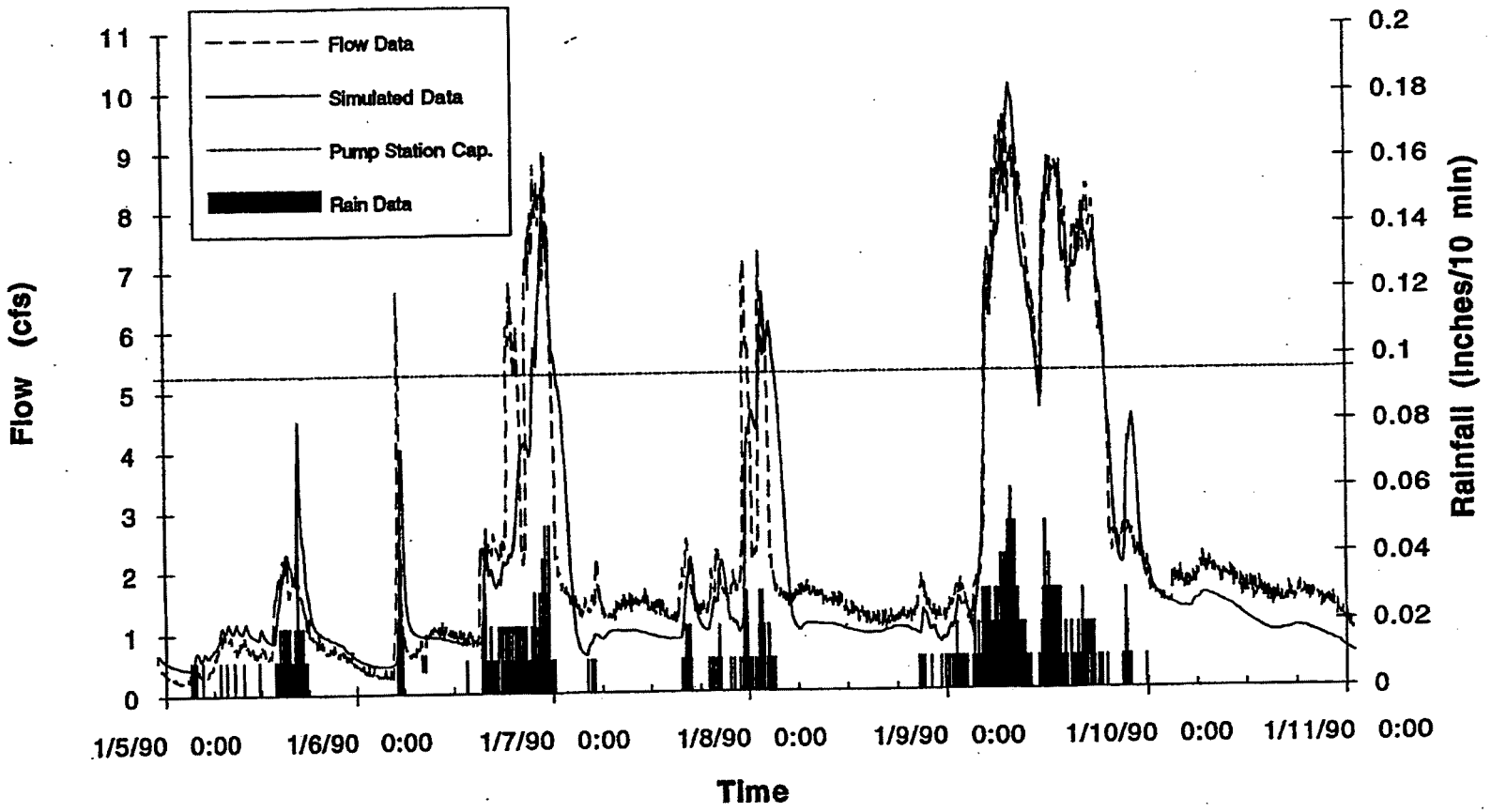


Figure 3. Comparison of Simulated Data to Flow Data
Jan. 30 - Feb. 2, 1990

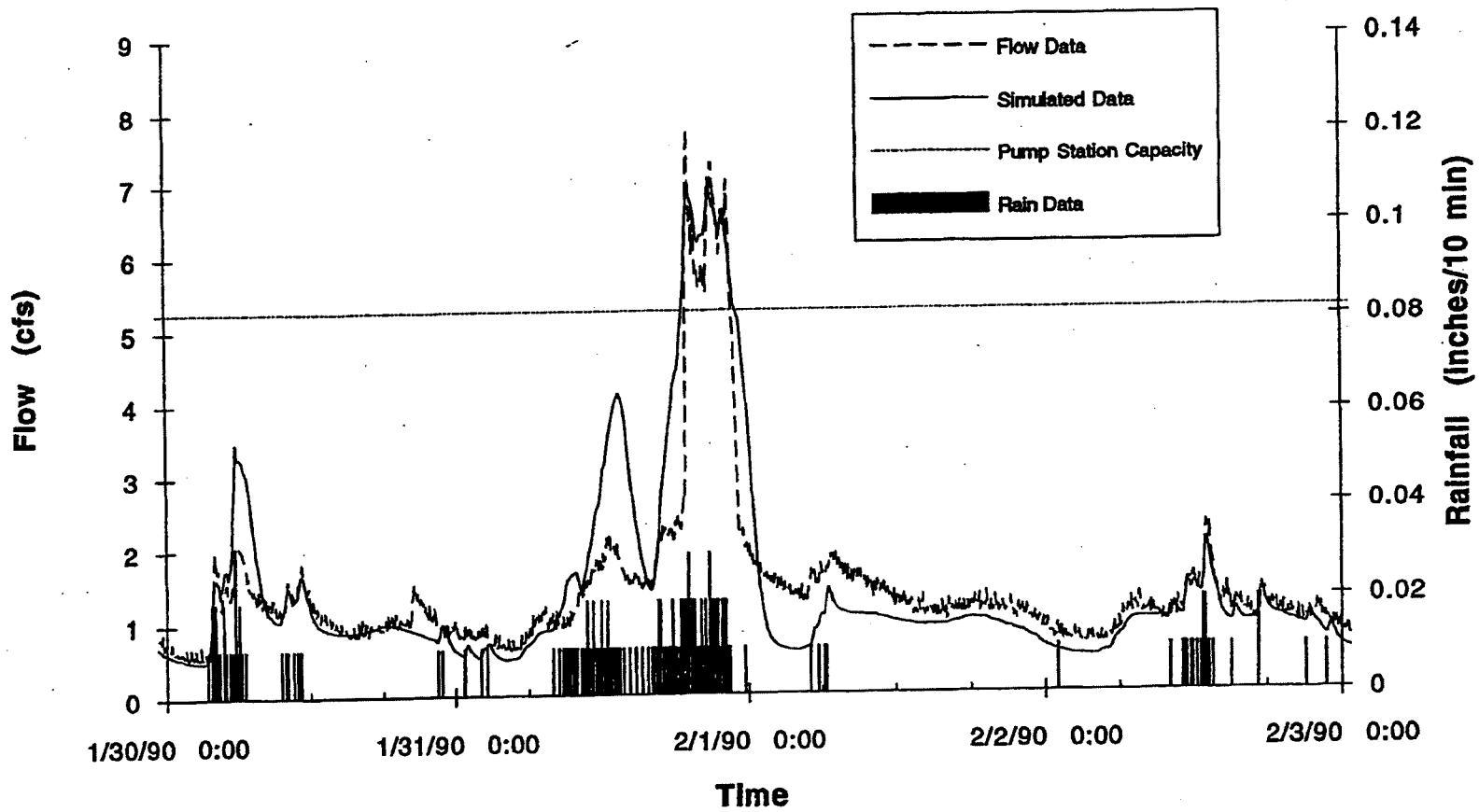


Figure 4. Comparison of Simulated Data to Flow Data
Nov. 23-26, 1990

