

CITY OF BREMERTON

**WARREN AVENUE COMBINED SEWER REHABILITATION
AND STORM DRAINAGE SEPARATION PROJECT**

**Water Quality Assessment
and
Basin Survey - Source Control Plan**

Prepared For:

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I. WATER QUALITY ASSESSMENT

1.0 INTRODUCTION

Currently, the City of Bremerton's combined sewer system in the Warren Avenue basin results in CSO events exceeding the one-per-year criteria established by the State of Washington. These overflows are discharged to the Port Washington Narrows through outfalls at two locations. The Warren Avenue CSO Reduction Project will reduce the frequency of CSO discharges by separating the stormwater portion of the flow from the sanitary sewer. When this action is implemented, the separated stormwater will be discharged to the Narrows through a new storm sewer system and outfalls.

1.1 Purpose and Scope

The purpose of this water quality assessment is to discuss potential water quality concerns resulting from the new stormwater outfalls. This assessment has been prepared in response to the Washington Department of Ecology (Ecology) condition of Engineering Report approval. Objectives of this assessment include:

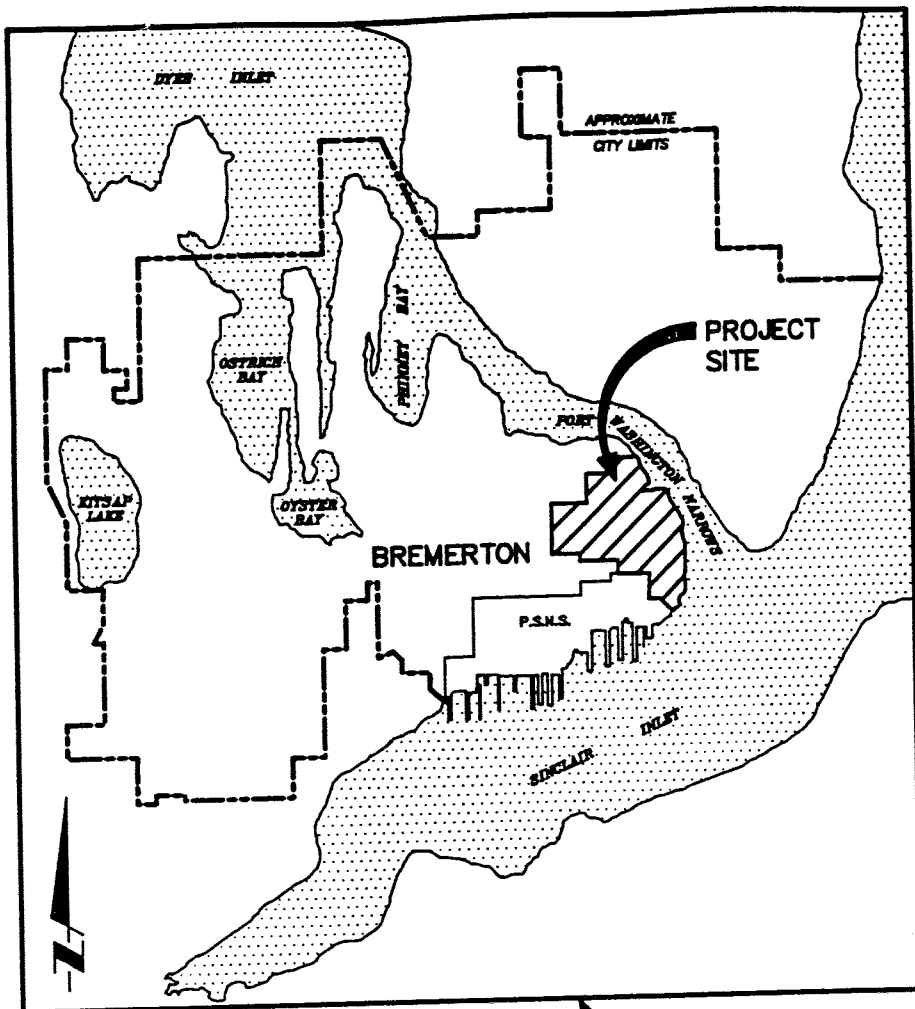
- Establish preliminary flow and wasteload estimates for key toxicants expected in the runoff.
- Evaluate alternatives for location, size, and depth of the new stormwater outfalls.
- Discuss state water and sediment quality standards as they apply to stormwater discharges.
- Assess potential water and sediment impacts and issues of compliance with the standards.

