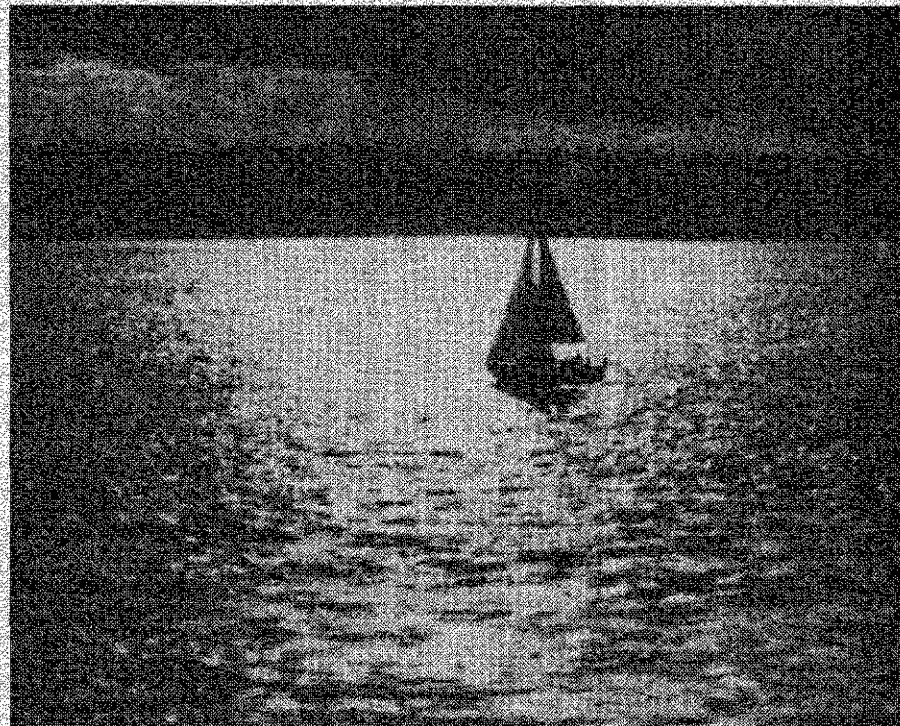

Final 1988 Combined Sewer Overflow Control Plan

Plan For Secondary Treatment Facilities and Combined Sewer Overflow Control

An Amendment to Metro's Comprehensive Water Pollution Abatement Plan

April 1988

Prepared by CWC-HDR, Inc.
Consulting Engineers
and Ott Water Engineers
Centrac Associates
Anne C. Symonds & Associates

Clean Water-A Sound Investment

METRO

CSO CONTROL PLAN

MUNICIPALITY OF METROPOLITAN SEATTLE

APRIL, 1988

CWC-HDR, INC.

OTT WATER ENGINEERS, INC.
CENTRAC ASSOCIATES, INC.
ANNE C. SYMONDS & ASSOCIATES, INC.

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SUMMARY

PURPOSE

On July 17, 1986, the Metro Council adopted a plan for secondary treatment and combined sewer overflow control. The adopted plan, approved by the State Department of Ecology (Ecology), calls for secondary treatment at the West Point Treatment Plant site. Base flows from the Carkeek Park and Alki service areas would be diverted to West Point and the Carkeek Park and Alki primary plants used for CSO treatment. In September 1986, Ecology advised Metro that changes in the adopted CSO plan would be required. In January 1987, Ecology published a new regulation regarding CSO control. This regulation required revising the 1986 CSO plan. The purpose of this report is to provide additional information, which coupled with earlier CSO reports, constitutes an overall CSO control plan meeting Ecology requirements.

SCOPE

The CSO requirements presented in earlier planning documents are not repeated. This report describes modifications made to previously-identified CSO projects following the 1986 report, and representative Metro CSO projects to achieve Ecology's requirement of a 75-percent CSO volume reduction in the overall service area over the next 20 years. It also identifies CSO projects that could be added to this 20-year plan to achieve the ultimate goal of one untreated CSO event per site per year.

CSO CONTROL PROJECTS FOR 75 PERCENT VOLUME REDUCTION

Some of the CSO control projects evaluated in earlier reports have been modified:

- **University Regulator CSO Control (Green Lake/Portage Bay Improvement Project)**--Costs have increased as a result of predesign information that shows more difficult construction conditions than originally anticipated. Pipe cost estimates have also been revised. The project is proceeding as a joint effort with the City of Seattle to improve the water quality of Green Lake and Portage Bay.

- **Hanford Separation (now the "Hanford/Bayview/Lander" Project)**--During the initial stages of design of the Hanford separation project, Metro and the City of Seattle explored the advantages of reactivating the abandoned Bayview tunnel. Combining the original Hanford separation project with reactivation of the Bayview tunnel for storage and with separation of sewers in the Lander area proved to be a cost-effective CSO project.

- **Denny Way CSO Control**--The 1986 plan included a plant located east of Myrtle Edwards Park to treat CSO. The City of Seattle subsequently initiated the planning of a project to separate sewers in the east Lake Union area upstream of Denny Way. In conjunction with this city project, it was found that partial separation of sewers in the Denny area was more economical than a CSO treatment plant.

- **Parallel Fort Lawton Tunnel**--Following the 1986 plan, Ecology required that the parallel tunnel, previously included as a CSO project to achieve 75 percent or greater CSO volume reduction, be an integral part of the secondary treatment plan. Thus, only the incremental costs associated with providing added capacity in the tunnel for CSO control purposes is considered a CSO cost in this report. Recent predesign work on the secondary treatment facilities has determined that 440 mgd can be routed through the parallel tunnel, the West Point Treatment Plant, and the existing outfall. As a result, capacity of the parallel tunnel for planning and predesign analysis has been increased from the 400 mgd capacity used in the 1986 plan to 440 mgd.

The representative projects to achieve about 75 percent volume reduction are:

<u>Southern Service Area (SSA)</u>

CATAD Modifications

Hanford Separation/Bayview Tunnel/Lander Separation

Diagonal Separation

Kingdome/Industrial Area Separation

Michigan Separation

Denny Separation

<u>Northern Service Area (NSA)</u>

CATAD Modifications

Increase Size of Parallel Fort Lawton Tunnel for CSO

University Regulator (Green Lake/Portage Bay Improvement Project)

The above projects are expected to achieve slightly more than 75 percent volume reduction. The plan would separate storm drainage from the sewer system in about 14 percent of the combined sewer area. Because the separation projects require new storm drains to reduce CSOs, Metro will evaluate each project carefully at the design stage to make sure storm water discharges will not result in adverse environmental impacts.

The total capital cost, including the Alki and Carkeek CSO projects is $125 million (1988 dollars) for 75 percent volume reduction. This is less than the $182 million shown in the 1986 plan for about the same volume reduction for several reasons:

- Seventy-five percent volume reduction for the overall service area rather than 75 percent reduction in both the NSA and SSA, permits a savings of $13,000,000 at the projected 75 percent volume reduction.

- When combined with the city's east Lake Union separation project, Metro's Denny separation project cost less than the Denny CSO plant used in the 1986 plan ($29,800,000 savings).

- A portion of the parallel Fort Lawton tunnel used for base flows is now considered a secondary cost rather than a CSO cost ($6,000,000 CSO cost reduction).

- The modified Hanford project provides added cost-effective CSO benefits ($11,600,000 savings).

- The Alki equalization/secondary facilities included in the 1986 plan were replaced with a storm-weather plant at Alki at a lower cost ($7,700,000 CSO cost reduction).

- Offsetting some of the savings was a $12,100,000 increase in the cost of controlling the University Regulator overflows (Green Lake/Portage Bay Improvement Project).

Based upon phasing the projects over the next 20 years, the present worth of the CSO projects for 75 percent volume reduction is $111,550,000. The inflated capital cost over the same period is $188,050,000.

Partial separation of about 8,300 acres of currently combined sewer area at a cost of about $168,000,000 (1988 dollars) would, when added to the above projects, achieve the ultimate goal of one event per year. Added projects to achieve this goal would not be undertaken until after 2005. In the interim, the effectiveness of the initial Metro projects will be measured, evaluated, and reported at five-year intervals to determine what adjustments may be needed to achieve this goal.

PUBLIC INVOLVEMENT PROCESS

Public participation related to Metro's CSO program was an integral part of the secondary treatment/CSO control program undertaken in the fall of 1984 and adopted by the Metro Council on July 17, 1986. Information about the CSO program was included in public information documents, reports to the community and news releases at specific intervals during the planning process.

Since adoption of the secondary treatment/CSO control program, information about the overall CSO plan and specific CSO projects has been included in the public information document *Clean Water*, provided to news media and when appropriate, news releases have been mailed to the media.

In late November, 1987, a public meeting was held at the Tyee Yacht Club to discuss Metro's overall CSO program and specific projects of interest to residents near Portage Bay.

A CSO public information document was developed and distributed to interested residents and agencies in February, 1988. This document provided information about a joint public hearing with the City of Seattle, held March 15, 1988, in the City of Seattle Council Chambers. See the Response Summary, Appendix C, for comments of that hearing.

Public participation will be a part of all project level activities as each CSO project is undertaken to implement the CSO control plan.

CHAPTER 1
INTRODUCTION

THE COMBINED SEWER OVERFLOW PROBLEM

Metro is a wholesale wastewater conveyance and treatment agency that is contractually obligated to maintain interceptor sewers capable of receiving flows from the City of Seattle and 32 other cities and districts. The City of Seattle, the largest discharger of the 33 local agencies, has a combined sewer system dating back to the early 1900s in some areas. The city system connects to the Metro interceptors by one of two methods:

- The sewers are directly connected to the interceptor and all flows from the area enter the interceptor. During storm events, runoff from Seattle's combined system creates high flows in the Metro system, and overflows from Metro's facilities.

- The sewers connect through a restriction. Flows up to the restriction capacity flow to the interceptor and excess flows beyond the restriction capacity are stored in the city sewers or overflow at the City of Seattle CSO sites.

Overflows caused by excess storm water in the combined sewers of the Seattle system have affected water quality along the shorelines of lakes Washington and Union, the Ship Canal, the lower Duwamish River, Elliott Bay and Puget Sound beaches in West Seattle and Magnolia. The location, frequency and volume of combined sewer overflows have been greatly reduced in recent years through City of Seattle sewer separation projects and construction of special storage tanks. Metro has also contributed with pumping station upgrades and implementation of CATAD, a computer-control system that regulates flows in the sewerage system to get maximum use of storage capacities in the existing pipes. All CSOs along Lake Washington and West Seattle beaches have been controlled to at least the one-year storm level. Figures 1-1 and 1-2 provide an overall description of the historic and current situation (see 1985 and 1986 plans for related discussion.)

While much progress has been made, overflows persist. In an average rainfall year, nearly 2.4 billion gallons of untreated sewage mixed with storm water still spill from 21 CSO points in Metro's West Point collection system. Additional overflows occur at a number of City of Seattle CSO points. Of the Metro total, about 460 million gallons overflow into the Ship

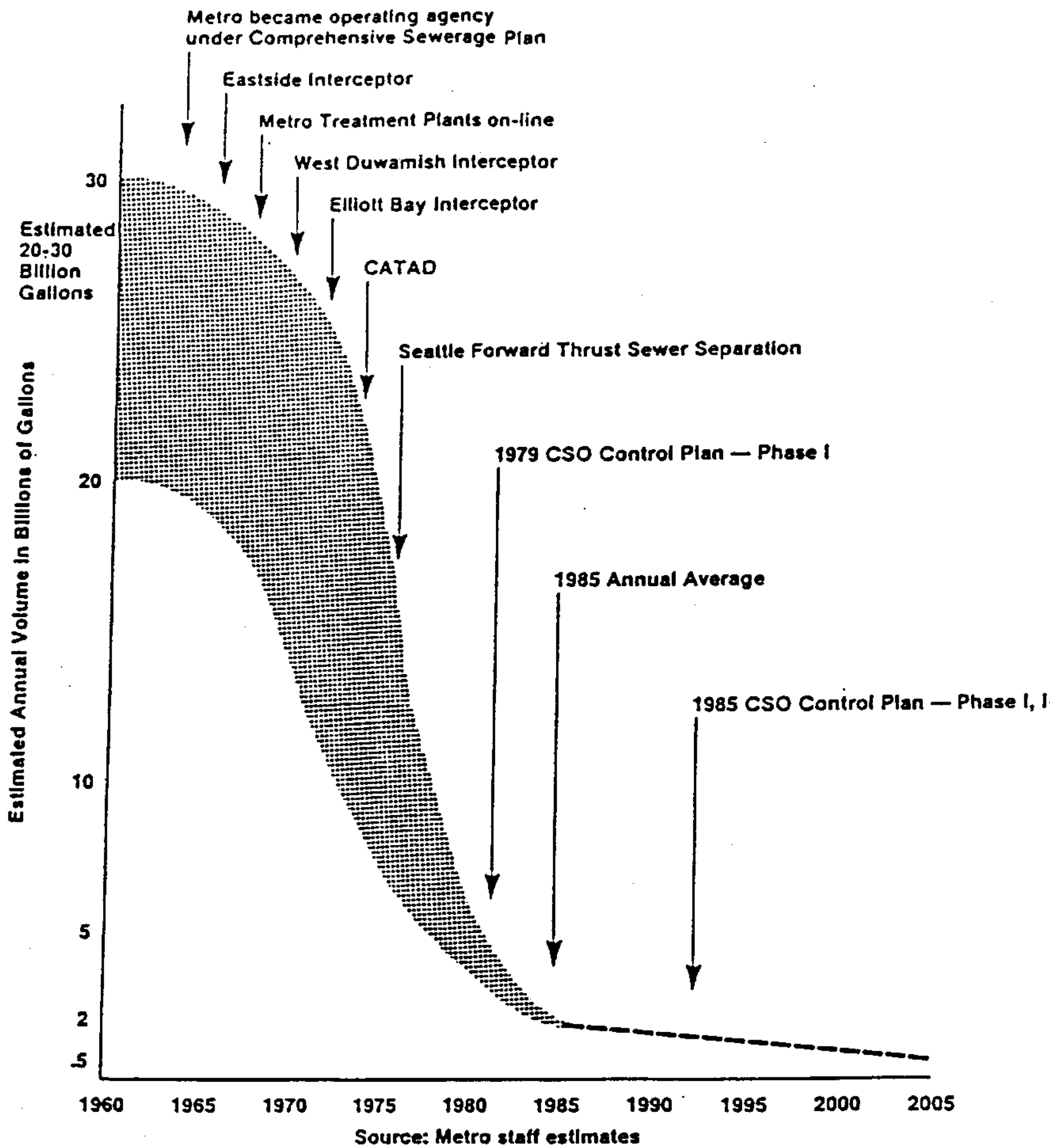


Figure 1-1

Reduction in Untreated Sanitary and Combined Sewer Overflows in the Seattle area since 1960.

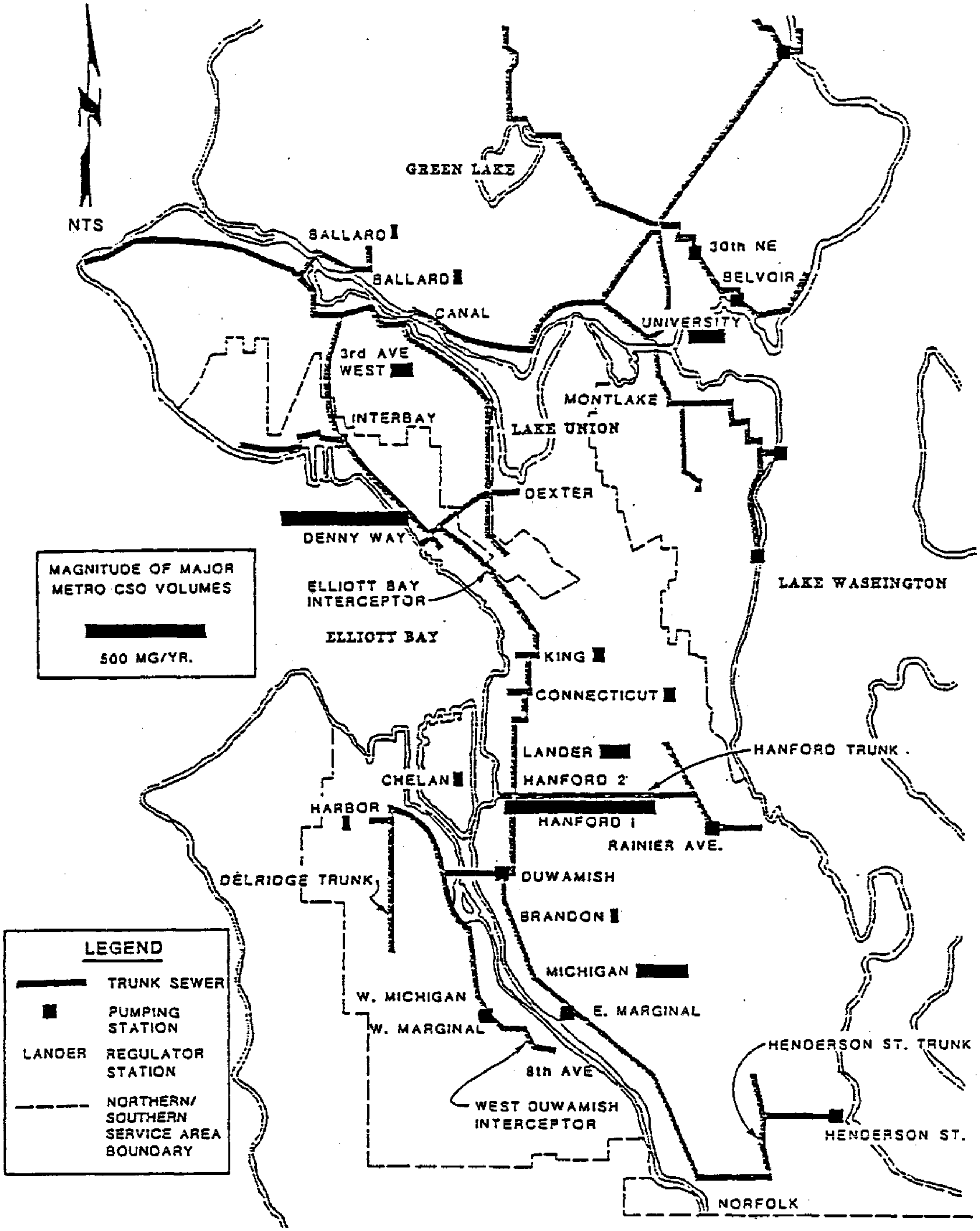


Figure 1-2 CSO LOCATIONS AND VOLUME

Canal and Lake Union, while 1.9 billion gallons spill into the lower Duwamish River and Elliott Bay.

PAST STUDIES OF CSO CONTROL

Several studies on CSO control for the Metro system have collected data on the amount and characteristics of overflows, data which has been used in preparing this report. An extensive evaluation of CSO control alternatives is contained in Metro's 1979 *CSO Control Program Report*. This Metro study, done in conjunction with the City of Seattle's CSO planning, evaluated controlling CSOs for a range of rainfall conditions and using a variety of control methods. The Metro plan recommended a combination of storage and treatment facilities. The city and Metro agreed that first priority be given to controlling CSOs into Lake Washington.

Metro's 1979 plan recommended a $71.2 million program (1988 dollars). Most of the top-priority storage projects built by the City of Seattle were specifically aimed at protecting Longfellow Creek and Lake Washington. Under the 1979 plan, Metro has adjusted weirs, modified CATAD operations and upgraded Lake Washington pumping stations. In addition, all of Metro's Alki collection system was upgraded to reduce CSO events to the one-year storm level.

In addition to its CSO control projects, the city has adopted a drainage ordinance (No. 108080) that will reduce city CSOs. A drainage control plan is required by the city for new development greater than 2,000 square feet (proposed to be reduced to 750 square feet) of impervious surface. The plan is for *"collecting, controlling, transporting, and disposing of storm water falling upon, entering, flowing within, and exiting the property under development."* The ordinance requires that new developments either provide separate storm sewers for drainage, or provide on-site control of storm water to reduce the peak flows leaving the development. Such measures will reduce CSOs.

As part of the planning for secondary treatment facilities in 1985, a further analysis of CSO control alternatives was made and reported in Volume III of the November 1985 secondary facility plan. This report analyzed the effects of four different secondary treatment system configurations on CSOs. The report established a reasonable, yet significant level of CSO reduction for both fresh- and saltwater areas and provided a comparable level of CSO reduction for all four system alternatives. All system alternatives with the CSO control projects recommended in the 1985 plan would reduce systemwide overflows over 20 years by 70 to 76 percent below today's (1985) condition. The recommended CSO control costs ranged from $88 million to $129 million (present worth, 1988 dollars), depending upon the secondary system alternative. The recommended level of CSO control was based on the "knee-of-the-curve" concept, where project costs increased most sharply relative to the CSO volume reduction attained, i.e., the breakpoint in the cost/benefit curve.

In 1986, at the request of the City of Seattle, Metro considered additional non-West Point configurations for secondary treatment and issued a supplemental facility plan, including a supplemental CSO control plan. In addition to evaluating the CSO projects at a redefined knee-of-the-curve (cost/benefit) level of control, Metro evaluated projects to achieve 75 and 90 percent volume reduction for all secondary system configurations. In addition to the CSO control projects identified in the November 1985 plan, Metro evaluated several additional projects and modified some of the CSO projects described in the 1985 plan based on technical refinements to the earlier work. The agency also improved and updated computer models used to analyze CSO options and estimate pollutant loadings for the 1986 analysis. The NSA CSO projects were reevaluated using updated basin characteristic data and the revised models. The present-worth costs for CSO control projects phased over a 20-year period ranged from $61 million to $90 million at the knee-of-the-curve, $104 million to $157 million at 75 percent CSO volume reduction, and $188 million to $256 million at 90 percent CSO volume reduction.

In the 1986 CSO plan, the knee-of-the-curve level of control was redefined as the point where the first break in the cost-benefit curve occurred rather than where the sharpest break occurred. The knee-of-the-curve level of control for the Core 4 secondary plan, for example, was 61 percent in the 1986 plan versus 74 percent in the 1985 plan. As a result, the knee-of-the-curve costs decreased relative to the 1985 plan.

This report builds on the analyses presented in the 1985 and 1986 plans. These earlier reports and their related technical appendices provide the detailed technical information for this analysis.

METRO'S ADOPTED PLAN FOR SECONDARY TREATMENT AND CSO CONTROL

On July 17, 1986, the Metro Council adopted a plan for secondary treatment and CSO control. The CSO control plan was based on implementing CSO projects until the knee-of-the-cost/benefit-curve was achieved. For the adopted secondary plan (Core Plan 4), the knee-of-the-curve corresponded to an overall (Southern and Northern Service Areas) CSO volume reduction of about 61 percent. The CSO control projects at this level of control included:

- Modifications to the CATAD system to improve its efficiency.
- The Hanford separation project.
- Separation of sewers in the Diagonal, Kingdome and Michigan Street areas.
- Separation of the Green Lake outflows, Densmore storm drain and I-5 drainage from the sewers upstream of the University regulator.
- Provisions for storm-water treatment at the Alki and Carkeek treatment plants.

The estimated present-worth cost of these projects phased over a 20-year period was $75.5 million in 1988 dollars.

DOE REVIEW OF METRO'S CSO PLAN AND NEW DOE CSO REGULATIONS

On September 25, 1986, the State Department of Ecology advised Metro that the knee-of-the-curve level of CSO control in the adopted CSO plan was unacceptable and that a 75-percent CSO volume reduction over a 20-year period would be required. Additional correspondence with Ecology further clarified the department's concerns. In achieving a 75-percent CSO volume reduction, Metro would be required to build facilities to control the Denny Way CSO and parallel the existing Fort Lawton tunnel within the 20-year planning period.