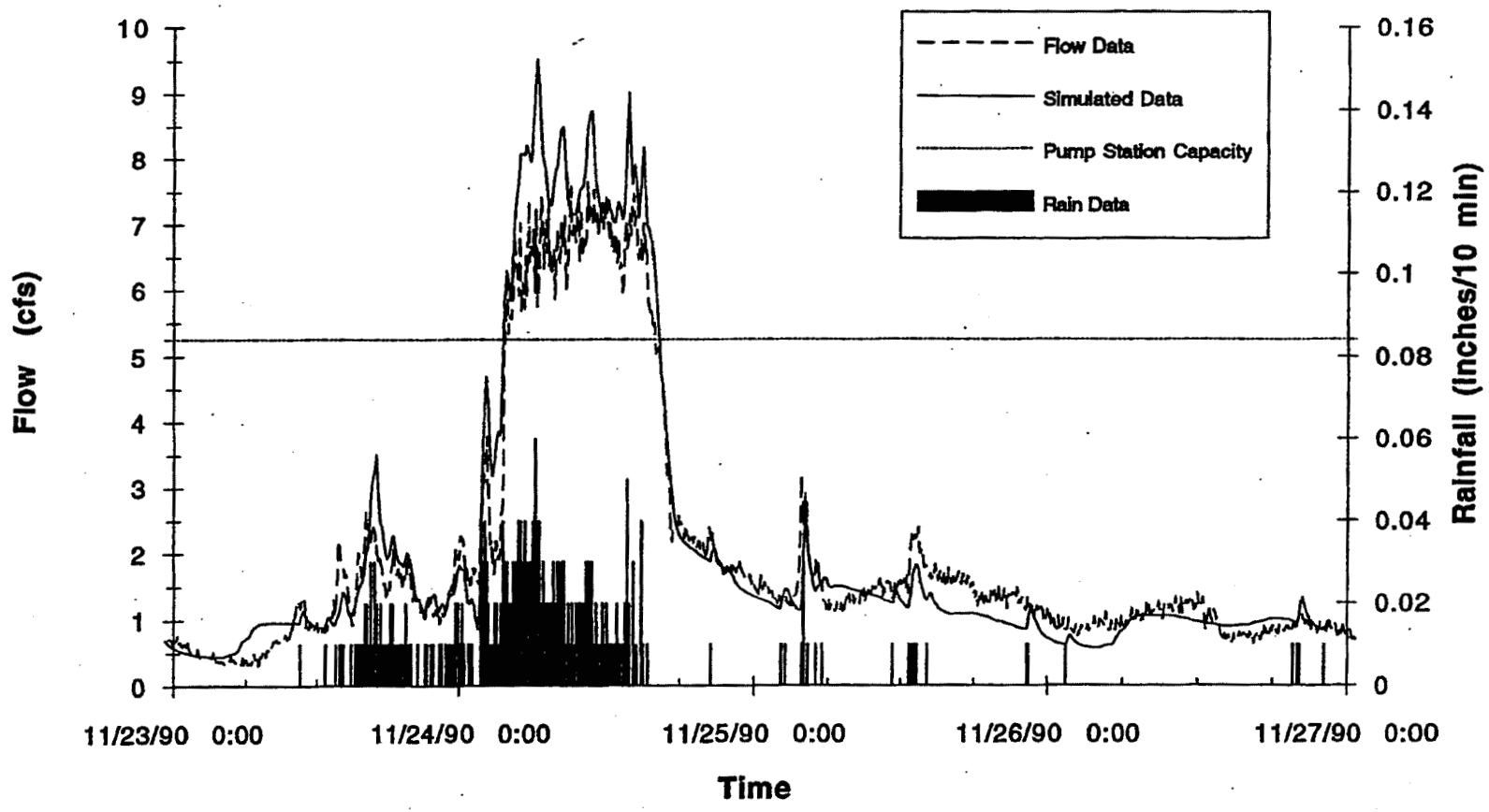


Figure 5. Comparison of Simulated Data to Flow Data
Feb. 1-4, 1991

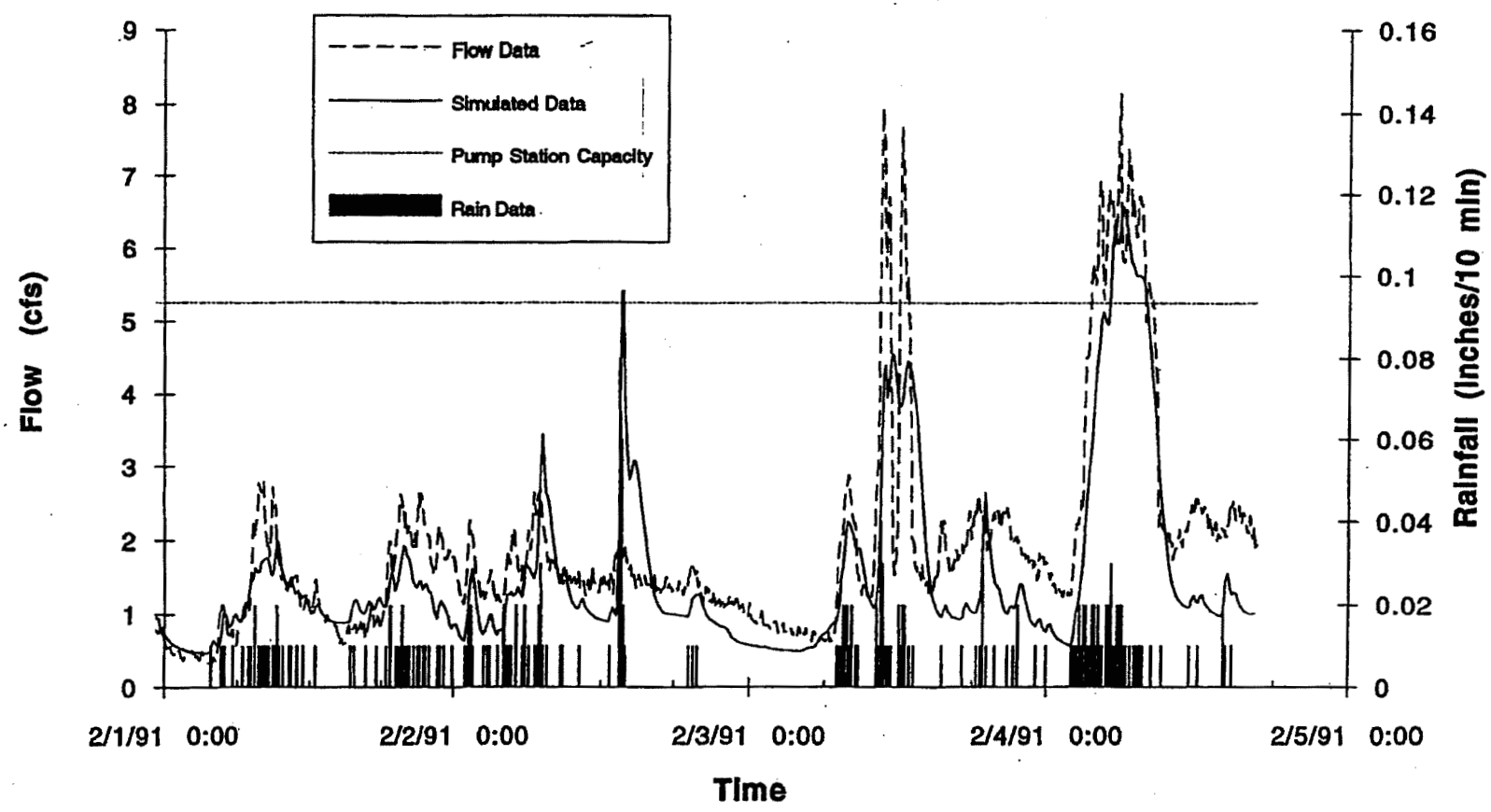


Table D
Basin Parameters

Parameter	Basin 2	Basin 3	Basin 4
Slope	.0396	.0604	.0765
Length of pipe (ft)	51305	43365	13870
Area (ac)	303	248	102
% impervious	25	25	25
Manning's n (imperv)	.014	.014	.014
Manning's n (perv)	.35	.35	.35
Soil permeability (in/hr)	.175	.175	.175
Soil porosity	.5	.5	.5
Suction head (in)	.03	.03	.03
Avg. Base flow (mgd)	.147	.117	.031
% connected imperv.	5	8.7	15.4
% connected perv.	0	0	0
Dry weather I/I (gpad)	109.4	579.3	15.8

volume of overflow simulated by the model was 2.81 million gallons, compared to 2.79 million gallons indicated by the flow meter.