No field data was collected in direct support of this assessment. Only preliminary modeling has been conducted, and other design criteria have not been finalized. Therefore, this assessment of potential water quality impacts is generally qualitative. It should be noted that this water quality assessment was performed based on existing conditions and does not reflect potential water quality benefits associated with City source control and public education efforts.

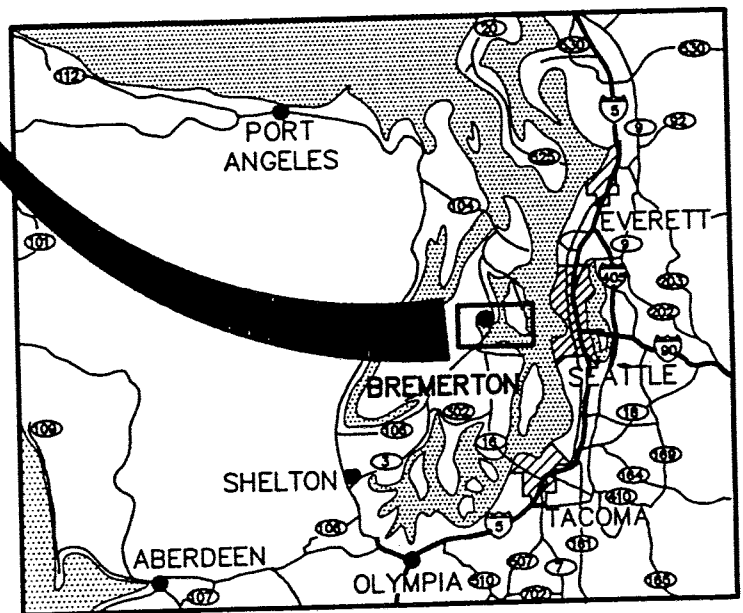
2.0 STORMWATER FLOW AND WASTELOAD

2.1 Drainage Sub-Basins

The Warren Avenue drainage basin is shown in Figures I-1 and I-2. Runoff from most of the basin will be collected and discharged through two separate outfalls. The largest sub-basin (207 acres) will be served by a new 48-inch outfall located on 14th Street. The existing 36-inch outfall through Evergreen Park will handle runoff from the other primary sub-basin (21 acres). The Park and Highland Avenue sub-basins (combined <10 acres) are minor areas that are not considered in this assessment.