In addition, Ecology published a new regulation regarding CSO control on January 27, 1987. This regulation contained several requirements affecting this current revision of Metro's CSO control plan:

- During earlier CSO planning, the State law required that Metro achieve " . . . *the greatest reasonable reduction of combined sewer overflow at the earliest possible date*". The new regulation defined *"greatest reasonable reduction"* as *"control of each CSO such that an average of one untreated discharge may occur per year"*. This level of control is to be achieved at each CSO outfall. An allowance of one event per year represents a considerably higher level of control than even the 90-percent volume reduction considered in the 1986 CSO plan. The schedule to achieve one event per year is to be developed considering economic and environmental impacts and will be negotiated with municipalities according to their individual requirements.

- Communities are to submit CSO plans complying with the new Ecology requirements by November 1, 1987 for approval by January 1, 1988. (Metro submitted a draft CSO control plan to Ecology on November 1. A schedule has been negotiated with Ecology whereby the final plan will be submitted in May, 1988.)

- Data collected in these plans must characterize the CSO discharges and estimate historical impacts. If there are industrial or commercial sources tributary to a CSO, the sediments must be analyzed for heavy metals and organic pollutants.

- Highest priority is to be given to controlling CSOs near water supply intakes, public primary contact recreation areas and potentially harvestable shellfish areas. Additional criteria to be used in priority ranking of projects include cost effectiveness and documented environmental impacts.

- The municipality is to propose a schedule to achieve the one-event-per-year goal. If the schedule exceeds five years, an initial five-year program is to be proposed. The program is to be reviewed at five-year intervals to report progress and make any needed modifications in the program.

PURPOSE AND SCOPE

Many of the new Ecology requirements for a CSO control plan were met in Metro's 1985 and 1986 CSO reports after careful coordination between Metro and Ecology staff. These requirements, which were presented in the earlier planning documents, include:

- Development and verification of a rainfall and storm-water runoff CSO model (see 1985 and 1986 CSO reports and related appendices).

- Location of CSOs and establishment of baseline conditions (see Chapter 3, 1985 CSO report).

- Identification and analysis of CSO control projects (see Chapters 5 and 6, 1985 CSO report and Chapter 4, 1986 CSO report). (Some modifications of these projects, as well as additional projects, are described in this report.)

- Estimates of CSO-related pollutant discharges (see Chapter 5 of 1986 CSO report).

This report provides the added material required by Ecology which, coupled with the earlier CSO reports, provides an overall CSO control plan meeting the new Ecology requirements. To accomplish this, the report:

- Presents information on modifications to the CSO control projects described in the earlier plans. These modifications include revised cost estimates based upon technical refinements to specific project components.

- Assesses the potential effects that the City of Seattle CSO control plan, being prepared concurrently with this report, may have on Metro CSOs and suggests approaches to improve both programs.

- Presents a revised schedule for phasing of Metro CSO control projects to achieve the requirement of 75 percent CSO volume reduction in 20 years and identifies projects to be initiated in the next five years.

- Identifies and describes CSO control projects that could be added to the previously described projects to achieve the ultimate one-event-per-year goal systemwide.

Sewer separation projects discussed in this and previous CSO plans have implications for the regional management of storm and surface waters. The potential regional significance of added discharges of storm water through new storm drains is discussed; however, it is beyond the scope of this report to develop a storm-water management plan. When project-specific impacts from new storm drains are ascertained, Metro will apply mitigation measures as appropriate.

ORGANIZATION OF REPORT

This document is organized in four chapters. It is a summary document intended to inform decision-makers and the public about the technical and economic aspects of the needed improvements. More detailed information about specific aspects of the planning work is included in previous Metro CSO reports and in a number of technical memoranda. The following chapters are included in this volume to aid the reader in locating specific information, including a brief description of each chapter:

Chapter 1 - Introduction

This chapter presents the purpose and scope of the present effort, a brief definition of CSO and past studies, and an introduction to the contents of the report.

Chapter 2 - CSO Control Projects for 75 Percent Volume Reduction

This chapter describes the CSO control projects that would be used to achieve the 20-year goal of 75 percent CSO volume reduction.

Chapter 3 - Additional CSO Control Projects to Achieve One CSO Event Per Year

This chapter describes CSO control projects which could be added to those described in Chapter 2 to achieve one CSO event per year.

Chapter 4 - Recommended CSO Control Program

This chapter summarizes the CSO control projects and other aspects of the recommended CSO control program.

Appendices

Appendix A describes several items still under consideration in the secondary predesign that could affect this CSO plan.

Appendix B contains the phasing and cash flow tables for the CSO projects.

Appendix C contains a response summary for public comments submitted during the draft plan review period.

Appendix D contains a rate analysis based on the phasing and cash flow tables presented in Appendix B.

Appendix E contains an Indemnification Statement that may be applied to separation projects that result in new storm drain systems for the City of Seattle.

Appendix F is an issue paper that addresses concerns related to CSO control alternatives and surface water management needs in the region.

A separate volume contains several technical memoranda that present the detailed work summarized in this report.

CHAPTER 2
CSO CONTROL PROJECTS
FOR 75 PERCENT VOLUME REDUCTION

PREVIOUSLY IDENTIFIED PROJECTS

The 1985 and 1986 Metro CSO reports defined the CSO control projects that could achieve the 20-year, 75-percent CSO volume reduction required by Ecology in a cost-effective manner. These projects are described in detail in the earlier reports and include:

- **Hanford Separation**--The storm-water separation project in the Rainier Valley would be completed by installing a new sanitary sewer inside the existing tunnel now used to convey combined flows from the valley to the Elliott Bay interceptor (see page 5-74, 1985 plan). About 1,132 combined acres would be partially separated upstream of the tunnel. This project has been completed.

- **CATAD Improvements**--Modifications to the CATAD control system would more fully use storage capacity in existing sewers (see pages 5-3 and 5-64, 1985 plan).

- **Diagonal Total Separation**--This project would complete the total separation of sanitary and storm drainage by installing new sanitary sewers in about 720 acres of combined or partially-separated industrial area (see page 5-74, 1985 plan).

- **Michigan Total Separation**--This project would totally separate the sanitary and storm sewers in 1,017 acres served by combined sewers and 68 acres served by partially separated sewers (see page 5-77, 1985 plan).

- **Kingdome/Industrial Area Total Separation**--New sanitary sewers would be constructed to totally separate the sanitary flows from the storm runoff in about 971 industrial acres connected to combined sewers (see page 5-76, 1985 plan).

- **University Regulator CSO Control (Green Lake/Portage Bay Improvement Project)**--Storm runoff from the Densmore drain, Interstate-5, Ravenna Park and outflow from Green Lake would be diverted from the North interceptor system to a new storm drain (see page 5-3, 1985 plan).

- **Denny CSO Treatment Facility**--The substantial overflows from the Denny Way regulators would be conveyed to a new CSO treatment facility for primary treatment. The treatment plant would be located on a site east of the railroad tracks about 1,000 feet from the regulators (see page 5-36, 1985 plan and page 4-7, 1986 plan).

- **Parallel Fort Lawton Tunnel**--A parallel tunnel would allow flows to West Point to be increased from 325 million gallons a day (mgd) to 400 mgd, reducing CSO in the NSA (see page 5-31, 1985 plan).

- **NSA Partial Separation Projects**--Fourteen potential partial separation projects were identified in the 1986 report that, in conjunction with other NSA CSO control projects, could achieve a 75 percent or greater reduction. For a 75-percent volume reduction in the NSA, 2,560 combined acres of mostly residential area would be partially separated using projects in nine of the 14 identified areas, removing about 630 acres of impervious area (see page 2-38, 1986 plan).

REVISIONS TO METRO PROJECTS

Subsequent to the 1986 CSO report, some of the projects listed above have been modified. The project modifications and the associated reasons are described below.

- **University Regulator CSO Control (Green Lake/Portage Bay Improvement Project)**--In response to a Seattle Parks Department request, measures were taken during predesign to analyze alternatives that would avoid construction of a pipeline under Ravenna Park. Predesign analysis of both the non-Ravenna Park and under-Ravenna Park options indicate that cost increases would occur because of more difficult construction conditions than originally anticipated and revised pipeline cost estimates. As a result, the cost increased from the earlier estimate of $10.5 million to $22.3 million (1988 dollars).

- **Hanford Separation (Hanford/Bayview/Lander Projects)**--The Hanford basin, primarily the area of the Rainier Valley, is about 3,800 acres in size. Combined flows from the Hanford basin have been conveyed to the Elliott Bay interceptor via a 108-inch Hanford tunnel. In 1987, work was completed on installation of a 36-inch pipe within the Hanford tunnel which is used to convey partially separated flows to the EBI. The 108-inch tunnel will now be used to convey storm water to the Diagonal storm drain. This is the Hanford separation project described in the earlier CSO plans. The project has been modified by adding the Bayview and Lander elements.

The Bayview tunnel is an old 72-inch by 48-inch egg-shaped structure from the Rainier Valley to the Lander basin trunk. This abandoned tunnel was reactivated in 1987 following installation of two new pipelines (22- and 40-inch) in the old structure. This system will convey partially separated flows from the Rainier Valley to the Lander basin.

The third element of this modified project is the Lander separation project. In this element, a new pipeline, about 96 inches in diameter, will be built parallel to the existing 84-inch trunk. The new line will convey partially separated flows from the Bayview tunnel and from the Lander basin. A new Lander regulator station will be built to allow use of the new oversized line for storage. Finally, complete separation in the Lander basin will take place and the existing combined sewer will be converted to a storm drain.

These projects, taken together, are a cost-effective method of reducing CSO in the SSA.

- **Denny Way CSO Control**--During the review of the 1986 CSO report, concerns were expressed about the impacts of the Denny Way CSO treatment plant on Myrtle Edwards Park. The plant would be located 1,000 feet east of the park and related CSO outfall. As part of this current plan, Metro staff reviewed additional alternatives to reduce the Denny Way CSO (see the appended Technical Memorandum 2.01).

It was found that partial separation of the Denny Local area and the area directly tributary to the Lake Union tunnel would achieve an 82-percent reduction in Denny CSO volumes. Partial separation would also reduce the frequency from 51 to less than 10 events a year at a capital cost (Metro cost of $20 million), substantially less than either the Denny Way CSO treatment facility ($49 million) or total separation of the same areas ($55 million). The City of Seattle's approach (see page 4-3, Task 1 report, 1987 Seattle CSO plan) to achieving the Ecology requirement of one event per year involves reducing inflows and *". . . vigorous enforcement of the drainage ordinance . . ."* to *". . . eventually provide control to the one CSO per year level . . ."* The volume of CSO remaining at Denny Way would be 67 million gallons a year, an 82-percent reduction from existing levels. The remaining volume would gradually decrease as the city's drainage ordinance is enforced. As a result, partial separation of 584 acres would replace the Denny Way CSO treatment facility in this plan as a means to achieve a 75-percent volume reduction. Enforcement of the drainage ordinance would further reduce the overflows at Denny.

- **Parallel Fort Lawton Tunnel**--The Metro Council's adopted CSO plan did not include the parallel tunnel. Although the tunnel was included in the CSO projects identified for 75 percent CSO control, it was not part of the knee-of-the-curve projects adopted by the council. As part of the 75-percent control plan, the tunnel was scheduled to be on-line in 1997. In a July 20, 1987 letter, Ecology stated:

  "Metro may select any CSO reduction project it deems necessary during each successive five-year plan to achieve the 75 percent reduction at the end of the 20-year period. However, the Director of Ecology has required Metro to include the Denny Way CSO and the parallel Fort Lawton Tunnel in the 20-year plan."

  This report considers a 440-mgd capacity parallel tunnel as a project which is basic to the secondary plan. The increased tunnel capacity primarily benefits the Ballard regulator and Third Avenue West weir. The cost of the tunnel capacity needed for base flows (358 mgd) is now considered a secondary cost rather than a CSO cost. The incremental cost to achieve the capacity of 440 mgd is considered a CSO cost. The predesign work for secondary treatment currently assumes that the tunnel will be completed by 1993. Additional on-site improvements will be made at the West Point Treatment Plant to handle the added flows from CSOs.

- **Kingdome/Industrial Area Separation**--The Lander separation project, which is now an integral element of the revised Hanford/Bayview/Lander project, was previously a part of the Kingdome/Industrial area separation project. The balance of the Kingdome/Industrial area project located in the Connecticut and Hanford No. 2 basins is still referred to by the same name.

EFFECT OF REVISED PROJECTS ON CSO

Table 2-1 summarizes the effects and costs of the revised Metro CSO projects, exclusive of the effects of future city CSO projects. Technical Memorandum 2.06 presents more detailed results of the computer model evaluations of the revised CSO projects. In addition to the CSO projects shown in Table 2-1, the year 2005 base-case conditions include:

TABLE 2-1

SUMMARY OF METRO CSO PROJECT EFFECTS - YEAR 2005[1]

	Annual CSO Volume Remaining (MG)	Cumulative Percent Reduction	Cumulative Cost (Millions, 1988 Dollars)	Unit Costs per MG of CSO Red.
SSA				
Existing CSO Volume	1,941[6]	--	--	
CATAD Modifications & Hanford/Bayview/Lander[2]	994	49	22.2	$23,400
Diagonal Separation	881	55	25.1	25,700
Kingdome/Industrial Area[3]	724	63	32.4	46,500
Michigan Separation	478	75	56.7	98,800
Denny Tunnel Separation	410	79	68.1	167,600
Denny Local Separation	374	81	76.7	238,900
NSA				
Existing CSO Volume	468[6]	--	--	
CATAD Modifications & Parallel Fort Lawton Tunnel[4]	323	31	13.2	38,400
University Regulator (Green Lake/Portage Bay Impr. Project)	168	64	35.5	143,900
Other				
Alki CSO Treatment	--	--	10.8[5]	--
Carkeek CSO Treatment	--	--	1.8[5]	--

(1) Year 2005 base case includes effects of CATAD improvements, previously planned city storage projects, the city separation of the east Lake Union area, effects of increased pumping rate from Interbay (133 mgd) and Dravus separation.

(2) Includes Lander basin portion of Kingdome/Industrial area separation project.

(3) Balance of Kingdome/Industrial area project not included in Hanford/Bayview/Lander project.

(4) Net effect of increased pumping rate from Interbay pumping station (133 mgd) is an increase in NSA CSO to 611 million gallons/year (including CATAD benefit); parallel tunnel reduces CSO from 611 million gallons/year to 323 million gallons/year. CSO costs for parallel tunnel and treatment plant upgrades include only the incremental cost between base flow capacity (358 mgd) and CSO capacity (440 mgd). This incremental cost is estimated as $11,067,000.

(5) Capital costs for Alki and Carkeek are for each project and are not cumulative.

(6) Baseline CSO volumes; all volumes expressed for year with average rainfall.

- The effects of existing and previously planned city storage projects.

- Separation of the east Lake Union area by the city (as originally envisioned during June 1987).

- The addition of Alki base flows to the Elliott Bay interceptor at the Duwamish pumping station, balanced by an equal base flow diversion rate at the Norfolk regulator to the Renton Treatment Plant.

- The addition of Carkeek service area base flows to the North interceptor system.

- The affects of the increased pumping rate at Interbay (133 mgd) resulting from the secondary treatment planning.

- The city's Dravus separation project.

The base flow additions to the West Point service area will not aggravate the baseline CSO condition. Alki inflow will be compensated by a diversion of equal flow to the Renton plant. Potential CSO increases due to the Carkeek addition will be compensated for by the NSA CSO control projects in this plan, mainly the parallel Fort Lawton tunnel.

After the 1986 CSO control plan was issued, Ecology clarified that an overall CSO volume reduction of 75 percent would be appropriate and that it would not be necessary to achieve 75 percent in both the NSA and SSA. The project combination shown in Table 2-1 would reduce today's overall (NSA plus SSA) CSO volume of 2,409 million gallons/year to 542 million gallons/year, slightly more than a 75-percent reduction. The total capital cost for a 75-percent reduction, including Alki and Carkeek CSO projects, is $125 million. This is $57 million less than the total capital cost of $182 million shown in the 1986 CSO plan (Table 4-3), because of the reduced costs for Denny Way, the inclusion of the Fort Lawton parallel tunnel base flow capacity as a secondary cost, the use of a 75-percent overall CSO reduction goal rather than 75 percent in both the SSA and NSA, the use of Alki as a storm-weather plant, and the added benefits from the modified Hanford project, and the city's east Lake Union separation project.

Figure 2-1 shows the location of the projects for 75 percent CSO volume reduction. The remaining volumes of CSO at each Metro overflow point are summarized in Table 2-2. Overflow volumes are reduced at all Metro overflow locations.

The approximate frequency of overflows with the 75-percent volume reduction program described above at each Metro overflow is shown in Table 2-3. Chapter 3 discusses other projects that could be used to reduce the ultimate frequency to one event per year.

PROJECT PRIORITIES

The Ecology regulations specify the criteria to be used in establishing project priorities [WAC 173-245-040,(2)(d)]:

> *"Priority ranking. Each municipality shall propose a ranking of its selected treatment/control projects. The rankings shall be developed considering the following criteria:*
>
> *(i) Highest priority shall be given to reduction of CSO's which discharge near water supply intakes, public primary contact recreation areas, and potentially harvestable shellfish areas;*
>
> *(ii) A cost-effectiveness analysis of the proposed projects. This can include a determination of the monetary cost per annual mass pollutant reduction, per annual volume reduction, and/or per annual frequency reduction achieved by each project;*
>
> *(iii) Documented, probable, and potential environmental impacts of the existing CSO discharges."*

Table 2-4 summarizes the ranking of the CSO control projects in terms of the Ecology-specified criteria.

- **CSO Near Water Supply Intake**--There are no water supply intakes near any of the CSO outfalls.

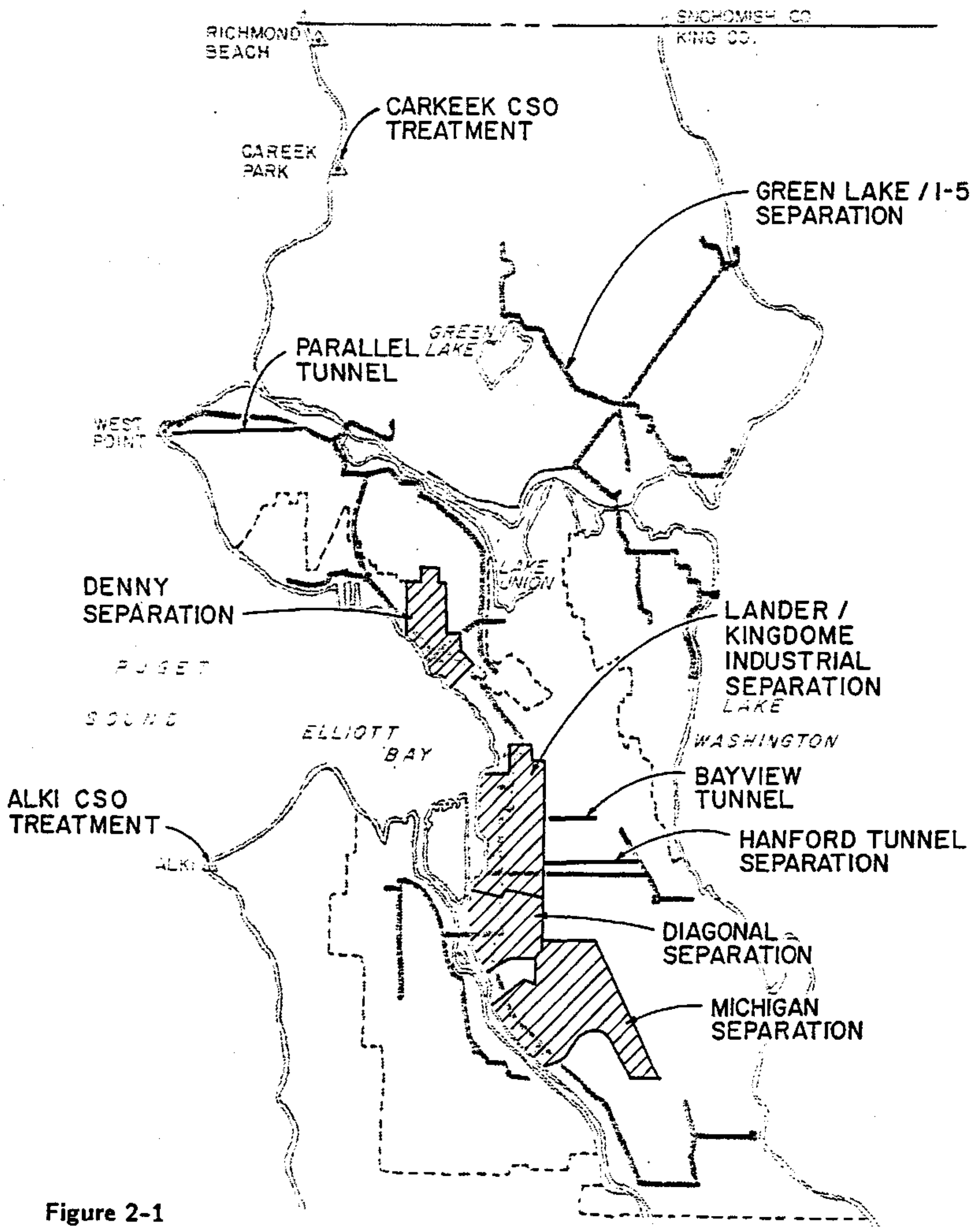


Figure 2-1

Location of CSO Projects for 75 Percent Volume Reduction

TABLE 2-2

VOLUME REMAINING AT EACH OVERFLOW (MILLION GALLONS/YEAR)

	Year 1985 Existing	Year 2005 With 75 Percent Volume Reduction
SSA		
King	70	0.5
Norfolk	4	1
West Michigan	2	0.7
Michigan	250	1
Duwamish Pump Station	130	19
Brandon	35	6
Chelan	25	4
8th Avenue	15	8
Denny	370	26
Connecticut	90	46
Harbor	55	44
Hanford	680	92
Lander	215	126
Totals	1,941	374
NSA		
Canal Street	10	2
Ballard and Ballard No. 1	90	5
Dexter	12	9
University	211	111
3rd Avenue West	105	10
Montlake	40	31
Totals	468	168

TABLE 2-3

APPROXIMATE FREQUENCY OF OVERFLOWS AT 75 PERCENT OVERALL CSO VOLUME REDUCTION

Overflow Location	Approximate Frequency/Year Existing[1]	With 75 Percent Volume Reduction[2]
SSA		
King	31	1
Norfolk	7	1
West Michigan	9	1
Michigan	31	1
Duwamish Pumping Station	--	1-2
Brandon	25	1-2
Chelan	16	2-5
8th Avenue	12	2-5
Denny/Lake Union	51	5-10
Denny Local	51	5-10
Connecticut	25	10-25
Harbor	46	10-25
Hanford	27	10-25
Lander	19	10-19[3]
NSA		
Canal Street	--	<1
Ballard	13	1-2
Ballard No. 1	13	5-10
Dexter	4	1-2
University	14	5-10
Third Avenue West	--	1-2
Montlake	16	5-10

(1) Estimated by Metro from CATAD data; -- denotes data unavailable.

(2) Frequency estimated from model results using seven design storms. (See Technical Memorandum 2.08.)

(3) Volume at Lander will be reduced by 51 percent and frequency will be reduced to less than 19 events per year.