Existing Overflows

Thirteen years of rainfall data (1978 - 1990) were used as input to the Runoff model to simulate 13 years of flow at the North Beach Pump Station. The existing pump station capacity was assumed to be 3.4 mgd, based on pump testing in 1991.

The resulting estimate of existing overflows at the North Beach Pump Station is shown in Table E..

Table E
Existing Overflows

Number of Overflows (Events/yr)	Volume of Overflow (MG/yr)
18	1.9

Peak Flow Analysis

The peak flow recorded by the flow meter in 1989 - 1992 at the North Beach Pump Station was 6.2 mgd, during the large January 9, 1990 storm.

Based on thirteen years of simulated flow data, the 10-minute peak flow with a return period of one year at the North Beach Pump Station is 6.8 mgd.

Reduction of Overflows to One Event per Year

Two options for reducing the overflows at the North Beach Pump Station to one event per year are 1)increasing pumping capacity and 2)adding storage. A combination of these measures can also be effective in reducing overflows. If the pump station is upgraded, the storage volume required to reach the one-per-year frequency will be reduced.

Storms are defined as separate in this analysis if there is at least 3 hours between overflows.

Sizing of a Storage Facility with Pump Station Upgrade

The capacity of the pump in the storage facility influences the storage required to reduce the overflows to one event per year. The pumpout rate of the storage facility affects the emptying time, which in turn, affects the available volume of storage for subsequent storms.

The pumps are assumed to be fixed speed pumps. Therefore, the inflow to the pump station would need to be equal to or lower than the pump station capacity minus the storage pump capacity before the storage pump would begin to empty the stored wastewater.

The storage volume required to reduce overflows to one event per year and the resulting average annual overflow volumes are listed in Table F for four pump station capacities and for four storage pump capacities.

Table F
Pump Capacity/Storage Relationships
to meet the One Overflow Event per Year Criteria

Pump Station Capacity (mgd)	Storage Pumpout Rate* (mgd)	Storage Required (gal)	Average Annual Overflow Remaining (MG)
3.4 (existing)	0.36	474,000	0.39
	0.72	460,000	0.40
	1.08	466,000	0.39
	1.44	466,000	0.39
4.0	0.36	248,000	0.29
	0.72	252,000	0.28
	1.08	252,000	0.27
	1.44	252,000	0.28
4.5	0.36	142,000	0.19
	0.72	133,000	0.20
	1.08	128,000	0.20
	1.44	119,000	0.21
5.0	0.36	70,000	0.12
	0.72	67,000	0.13
	1.08	67,000	0.13
	1.44	67,000	0.13

* Constant flow rate

Interim Benefits from a Pump Station Upgrade

Overflow reduction can be achieved on an interim basis by either upgrading the pump station while delaying the addition of storage or by adding some storage and delaying the upgrade of the pump station. The estimated number of overflows per year and the corresponding overflow volumes for four pump station capacities without the addition of off-line storage are listed in Table G.

Table G
Overflow Frequency and Volume with Interim Pump Station Upgrade

Pump Station Capacity (mgd)	Number of Overflows/year	Overflow Volume/yr (MG)
3.4 (existing)	18	1.91
4.0	12	0.96
4.5	8.5	0.51
5.0	5.0	0.27

Interim Benefits from Storage Capacity

The interim benefits from adding off-line storage at North Beach Pump Station while delaying the upgrade of the pump station capacity are listed in Table H.