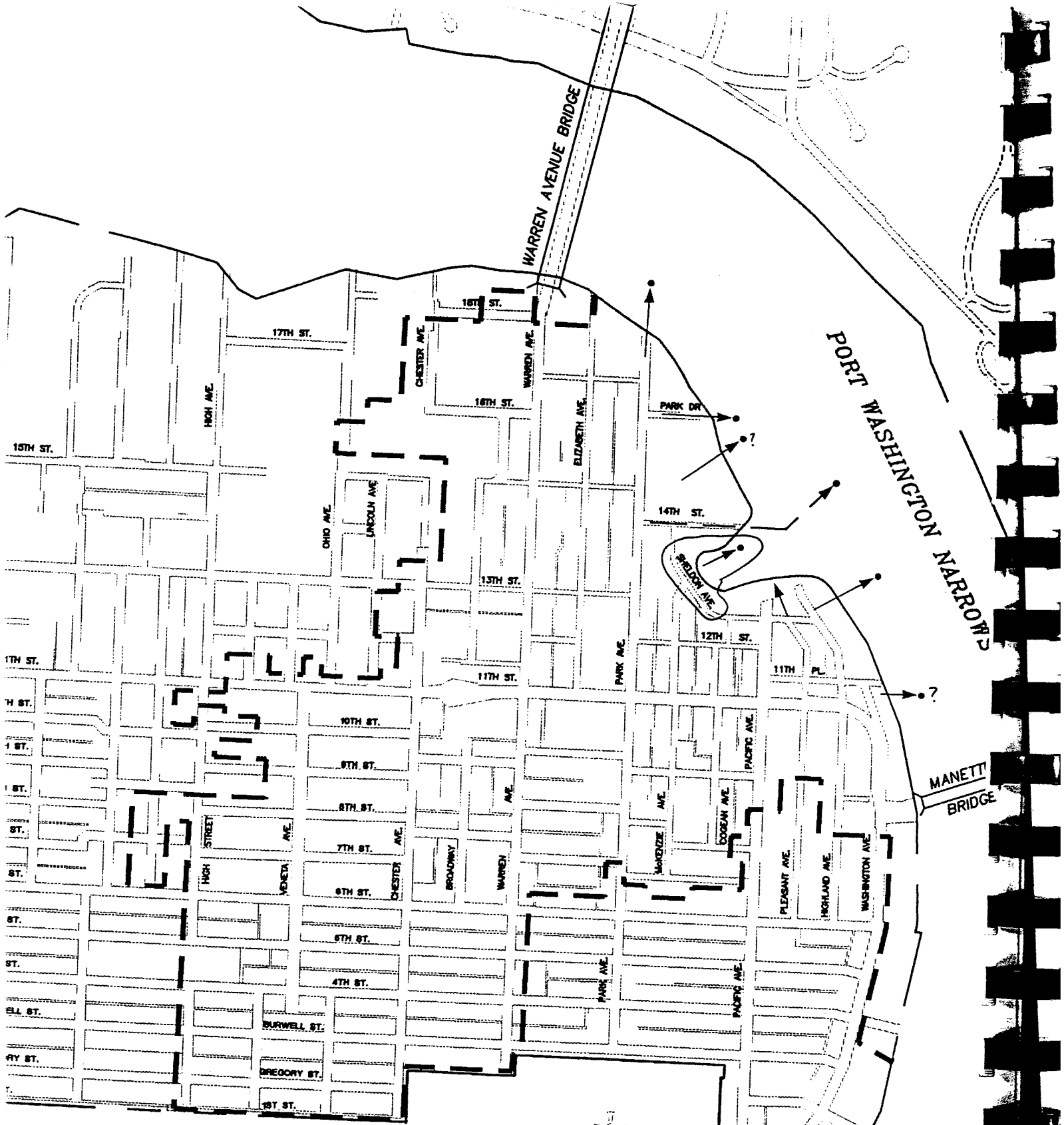


LOCATION MAP



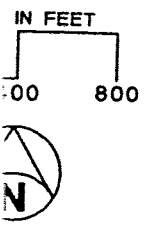
VICINITY MAP

**Figure I-1.
 Project Vicinity
 and Location.**



PUGET SOUND NAVAL SHIPYARD

SOURCE: CITY OF BREM



- LEGEND**
- BASIN BOUNDARY
 - EXISTING CSO OUTFALL
 - EXISTING STORM OUTFALL
 - - - →•** PROPOSED REPLACEMENT STORM OUTFALL

Figure I-2.
Warren Avenue CSO
Separation Project Area.

2.2 Hydrographs

The hydrographs for the one-year storm in the 14th Street and Evergreen Park basins are shown on Figures I-3 and I-4. The hydrographs are based on the model HYDRA™ and a Soil Conservation Service (SCS) Type 1A 24-hour storm totalling 2.4 inches of rain. The peak one-hour flows are approximately 80 cubic feet per second (cfs) for the 14th Street basin, and 10 cfs for the Evergreen Park basin.

2.3 Annual Flow Volume

Based on annual rainfall, basin size, and assumed C value of approximately 0.55, the order-of-magnitude runoff estimates for both basins are:

- 14th Street - 100 million gallons
- Evergreen Park - 10 million gallons

2.4 Toxicant Concentration - Sediments

Ecology personnel collected sediment samples from eight storm drainage pipes in Bremerton in June 1992, which were analyzed for metals, volatiles, semi-volatiles and pesticides (Cubbage, 1992). Three of the sites were in the Warren Avenue basin at locations generally near discharge points. Results of these analyses are shown in Table I-1.

	Marine Sediment			
	Standard	End of 11th Street	End of Park Avenue	* Sheldon Avenue
Metals on Dry Weight Basis (mg/kg)				
Arsenic	57	6.9	2.0	8.4
Cadmium	5.1	1 U	1 U	3.8 J
Chromium	260	23	20	59
Copper	390	32	28	150
Lead	450	339	52	390
Mercury	0.41	0.019	0.12	0.45
Nickel		31 J	25 J	57
Zinc	410	170	115	560
Phenols on Dry Weight Basis (µg/kg)				
2-Methylphenol	63			470 J
4-Methylphenol	670			540 J
Pentachlorophenol	360			