TABLE 2-4

PROJECT RANKING CRITERIA

	CSO Near Water Supply Intake	CSO Near Recreation Areas	CSO Near Potentially Harvestable Shellfish Areas	Previously Documented Environmental Impacts	Cost Effectiveness (Dollar per MG of Reduction)
Hanford/Bayview/Lander	N	N	Y	Y	$23,400
Diagonal Separation	N	N	N	Y	$25,700
Parallel Fort Lawton Tunnel[1]	N	N	N	Y	$38,400
Kingdome/Ind. Area	N	N	N	Y	$46,500
CATAD Modifications	N	Y	N	Y	$35,700
Michigan Separation	N	N	N	Y	$98,800
University Regulator (Green Lake/Portage Bay Improvement Project)	N	Y	N	Y	$143,900
Denny Tunnel Separation	N	Y	Y	Y	$167,600
Denny Local Separation	N	Y	Y	Y	$238,900

[1] Incremental (358 to 440 mgd) CSO capacity.

- **CSO Near Primary Contact Recreation Areas**--During the 1979 CSO planning process, high priority was given to projects that would protect the bathing beaches on Lake Washington. CSO control projects have been installed to control the one-year storm in these areas. Of the CSO projects now under consideration, the Denny Way and CATAD projects would affect overflows occurring near Myrtle Edwards park. The University Regulator project (Green Lake/Portage Bay Improvement project) would reduce CSO at the University regulator which spills to the Ship Canal near Portage Bay, an area used for recreation by houseboat residents and others. The other CSO projects are not adjacent to primary contact recreation areas.

- **CSO Near Potentially Harvestable Shellfish Areas**--The 1979 plan gave high priority to CSOs adjacent to Alki and West Seattle beaches and they have been controlled. Beaches at Myrtle Edwards and Don Armeni parks, which are used for recreational shellfish harvesting, are affected by the Denny Way and Lander CSOs respectively. Reduction of the Denny Way and Lander CSOs would be a positive step towards reducing fecal coliform levels at these beaches.

- **Cost Effectiveness**--The numeric rankings in Table 2-3 are based on the cost per million gallons of CSO reduction.

- **Previously Documented Environmental Impacts**--The final environmental impact statement prepared as part of the secondary treatment facility plan addressed environmental impacts related to CSO (page 4-21):

> *"CSOs have been recognized for a number of years as a serious source of local water pollution. Early perception of CSO problems--and the priority for past CSO control efforts focused on the direct human health concerns associated with water contact (e.g., swimming) in an area contaminated with untreated sewage. CSOs release bacteria and potential human pathogens into receiving waters. CSO events have caused periodic closures of public swimming beaches and have contributed to decertification of areas for shellfish harvesting because of direct health hazards.*

The final environmental impact statement concluded (page 4-25):

> *"All of the proposed CSO control projects would affect water quality at existing discharge points."*

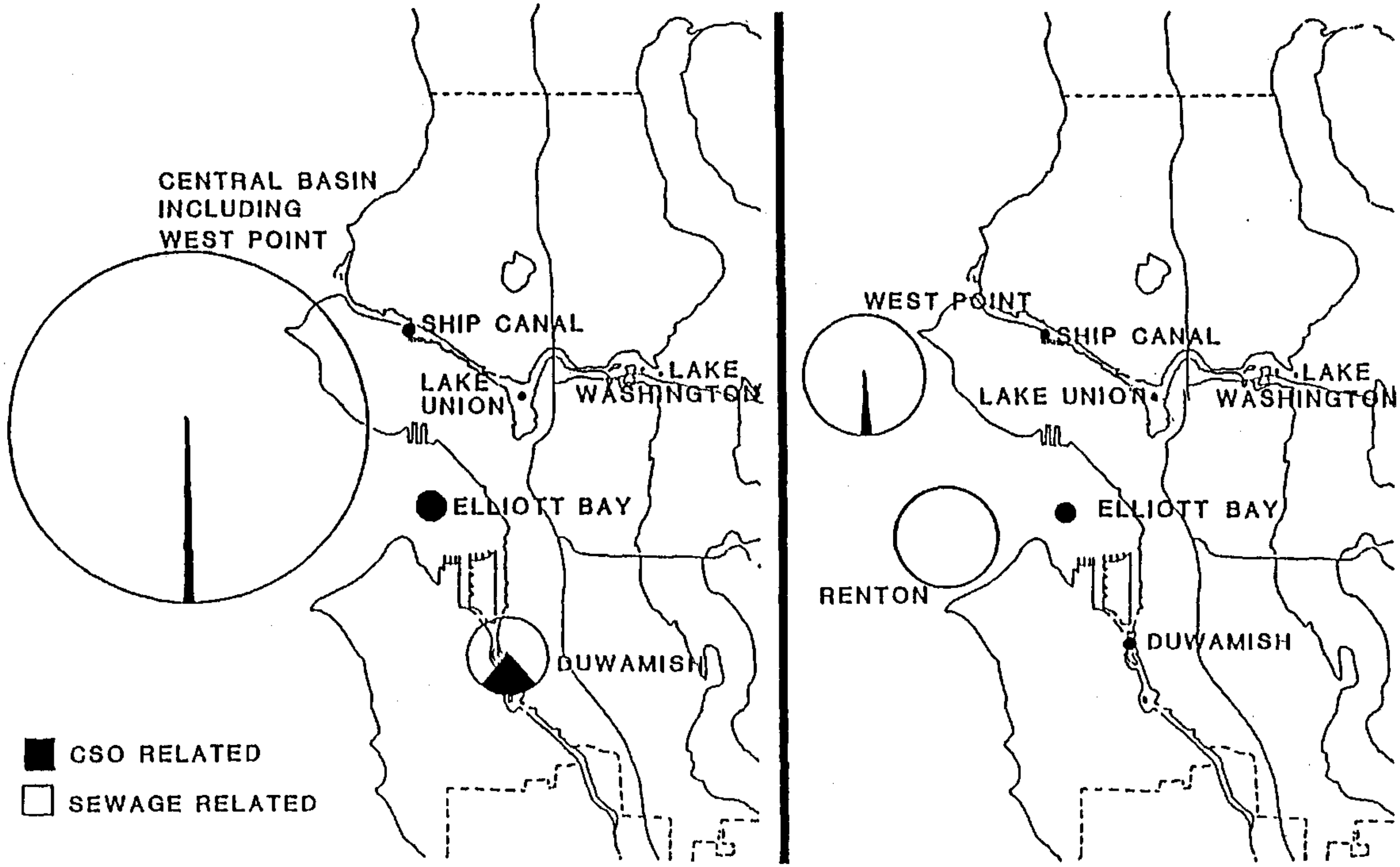
Thus, all of the CSO projects will affect areas with previously documented environmental impacts. There is no way to evaluate these impacts quantitatively because there are many other sources of pollutants affecting water quality at the same locations.

EFFECT OF METRO CSO CONTROL PROJECTS ON METRO CSO VOLUME, FREQUENCY AND EFFECT ON PREVIOUSLY ESTIMATED POLLUTANT LOADINGS

The effect of the revised Metro CSO projects has been estimated based on the previous (1986 plan) modeling of pollutant loadings. The changes in the CSO projects are summarized below:

	For 75 Percent Volume Reduction	
	1986 Plan	1988 Plan
SSA		
CATAD	x	x
Hanford Separation	x	
Hanford/Bayview/Lander		x
Diagonal Separation	x	x
Kingdome/Industrial Area Sep.	x	x
Michigan Separation	x	x
Denny CSO Treatment	x	
Denny Separation		x
NSA		
CATAD	x	x
Parallel Fort Lawton Tunnel	x (400 mgd)	x (440 mgd)
University Regulator (Green Lake/ Portage Bay Improvement Project)	x	x
NSA Separation	x	

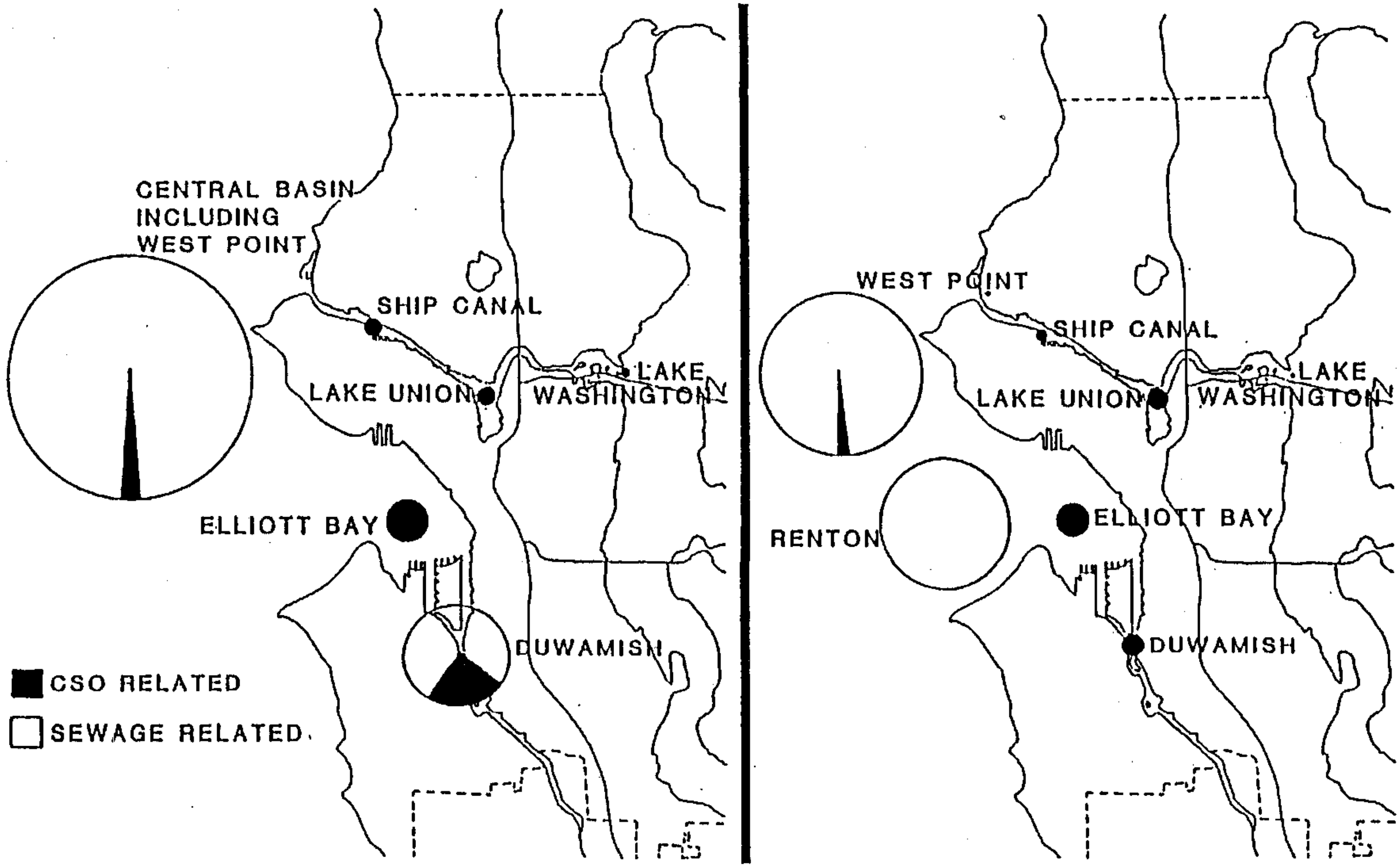
Figures 2-2, 2-3 and 2-4 compare current estimated loadings for biochemical oxygen demand, suspended solids and lead with projected loadings. Table 2-5 compares the revised loadings with those in the 1986 plan and with current, estimated loadings. After combined sewers are separated to eliminate spills of sanitary sewage, the storm water that previously went to West Point will be discharged from the new separate storm drains to other receiving waters. Whenever a storm causes runoff, there will be a discharge from the new storm drain. Total separation of the sewers eliminates the spills of raw sewage and the related viruses and bacteria--an important achievement. However, the discharge of storm water, a portion of which previously was treated at West Point, can in some instances increase the loadings of certain pollutants since they are predominantly found in storm runoff, specifically suspended solids and some metals. Appendix F discusses concerns related to urban storm-water discharges in detail.



CURRENT ANNUAL BOD DISCHARGES VS. YEAR 2005 COMPARATIVE CSO-RELATED BOD ANNUAL LOADINGS

75% CSO VOLUME REDUCTION

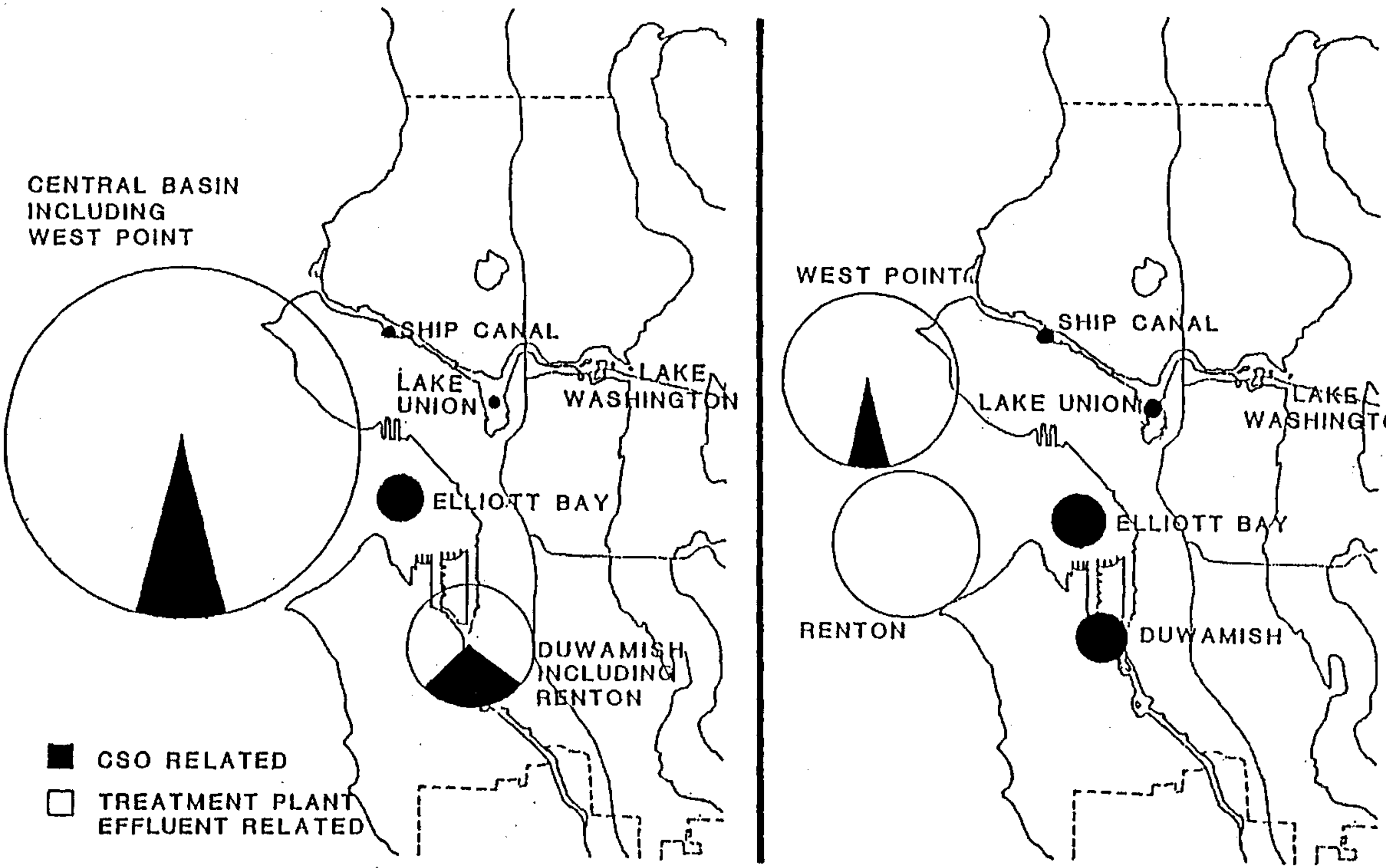
Figure 2-2



CURRENT ANNUAL SUSPENDED SOLIDS DISCHARGES VS. YEAR 2005 COMPARATIVE CSO-RELATED SUSPENDED SOLIDS ANNUAL LOADINGS

75% CSO VOLUME REDUCTION

Figure 2-3



CURRENT ANNUAL LEAD DISCHARGES VS. YEAR 2005 COMPARATIVE CSO-RELATED LEAD ANNUAL LOADINGS

75% CSO VOLUME REDUCTION

Figure 2-4

TABLE 2-5

CSO POLLUTANT LOADINGS (POUNDS PER YEAR) AT 75 PERCENT CSO REDUCTION 1986 PLAN VS. REVISED PLAN

Receiving Water	CSO-Related Pollutant	Existing-- No CSO Control	75% Vol. Reduction, 1986 Plan	Revised 75% CSO Control Projects
Duwamish	Flow (MG)	1,406	373	301
	BOD	499,000	249,200	212,000
	SS	854,000	532,000	477,100
	Cadmium	47	26	23
	Lead	3,500	2,770	2,630
	Zinc	3,680	2,990	2,800
Elliott Bay	Flow (MG)	535	112	73
	BOD	467,000	165,900	122,000
	SS	519,000	300,100	468,800
	Cadmium	57	30	31
	Lead	1,930	2,220	3,005
	Zinc	2,230	2,405	3,215
Ship Canal/Lake Union/Portage Cut	Flow (MG)	454	97	166
	BOD	83,000	55,000	37,700
	SS	236,000	335,000	229,600
	Cadmium	7	9	6
	Lead	930	1,615	1,015
	Zinc	940	1,595	990
Lake Washington/Union Bay	Flow (MG)	13	2	2
	BOD	3,500	400	400
	SS	9,300	1,200	1,200
	Cadmium	0	0	0
	Lead	28	4	4
	Zinc	30	4	4
Central Basin[1]	Flow (MG)	4,200	--	--
	BOD	184,000	225,000	235,000
	SS	501,000	288,500	284,000
	Cadmium	36	27	27
	Lead	6,160	2,120	2,100
	Zinc	6,325	2,500	2,500

(1) Based on annual average flow of 240 mgd and Renton secondary effluent composition shown in TPPS in Table D-5, TPPS Report A1, annual secondary effluent loadings to central basin could be: flow=87,600 mg/year; BOD=11,000,000 lbs; SS=18,250,000 lbs; lead=32,900 lbs; cadmium=1,460 lbs; zinc=35,100 lbs. Loadings shown in this table for "No CSO Control, Existing" are those resulting from storm water that is conveyed to West Point, treated and discharged to Central basin. Future Central basin loads include those from storm water plus the CSO loads that are transferred to a secondary plant as a result of CSO projects.

(2) Flow volumes are annual volumes and are untreated CSO only. Loadings are expressed as pounds per year and include CSO-related loads discharged from outfalls from treatment facilities, loads in remaining spills of untreated CSO, and loads from separated storm water.

The regional significance of the increased volume of storm water discharged from new storm drains associated with sewer separation projects can be illustrated by considering the existing fate of storm water in the West Point service area. Storm water that runs off from the West Point service area will ultimately be:

- **Directly discharged**--Storm-water runoff from areas with separate sanitary and storm sewers is directly discharged through existing storm drains to local receiving waters. In partially separated areas, the street drainage (representing about two-thirds of the runoff) is directly discharged, while roof drainage continues to be mixed with sanitary sewage. In the West Point service area, runoff from about 65 percent of the total area is directly discharged from separated and partially separated areas.

- **Treated**--In the combined and partially separated areas, runoff can enter the sewers that ultimately discharge to the West Point plant where the combined storm and sanitary sewage receives treatment.

- **Spilled as CSO**--Runoff entering the combined sewers that exceeds the downstream capacity of the sewer spills as a mixture of storm and sanitary sewage.

Considering the total service area, the existing fate of storm water and the fate after implementation of the 75-percent CSO control program is as follows:

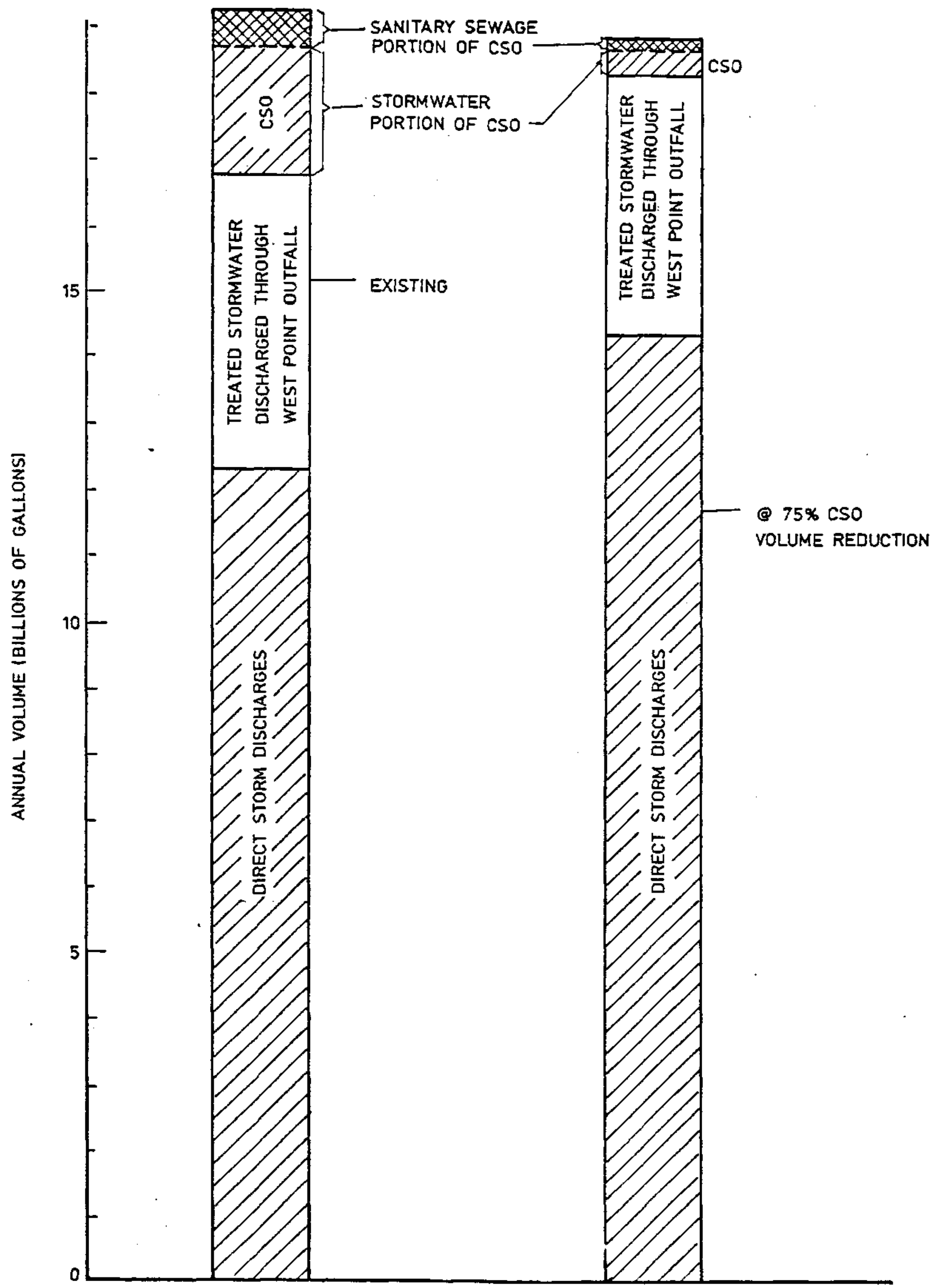
	Volume, (MG/Year)	
	Existing	At 75% CSO Reduction
Direct Storm Discharges	12,338	14,398
Treated Storm Water	4,447	3,894
Storm-water Portion of CSO	1,927	420
Subtotal, Storm Water	18,712	18,712
Sanitary Portion of CSO	482	182
	19,194	18,894

As shown above, the amount of direct storm-water discharges is increased by about 17 percent. Such a relatively small increase does not alter the regional significance of existing direct storm discharges. The great bulk of regional storm-related pollutant loadings are related to existing direct storm drain discharges rather than to the increases resulting from proposed sewer separation projects. Figures 2-5, 2-6 and 2-7 graphically present the effects of the 75-percent reduction program on regional volume, suspended solids, BOD, lead, and zinc associated with storm water and CSO.