Table H
Overflow Frequency and Volume with Interim Off-line Storage
(Pump Station capacity kept at 3.4 mgd)

Storage Volume Provided (gal)	Storage Pump-out Rate* (mgd)	Number of Overflows/yr	Overflow Volume/yr (MG)
70,000	0.36	6.0	1.30
67,000	0.72	5.9	1.31
67,000	1.08	5.8	1.32
67,000	1.44	6.1	1.33
133,000	0.72	3.8	1.01
128,000	1.08	3.9	1.03
119,000	1.44	4.2	1.08
252,000	1.08	2.0	0.68
252,000	1.44	2.1	0.69

* Constant flow rate

Peak Flow to Force Main from Gravity Line from NW Woodbine Way

There are 85 acres in the gravity line basin entering the North Beach force main from NW Woodbine Way. The sewers in the gravity line basin and North Beach sub-basin #4 were constructed about the same time and the land use is similar. Therefore, the basin parameters from sub-basin #4 were used as the characteristics for the gravity line basin for computer simulations of flows.

A rehabilitation project to reduce inflow was completed in the gravity line basin in 1986. No metering data since then is available to validate the peak flow estimate.

Based on thirteen years of simulated flow data, the 10-minute peak flow with a return period of one year is 1.0 mgd.

The average dry weather flow from this basin is estimated to be 0.04 mgd and the average wet weather flow is approximately 0.05 mgd.

APPENDIX B

COST ESTIMATE SUMMARY
PHASE 1

North Beach Pump Station -- Predesign Cost Estimate				
140,000 Gallon Storage Basin				
	Quantity	Unit	Unit cost	Price
Storage Basin				
Excavation	2275	CY	5.00	11375
Haul & disposal	2275	CY	9.00	20475
Shoring	6010	SF	38.00	228380
Dewatering		LS		15000
Slab on grade	45	CY	350.00	15750
Walls	142	CY	400.00	56800
Elevated slabs	39	CY	450.00	17550
Columns and Beams		LS		5100
Misc. Concrete	46	CY	400.00	18400
Conc. Sack & Paint	6150	SF	2.50	15375
Imported backfill	725	CY	25.00	18125
Water and Washdown		LS		19100
Ventilation fans	2	EA	17550.00	35100
Misc. Metals		LS		26350
Return Pumping				
Excavation and Disposal	260	CY	14.00	3640
Sheeting	2600	SF	11.00	28600
Concrete lift station		LS		10400
Bedding/Backfill	200	CY	25.00	5000

Pumps	2	EA	4260.00	8520
Pump install & testing		LS		4260
Pump control panel	1	EA	6000.00	6000
Lift station mech.		LS		23300
Discharge pipe & trench		LS		4500
Electrical		LS		45969
Other				
Surveying		LS		5000
Sitework & Demolition		LS		17950
Subtotal				666019
Mobilization		5%		33301
Subtotal				699320
Contractor OH & P		20%		139864
Subtotal				839184
Sales tax		8.20%		68813
Subtotal				907997
Contingency		30%		272399
Subtotal				**1180396**
Permits, easements				40000
Allied costs		31%		382000
Total				**1602396**

1,220,396

APPENDIX C

COST ESTIMATE SUMMARIES
PHASE 2

North Beach Pump Station -- Predesign Cost Estimate				
Replace 2060 LF of Force Main with HDPE / City Pipeline Modifications				
	Quantity	Unit	Unit cost	Price
Excavation	2230	CY	5.00	11150
Haul & disposal	1430	CY	9.00	12870
Trench box	1	LS	2000.00	2000
Trench support	6500	SF	1.20	7800
HDPE pipe - 18 ", 160 PSI	2060	LF	24.00	49440
Pipe install. labor - west	1860	LF	3.50	6510
Pipe install. labor - east	200	LF	5.50	1100
Jacked casing	200	LF	230.00	46000
Pipe bedding & backfill	1085	CY	30.00	32550
Native backfill	800	CY	10.00	8000
Tee structure	1	LS	9800.00	9800
Fusion truck	1	LS	5400.00	5400
Bypass pumping	1	LS	9000.00	9000
Pipe testing	1	LS	5000.00	5000
Clearing and landscaping	1	LS	13400.00	13400
Pavement demo & replace	1	LS	4800.00	4800
Misc. special costs	1	LS	30750.00	30750
City Pipeline Modifications	1	LS	29400.00	29400
Subtotal				284970
Mobilization		5%		14249