**Table I-1
Catch Basin Sediment Concentrations
in Warren Avenue Study Area**

	Marine Sediment				
	Standard	End of 11th Street	End of Park Avenue	Sheldon Avenue	
TOC		0.9%	1.1%	8.6%	
Total Organic Carbon Basis (mg/kg OC)					
Dimethylphthalate	53	<i>Not above max.</i>	0.91 J	0.62 J	
Dibenzofuran	15		1.9 J		
N-Nitrosodiphenylamine (1 Carbazole)	11		3.4 J	4.2 J	
Di-n-butylphthalate	220		3.9	5.4 UJ	10 J
Butylbenzylphthalate	4.9		14 J	3.6 J	
bis(2-Ethylhexyl)phthalate	47		100	51 J	190
Di-n-octylphthalate	58		12 J		13 J
PAH					
Naphthalene	99	1.3 J		3.0 J	
2-Methylnaphthalene	38	1.1 J		7.4 J	
Acenaphthylene	66		1.1 J		
Acenaphthene	16		1.5 J		
Fluorene	23	1.3 J	2.4 J	5.0 J	
Phenanthrene	100	13 J	28 J	24 J	
Anthracene	220		5.6 J	20 J	
Total LPAH	370	17 J	39 J	59 J	
Fluoranthene	160	13 J	42 J	30 J	
Pyrene	1,000	17 J	45 J	33 J	
Benzo(a)anthracene	110	5.1 J	20 J	11 J	
Chrysene	110	7.3 J	24 J	15 J	
Benzo fluoranthenes	230		36 J	24 J	
Benzo(a)pyrene	99	5.2 J	21 J	10 J	
Ideno (1,2,3-cd)pyrene	34		14 J	3.8 J	
Dibenz(a,H)anthracene	12		5.8 J		
Benzo(g,h,i)perylene	31		11 J	3.6 J	
Total HPAH	960	48 J	220 J	130 J	

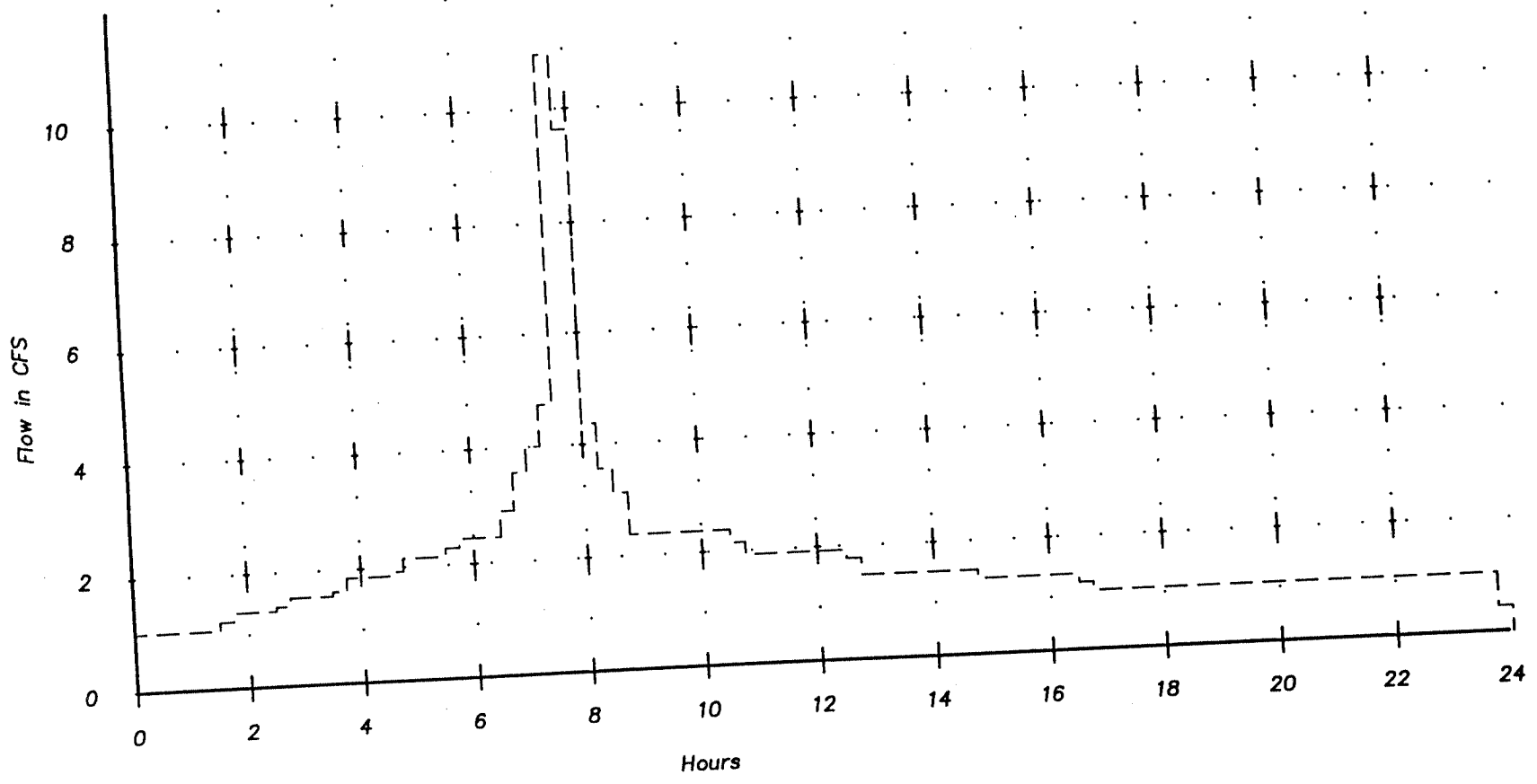
Sediment Management Standards; Chapter 173-204 WAC.