Metro has recently made an assessment of the health risk of various pollutants found in storm water and concluded that lead is the only pollutant of those studied with potential risk (only to urban children eating crayfish). As shown in Figure 2-7, the 75-percent CSO program, coupled with treatment facility upgrades, provides a slight reduction in regional discharges of lead. The lead loadings in Figure 2-7 are projected from the pollutant concentration information described in the 1986 CSO plan, which was based predominantly on pre-1980 data. Since 1980, the use of lead in various products (i.e., gasoline) has decreased. Samples of CSO and storm water collected by Metro in 1986 show much lower concentrations for lead than used in pollutant loading calculations, although suspended solids concentrations are unchanged. The number of samples analyzed in 1986 is too limited to reach any firm conclusions; however, if these lower concentrations are verified through further sampling, then estimated lead loadings would decrease substantially. Figure 2-8 illustrates the potential effect.

Whether or not localized increases in loadings are significant at a given location depends upon the portion of the total loadings that they contribute at that location and whether or not they cause a violation of a water quality standard. Careful evaluation of potential effects from storm drain discharges will be made during the predesign environmental process for each project. If necessary, corrective measures will be identified and implemented on a project-specific basis. These measures could include:

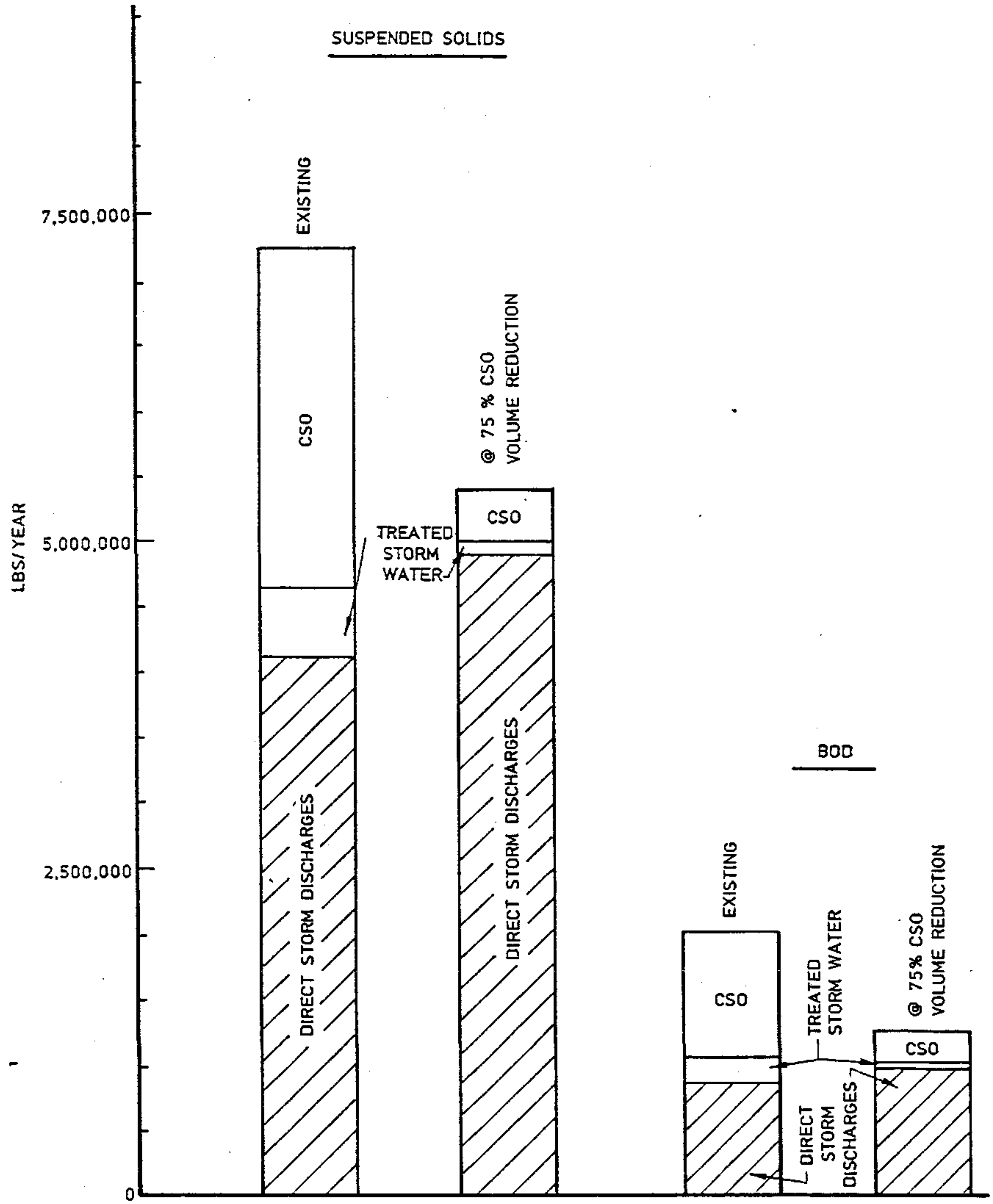
- **Source Control**
  - Source tracing
  - Hazardous material storage, handling, disposal
  - Citizen and business education programs
  - Good housekeeping for business and industry
  - Implementation of regulatory agency programs
  - Vehicle emission testing



Effect of 75% CSO Volume Reduction on Stormwater/CSO Discharges in West Point Service Area

CWC-HDR, INC.

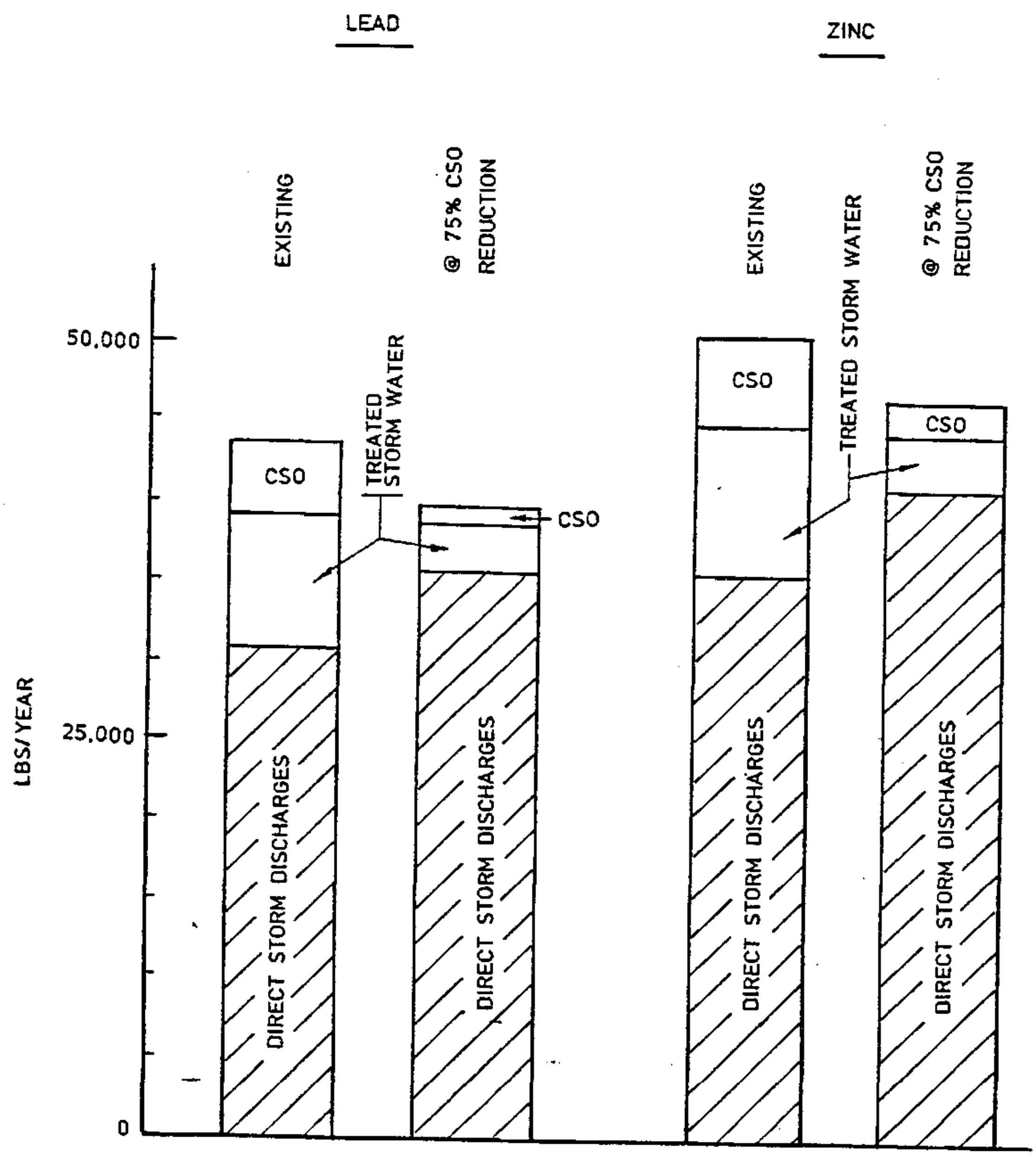
FIGURE 2-5



Effect of 75% CSO Volume Reduction on Stormwater/CSO Discharges in West Point Service Area Suspended Solids and BOD

CWC-HDR, INC.

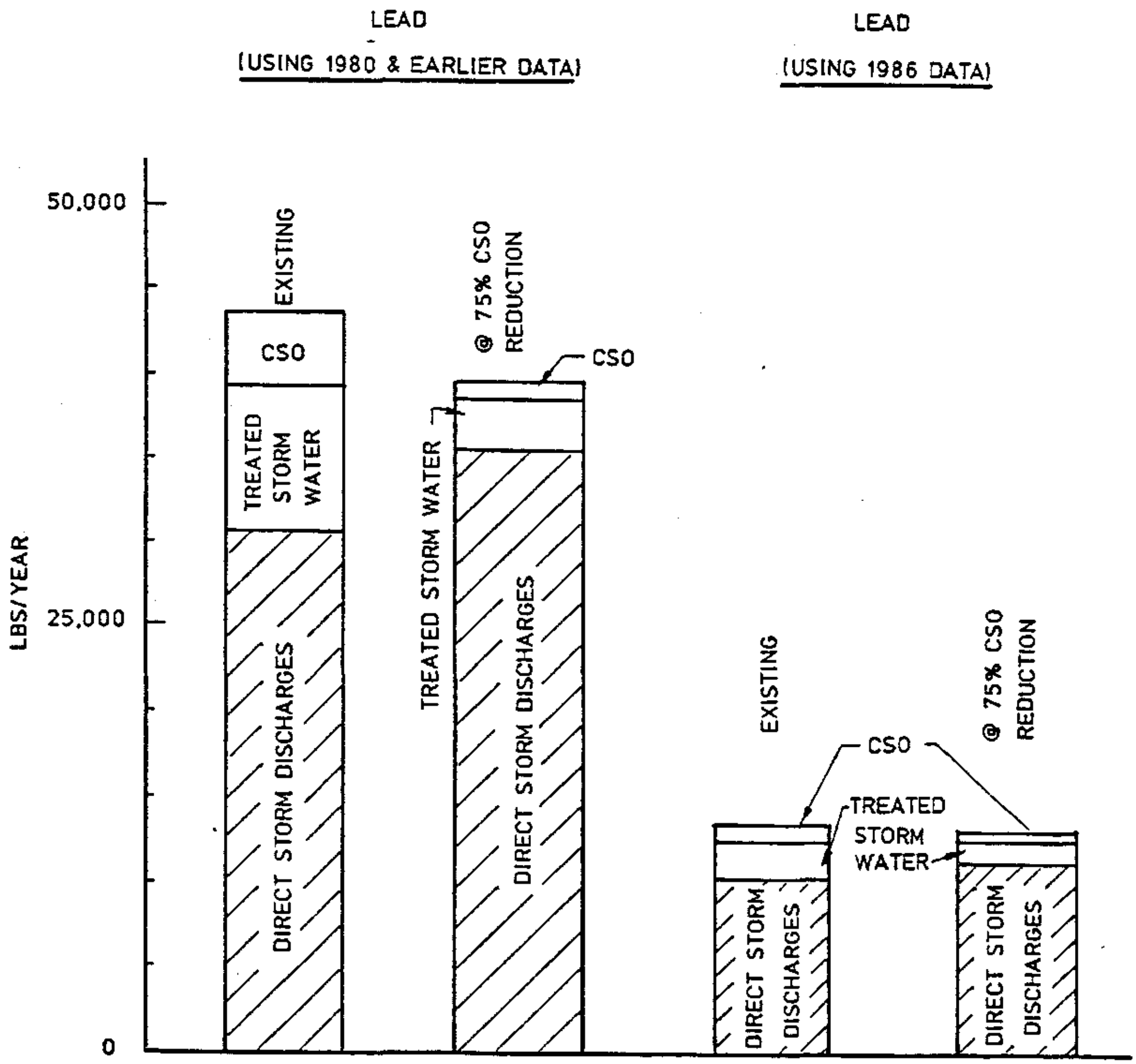
FIGURE 2-6



Effect of 75% CSO Volume Reduction on Stormwater/CSO Discharges in West Point Service Area
Lead and Zinc

CWC-HDR, INC.

FIGURE
2-7



Potential Effect of Lead Concentrations Measured in 1986 on Projected Loadings

CWC-HDR, INC.

FIGURE 2-8

■ **Management Practices**

Construction of detention facilities
Use of oil/water separators
Artificial wetlands for storm-water retention
Erosion and sediment control for construction
Improved operation and maintenance of catch basins
Dry well infiltration basins
Appropriate ordinances for new construction

As shown in Table 2-5, the projected loadings of metals to the Ship Canal and Lake Union are about 35 percent lower than shown in the 1986 plan. The decrease is a result of eliminating the NSA separation projects from the 75-percent volume reduction program. The projected metal loadings to Elliott Bay are higher because of the addition of the Denny Way separation project. However, as noted in the 1986 plan (page 5-4), the CSO-related pollutant loadings are a small fraction of the total suspended solids and metal loadings to Elliott Bay. The small increases in pounds per year of these pollutants discharged to Elliott Bay from those in the 1986 plan are fractions of a percent of the total input to Elliott Bay.

The city has raised questions about the effects of Metro's sewer separation projects on water quality. Metro has developed preliminary language to address these concerns in the form of an indemnification statement, which is presented in Appendix E.

THE CITY'S CSO CONTROL PROJECTS

As described in detail in the 1985 and 1986 plans, the City of Seattle and the Metro systems are tied together at numerous locations. City CSO projects can directly affect CSO from the Metro system. For example, city storage projects that return stored CSO to the Metro system can aggravate Metro CSO by increasing the duration of peak flows into the Metro system. For this reason, it is important to assess the nature of the city CSO projects and their potential effect on Metro. It was not possible to do so in the 1985 and 1986 plans because the city had not yet published their plan. The City of Seattle published a draft CSO plan in November 1987 that describes several proposed CSO control projects.

The effects of certain City of Seattle CSO reduction facilities were already included in the Metro base-case conditions for the year 2005. Several in- and off-line storage projects were proposed in the city's 1980 CSO plan that have been or will be built before 1990. These projects have constituted a base case assumption for the Southern Service Area since the 1985 Metro plan. Northern Service Area storage projects were incorporated during the 1986 supplemental planning effort when the entire NSA plan was reassessed. The city storage projects assumed in Metro's base future condition are presented in Technical Memorandum 4.01 These projects are identical to those presented in the city's 1987 draft CSO control plan on Tables 9-3 and 9-4, for the 1980 to 1985 and 1986 to 1990 planning periods, respectively. Also, the NSA base case includes the Dravus (Queen Anne) separation project built by the city.

The city's east Lake Union separation project as proposed by the city in June 1987, was also included in the Metro base-case assumptions for the draft CSO plan. When Metro prepared the draft CSO control plan, the city had identified certain projects to be initiated in 1987, including design of partial separation of six areas in the Lake Union area. Along with previously identified city CSO control projects (primarily storage facilities), these new separation projects covering 715 acres (523 upstream of the Denny tunnel and 192 tributary to the tunnel) were added to the base-case assumptions for planning Metro's future CSO control activities. As its planning progressed through the fall of 1987, the city discussed potential changes in its strategies for the Lake Union area. The alternative strategy would separate a smaller area in the east Lake Union basin and also include a storage tank along south Lake Union.

Although when this final Metro 1988 plan is published, the city CSO project selection will not yet be final, the potential effects of the projects proposed in the city's draft CSO plan were tested by making computer model runs using the city's proposed projects as model inputs in addition to the Metro projects described in Metro's draft 1988 plan. The results are described in Technical Memorandum 4.02. The model runs incorporated the city's alternative to the east Lake Union separation project (smaller separated area plus storage tank) to determine how this change from the base case projects used in preparing Table 2-1 could affect Metro's overflows.

Annual volumes for the Metro projects as described in this plan and the city's 1987 draft CSO plans are as follows:

Metro Plan	Annual Volume of CSO (MG) SSA	NSA
Without City Projects*	374	168
With City Projects	401	163

* Includes those city projects in base case future conditions in Metro's draft 1987 CSO control plan (Hanford tunnel, Dravus separation, separation of 715 acres in east Lake Union area, and previously-planned city storage projects, see Table 4.01.1 in TM 4.01).

The difference between the remaining volumes for each service area is minimal. In the SSA, city projects reduce Metro CSO discharges to the Duwamish by about 17 million gallons/year. City storage facilities cause a slight increase (about 2 million gallons/year) at Connecticut. The net increase in the SSA of 27 million gallons/year is primarily due to the revised east Lake Union project under consideration by the city. This alternative city project would increase Denny Way CSOs by about 42 million gallons/year over those projected using the originally proposed city east Lake Union separation project. Should the final city CSO plan include the scaled down separation project, the overall reduction in Metro CSOs would decrease from 77.5 percent to 76.5 percent.

In the NSA, the city projects result in a slight increase of Ballard (about 1 million gallons/year) and a decrease at the University regulator of about 6 million gallons for a net decrease of 5 million gallons/year.

Other than at the Denny/Lake Union and Denny Local regulators, where the city's choice of projects for east Lake Union will affect Metro, the impact of the city's draft plan on Metro's overflows is small. Metro expects to work with Ecology and the city to best achieve community objectives within the requirements of state CSO control law.

CHAPTER 3
ADDITIONAL CSO CONTROL PROJECTS TO ACHIEVE ONE CSO EVENT PER YEAR

CSO REMAINING AFTER 75 PERCENT CSO VOLUME REDUCTION PROGRAM

Tables 2-2 and 2-3 summarize the frequency and volume of remaining CSOs. Although both frequency and volume are reduced substantially, the frequency exceeds one event per year at several locations.

METHOD USED TO APPROXIMATE ACHIEVING ONE EVENT PER YEAR

As described in Chapter 2, hydrologic/hydraulic model runs were made for the NSA and SSA to determine the volume of CSO remaining at each outfall with the above 75-percent CSO volume reduction package of CSO control projects for the seven design storms. The design storms were evaluated to determine which one most closely approximates the control level needed to achieve one CSO event per year (see Technical Memoranda 2.05 and 2.08). It was found that design Storm 6 was the appropriate storm. The model run outputs were evaluated to determine which outfall overflows still occur for Storm 6, even after application of all previously-identified CSO projects. For these outfalls, projects were identified in the tributary drainage areas that could reduce or eliminate overflows from Storm 6. In this manner, an approximation was made of the long-term projects needed to supplement the initial CSO control projects to ultimately achieve the one-event-per-year goal.

CSO CONTROL PROJECTS WHICH COULD BE ADDED TO THE 75 PERCENT CSO CONTROL PROGRAM TO ACHIEVE ONE EVENT PER YEAR

Previously Identified Projects

Metro's 1985 and 1986 CSO reports identified potential projects that could be applied to achieve one CSO event per year. These are summarized below (refer to earlier reports for detailed information):

NSA Separation Projects--

The 1986 CSO control plan identified 14 separation projects in the NSA involving a total of 882 impervious acres. Of this total, nine projects involving 632 acres were included in the 1986 plan for achieving 75 percent reduction in NSA CSO. As discussed in Chapter 2, none of these projects are included in the overall-75 percent volume reduction program.

Duwamish CSO Treatment Facility--

A CSO treatment facility would be located near the Duwamish pumping station. The treated CSO would be conveyed to Elliott Bay in the vicinity of King Street. This facility was described in the November 1985 CSO plan, and some modifications to the project were described in the July 1986 plan.

University Regulator Storage--

This project, involving 20 million gallons of storage in a University of Washington parking area, was described and evaluated in Volume III of the 1985 CSO control plan. This project was considered as an alternative to be used to achieve one event per year. The location of the storage will be reviewed during this evaluation. Subsurface conditions and concerns expressed by the University raise questions about the site identified in Volume III. Also, an alternative site was proposed during the public hearing on the CSO plan which will be evaluated.

Dexter Regulator Storage--

A storage site in the area draining toward the Dexter regulator station was proposed in the November 1985 CSO control plan. That storage project, however, called for transfer of stored combined sewage to the Elliott Bay interceptor by means of the Lake Union tunnel. Since the tunnel's capacity during some storms is full, a second site was identified in the 1986 plan that did not use the tunnel. The storage project would provide 2.5 million gallons of volume immediately adjacent to the Dexter regulator in the block bounded by Dexter Avenue North and Eighth Avenue North, and Garfield and Galer streets. When capacity was available in the Central interceptor, the stored combined sewage would be pumped back into the interceptor at an existing manhole in Garfield Street.

Third Avenue West Weir Storage--

As described in the 1986 CSO plan, 2.7 million gallons of storage would be located beneath Wallace Field in the eastern portion of the block bounded by Queen Anne Avenue, West

Nickerson Street, Third Avenue West and the Lake Washington Ship Canal. The concrete storage structure would be constructed beneath the existing playing field, and the field would be restored to its present condition at the end of construction. The 2.7 million-gallon facility would be gravity-fed from a diversion structure in the Central interceptor in Nickerson Street. When capacity became available following a storm, the stored combined sewage would be pumped through a new force main to a new connection with the interceptor between the Third Avenue West weir and the junction structure joining the Central and North interceptors.

Ballard Regulator Storage--
As described in the 1986 CSO plan, a 2.5-million-gallon underground structure would be located in the block bounded by Ballard Avenue Northwest, Shilshole Avenue Northwest, Northwest Dock Place and 17th Avenue Northwest. When completed, the surface could be used for parking, as a park, or a combination of both. The storage facility would be gravity-fed. When capacity was available in the trunk, the contents of the storage structure would be pumped into the trunk at a point between the regulator station and the forebay of the Ballard siphon.