Subtotal				299219
Contractor OH & P		20%		59844
Subtotal				359062
Sales tax		8.20%		29443
Subtotal				388505
Contingency		30%		116552
Subtotal				505057
Allied costs		31%		156568
Total				**661625**

North Beach Pump Station -- Predesign Cost Estimate			
Station Upgrade to 4.5 MGD			
SUMMARY			
Detail Sheet / Item			Dollars
1 / Structural, site work			115290
2 / Pumps, motors, piping			179330
3 / Other mechanical			33700
4 / Electrical			171810
Subtotal			500130
Mobilization	5%		25007
Subtotal			525137
Contractor OH & P	20%		105027
Subtotal			630164
Sales tax	8.20%		51673
Subtotal			681837
Contingency	30%		204551
Subtotal			886388
Permits, easements			40000
Allied costs	31%		287180
Total			1213569

North Beach Pump Station -- Predesign Cost Estimate				
Pump Station Upgrade to 4.5 MGD				
Pump Station Addition - Structure and Site Work				
	Quantity	Unit	Unit cost	Price
Excavation	600.00	CY	5.00	3000
Haul & disposal	600.00	CY	9.00	5400
Shoring	1880.00	SF	21.00	39480
Dewatering		LS		10000
Slab on grade	23.00	CY	350.00	8050
Walls & Misc. conc.	37.00	CY	400.00	14800
Elevated slabs	13.00	CY	450.00	5850
Beams	8.00	CY	550.00	4400
Doorway		LS		1000
Conc. Sack & Paint	1825.00	SF	1.60	2920
Imported backfill	320.00	CY	26.00	8320
Plumbing fittings		LS		500
Drainage piping	60.00	LF	24.00	1440
Relocate Water Line	35.00	LF	18.00	630
Surveying		LS		2500
Sitework		LS		7000
Subtotal				115290

North Beach Pump Station -- Predesign Cost Estimate				
Pump Station Upgrade to 4.5 mgd				
Pump Room -- Raw Sewage Pumps and Piping				
	Quantity	Unit	Unit cost	Total
Pumps				
Pumps, 100 hp	2	EA	25500.00	51000
Pumps, 30 hp	2	EA	20500.00	41000
Subtotal				92000
Pump Install & Test	50%			46000
Total				138000
Raw Sewage Piping				
Remove existing pumps	4	EA	2000.00	8000
Remove pump bases	4	EA	125.00	500
Remove seal water piping	4	EA	100.00	400
10-inch spool	2	EA	500.00	1000
10-inch plug valve	2	EA	2600.00	5200
10-8 Reducer coupling	2	EA	500.00	1000
6-inch 45 elbow	2	EA	355.00	710
6-8 Reducer coupling	2	EA	400.00	800
8-inch check valve	2	EA	1000.00	2000
8-inch elbow, flanged	2	EA	425.00	850
8-inch elbow, welded	2	EA	190.00	380
8-inch plug valve	4	EA	1600.00	6400
8-inch flex coupling	4	EA	200.00	800
8-inch spool	4	EA	400.00	1600
4-inch 45 elbow	2	EA	140.00	280
4-6 Reducer coupling	2	EA	300.00	600
6-inch spool	2	EA	300.00	600
6-inch check valve	2	EA	650.00	1300
6-inch elbow, flanged	2	EA	320.00	640
6-inch plug valve	2	EA	1000.00	2000
6-inch flex coupling	2	EA	150.00	300
6-inch elbow, welded	2	EA	185.00	370
Pipe supports	12	EA	250.00	3000
Chem seal & gages	4	EA	650.00	2600
Total				41330