Bold and Italics = Exceeds Sediment Standards

Qualifiers

U = Not Found at Detection Limit Shown

J = Estimated Value



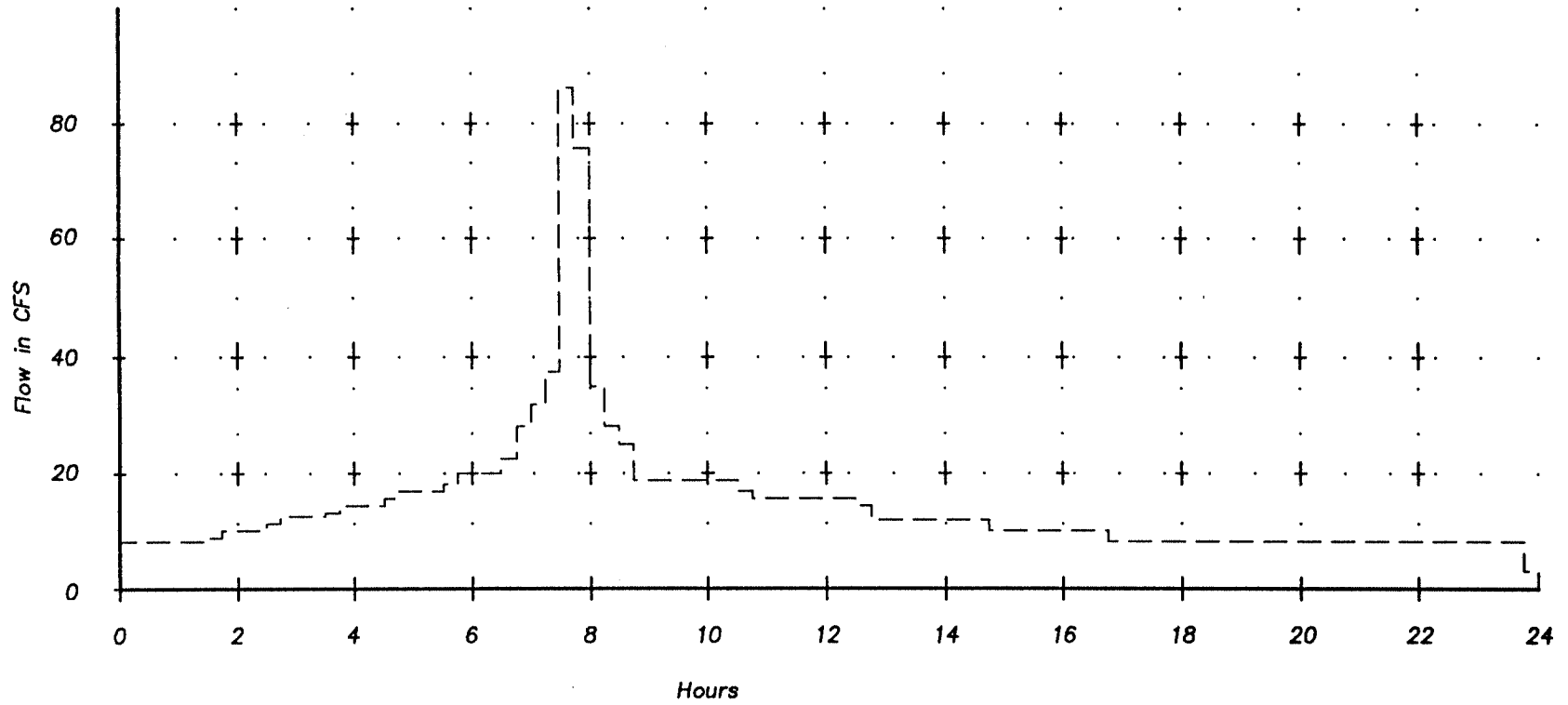
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Note: SCS Type IA curve. One year recurrence interval.