Ballard No. 1 Weir Storage--
As described in the 1986 CSO plan, a storage facility would be located in the western half of the block bounded by Northwest Ballard Way, Northwest 46th Street, 11th Avenue Northwest, and Ninth Avenue Northwest. The storage facility would be gravity-fed. When capacity was available in the trunk, the contents of the storage facility would be pumped back to the Ballard trunk through a new 18-inch force main. The force main would reconnect with the trunk just downstream of the Ballard No. 1 weir.

Central Interceptor Expansion Downstream of Dexter Regulator Station--
The 4,000 feet of the Central interceptor upstream of the Dexter regulator station consists of 84-, 66- and 60-inch pipe. The first 4,000 feet of pipe downstream of the regulator consists of 48- and 54-inch pipe. The smaller downstream pipe acts as a bottleneck, causing overflows into Lake Union from the Dexter regulator at Galer Street. This project would replace the 4,000 feet of downstream pipe (48-inch and 54-inch) with 60-inch pipe (see 1986 CSO plan for details). This change would double the capacity of this portion of the Central interceptor from about 36 mgd to 72 mgd.

Southwest Lake Washington Interceptor Downstream of Montlake Regulator Station--
The 3,000 feet of the Lake Washington interceptor upstream of the Montlake regulator station consists of 114-inch sewer, a double-barreled (42-inch and 108-inch) siphon and 90-inch pipe. The 1,800 feet of pipeline downstream of the Montlake regulator, to the junction with the North interceptor, consists of a single 48-inch siphon under the Montlake cut and 1,100 feet of 48-inch pipe. The smaller downstream line acts as a bottleneck in the Lake Washington interceptor system, causing overflows from the Montlake regulator into the Montlake cut, between Lake Union and Portage Bay. This project would add a parallel 36-inch siphon under the Montlake cut and a parallel 36-inch pipeline from the end of the siphon to the junction with the North interceptor. This change would increase the present capacity of the system to about 85 mgd. The parallel siphon and sewer would be installed next to the existing line, under the Montlake Bridge and along Northeast Pacific Street to the North interceptor. This project would only add to overflows downstream along the North interceptor. Therefore, removing this bottleneck could only be done with projects that would provide capacity for the higher Lake Washington interceptor flows.

West Marginal Way Sewers--
As described in the 1985 CSO plan, the sewage from the west side of the Duwamish River is conveyed to the east side with parallel 21-inch and 42-inch siphons under the Duwamish River. The storm-generated flows from the west side of the Duwamish frequently exceed the capacity of the siphons. Added conveyance capacity from the west side to the east side would relieve the overflows on the west side, but would transfer the overflows downstream. A 48-inch sewer from Chelan to the juncture of a new 42-inch sewer from West Michigan would combine with a new 60-inch sewer to the siphon. A new 48-inch siphon would be required and would discharge to a new 60-inch sewer connecting to the Duwamish pumping station.

Projects Not Previously Identified

City of Seattle Drainage Ordinance--
The City of Seattle's grading and drainage ordinance No. 108080 requires that new developments greater than 2,000 square feet (a reduction to 750 square feet has been proposed) must have a drainage control plan. As new development occurs, this ordinance will reduce CSO volumes and frequency. The city estimates that by the year 2030, at current rates of construction, a majority of available acreage for development will have been constructed or reconstructed in compliance with the drainage ordinance.

Several added partial separation projects have been identified and evaluated for this report. The general location of these projects is shown in Figures 3-1 and 3-2. Technical Memorandum 2.08 presents detailed information. The projects are summarized below.

In the NSA, the separation project effects are largely isolated to one CSO location which is identified. In the SSA, projects affect several locations. Basins 1 through 6 in the SSA for example, affect Harbor, Chelan and Hanford. Thus, no specific CSO is identified for the SSA projects.

Reduce Ballard No. 1 CSO (Basins 1 and 2, Figure 3-1)

Separate Greenwood/Eighth Avenue Area (Basin 1)--
The residential area north of Northwest 65th Street between Greenwood Avenue North and Eighth Avenue Northwest is served by a combined sewer system that connects into a partially separated sewer system south of Northwest 65th Street before connecting into the North interceptor. This project would partially separate the storm-water runoff from the combined area (314 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Lake Washington Ship Canal.

Separate 15th Avenue/Eighth Avenue Area (Basin 2)--
The residential area north of Northwest 65th Street between Eighth Avenue Northwest and 15th Avenue Northwest is served by a combined sewer system. This system connects into a partially separated sewer system south of Northwest 65th Street before reaching the North interceptor. This project would partially separate the storm-water runoff from the combined area (390 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Salmon Bay waterway.

Reduced Ballard CSO (Basins 3 and 4, Figure 3-1)

Separate 16th Avenue/25th Avenue Area (Basin 3)--
The residential area north of Northwest 65th Street between 16th Avenue Northwest and 25th Avenue Northwest is served by a combined sewer system. That system connects into a partially separated sewer system south of Northwest 65th Street before reaching the North interceptor. This project would partially separate the storm-water runoff from the combined area (346 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Salmon Bay waterway.

3-6

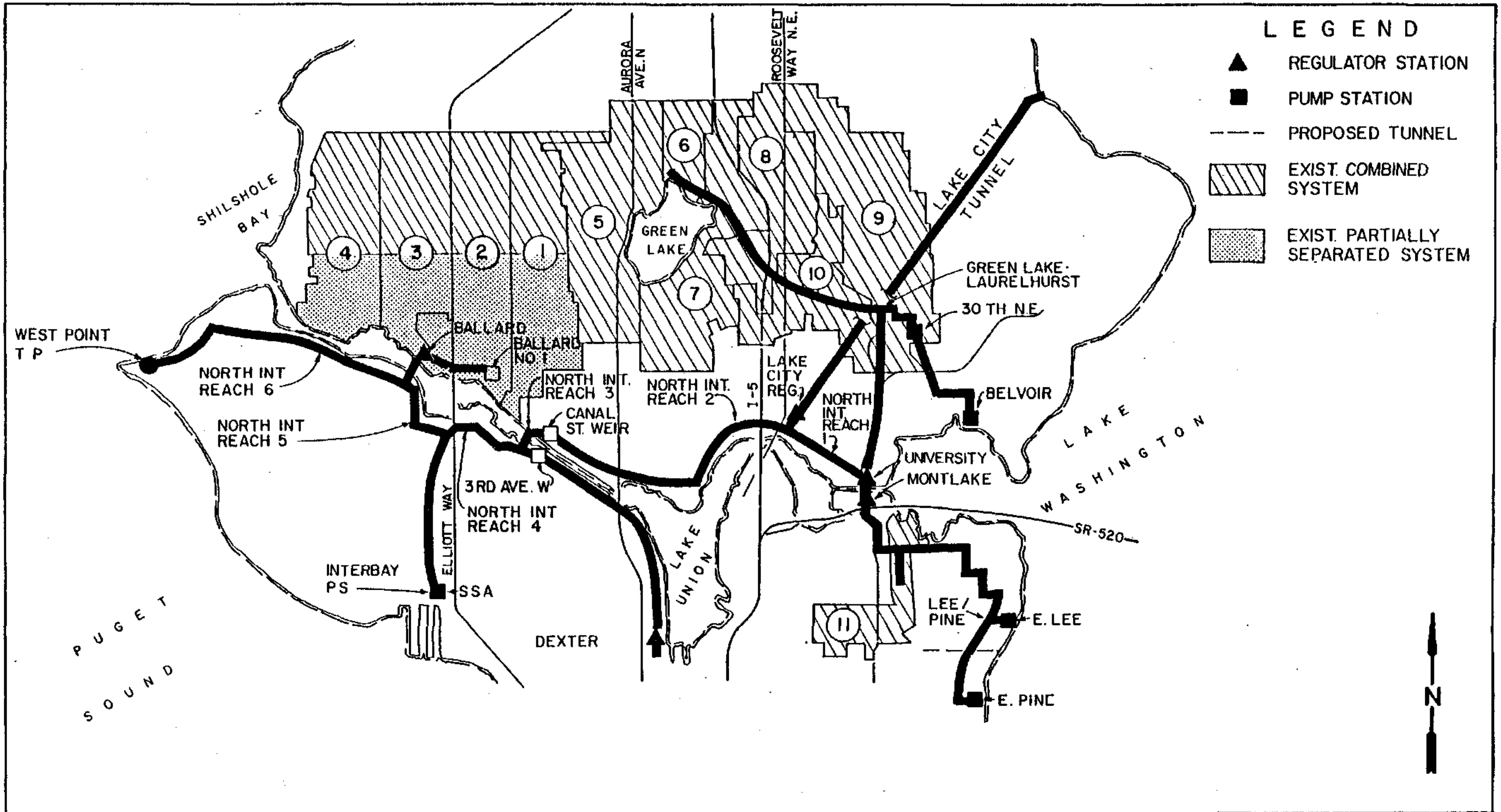


FIGURE 3-1
NORTH SERVICE AREA COMBINED SEWER STUDY
ADDITIONAL POTENTIAL SEPARATION PROJECTS
CENTRAC ASSOCIATES INC

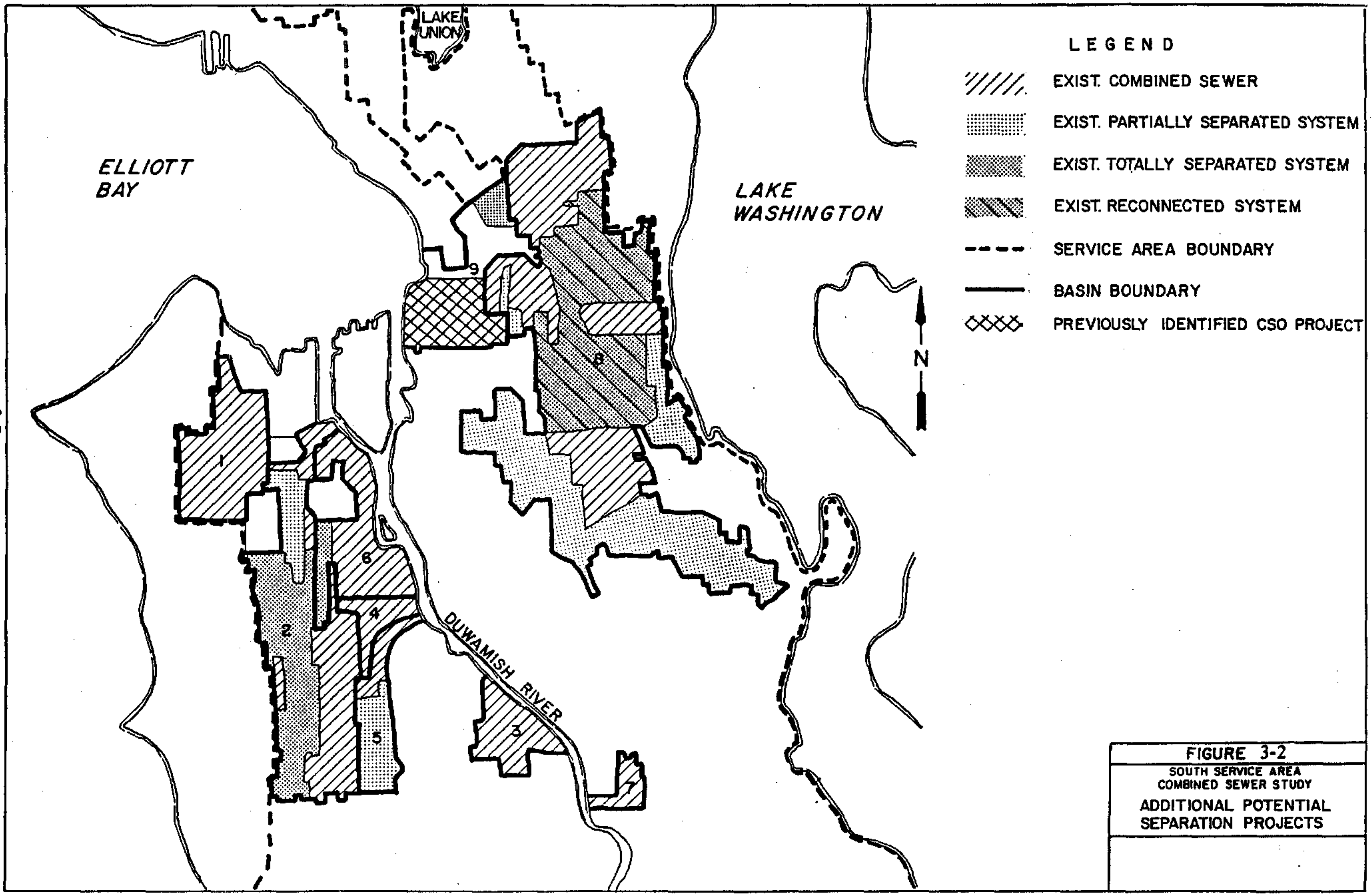


FIGURE 3-2
SOUTH SERVICE AREA COMBINED SEWER STUDY
ADDITIONAL POTENTIAL SEPARATION PROJECTS

Separate 26th Avenue/33rd Avenue Area (Basin 4)--
The residential area north of Northwest 65th Street between 26th Avenue Northwest and 33rd Avenue Northwest is served by a combined sewer system which connects into a partially separated sewer system south of Northwest 65th Street before connecting into the North interceptor. This project would partially separate the storm-water runoff from the combined area (326 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Salmon Bay waterway.

Reduce University CSO (Basins 5 through 10, Figure 3-1)

These separation projects are an alternative to the University storage project described in the 1986 plan.

Separate West Green Lake Area (Basin 5)--
The residential area west of Green Lake is served by a combined and a totally separated sewer system that connects into the Green Lake trunk. This project would partially separate the storm-water runoff from the combined area (659 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the proposed Green Lake drainage trunk (Green Lake/Portage Bay Improvement project).

Separate North Green Lake Area (Basin 6)--
The residential area north of Green Lake is served by a combined and a totally separated sewer system that connects into the Green Lake trunk. This project would partially separate the storm-water runoff from the combined area (131 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Green Lake drainage trunk.

Separate Southeast Green Lake Area (Basin 7)--
The residential area southeast of Green Lake is served by a combined and a totally separated sewer system that connects into the Green Lake trunk. This project would partially separate the storm-water runoff from the combined area (539 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Green Lake drainage trunk.

Separate East Green Lake Area (Basin 8)--

The residential area east of Green Lake is served by a combined and a totally separated sewer system that connects into the Green Lake trunk. This project would partially separate the storm-water runoff from the combined area (428 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Green Lake drainage trunk.

Separate North University Area No. 1 (Basin 9)--

The residential area north of the University of Washington is served by a combined and a partially separated sewer system that connects into the Laurelhurst trunk. This project would partially separate the storm-water runoff from the combined area (796 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Green Lake drainage trunk.

Separate North University Area No. 2 (Basin 10)--

The residential area north of the University of Washington is served by a combined and a totally separated sewer system that connects into the Green Lake trunk. This project would partially separate the storm-water runoff from the combined area (423 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into the Green Lake drainage trunk.

Reduce Montlake CSO (Basin 11)--

The residential area in the Montlake neighborhood is served by a combined and a partially separated sewer system that connects into the Arboretum and southwest Lake Washington trunks. This project would partially separate the storm-water runoff from the combined area (191 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into Union Bay.

Enlarge Green Lake Drainage Trunk--

Several of the above NSA separation projects would result in storm discharges to the proposed Green Lake drainage trunk. As a result, the capacity of the trunk would have to be increased. The estimated cost is $5.3 million.

In the earlier CSO plans, a Duwamish CSO treatment plant was considered. The following SSA separation projects are an alternative to the Duwamish CSO treatment plant. As shown in

Table 3-1, the one-event-per-year goal can be achieved by separating basins 1, 2, 3, 8 and 9. The cost is less than the cost of the Duwamish CSO plant and related outfall.

Separate West of Harbor Regulator (Basin 1)--

This residential area in West Seattle is served by a combined sewer system that connects into the Delridge trunk. This project would partially separate the storm-water runoff from the combined area (413 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into Elliott Bay.

Separate Area South of Chelan Regulator (Basin 2)--

This residential area in West Seattle is served by combined, partially separated and totally separated sewer system that connects into the Delridge trunk. This project would partially separate the storm-water runoff from the combined area (573 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into Elliott Bay.

Separate South Park Area (Basin 3)--

This residential area in West Seattle is served by a combined sewer system that connects into the Duwamish interceptor on its way to the West Point Treatment Plant. This project would partially separate the storm-water runoff from the combined area (306 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging into the Duwamish River.

Separate West Holly Area (Basin 4)--

This residential/industrial area in West Seattle is served by a combined sewer system that connects into the west Duwamish interceptor. This project would partially separate the storm-water runoff from the combined area (6 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging into the Duwamish River.

Separate Highland Park Way Area (Basin 5)--

This residential/industrial area in West Seattle is served by a combined sewer system that connects into the west Duwamish interceptor. This project would partially separate the storm-water runoff from the combined area (11 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging into the Duwamish River.

Separate Charleston Street/Dakota Street Area (Basin 6)--
This residential/industrial area in West Seattle is served by a combined sewer system that connects into the west Duwamish interceptor. This project would partially separate the storm-water runoff from the combined area (117 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging into the Duwamish River.

Separate South Norfolk Street Area (Basin 7)--
This residential/industrial area in South Seattle is served by a combined sewer system that connects into the East Marginal Way interceptor. This project would partially separate the storm-water runoff from the combined area (169 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging into the Duwamish River.

Separate North Hanford Area (Basin 8)--
This residential area in Seattle is served by a combined, partially separated and totally separated sewer system that connects into the Hanford trunk. This project would partially separate the storm-water runoff from the combined area (953 acres) by installing storm drains, connecting the existing catch basins or adding new catch basins and discharging directly into Lake Washington.

Separate Connecticut Area (Basin 9)--
This area in Seattle is served by a combined sewer system that connects into the Elliott Bay interceptor. This project would partially separate a combined area of 372 acres, 162 of which is urbanized, by installing storm drains connecting the existing catch basins or adding catch basins and discharging into Elliott Bay.

APPROXIMATE COSTS TO ACHIEVE ONE EVENT PER YEAR USING REPRESENTATIVE PROJECTS

The initial goal of the CSO program is to achieve a 75 percent reduction over the next 20 years; thus, the program to achieve one event per year will not be initiated until after the year 2005. During this period, Metro will evaluate the effectiveness of its initial CSO program and make appropriate adjustments to the computer models as more data are collected and future land uses are better defined. The effects of Seattle's CSO projects will also be evaluated. It is also possible that the current Ecology regulations calling for one event per year will be modified and the effects of the city drainage ordinance will become better defined. Because of the many uncertainties affecting the post-2005 program, the purpose of this section is to approximate the potential future costs to achieve one event per year. The projects described in this chapter will all be considered to determine the most desirable combination in light of the information that becomes available in the next few years. Representative separation projects that would achieve one event per year are used to approximate costs for this report. As more data becomes available, project selection can be refined and optimized. Although other combinations of the projects previously described may be later selected, these representative projects provide an indication of the potential future costs to achieve one event per year.

For its initial analysis of costs, Metro evaluated partial separation projects by modeling combinations of partial separation projects until overflows from design Storm 6 were eliminated. The results are shown in Table 3-1 and the project locations shown in Figures 3-3 and 3-4. The costs to achieve one event per year in the NSA are larger than in the SSA. There is less volume reduction in the initial program in the NSA (64 percent) than in the SSA (81 percent). The partial separation project combination for the NSA shown in Table 3-1 resulted in model predictions of zero overflow at all Metro NSA locations for Storm 6. In the SSA, the project combination shown in Table 3-1 resulted in a prediction of zero overflow at seven of the 14 Metro locations, 0.1 million gallons or less at four of the others (essentially zero considering the modeling accuracy), and small overflows totalling less than 6 million gallons at three locations: Hanford, Lander, Denny. It is anticipated that the city drainage ordinance and the benefits of CATAD modifications (not accounted for in the analysis) will reduce these three locations to the one event per year level. If monitoring results show that there remains more than one event per year at these locations, use of total rather than partial separation may be necessary in portions of these basins, and future costs would increase. The approximate overall cost to achieve each level of CSO control is:

	Capital Cost (Millions, 1988 Dollars)	Reduction in CSO Volume (MG/Year)	Cost/MG of CSO Reduction
75 Percent Volume Reduction	$124.9	1,865	$ 67,000
Increase Reduction to One Event per Year	$168.0	~500	$335,000
TOTAL	$294.0		