North Beach Pump Station -- Predesign Cost Estimate				
Pump Station Upgrade to 4.5 MGD				
Ancilliary Mechanical Systems				
	Quantity	Unit	Unit cost	Total
Generator System				
Silencer	1	EA	1200.00	1200
Day Tank and transfer pump	1	LS	2000.00	2000
Cooling water piping	75	LF	12.00	900
Motor Room/Seal Water				
Seal water pumps	2	EA	500.00	1000
Flushing water pump	1	EA	500.00	500
Air break tank	1	EA	1500.00	1500
Pump room seal piping	60	LF	10.00	600
Instrument Air System				
Replace system in kind	1	LS	2500.00	2500
Sump Pump				
Replace in kind	1	EA	600.00	600
HVAC				
Ductwork in new room	1	LS	1000.00	1000
Wet well supply/exh fans	2	EA	4500.00	9000
Dry well supply/exh fans	2	EA	3500.00	7000
Hole in wall for duct.	1	LS	900.00	900
Other				
Repair hatch	1	LS	1500.00	1500
Equip./Pipe Painting	1	LS	2500.00	2500
Hoist rail relocation	1	LS	1000.00	1000
Subtotal				33700

METRO-Systems Integration

PROJECT INFORMATION: 100 HP OPTION

PROJECT TITLE: NORTH BEACH PUMP STATION

LOCATION: TRITON DRIVE OFF 28TH AVE NW NORTH SEATTLE

PROJECT NUMBER: A43301 TASK #: W03

PREPARED BY: CHARLES D. REYNOLDS DATE: 18-Nov-92

ITEM DESCRIPTION	MATERIAL QTY	MATERIAL UNIT	MATERIAL UNIT PRICE	MATERIAL TOTAL	LABOR LABOR RATE	LABOR TOTAL	TOTAL PER UNIT	TOTAL
DEMOLITION:								
Remove 4 #1/0 wires and conduit (75HP)	80	LF			1.55	124.00	1.55	124.00
Remove 4 #8 wires and conduit (20HP)	80	LF			1.26	100.80	1.26	100.80
Remove existing Generator	1	LS			1500.00	1500.00	1500.00	1500.00
Remove existing Automatic Transfer Switch	1	EA			220.00	220.00	220.00	220.00
Remove Existing Incoming/Metering Section	1	EA			300.00	300.00	300.00	300.00
CONSTRUCTION:								
100HP VFD W/200A CB (Size 4 Starter)	2	EA	25725.00	51450.00	551.00	1102.00	26276.00	52552.00
2" RGS, 3#2/0, 1 #6 Ground	120	LF	8.81	1057.20	7.82	938.40	16.63	1995.60
30 HP Starter in MCC W/70A CB	2	EA	1446.00	2892.00	280.00	560.00	1726.00	3452.00
1 1/4" C, 3 #6, 1 #8 Ground	140	LF	3.75	525.00	5.17	723.80	8.92	1248.80
New 600A - ATS in MCC	1	EA	8350.00	8350.00	420.00	420.00	8770.00	8770.00
New Generator (500kW)	1	EA	50000.00	50000.00	3930.00	3930.00	53930.00	53930.00
New Incoming (Service Entrance) Section	1	EA	3030.00	3030.00	380.00	380.00	3410.00	3410.00
New MCC Equipment mounting sections	3	EA	1060.00	3180.00	260.00	780.00	1320.00	3960.00
Generator set to MCC feeder section (3) 3" C, 4 #300kcmil, 1 #1/0 ground	30	LF	63.96	1918.80	42.87	1286.10	106.83	3204.90
1" C, #4/0 Bare Cu. (Ground Wire)	100	LF	3.76	376.00	4.26	426.00	8.02	802.00
Exothermic Weld	4	EA	7.95	31.80	30.00	120.00	37.95	151.80
2 lamp - Industrial Fluorescent fixture	6	EA	63.00	378.00	37.00	222.00	100.00	600.00
Convenience outlets	4	EA	32.00	128.00	36.00	144.00	68.00	272.00
3/4" C, 2 #12, 1#12 Ground	140	LF	1.76	246.40	3.41	477.40	5.17	723.80
CONTROL SYSTEM REWORK:								
Moore Controllers	4	EA	1000.00	4000.00	120.00	480.00	1120.00	4480.00
Control wiring	200	LF	0.54	108.00	0.44	88.00	0.98	196.00
SUBTOTAL				127,671		14,323		141,994
OVERHEAD	10.00%							14,199
PROFIT	10.00%							15,619

ELECTRICAL TOTAL $171,812