LEGEND

Sto — — — —

**Figure I-3.
 Warren Avenue CSO
 Evergreen Park
 Outfall Hydragraph.**



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Note: SCS Type IA curve. One year recurrence interval.

LEGEND

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**Figure I-4.
 Warren Avenue CSO
 14th St. Outfall
 Hydragraph.**

2.5 Toxicant Concentration – Water

Since the Warren Avenue basin is a combined system, there are no data available for predicting toxicant concentrations in storm water runoff. However, as part of their CSO reduction program, Seattle METRO has conducted comprehensive runoff sampling and risk analysis for CSO separation projects. Stormwater toxicant concentrations in the Warren Avenue basin will probably be similar to the 1,900 acre Densmore drainage basin in north Seattle, which has a mix of high-density commercial and residential land use. The whole water concentrations for Densmore runoff have been monitored intermittently since 1986. The results for selected toxicants are shown in Table I-2 (METRO, 1989, 1993).

Parameter	Maximum	Mean	Acute WQS	Chronic WQS
TSS	77 mg/l	49 mg/l		
Cadmium	1.7 µg/l	0.7 µg/l	37	8.0
Copper	30	20	2.5	—
Lead	190	78	151	5.8
Nickel	6.2	2.5	71	7.9
Zinc	190	130	85	77

Based on Seattle METRO data in Densmore drainage basin, WQS = Water Quality Standard (WAC 173-201A).

3.0 OUTFALL ALTERNATIVES

Inner and outer harbor lines are established for the Port Washington Narrows. The inner harbor line generally lies on the beach at intertidal elevations. The outer harbor line appears to be established at a depth of approximately -10 feet MLLW. Peak depth in the Port Washington Narrows is approximately -30 feet MLLW, located near the eastern (far) shoreline. Three outfall alternatives (for each site) have been considered for evaluation of water and sediment quality impacts:

1. Open-ended outfall located at the inner harbor line (exposed on the beach).
2. Open-ended at the outer harbor line (depth - 10 feet MLLW).
3. Diffuser at the outer harbor line (depth -10 feet MLLW).

4.0 WATER QUALITY STANDARDS

The state water quality standards, WAC 173-201A, were modified in November 1992. The key modifications, as they affect this project, include:

- Add and refine numerical limits for toxic substances, including guidance for dissolved versus total recoverable metals.
- Allocation of mixing zones for NPDES permitted discharges, including separate criteria for acute and chronic toxicity.
- Guidance for establishing mixing zones specifically for stormwater discharges.

4.1 Toxicant Limits and Duration of Exposure

Numerical limits are specified in the standards for acute and chronic toxicity (see Table I-2). The acute standards are based on a one-hour duration of exposure, which is applicable to stormwater discharges. The peak one-hour flows for each sub-basin were given previously (see Section 2.2). However, the chronic standards are based on a 96-hour (or longer) exposure to toxicants. Stormwater flows are intermittent events that make it difficult to evaluate chronic toxicity. Previous studies have determined that for Seattle, storm duration is rarely over 24 hours, and the average duration between storms is 101 hours.

The Nationwide Urban Runoff Program (NURP) studies (EPA, 1983) addressed the issue of acute and chronic toxicity from intermittent discharges. Acute toxicity during storms has been documented. However, the report noted that while most urban runoff exceeds chronic criteria at the end-of-pipe, few chronic water quality impairments were noted throughout the country. Based on this observation, the NURP studies proposed Estimated Effect Levels for Intermittent Exposures. This issue is further discussed in the *Quality Criteria for Water (EPA, 1986)* and the *Technical Support Document for Water Quality-Based Toxics Control (EPA, 1991)* and other references.

The guidance given in the Technical Support Document acknowledges that organisms in the receiving water are not experiencing constant, steady exposure to toxicants in urban runoff. This is why EPA gives a time period over which to average the concentration that an organism is exposed to. As stated in the Technical Support Document (EPA, 1991), "EPA selected the four-day averaging period based on the shortest duration in which chronic effects are sometimes observed for certain species and toxicants, and thus should be fully protective even for the fastest-acting toxicants."

Utilizing the definitions and guidance given in the *Quality Criteria for Water* and the EPA *Technical Support Document for Water Quality-Based Toxics Control*, the adjusted concentration to compare with the chronic criteria is computed by determining the average length of time for the discharge and the average length of time between discharge events. The concentration and flow rate from the discharge is then weighed based on the average amount of time during a 96-hour period that a storm event occurs.