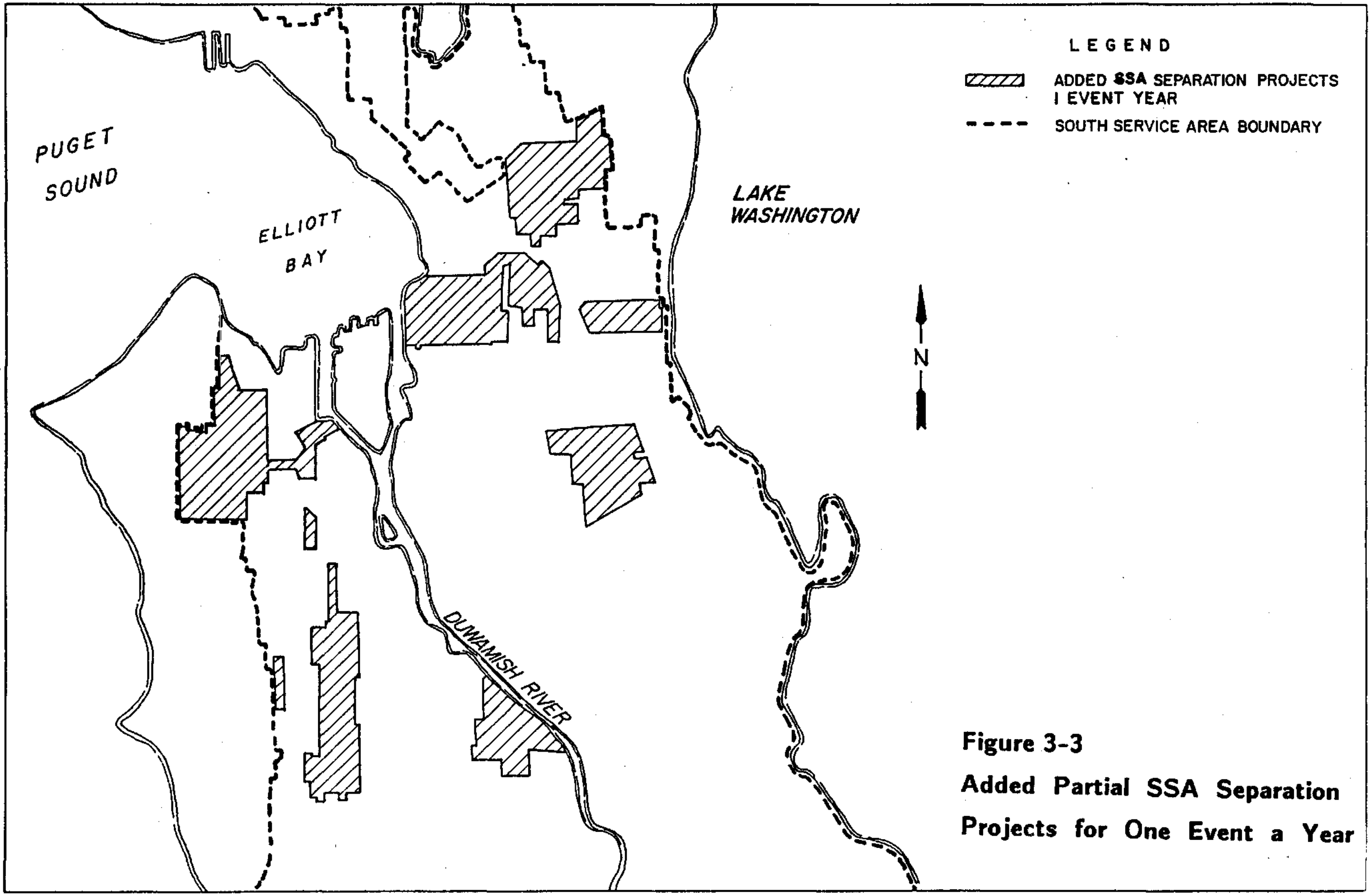


Figure 3-3
Added Partial SSA Separation Projects for One Event a Year

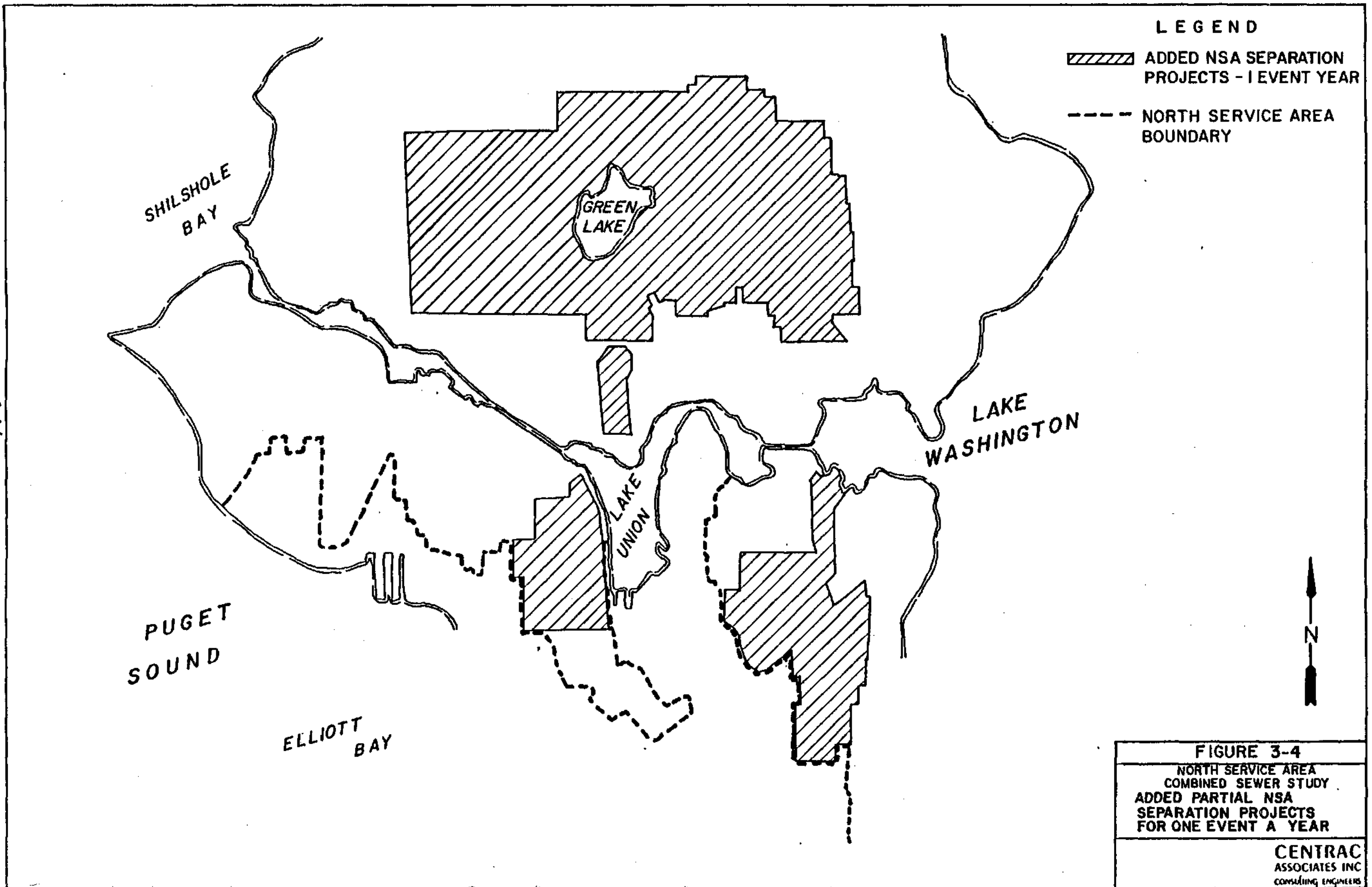


FIGURE 3-4
NORTH SERVICE AREA COMBINED SEWER STUDY
ADDED PARTIAL NSA SEPARATION PROJECTS FOR ONE EVENT A YEAR

TABLE 3-1

PARTIAL SEPARATION PROJECTS ADDED TO 75 PERCENT CSO VOLUME REDUCTION PROGRAM TO ACHIEVE ONE EVENT PER YEAR

			Capital Cost (Millions of 1988 Dollars)
NSA			
Project Area (Figure 3-1)			
1	-	Greenwood/8th Avenue	$ 5.2
2	-	15th Avenue/8th Avenue	8.4
5	-	West Green Lake	9.9
6	-	North Green Lake	1.5
7	-	Southeast Green Lake	11.4
8	-	East Green Lake	9.0
9	-	North University Area No. 1	18.6
10	-	North University Area No. 2	8.1
11	-	Montlake Area	5.6
	-	Separation Projects (portion of those included in the 1986 plan)	35.0
	-	Enlarge Green Lake Drainage Trunk	5.3
		Subtotal, NSA	$118.0
SSA			
Project Area (Figure 3-2)			
1	-	West Harbor	$ 7.7
2	-	South Chelan	16.9
3	-	South Park	6.1
8	-	North Hanford	14.4
9	-	Connecticut	4.9
		Subtotal, SSA	$ 50.0
		TOTAL	$168.0

As shown by the above costs, the cost per million gallons of CSO reduction increases dramatically as the level of control increases from the 75 percent volume reduction to one event per year.

Figure 3-5 also provides a perspective on the relative cost of achieving various levels of CSO control. It is clear that costs increase dramatically; it is less certain that the benefits to the environment increase proportionately. Monitoring of the performance and impacts of the initial CSO control projects will provide data to better judge these benefits.

The representative projects used to estimate the cost of achieving one event per year involve partial separation of 2,617 acres in the SSA and 5,710 acres in the NSA. Table 3-2 and Figure 3-6 summarize how the characteristics of the existing service area would change at 75 percent CSO volume reduction and with the one-event-per-year projects. In partially separated areas, about one-third of the storm runoff continues to enter the sanitary sewer system. Thus, the total equivalent acres from which runoff enters the sanitary sewer system can be summarized as follows:

	Acres From Which Runoff Enters Sanitary Sewer System		
	Existing	75 Percent Volume Reduction	One Event per Year
Combined	20,497	17,429	9,102
Partially Separated (0.33 of total area)	3,749	3,482	6,230
	24,246	20,911 (-14%)	15,332 (-37%)

Although separation plays a major role in the 75-percent control plan, runoff from 86 percent of the existing combined area will continue to enter the sanitary sewer system and receive treatment. Impacts of storm discharges from the 14-percent decrease in combined area must be carefully evaluated; however, runoff from a substantial part of the existing combined area will continue to enter the sanitary system and receive treatment. At one event per year, runoff from 63 percent of the current combined system will continue to enter the system.

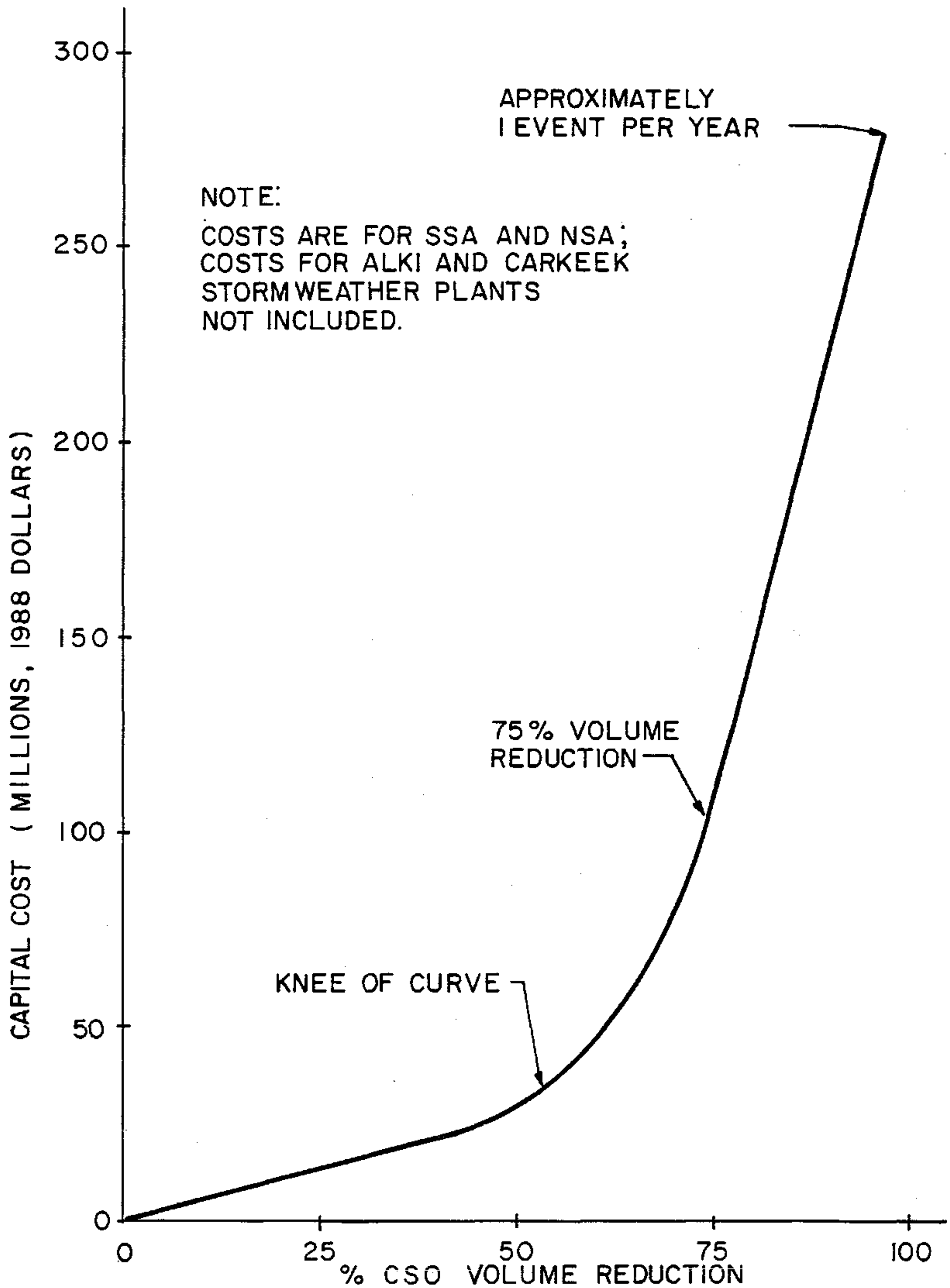


FIGURE 3-5

NORTH SERVICE AREA
COMBINED SEWER STUDY

CAPITAL COST VS CSO VOLUME REDUCTION

CENTRAC
ASSOCIATES INC
CONSULTING ENGINEERS

TABLE 3-2
SERVICE AREA CHARACTERISTICS
Existing Conditions, 75% CSO Volume Reduction, and One Event per Year

	Existing Area (acres)*			Area (acres) at 75% Volume Reduction**			Area (acres) at One Event/Year***		
	SSA	NSA	Total	SSA	NSA	Total	SSA	NSA	Total
Combined	8,684	11,813	20,497	5,616	11,813	17,429	2,899	6,203	9,102
Totally Separated	5,801	1,751	7,552	8,577	2,851	11,428	8,577	2,851	11,428
Partially Separated	6,550	4,811	11,361	6,842	3,711	10,553	9,559	9,321	18,880
TOTAL	21,035	18,375	39,410	21,035	18,375	39,410	21,035	18,375	39,410

* From 1986 plan Appendix, Table 1.03.1 for SSA, Table 3.01.4 for NSA.

** From individual project descriptions in 1985, 1986, and this CSO report: Lander/Kingdome separation - 971 combined acres to totally separated; Diagonal separation - 496 combined acres to totally separated; and 224 partially separated acres to totally separated; Michigan separation - 1,017 combined acres to totally separated and 68 partially separated acres to totally separated; Denny separation - 584 combined acres to partially separated; University Regulator (Green Lake/Portage Bay Improvement Project - 1,416 combined acres to totally separated.

*** From Appendix to this plan, Technical Memorandum 2.08; SSA - 2,617 combined acres to partially separated; NSA - 5,710 combined acres to partially separated.

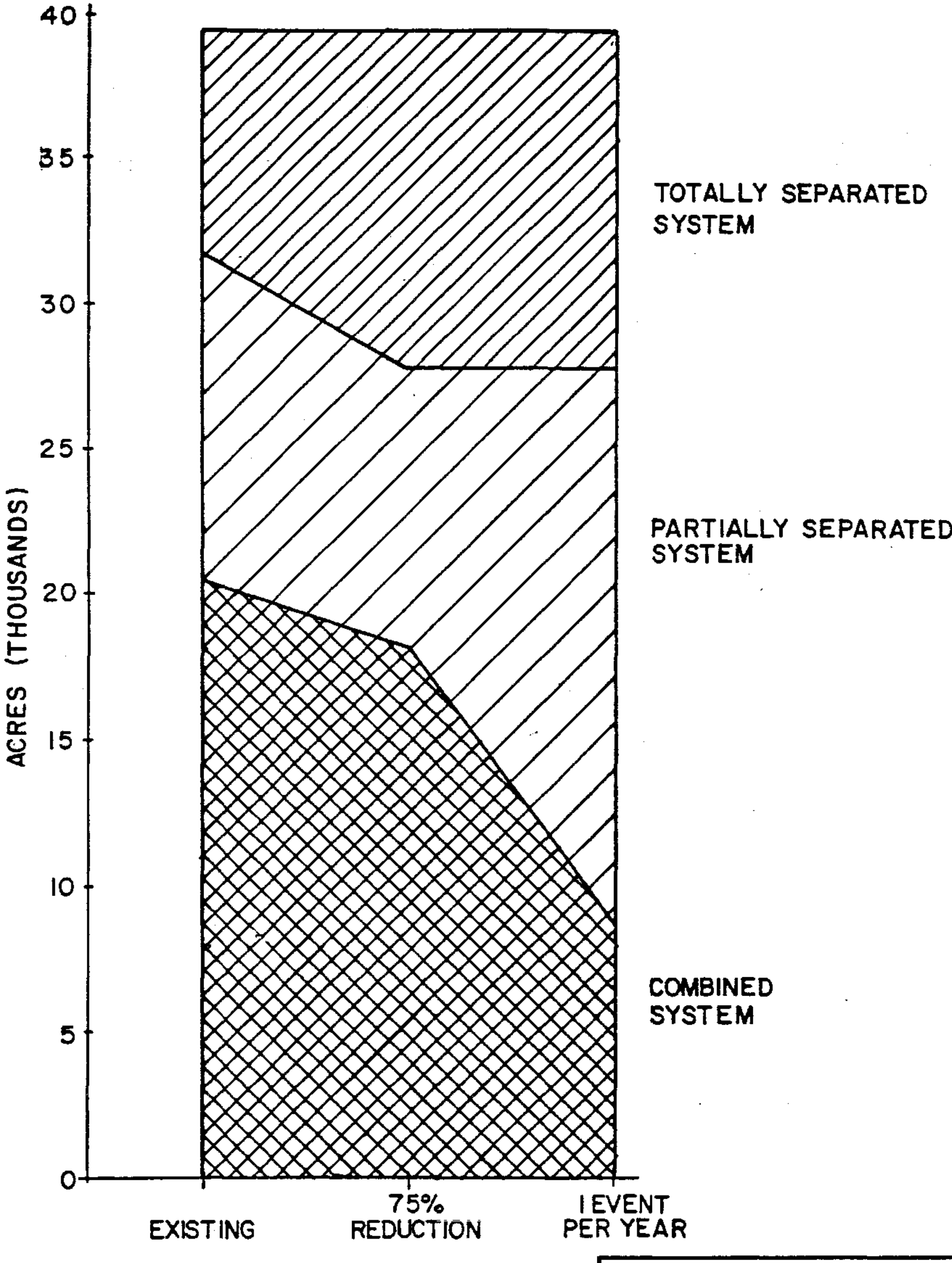


Figure 3-6

Characteristics of Service Area for Various Levels of CSO Control

CHAPTER 4

RECOMMENDED CSO CONTROL PROGRAM

PROJECTS AND PHASING

Chapter 2 describes the basis for selecting the CSO control projects to achieve the 20-year goal of 75 percent CSO volume reduction. Figure 2-1 shows the locations of the proposed CSO control projects. The proposed phasing of these projects which will achieve a projected 75-percent CSO volume reduction is:

Project	For Descriptions[1] of Project, Refer to	Year Design Initiated	Year On-Line	Cost (Millions)
Hanford/Bayview/Lander	1985; p 5-74 1988; p 2-2	1986	1992[2]	$20.1
CATAD Modifications	1985; p 5-3; and p 5-64	1987	1991	4.2
Parallel Fort Lawton Tunnel	1985; p 5-31	1987	1993	11.1
Carkeek CSO Treatment	1985, p 5-87	1988	1992	1.8
University Regulator (Green Lake/Portage Bay Improvement Project)	1985; p 5-3	1986	1992	22.3
Alki CSO Treatment	1985; p 5-81	1989	1995	10.8
Denny Partial Separation	1988; p 2-3 & TM 2.01	1993	1999	20.0
Diagonal Total Separation	1985; p 5-74	1995	1999	2.9
Michigan Total Separation	1985; p 5-77	1997	2003	24.3
Kingdome Total Separation	1985; p 5-76	2000	2006	7.3

1 1985 refers to 1985 CSO Plan; 1988 refers to this document. Modeling assumptions described in Technical Memorandum 2.04.

2 Hanford tunnel separation portion will be on-line in 1988.

The Hanford/Bayview project work was initiated in 1986, and construction is under way on portions of the project. The Lander separation portion of the project is being designed, and it is anticipated that it can be on-line by 1992. The CATAD modification study has been initiated and should be on-line by 1991. To take advantage of potential grant funding, Metro will begin the Carkeek project in 1988 and the Alki project in 1989. The timing of the parallel Fort Lawton tunnel is dictated by the secondary treatment project schedule.

As described in Technical Memorandum 4.01, the city and Metro CSO projects were grouped into four five-year phases:

- **Phase 1: Complete Ongoing CSO Control Projects (1987 - 1991)**

  City

  Queen Anne West Separation
  Puget Sound Beaches/Magnolia Storage
  Lake Washington North Storage
  Lake Washington South Storage
  Alaskan Way Separation
  Denver Avenue Separation

  Metro

  Hanford Separation/Bayview Storage
  CATAD Modifications

- **Phase 2: Begin Immediately (1992 - 1996)**

  City

  Lake Union South and East Storage/Separation
  Interlaken/Portage Bay Separation
  Interbay/Pier 91 Storage

  Metro

  Alki CSO Treatment
  Carkeek CSO Treatment
  Parallel Fort Lawton Tunnel
  University Regulator (Green Lake/Portage Bay Improvement Project)
  Lander Separation

- **Phase 3: Stage Per Metro (1997 - 2001)**

  City

  Duwamish-West Waterway Separation/Storage
  Diagonal Storage/Separation

  Metro

  Denny Partial Separation

■ **Phase 4: Stage Per Metro (2002 - 2006)**

City

Vine Street Separation and Weir Modification
Elliott Bay Waterfront Partial Separation and Inlet Modifications
Ship Canal Weir Modifications
Ballard Storage (after 2006)

Metro

Michigan Separation
Kingdome/Industrial Separation (remainder)

The city plan indicates that the Ballard storage project will not be completed until after 2006. It was included in Phase 4 to determine what effect it will have on Metro CSO. Although the impact may not occur until after 2006, the large size of the Ballard storage tank made it desirable to determine its effect. Although the Diagonal separation project remains on the Metro project list, the above phasing includes it as a city project. As described in TM 4.02, the city and Metro Diagonal projects produce essentially the same result.

Table 4-1 presents the estimated volume of CSO remaining at the end of each phase.

TABLE 4-1

CSO VOLUMES REMAINING AT THE END OF EACH PHASE
(Includes Effects of City CSO Projects)

	Metro CSO Volume Remaining (MG/Year)			
	SSA	NSA	Total	Percent CSO Volume Reduction
Phase 1 (1987 - 1991)	1,233	611	1,844	23
Phase 2 (1992 - 1996)	1,038	171	1,209	50
Phase 3 (1997 - 2001)	795	171	966	60
Phase 4 (2002 - 2006)	401	167	568	76

COSTS

The costs of the above Metro program are as follows (see Appendix B):

Present Worth (Capital, O&M, Equipment Replacement)	
Through 1995	$ 70,490,000
Through 2030	$122,940,000
Capital (1988 Dollars)	
Through 2005	$124,855,000
Inflated Capital	
Through 1995	$ 83,980,000
Through 2005	$188,050,000

FIVE YEAR REVIEW OF PROGRAM

The effects of the CSO projects will be evaluated by collecting and examining data on overflows as specific projects are completed. At five-year intervals, a report will be prepared that presents this information. The report will also examine the potential significance of observed effects in regard to modifying subsequent, planned projects. Appropriate adjustments will then be made to the CSO control program.

CSO DISCHARGE AND SEDIMENT CHARACTERIZATION AND SAMPLING PLAN

Metro has sampled both CSO discharge and sediment in various drainage basins that can be used to chemically characterize specific CSOs. In addition to data that Metro has collected, other agencies have collected samples characterizing the sediments in front of CSO discharges. The following table lists the current Metro CSO locations and notes if there is chemical information for the discharge or sediments.

Of the ten CSOs with available discharge information, only five had the actual overflows sampled. These five are Michigan, Hanford, Lander, Denny Way and University. The first four are discussed in the *Toxicant Pretreatment Planning Study (TPPS) A-2, Collection System Evaluation.* The University regulator information is presented in the University regulator

CSO predesign reports. The other five CSOs can be characterized by samples taken from the drainage basins during rainfall events. These basins were sampled as part of the TPPS. It was noted on the data base whether the samples were taken during storm events or not. By summarizing the data for samples taken only during storm events, a usable characterization of the CSO discharge can be made. The characterization is potentially biased high as the storm may not have been sufficient to cause an overflow; and as the samples were 24-hour composites, they may have included more than the storm event.

TABLE 4-2

AVAILABILITY OF CHEMICAL DATA

Combined Sewer Overflow	Discharge	Sediments
West Michigan	x	
Harbor		
Chelan		
Eighth Avenue		
Michigan	x	x
Brandon		
Duwamish Pumping Station		
Hanford	x	x
Lander	x	x
Connecticut		x
King	x	x
Denny Way	x	x
Norfolk		
Ballard & Ballard No. 1	x	
Third Avenue West	x	
Dexter		
Montlake		
University	x	x

Table 4-3 gives the geometric mean concentrations for the ten CSOs. The data taken from the Ballard CSO are also used to characterize Ballard No. 1 as the drainage basins are almost identical. No organics data were taken for Ballard or Third Avenue West.