Averaging the flow volume from the one-year storm of 2.4 inches (7 million gallons) over the 96-hour exposure period, the average runoff rates are approximately 3 cfs and 0.3 cfs for the 14th Street and Evergreen Park outfalls, respectively.

4.2 Mixing Zones

Mixing zones are areas adjacent to effluent outfalls where rapid effluent mixing results in the dilution of effluent with receiving water. Water quality standards must be satisfied outside of the mixing zones. In estuaries, mixing zones shall not extend in any horizontal direction over 200 feet from the outfall plus the depth of water, or exceed 25 percent of the width of the estuary. For an outfall located at the outer harbor line, the mixing zone would be a radius of 210 feet from the point of discharge. Chronic toxicity criteria must be met at the boundary.

Acute toxicity criteria must be achieved within a much smaller zone around the outfall. The acute zone dimension is 10 percent of the chronic mixing zone, or 21 feet for the outfall at the outer harbor line. An outfall located at the inner harbor line, at intertidal depths, may not receive a mixing zone. Acute criteria would need to be met at end-of-pipe.

5.0 EFFLUENT MIXING

When runoff is discharged to salt water through a submerged outfall, the effluent plume is buoyant and rises toward the water surface. This turbulent action creates significant rapid mixing, typically producing a visible surface "boil." The currents in the Port Washington Narrows are also very strong, which increases effluent mixing. Since outfall design criteria are not finalized, and no site specific current or density investigations have been performed at the proposed outfall sites, the modeling performed for this issue paper provides only first-order estimates of mixing. Field studies and additional modeling may be necessary to refine these estimates in the future.

The EPA initial mixing model UMERGE was run for the following cases:

	<u>Flow Rate</u>	<u>Current Speed</u>	<u>Depth</u>
14th Street			
Acute Condition	80 cfs	8 cm/s	10 ft
Chronic Condition	3 cfs	80 cm/s	10 ft
Evergreen Park			
Acute Condition	10 cfs	8 cm/s	10 ft
Chronic Condition	0.3 cfs	80 cm/s	10 ft

Each case is run for an open-ended outfall and a four-port diffuser. The results are shown in Table I-3 and Appendix A.

Table I-3 Preliminary Initial Dilution Factors				
	14th Street Outfall		Evergreen Park	
	Acute	Chronic	Acute	Chronic
Open Ended @ 10' deep	4.0	105	3.5	74
4-Port Diffuser @ 10' deep	6.5	250	10	125

6.0 WATER QUALITY IMPACTS

The projected concentrations of several toxicants at the mixing zone boundaries are shown in Table I-4. Acute concentrations are based on the maximum runoff concentrations from Table I-2, and the chronic are based on the mean concentrations. Based on anticipated dilution factors and the projected runoff concentrations, water quality standards are expected to be met if the outfall is submerged to a depth of approximately 10 feet, except for copper, with or without a diffuser. Other acute standards are not likely to be met consistently for the intertidal outfall alternative. Acute toxicity impacts are much more critical than chronic toxicity due to the intermittent nature of the discharge.

**Table I-4
Predicted Toxicant Concentrations at Mixing Zone Boundaries**

	Acute M.Z. Boundary		Chronic M.Z. Boundary	
	Without Diffuser	With Diffuser	Without Diffuser	With Diffuser
Cadmium	0.42	0.26	<0.01	<0.01
Copper	7.5 ⁽¹⁾	4.6 ⁽¹⁾	0.2	0.1
Lead	47.5	29.2	0.8	0.4
Nickel	1.55	0.38	0.03	0.01
Zinc	47.5	29.2	1.3	0.7

NOTES: All concentrations are in mg/l.
 Assumed Dilution Factors: Acute without diffuser = 4
 Acute with diffuser = 6.5
 Chronic without diffuser = 100
 Chronic with diffuser = 200

⁽¹⁾ Based on this analysis, there is a potential that the copper standard would be exceeded.

7.0 SEDIMENT MANAGEMENT STANDARDS

Sediment management standards were promulgated in 1991 (WAC 173-204). Marine sediment quality standards (SQS) were shown in Table I-2. In the three catch-basin sediment samples obtained by Ecology, there were several SQS exceedances; however, it should be noted that samples were collected upstream of discharge points in catch basins which had been accumulating sediment deposits for an undetermined period. These catch basin samples may therefore not accurately reflect sediment quality conditions near actual marine outfalls. If the stormwater discharge causes the sediments around the outfall to exceed SQS, then the management standards allow a sediment impact zone (SIZ) adjacent to the outfall. The SIZ is analogous to the mixing zone for water quality standards; i.e., SQS must be met outside the SIZ.

8.0 SEDIMENT DEPOSITION

This section presents a discussion of potential sediment deposition in the Narrows from particulates discharged from the proposed new stormwater outfalls.

8.1 Annual Sediment Load

Based on the stormwater sampling conducted by Metro, the average suspended solids concentration of storms in the Densmore drainage basin is 42 mg/l. Based on projected annual runoff for each basin, the expected particulate loading is as follows:

- 14th Street Outfall - 35,000 lb/yr
- Evergreen Park Outfall - 3,500 lb/yr

8.2 Sediment Size and Settling Velocity

The most appropriate data regarding the size distribution of suspended sediments in storm drainage is from a study conducted by U.S. Geological Survey in Bellevue, Washington (Prych and Ebbert, 1986). Table I-5 summarizes the data from stormwater samples collected at three monitoring stations in Bellevue:

Particle Size Range (microns)	Description	Percent of Total Solids
< 2	Clay	4
2-62	Silt	60
62-125	Very Fine Sand	16
125-250	Fine Sand	9
250-500	Medium Sand	7
500-1,000	Coarse Sand	4
> 1,000		< 1

Settling velocity in a quiescent environment for each of these size fractions is taken from Gibbs et al. (1971), and is shown in Table I-6.

Particle Size Range (microns)	Description	Settling Velocity (ft/s)
<2	Clay	---
2-62	Silt	0.004
62-125	Very Fine Sand	0.019
125-250	Fine Sand	0.059
250-500	Medium Sand	0.17
500-1,000	Coarse Sand	0.32

8.3 Settleable Fraction

Some particles in a moving water body will be maintained in suspension by the ambient turbulence. This section will determine the fraction of effluent particles that are expected to settle out, based on the current velocities expected in the Narrows.

Hjulstrom diagrams, shown in Figure I-5, demonstrate the relationship between stream velocity, particle size, and regimes of sediment erosion, transportation, and deposition (Hjulstrom, 1938; Nowell, 1981). The Hjulstrom diagram is also used in the documentation for the EPA sediment impact model WASP4.

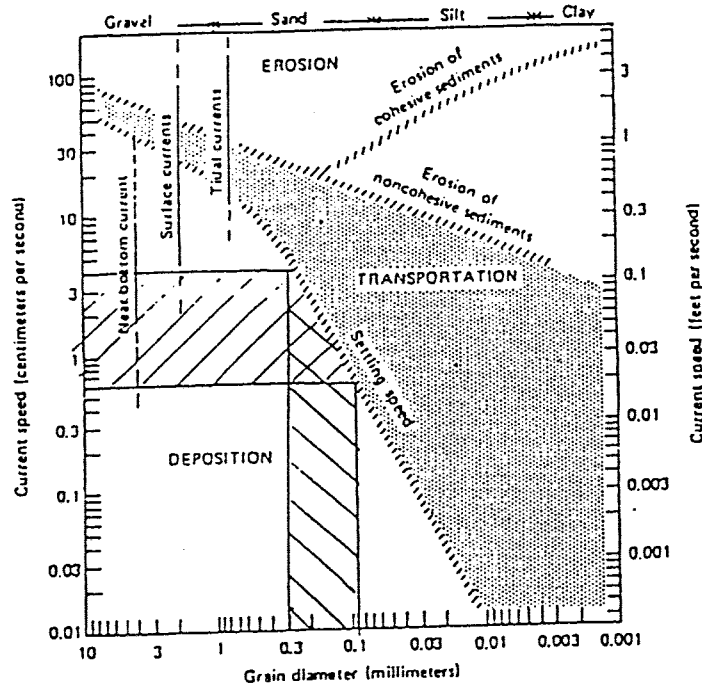


Figure I-5. Hjulstrom Diagram

At lower current speeds, all particles below 100 μm in size would be transported, or suspended, in the water column by ambient turbulence. Particles up to 300 μm would be maintained in suspension during the higher currents. At worst, only the medium and coarse sands ($> 250 \mu\text{m}$) are expected to settle near the proposed outfall. Fine sands (125–250 μm) may settle during the slack water periods.

The fraction of particles that will be maintained in suspension will account for at least 80 percent of the total sediment load. Therefore, the maximum total mass of settleable particulates will be approximately 8,000 lb/yr. Due to the shallow depth and high currents in the Narrows, any particulates that do settle out will settle out rapidly and be deposited near the outfall. It is not possible to predict areal deposition patterns without additional design criteria for the outfalls and current speeds at the points of discharge.

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