TABLE 4-3
GEOMETRIC MEAN CONCENTRATIONS

	Michigan	Lander	Denny Way	Hanford	Harbor	King	University	Ballard	3rd Ave West
PRIORITY POLLUTANT ORGANICS (UG/L)								No Samples	No Samples
ACIDS									
Phenol	7.00	1.50	3.00	0.95	6.20	12.00			
2,4-Dimethylphenol				0.03	1.50				
BASES									
N-Nitrosodiphenylamine			1.00						
NEUTRALS									
1,3-Dichlorobenzene			0.01		5.80				
1,2-Dichlorobenzene			0.50		9.80	0.12	1.30		
1,4-Dichlorobenzene			0.15		0.94	0.50			
1,2,4-Trichlorobenzene			0.01						
Isophorone			0.35						
PHTHALATE ESTERS									
Dimethly phthalate			0.08	0.01	0.25				
Diethyl phthalate			2.80	0.50	4.50	0.87			
Di-n-butyl phthalate	18.00	12.00	13.00	12.00	26.00	6.50	0.33		
Benzyl butyl phthalate	6.70	11.00	44.00	26.00	8.60	5.20	2.00		
Di-octyl phthalate	3.00	2.00	7.00	7.20	20.00	8.50			
Di-n-octyl phthalate							0.22		
Bis (2-ethylhexyl) phthalate							8.10		
Sum of Phthalate Esters	27.70	25.00	66.88	45.71	59.35	80.42	10.65		
LOW MOLECULAR WEIGHT PAH									
Naphthalene	0.17	0.50	2.30	1.00	1.30		0.24		
Acenaphthylene			0.01						
Acenaphthene			0.01						
Fluorene	0.17		0.01						
Phenanthrene	0.33	0.50	0.32		0.33		0.43		
Anthracene									
Sum of LMW-PAH	0.67	1.00	2.65	1.00	1.53		[illegible]		

TABLE 4-3 (Continued)

	Michigan	Lander	Denny Way	Hanford	Harbor	King	University	Ballard	3rd Ave West
HIGH MOLECULAR WEIGHT PAH									
Pyrene	0.33	1.00	0.01				0.74		
Chrysene	0.17								
Fluoranthene	0.33	1.00	0.01				0.77		
Benzo (a) anthracene	0.17								
Benzo (b) fluoranthene									
Benzo (k) fluoranthene							0.17		
Benzo (a) pyrene									
Dibenzo (a-h) anthracene									
Indeno (1,2,3,c-d) pyrene	0.33								
Benzo (g,h,i) perylene	0.33								
Sum of HMW-PAH	1.66	2	0.02	0	0		1.68		
AROCLORS AND PESTICIDES									
Aroclor 1242			0.01			0.17			
Aroclor 1248			0.01			0.17			
Aroclor 1256			0.01			0.17			
Aroclor 1260						0.08			
G-BHC						0.05	0.03		
VOLATILES									
Methyl chloride		52.00							
Methyl bromide	13.00		85.00			3.00			
Chloroethane						5			
Trichlorofluoromethane	9.30	5.00	12.00						
1,1-Dichloroethylene		1.70	7.80						
1,2-trans-Dichloroethylene		0.33	0.25	0.25	133.00				
Methlylene chloride	84.00	22.00	28.00	26.00	12.00	3.20			
Vinyl chloride		37							
Chloroform	3.00	2.80	3.40	2.10	0.47	3.50			
1,1,1-Trichloroethane	8.20	1.30	1.50	2.50					
1,2-Dichloroethane	3.70								
Benzene	0.94	1.30	0.50	1.00	0.58	0.82			
Trichlorotheylene	2.70	19.00	1.00	1.20	0.67				
1,1,2-Trichloroethane		0.67							
Toluene	17.00	7.10	19.00	4.90	2.10	2.30			
Tetrachloroethylene	9.00	2.30	4.60	2.00	10.00	0.63	2.30		
Ethylbenzene	2.70	2.10	4.70	1.70	0.33	0.62	0.37		

TABLE 4-3 (Continued)

	Michigan	Lander	Denny Way	Hanford	Harbor	King	University	Ballard	3rd Ave West
METALS (UG/L)									
Antimony	1.70	3.40	2.40	1.20	1.60	0.53		0.00	0.00
Arsenic	9.10	10.00	10.00	11.00	4.80	1.60	1.00	0.93	1.20
Beryllium	0.10	0.09	0.03	0.07	0.03	0.00			
Cadmium	4.10	5.10	2.00	1.80	1.90	1.20	0.71	0.63	2.20
Chromium	42.00	71.00	23.00	23.00	19.00	22.00	5.70	27.00	24.00
Copper	60.00	150.00	73.00	48.00	73.00	79.00	25.00	53.00	90.00
Lead	220.00	110.00	150.00	120.00	150.00	90.00	58.00	42.00	25.00
Mercury	0.27	0.11	0.39	0.29	0.48	0.25		0.00	0.00
Nickel	29.00	77.00	27.00	26.00	16.00	150.00	5.20	24.00	26.00
Selenium	0.00	0.00	0.00	0.00	0.20	0.00			
Silver	4.20	1.70	14.00	4.10	1.40	7.50	1.70	3.20	6.10
Thallium	0.40	3.80	0.00	0.00	0.00	0.40			
Zinc	200.00	280.00	220.00	180.00	220.00	170.00	160.00	280.00	110.00
Sum of metals	570.87	712.20	521.82	415.46	488.41	522.48	257.31	430.76	284.50
Aluminum	5800	5100	2900	5300	3000	940	1700	1100	910
Iron	5100	4900	2300	3900	3300	950	2000	810	850
Manganese	110	190	60	110	190	45			
CONVENTIONALS (MG/L)									
Biochemical Oxygen Demand (BOD)	49	55	72	61	170	190	14	64	100
Chemical Oxygen Demand (COD)	100	130	180	160	300	260		180	260
Total Suspended Solids (TSS)	98	130	100	120	290	150	110	45	46
Total Volatile Suspended Solids (TVSS)		64	60	56	230	120	41	38	34
Total Organic Carbon (TOC)	12	38	42	37	153	91		40	23
Oil & Grease		7	10	9	8	6	18	7	5
pH		6.98	6.80	7.08	7.22	7.13		7.05	7.04
Discharge Volume MG	6.056	2.925	10.616	12.437	1.145	3.206		4.145	55.674
Number of Samples	3	3	4	4	6	5	3	4	3

The data shows that the CSOs from the SSA have generally higher concentrations for metals, conventional pollutants and organics, especially the solvents or volatiles. The drainage basins for these overflows have a significant amount of industrial activity. The drainage basins for the NSA are primarily residential. The overflows from the NSA have a greater potential to directly affect human health through the discharge of pathogenic bacteria and viruses to nearby swimming areas.

The sediment chemistry data were collected from three sources given in Table 4-4 at the end of this chapter. The chemistry data from sediments in front of the Denny Way CSO are from *TPPS, C.1, Presence, Distribution and Fate of Toxicants in Puget Sound and Lake Washington.* The University regulator CSO sediment chemistry is from the water quality impact supplement of the University regulator CSO control predesign project report. The other CSO sediment chemistry is unpublished draft data from the Elliott Bay toxics action program. The notation directly under the name of the CSO is the station name from which the data came.

For the organics data, a blank signifies that the compound was below the detection limit. "NA" means the compound was not analyzed. For metals and conventionals, a blank signifies that the parameter was below the detention limit. Finally, di-octyl phthalate is di-n-octyl and bis (2-ethyhexyl) phthalate combined. Di-octyl was only analyzed during the TPPS.

Table 4-4 shows the sediment with the highest concentration of toxicants is in front of the King Street regulator CSO. The King Street CSO does not have high toxicant concentrations in its discharge and has the lowest annual average discharge volume. There appears to be no correlation with either the amount or toxicant concentration of a discharge to the toxicant concentration of sediments in front of a CSO. As was hypothesized in the *University Regulator Water Quality Report*, the location of the discharge is the most important factor in determining sediment concentrations. The King Street regulator discharges in the backwater of a slip. All of the other CSOs discharge to areas with a greater potential for dispersion. The particulates from the discharge are dispersed over a much greater area, thereby lowering the sediment concentrations.

As can be seen from the tables, Metro has not sampled all CSOs or sediments in front of the discharges. To comply with the sampling requirement of WAC 173-245, Metro has incorporated additional CSO sampling with requirements for the West Point NPDES permit. The sampling program will collect data for five CSO sites per year. The CSOs will be sampled four times per year for chemical characterization and monitored continuously to determine the annual volume and frequency of discharge. For the wet season of 1987-1988, the following five CSOs are to be monitored (NPDES permit number in parentheses):

1. Ballard (W003)
2. Third Avenue West (W008)
3. Denny-Lake Union (W027)
4. Lander (W030)
5. Michigan (W039)

It is expected to take four years to complete the CSO sampling program.

TABLE 4-4
SEDIMENT CHEMISTRY DATA

METRO CSO SEDIMENTS

	Michigan DR-13	Hanford-2 EW-05	Landford EW-09	Conneticut SS-01	King SS-03	Denny Way TPPS	University F
PRIORITY POLLUTANT ORGANICS (UG/L)							
ACIDS							
Phenol					27.0	4.6	
2,4-Dimethylphenol						0.0	
BASES							
N-Nitrosodiphenylamine						31.0	
NEUTRALS							
1,3-Dichlorobenzene						0.0	
1,2-Dichlorobenzene						15.0	
1,4-Dichlorobenzene						29.0	
1,2,4-Trichlorobenzene							
PHTHALATE ESTERS							
Dimethly phthalate	19.0				300.0	3.6	
Diethyl phthalate	NA	NA	NA	NA	NA	25.0	
Di-n-butyl phthalate	NA	NA	NA	NA	NA	450.0	110.0
Benzyl butyl phthalate	54.0	1200.0	1800.0	11.0	47.0	250.0	67.0
Di-octyl phthalate						4400.0	
Di-n-octyl phthalate		500.0					
Bis (2-ethylhexyl) phthalate	NA	NA	NA	NA	NA		740.0
Sum of Phthalate Esters	73.0	1700.0	1800.0	11.0	347.0	5128.6	917.0
LOW MOLECULAR WEIGHT PAH							
Naphthalene	42.0			150.0	410.0	100.0	
Acenaphthylene	17.0			14.0	190.0	24.0	
Acenaphthene	34.0			29.0	420.0	70.0	25.0
Fluorene	42.0			53.0	590.0	170.0	28.0
Phenanthrene	300.0	960.0	670.0	230.0	2400.0	560.0	260.0
Anthracene	110.0	390.0	240.0	120.0	1200.0	230.0	57.0
Sum of LMW-PAH	545.0	1350.0	910.0	596.0	5210.0	1254.0	370.0

TABLE 4-4 (Continued)

METRO CSO SEDIMENTS

	Michigan DR-13	Hanford-2 EW-05	Landford EW-09	Conneticut SS-01	King SS-03	Denny Way TPPS	University F
HIGH MOLECULAR WEIGHT PAH							
Fluoranthene	460.0	1100.0	2200.0	290.0	2400.0	1400.0	360.0
Pyrene	560.0	1200.0	2400.0	460.0	2600.0	1600.0	360.0
Chrysene	310.0	870.0	1600.0	210.0	2000.0	1900.0	180.0
Benzo (a) anthracene	230.0	410.0	970.0	130.0	1700.0	1000.0	140.0
Benzo (b) fluoranthene	230.0	370.0	1000.0		2300.0	2100.0	120.0
Benzo (k) fluoranthene	240.0	350.0	480.0	150.0	1300.0	2400.0	160.0
Benzo (a) pyrene						1500.0	150.0
Dibenzo (a-h) anthracene						230.0	35.0
Indeno (1,2,3,c-d) pyrene						420.0	130.0
Benzo (g,h,i) perylene						540.0	140.0
Sum of HMW-PAH	2030.0	4300.0	8650.0	1240.0	12300.0	13090.0	1775.0
AROCLORS AND PESTICIDES							
Aroclor 1242						38.0	
Aroclor 1248						80.0	
Aroclor 1254						210.0	92.0
Aroclor 1260						230.0	
Sum of Aroclors	950.0	2600.0	530.0		570.0	508.0	92.0
4-4-DDD						4.8	
4-4-DDE						14.0	
4-4-DDT						8.9	
G-BHC (Lindane)						0.0	
Isophorone						2.1	
VOLATILES				No Sample			
1,1-Dichloroethylene							
1,2-trans-Dichloroethylene							
Methlylene chloride						2000.0	
Chloroform							
1,1,1-Trichloroethane							
1,2-Dichloroethane							
Benzene						17.0	
Trichloroethylene	1.3		3.4				
1,1,2-Trichloroethane							
Toluene						1.8	
Tetrachloroethylene							
Ethylbenzene							
Total Xylenes	4.1		2.9		35.0		
Sum of Volatiles	5.4	0.0	6.3		35.0	2018.8	0.0

TABLE 4-4 (Continued)

METRO CSO SEDIMENTS

	Michigan DR-13	Hanford-2 EW-05	Landford EW-09	Connecticut SS-01	King SS-03	Denny Way TPPS	University F
METALS (UG/L)							
Antimony	25.00	22.00	20.00	2.90	690.00	1.30	
Arsenic	16.00	4.80	14.00	3.90	580.00	11.00	2.40
Beryllium						0.33	
Cadmium	0.86	13.00	2.80	0.15	7.20	0.79	0.50
Chromium	70.00	154.00	84.00	204.00	220.00	55.00	25.00
Copper	76.00	248.00	160.00	46.00	1000.00	68.00	43.00
Lead	132.00	431.00	137.00	22.00	650.00	130.00	120.00
Mercury	0.30	3.60	0.57	0.05	0.90	0.64	
Nickel	30.00	48.00	46.00	58.00	45.00	47.00	31.00
Selenium	0.11	0.30	0.58	0.00	0.70	0.14	
Silver	1.30	4.00	1.00	0.10	2.70	2.10	0.00
Thallium						0.01	
Zinc	180.00	560.00	280.00	55.00	4800.00	154.00	86.00
Sum of metals	531.57	1488.70	745.95	402.10	7996.50	470.31	308.90
Aluminum						15000	8000
Iron	46000	29000	48000	36000	100000	24000	10000
Manganese	600	420	650	590	1100	290	160
CONVENTIONALS (MG/L)							
Total Solids (TS)	560000	470000	520000	740000	570000	380000	520000
Total Volatile Solids (TVS)	73000	98000	73000	16000	56000		240000
Total Organic Carbon (TOC)	19000	68000	23000	4000	21000	5300	26000
Oil & Grease	640	6500	2400	190	2100		330
Sulfide	98	390	170	5	190		
Discharge Volume MG/YR	250	270	215	90	70	370	200
Number of Samples	1	1	1	1	1	21	1

APPENDIX A

SECONDARY PLANNING CONTINGENCIES WHICH COULD AFFECT CSO

POTENTIAL CSO EFFECTS FROM SECONDARY PLANNING CONTINGENCIES

Off-Site Dewatering

The secondary planning team is investigating the possibility of sludge dewatering facilities at a site other than West Point. This alternative would involve the return of 1.1 to 2.5 mgd of sludge recycle streams at either the Duwamish pumping station or the North interceptor in the Interbay area.

The potential effects on CSO volume are as follows:

	Without Sludge Return Flow	With Sludge Return Flow Rate of[3] 1.1 mgd	With Sludge Return Flow Rate of[3] 2.5 mgd
Return of Flows to Duwamish Pumping Station			
SSA Overflow[1] (MG/Year)	994	1,010	1,030
Return of Flows to Interbay			
NSA Overflow[2] (MG/Year)	614	618	623

1 2005 base case including effects of Hanford/Bayview/Lander project, city's east Lake Union separation, city storage facilities, CATAD modifications, and increased pumping rate (133 mgd) at Interbay.

2 2005 base case including effects of city's Dravus separation, city storage facilities, CATAD modifications, and increased pumping rate (133 mgd) at Interbay.

3 Constant flow rate.

In the case of the Duwamish return location, the increased overflows occur primarily at Hanford. When flows are returned in the Interbay area, the increased overflows occur at the Third Avenue West weir.

The return of 1.1 mgd to the Duwamish pumping station increases SSA overflows by 16 mg/year. Using the Michigan separation project capital cost ($100,000 per mg/year reduction) as representative of the added cost to offset this effect by separation, the approximate added cost of CSO control would be $1.6 million. For return of 2.5 mgd, the added CSO cost would be $3.6 million.

The return of 1.1 mgd in the Interbay area increases NSA overflows by 4 mg/year. The NSA separation projects have a cost of about $300,000 per mg/year reduction. Thus, the added CSO cost would be about $1.2 million. Return of 2.5 mgd would increase NSA CSO costs about $2.7 million.

Increased Diversion of Flow to Renton Treatment Plant

Metro considered alternatives for reducing the currently planned size of secondary facilities at West Point. Current engineering plans are based on an ultimate base flow capacity of 159 mgd (average), increasing from 133 mgd by the year 1995. In order to hold the West Point base flow capacity to 133 mgd, Metro evaluated diverting various levels of wastewater flow to the Renton Treatment Plant. Details on the CSO effects of these alternatives are presented in Technical Memorandum 8.01.

Edmonds/Richmond Beach Flow Swap

Metro is considering an alternative that would convey Richmond Beach flows (2.4 mgd average wet weather flow, 5.4 mgd peak) to Edmonds for treatment. In exchange, the same volume of flows from the eastern portion of the Edmonds service area would be conveyed to the West Point Treatment Plant for treatment through the NSA collection system. About 35 impervious acres would require separation in the NSA to offset the increase in CSOs resulting from diversions of east Edmonds flows to West Point. The capital cost to provide the added separation is estimated at $3.5 million. This flow exchange is now under study. These impacts will be dealt with as part of the Richmond Beach facility plan.

Parallel Kenmore Interceptor

The existing Kenmore interceptor (on line as of late 1987) is nearing capacity. Increased sewage flows received at the Kenmore pumping station would be accommodated downstream by building an interceptor parallel to the recently constructed Kenmore interceptor between the existing Kenmore and Mathews Park pumping stations. The construction of the North Creek/Redmond connection defers the required construction of the second, parallel Kenmore interceptor until after 2025. As part of the analysis noted above, Metro considered diverting future base flows from the West Point service area to Renton in order to avoid construction of a parallel Kenmore line by the year 2025. An estimate of CSO impacts was determined (see TM 8.01).

Rehabilitation of Brick Interceptors

Methods to rehabilitate brick interceptors in the Metro system are being evaluated. Some alternatives would reduce interceptor capacity and, as a result, would increase CSO volume and frequency at some locations. After the locations and methods of rehabilitation are finalized, any appropriate modifications to this CSO plan will be made.

Use of Existing Fort Lawton Tunnel

The West Point secondary treatment project team evaluated the need for a new influent tunnel to convey base flows (358 mgd) to the plant. The team decided that a new tunnel is necessary because of the deteriorating condition of the existing Fort Lawton tunnel and the need to provide an alternative means of getting flows to the plant during construction of the new secondary treatment facilities.

With the decision to build a new Fort Lawton tunnel, an analysis of the system was performed in an effort to optimize conveyance and treatment capacities. This analysis indicated that significant CSO benefit could be achieved by increasing the conveyance capacity to the treatment plant from 358 mgd (base flow) to 440 mgd. Flows in excess of the base flow would receive primary treatment and then be blended with secondary effluent before discharge through the existing outfall at West Point.

Considering the entire conveyance system, the most efficient way to provide the 440-mgd capacity is by use of the existing Fort Lawton tunnel in conjunction with the new tunnel. This will require some rehabilitation of the old tunnel and a new on-site pipeline from the tunnel to the influent control structure at the treatment plant. The existing tunnel could convey up to 80 mgd to the plant. It would also provide partial redundancy in the conveyance system to West Point.

APPENDIX B

PHASED COSTS FOR CSO PROJECTS

FOR 75 PERCENT VOLUME REDUCTION

CAPITAL PHASED COSTS 75% CSO VOLUME REDUCTION

ON LINE	75% CSO VOLUME REDUCTION CAPITAL COST; INFLATION RATE 6.00% DISCOUNT RATE = 8.00%	BASE CAPITAL COST ($MIL)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1991	CATAD Modifications	4.218	0.180	0.590	2.014	0.933	0.193	0.308															
1992	Green Lake/I-5 Separation	22.345	0.274	0.471	0.772	0.742	10.314	9.772															
1992	Hanford/Bayview/Lander	20.124	0.112	2.485	1.880	5.050	6.502	4.095															
1992	Carkeek CSO Treatment	1.799			0.200	0.295	0.652	0.652															
1993	Par. Ft. Lawton Tunnel/WP Add.	11.067		0.001	0.406	1.072	4.356	1.032	4.200														
1995	Alki CSO Treatment	10.800			0.138	0.375	0.624	1.327	1.952	4.340	2.044												
1999	Denny Separation	19.998								0.733	0.733	0.733	5.933	5.933	5.933								
1999	Diagonal Separation	2.902										0.160	0.160	1.291	1.291								
2003	Michigan Separation	24.300												0.891	0.891	0.891	7.209	7.209	7.209				
2006	Kingdome Separation	7.302															0.268	0.268	0.268	2.166	2.166	2.166	
	TOTAL CAPITAL COST IN 1988 DOLLARS	124.855	0.566	3.547	5.410	8.467	22.641	17.186	6.152	5.073	2.777	0.893	6.093	8.115	8.115	0.891	7.477	7.477	7.477	2.166	2.166	2.166	0.000
	CAPITAL COST IN YEAR SHOWN		0.504	3.346	5.410	8.975	25.439	20.469	7.767	6.789	3.939	1.343	9.711	13.710	14.533	1.691	15.045	15.948	16.905	5.191	5.502	5.833	0.000
	CUMULATIVE TOTAL (IN YEAR SHOWN)		0.504	3.850	9.260	18.235	43.674	64.143	71.910	78.699	82.638	83.981	93.692	107.402	121.935	123.626	138.672	154.619	171.524	176.715	182.218	188.050	188.050
	PRESENT WORTH VALUE OF CAPITAL COST (1988 DOLLARS)	111.551	0.588	3.614	5.410	8.310	21.810	16.249	5.709	4.620	2.482	0.783	5.247	6.858	6.731	0.725	5.975	5.864	5.755	1.636	1.606	1.576	0.000
	CUMULATIVE PRESENT WORTH		0.588	4.201	9.611	17.922	39.732	55.981	61.689	66.310	68.792	69.576	74.822	81.681	88.412	89.138	95.112	100.976	106.732	108.368	109.974	111.551	111.551

ON LINE	75% CSO VOLUME REDUCTION CAPITAL COST; INFLATION RATE 6.00% DISCOUNT RATE = 8.00%	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1991	CATAD Modifications																				
1992	Green Lake/I-5 Separation																				
1992	Hanford/Bayview/Lander																				
1992	Carkeek CSO Treatment																				
1993	Par. Ft. Lawton Tunnel/WP Add.																				
1995	Alki CSO Treatment																				
1999	Denny Separation																				
1999	Diagonal Separation																				
2003	Michigan Separation																				
2006	Kingdome Separation																				
	TOTAL CAPITAL COST IN 1988 DOLLARS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	CAPITAL COST IN YEAR SHOWN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	CUMULATIVE TOTAL (IN YEAR SHOWN)	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050	188.050
	PRESENT WORTH VALUE OF CAPITAL COST (1988 DOLLARS)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	CUMULATIVE PRESENT WORTH	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550	111.550

ON LINE	75% CSO VOLUME REDUCTION CAPITAL COST; INFLATION RATE 6.00% DISCOUNT RATE = 8.00%	2027	2028	2029	2030	PRESENT WORTH TOTAL	PW TOTAL 2005	PW TOTAL 1995
1991	CATAD Modifications							
1992	Green Lake/I-5 Separation							
1992	Hanford/Bayview/Lander							
1992	Carkeek CSO Treatment							
1993	Par. Ft. Lawton Tunnel/WP Add.							
1995	Alki CSO Treatment							
1999	Denny Separation							
1999	Diagonal Separation							
2003	Michigan Separation							
2006	Kingdome Separation							
	TOTAL CAPITAL COST IN 1988 DOLLARS	0.000	0.000	0.000	0.000			
	CAPITAL COST IN YEAR SHOWN	0.000	0.000	0.000	0.000			
	CUMULATIVE TOTAL (IN YEAR SHOWN)	188.050	188.050	189.050	188.050			
	PRESENT WORTH VALUE OF CAPITAL COST (1988 DOLLARS)	0.000	0.000	0.000	0.000	111.551	111.551	69.576
	CUMULATIVE PRESENT WORTH	111.550	111.550	111.550	111.550			

O&M PHASED COSTS 75% CSO VOLUME REDUCTION

YEAR ON LINE	75% CSO VOLUME REDUCTION O & M COST; INFLATION RATE = 6.00% DISCOUNT RATE = 8.00%	BASE ANNUAL O & M COST ($MILLION)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1991	CATAD Modifications	0.000																									
1992	Green Lake/I-5 Separation	0.002							0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1992	Hanford/Bayview/Lander	0.071							0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
1992	Carkeek CSO Treatment	0.086							0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
1993	Par. Ft. Lawton Tunnel/WP Add.	0.035							0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
1995	Alki CSO Treatment	0.244										0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244
1999	Denny Separation	0.000																									
1999	Diagonal Separation	0.000																									
2003	Michigan Separation	0.000																									
2006	Kingdome Separation	0.000																									
	TOTAL O & M COST IN 1988 DOLLARS	0.438	0.000	0.000	0.000	0.000	0.000	0.000	0.194	0.194	0.194	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438
	O & M COST IN YEAR SHOWN		0.000	0.000	0.000	0.000	0.000	0.000	0.245	0.260	0.275	0.659	0.698	0.740	0.784	0.831	0.881	0.934	0.990	1.050	1.113	1.179	1.250	1.325	1.404	1.489	1.578
	CUMULATIVE TOTAL (IN YEAR SHOWN)		0.000	0.000	0.000	0.000	0.000	0.000	0.245	0.505	0.780	1.438	2.136	2.876	3.661	4.492	5.374	6.308	7.298	8.348	9.460	10.640	11.890	13.21	14.62	16.10	17.68
	PRESENT WORTH VALUE OF O & M COST (1988 DOLLARS)	10.694	0.000	0.000	0.000	0.000	0.000	0.000	0.180	0.177	0.173	0.384	0.377	0.370	0.363	0.357	0.350	0.344	0.337	0.331	0.325	0.319	0.313	0.307	0.301	0.295	0.290
	CUMULATIVE PRESENT WORTH		0.000	0.000	0.000	0.000	0.000	0.000	0.180	0.357	0.530	0.914	1.292	1.662	2.025	2.382	2.732	3.075	3.412	3.743	4.068	4.387	4.700	5.006	5.308	5.603	5.894

O&M PHASED COSTS 75% CSO VOLUME REDUCTION

08-Apr-88

75% CSO VOLUME REDUCTION
O & M COST; INFLATION RATE = 6.00%
DISCOUNT RATE = 8.00%

YEAR ON LINE		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	PRESENT WORTH TOTAL	PW TOTAL 2005	PW TOTAL 1995
1991	CATAD Modifications																							
1992	Green Lake/I-5 Separation	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002			
1992	Hanford/Bayview/Lander	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071			
1992	Carkeek CSO Treatment	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086			
1993	Par. Ft. Lawton Tunnel/WP Add.	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035			
1995	Alki CSO Treatment	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244			
1999	Denny Separation																							
1999	Diagonal Separation																							
2003	Michigan Separation																							
2006	Kingdome Separation																							
	TOTAL O & M COST IN 1988 DOLLARS	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438			
	O & M COST IN YEAR SHOWN	1.673	1.773	1.879	1.992	2.112	2.238	2.373	2.515	2.666	2.826	2.996	3.175	3.366	3.568	3.782	4.009	4.250	4.505	4.775	5.061			
	CUMULATIVE TOTAL (IN YEAR SHOWN)	19.36	21.13	23.01	25.00	27.11	29.35	31.73	34.24	36.91	39.73	42.73	45.91	49.27	52.84	56.62	60.63	64.88	69.39	74.16	79.23			
	PRESENT WORTH VALUE OF O & M COST (1988 DOLLARS)	0.284	0.279	0.274	0.269	0.264	0.259	0.254	0.249	0.245	0.240	0.236	0.231	0.227	0.223	0.219	0.215	0.211	0.207	0.203	0.199	10.694	4.387	0.914
	CUMULATIVE PRESENT WORTH	6.179	6.458	6.733	7.002	7.267	7.526	7.781	8.031	8.276	8.517	8.753	8.985	9.213	9.437	9.656	9.871	10.08	10.29	10.49	10.69			

EQUIPMENT REPLACEMENT PHASED COSTS 75% VOLUME REDUCTION

08-Apr-88

YEAR ON LINE	75 % CSO VOLUME REDUCTION EQUIPMENT REP. INFLATION RATE= 6.00% DISCOUNT RATE = 8.00%	EQUIP. BASE COST ($1988)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1991	CATAD Modifications	0.000																								
1992	Green Lake/I-5 Separation	0.000																								
1992	Hanford/Bayview/Lander	0.000																								
1992	Carkeek CSO Treatment	0.196																								
1993	Par. Ft. Lawton Tunnel/WP Add.	0.000																								
1995	Alki CSO Treatment	1.188																								
1999	Denny Separation	0.000																								
1999	Diagonal Separation	0.000																								
2003	Michigan Separation	0.000																								
2006	Kingdome Separation	0.000																								
	TOTAL EQ. REP. COST IN 1988 DOLLARS	1.384	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	EQ. REP. COST IN YEAR SHOWN		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	CUMULATIVE TOTAL (IN YEAR SHOWN)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	PRESENT WORTH VALUE OF EQ. REP. COST (1988 DOLLARS)	0.698	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

EQUIPMENT REPLACEMENT PHASED COSTS 75% VOLUME REDUCTION

08-Apr-88

YEAR ON LINE	75 % CSO VOLUME REDUCTION EQUIPMENT REP. INFLATION RATE= 6.00% DISCOUNT RATE = 8.00%	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	PRESENT WORTH TOTAL	PW TOTAL 2005	PW TOTAL 1995	PW TOTAL 2015
1991	CATAD Modifications																									
1992	Green Lake/I-5 Separation																									
1992	Hanford/Bayview/Lander																									
1992	Carkeek CSO Treatment			0.196																		-0.020				
1993	Par. Ft. Lawton Tunnel/WP Add.																									
1995	Alki CSO Treatment						1.188															-0.297				
1999	Denny Separation																									
1999	Diagonal Separation																									
2003	Michigan Separation																									
2006	Kingdome Separation																									
	TOTAL EQ. REP. COST IN 1988 DOLLARS	0.000	0.000	0.196	0.000	0.000	1.188	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.317				
	EQ. REP. COST IN YEAR SHOWN	0.000	0.000	0.794	0.000	0.000	5.729	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-3.659				
	CUMULATIVE TOTAL (IN YEAR SHOWN)	0.000	0.000	0.794	0.794	0.794	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	6.523	2.864				
	PRESENT WORTH VALUE OF EQ. REP. COST (1988 DOLLARS)	0.000	0.000	0.125	0.000	0.000	0.717	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.144	0.698	0.000	0.000	0.125

APPENDIX C

COMMENTS AND RESPONSES

APPENDIX C
COMMENTS AND RESPONSES

INTRODUCTION

This appendix summarizes comment letters received during the review period on the draft combined sewer overflow control plan. Overall comments were received from three agencies, eight organizations and sixteen individuals. The full text of the comment letters are available upon request. A joint Metro/Seattle public hearing on Metro's CSO plan and Seattle's draft CSO plan EIS was held on March 15, 1988. The transcript of the hearing is available for review at Metro's Library, Eighth Floor, Exchange Building, 821 Second Avenue, Seattle.

This section also includes Metro's responses to comments received. Six general comments were expressed and are summarized in the first part of this appendix, along with Metro's responses. The second section of this appendix summarizes thirty specific comments by agencies, organizations and interested citizens followed by Metro's responses.

GENERAL COMMENTS AND RESPONSES

General Comment 1

Many commentors expressed a concern that Portage Bay residents have not been informed of the health risks associated with swimming in that area.

Response to General Comment 1

The Seattle-King County Department of Public Health notifies residents when a known health risk associated with swimming in Seattle area waters is present. The Health Department posts signs along designated swimming beaches when a known health risk is present. There are currently no designated beaches or swimming areas in Portage Bay, the Ship Canal or Lake Union. The Health Department has long held the position that conditions in Portage Bay, Lake Union, and the Ship Canal are such that swimming and other primary human water-contact activity should be discouraged. The risks are not only those associated with CSO discharges, but include most of the industrial activities along the shore, boat traffic, discharges associated with live-aboards, recreational and commercial boat owners, steep drop offs and the presence of glass or other hazardous debris on the lake bottom.

These hazards together pose sufficient risk to swimmers such that the Health Department does not anticipate that they would be in a position to recommend swimming in these waters at any time.

General Comment 2

Many citizens suggest accelerating the schedule for the University Regulator (Green Lake/Portage Bay Improvement Project) in the final version of the CSO plan in order to reduce the discharge of CSOs into Portage Bay from 251 mg/year by the year 1992.

Response to General Comment 2

The project has been accelerated in the final plan.

General Comment 3

Many commentors suggest that Metro should reduce sewage flow into Portage Bay by 75 percent by the year 2008 as required by State regulations.

Response to General Comment 3

Ecology has agreed to a 20-year goal of 75 percent overall volume reduction, e.g., the total existing CSO volume in the NSA and SSA must be reduced by 75 percent. This goal does not apply to each individual CSO or receiving water. As shown in Table 2-2 on page 2-8, the percentage reduction at each outfall varies although the combined result is an overall volume reduction of 75 percent.

General Comment 4

Commentors requested that letters be circulated to all members of the Water Quality Committee for review.

Response to General Comment 4

All CSO plan comment letters received by Metro have been distributed to the Water Quality Committee of the Metro Council for review along with the response summary.

General Comment 5

Many commentors request a public hearing on the draft CSO control plan before the final document is issued.

Response to General Comment 5

A joint Metro/City of Seattle public hearing on Metro's draft CSO control plan and Seattle's draft CSO plan EIS was held on March 15, 1988. Comments received at the public hearing are included in the response summary.

General Comment 6

The City of Seattle expressed a general concern that Metro's other CSOs discharging into Lake Union/Ship Canal will limit the city's effectiveness in dealing with CSO control efforts in that area.

Response to General Comment 6

Metro is committed to working with the City of Seattle within the CSO program guidelines and budget to develop a project phasing schedule that is mutually agreeable to both agencies. At this time, data are not available to quantify the effects of various levels of CSO control on receiving water quality. Metro and Seattle are both aware that there are many past and present discharges other than CSO that also affect water quality. Metro will define a CSO sampling program as part of the final plan. The data from this sampling program will be used to update and revise the CSO plan at five-year intervals. Also, a city study and sampling program on Lake Union water quality as well as the city's CSO plan sampling program should all provide useful data for evaluating the effects of CSO discharges on Lake Union/Ship Canal water quality.

SPECIFIC COMMENTS AND RESPONSES

Specific Comments 1, 2 and 3

Interested citizens and community representatives expressed concerns on the CSO control plan in the following areas:

1. The draft combined sewer overflow control plan only considers cost for setting project priorities and not other factors such as health impacts.

2. Recreational impacts of Portage Bay CSOs were narrowly defined in the draft CSO plan.

3. How can "Metro decide to reduce and delay the CSO control of Portage Bay without comparable sampling data to evaluate against each other?" Additionally, there is a request for an "environmental analysis of the heavy metal and other pollutants' impact on Portage Bay if separation rather than storage is pursued."

Responses to Specific Comments 1, 2 and 3, Respectively

1. In addition to costs, Table 2-4 in the draft plan compared the CSO projects with four criteria specified by Ecology for establishing project priorities. The greatest difference in the projects is in their relative costs. Factors other than cost were considered and the final plan priorities reflect this fact. For example, the Green Lake/Portage Bay Improvement project precedes projects with lower costs.

2. Agree. The final plan reflects the recreational uses of the bay.

3. The Green Lake/Portage Bay Improvement project schedule has been accelerated in this final plan. The project predesign effort included an analysis of water quality impacts and a report is available from Metro.

Specific Comments 4, 5, 6, and 7

The Magnolia Community Club request clarifications on some statements in the draft CSO control plan and also expressed some concerns summarized below:

4. The club expressed doubts about whether " . . . the proposed plan achieves the greatest reasonable reduction of combined sewer overflows at the earliest possible date." The draft is not explicit about whether and how the plan would enhance the attainment of the Federal Clean Water Act for the "fishable/swimmable goal." Also, by delaying any CSO flow reduction in Lake Union until the year 2006, even after 34 years, the "fishable/swimmable" clean water goal would still *not* be achieved.

5. The club also expressed objection to the change in volume reduction at Denny Way from 95 percent (1986 SEIS) to 82 percent as proposed in the draft CSO plan. By this change, the use of separation projects would further increase pollutants into Elliott Bay and subsequently onto Magnolia Beaches.

6. A further concern expressed by the club was that separation projects would likely involve "extensive disruption of residential areas over an unidentified period, but the magnitude of social and environmental impacts has not been identified and compared with other options in the draft CSO plan."

7. The club also noted that there is an apparent inconsistency between Ecology's correspondence regarding "75 percent volume over 20 years" and the State legislature (RCW 90.48.480) which requires the "greatest reasonable reduction of combined sewer overflows at the earliest possible date." The commentor doubts Ecology's authority to establish a compliance schedule without public discussion before implementing the CSO regulations.

Responses to Specific Comments 4, 5, 6, and 7, Respectively

4. It is Metro's position that the plan does achieve the greatest reasonable reduction at the earliest possible date. Ecology has agreed with the 20-year schedule to achieve 75 percent reduction. The plan also identifies the projects to achieve one event per year, meeting Ecology's requirement in this regard.

   In regard to Lake Union, there are other past and present discharges other than CSO that affect water quality. A city study is currently underway to evaluate the effects of storm and CSO discharges on water quality in Lake Union. Appendix F discusses storm-water issues. The study included sediments as well as water quality samples.

5 & 6 There is no indication that the 13 percent difference in volume reduction at Denny Way would have any significant impact on water quality. Separation at Denny Way provides a significant reduction at less cost allowing Metro to accelerate other projects (i.e., Green Lake/Portage Bay Improvement project). A project-specific EIS will be prepared during the predesign phase of each project. Both separation and storage alternatives involve impacts. For example, attempts to locate CSO treatment facilities or storage at Denny Way were rejected because of public opposition to the impacts.

7. Ecology's written approval of a goal of 75 percent volume reduction over a 20-year period is in concert with Ecology's responsibility to negotiate compliance schedules based on factors specific to each municipality. The development of these regulations included extensive public hearings. Questions about Ecology authority would best be directed to Ecology.

Specific Comments 8 and 9

The Site Alternative Coalition group offered comments:

8. The coalition is concerned because the "draft CSO plan merely attempts to comply with regulations, but does not show how it relates to regional water quality."

9. The coalition also wanted to know why the draft CSO plan ignores the probability of storm-water treatment from urban areas and wonders if future consideration for storm water treatment would make separation projects less cost-effective. The coalition additionally requested a reevaluation of separation projects.

Responses to Specific Comments 8 and 9, Respectively

8. As described in Appendix F, an efficient CSO program coupled with an aggressive surface water management plan is needed to address regional water quality concerns.

9. The CSO planning effort has recognized the possibility of storm-water treatment (see page 3-5 of the 1986 CSO plan). Ecology has stated that sewer separation is an acceptable practice so long as storm-water discharges do not violate water quality standards. Pages 2-19 and 2-24 of the final 1988 plan lists several alternatives, other

than storm-water treatment, to reduce the pollutant loadings from storm drains. Appendix F also addresses this issue.

Specific Comment 10

The Carkeek Watershed Community Action Project expressed concern about lack of uniformity in Metro's draft CSO plan.

Response to Specific Comment 10

The Ecology CSO control regulations evolved during the three-year CSO planning period. Thus, the 1985, 1986 and 1988 CSO plans incorporate changes to meet changing Ecology policies.

Specific Comments 11 and 12

A concerned citizen, Jim Drury, offered the following comments:

11. The draft CSO plan "does not address the planning for treatment of CSO or treatment of separated surface drainage waters."

12. The draft CSO is not a "plan" document but a summary of facts and figures and therefore requested that the word "plan" be dropped from the title.

Response to Specific Comments 11 and 12, Respectively

11. Separate treatment of CSO was addressed as an option to separation or storage in the CSO planning process. CSO treatment facilities in the Denny Way, Kingdome and Duwamish areas received detailed consideration. Also see Item 10.

12. The document presents Metro's plan to comply with DOE regulations and has an appropriate title.

Specific Comments 13 and 14

The City of Bellevue inquired as follows:

13. The table on page 3-12 should be related to sewer rate projections so that this becomes more meaningful to ratepayers.

14. Why are there "gaps between 1993 and 1999 and again between 1999 and 2002, and 2003 and 2006 in projects on line?"

Responses to Specific Comments 13 and 14

13. Rate projections have been calculated by Metro and are included in the final plan in Appendix D.

14. As described on page 4-1, the timing of several projects (Hanford/Bayview/Lander, CATAD, Carkeek, Alki and Fort Lawton tunnel) are dictated by other factors. The remaining project timing was selected to spread the annual expenditures as uniformly as possible (see Appendix B). The result was that there were some time periods, such as 1999 to 2002, where no new CSO projects would come on line; however, substantial expenditures will be incurred in these periods for the design and construction of the projects that come on line in later years.

Specific Comments 15, 16, 17, 18 and 19

The City of Seattle Office for Long Range Planning and the Engineering Department requested additional information or clarification of comments as specifically noted below:

15. In reference to Table 2-1 on page 2-5, "Clarify if there will be any reduction in discharge volume by the year 2005."

16. On pages 2-10 and 2-11 of the draft CSO plan, discuss project priorities and rank the CSO control projects on the basis of cost-effectiveness rather than Ecology's highest priority criterion. The city Engineering Department recommends that Metro follow Ecology's guidelines for priority ranking of CSO control projects.

17. Metro's indication that careful evaluation of potential effects from storm drain discharges and risk assessment during the predesign environmental process is commended by the City of Seattle. However, the city requests implementation of corrective measures based on data collected from the proposed risk assessment survey.

18. Table 2-3 shows that there is a big gap between CSO frequency/year with 75 percent volume reduction and the ultimate goal of one CSO event per year at each project location.

19. The city is also concerned about increased toxics loading from storm water that would result from separation projects since significant portions of the NSA shoreline have industrial and commercial land uses.

Responses to Specific Comments 15, 16, 17, 18 and 19, Respectively

15. All of the projects shown in Table 2-1 are proposed to be on line by 2005 and would reduce the total CSO volume by 75 percent.

16. Page 2-10 quotes Ecology guidelines for priority ranking and Table 2-4 compares the projects against Ecology's criteria. Beyond such a ranking, decisions on priority become a policy issue to be resolved by the Metro Council. (Also see response to Item 1.)

17. As noted on page 2-13, if the environmental analysis of a specific project shows that corrective measures are required, Metro will implement them.

18. Table 2-3 shows that overflow frequency is reduced by the 75-percent reduction program to the one-event-per-year level at five locations where frequencies are now as high as 31 events per year and to less than two per year at four other locations which now spill as often as 25 times per year. The frequency of spills at Denny Way is also substantially reduced from 51 to less than 10 events per year. CSO volumes and frequency are reduced substantially by the 75-percent volume reduction program. As recognized on page 3-1, additional projects are required to achieve one event per year. The report shows (page 3-12) that the 1988 capital cost to move from 75 percent volume reduction to one event per year is substantially greater ($168 million) than the cost to achieve 75 percent reduction, which will be $125 million. The costs relative to the effects increase dramatically as volume reduction goes beyond 75 percent.

19. As noted on page 2-13, each project will be subject to an environmental analysis during predesign. If it is found that increased storm discharges would inhibit or restrict a beneficial use associated with a water body, appropriate corrective measures will be taken.

Specific Comments 20 and 21

A concerned citizen, David Foecke, expressed the following concerns:

20. That "even in its current form, the draft CSO plan only reduced Portage Bay dumping by 50 percent," but this figure is still below the State regulation for 75 percent reduction.

21. The commentor further inquired "why will Metro not consider spending the extra funds to do it right the first time, by reinstating a storage option for sewage being dumped in Portage Bay, rather than a separation option which actually increased many potential hazards?"

Responses to Specific Comments 20 and 21, Respectively

20. Ecology has agreed to a 20-year goal of 75 percent overall volume reduction, e.g., the total existing CSO volume in the NSA and SSA must be reduced by 75 percent. This goal does not apply to each individual CSO or receiving water. As shown in Table 2-2 on page 2-8, the percentage reduction at each outfall varies although the combined result is an overall volume reduction of 75 percent.

21. It is difficult to find locations suitable for building the large tanks needed to provide storage required to equal the CSO reduction provided by separation. To provide some perspective, the existing city storage projects use tanks with 1 to 1.5 million gallon capacity. Storage for reduction of University regulator overflows has been evaluated (see page 5-9, 1985 CSO plan). A 20-million gallon storage tank was found to provide a 50 percent reduction in CSO volume at University regulator (page 5-13, 1985 plan), about the same reduction as using alternatives other than storage. The 20-mg project in the Seattle area would, with a 10-foot water depth, be the size of nine football fields laid end-to-end. To achieve more than 50 percent volume reduction, more than

20-mg of storage would be required. There are substantial doubts about the practicality of eliminating the University regulator overflows through storage alone, no matter how much money is spent. For example, if storage alone were used, about 50 million gallons of storage would be required to capture the existing spill at University regulator from one of the larger design storms (Storm 1) and over 100 million gallons would be needed for the most severe design storm (Storm 7). Recognizing that even a 20-mg storage tank would be costly and of questionable practicality, one can appreciate the complexity and cost of trying to eliminate spills at University through use of a 50- to 100-mg storage tank. The significance of added pollutant loadings from new storm drains can only be determined when a total "budget" of loadings from all sources is completed. If such loadings related to storm drain discharges are found to cause water quality problems, corrective measures will be taken.

Specific Comments 22, 23, 24, 25, 26 and 27

The State Department of Ecology offered the following comments:

22. Ecology suggested including some summaries of earlier related reports or studies (such as secondary treatment plan) in order to enhance the readability of the draft CSO plan.

23. Ecology suggests that Figure 2-1 should be repeated in Chapter 4, along with more detailed drawings and diagrams for each project if possible.

24. Ecology also suggested that a table similar to Table 2-2 on page 2-8 should be added to Chapter 4 showing the effect on CSO as the various construction projects are implemented.

25. Ecology also requested detailed descriptions and analyses of projects and schedules and a demonstration of how the CSO projects would interface with major elements of the plan for secondary treatment.

26. Ecology also inquired if West Point comes on line before the Green Lake basin is separated, "will the West Point Treatment Plant be resized, or has it already been resized to accommodate the Green Lake flows?"

27. Ecology asked if the CSO sampling and monitoring program incudes sampling sediments adjacent to CSOs.

Responses to Specific Comments 22, 23, 24, 25, 26 and 27, Respectively

22. Metro specified that the 1988 CSO plan should be concise and rely upon reference to other earlier documents which are readily available rather than repeating material to create a voluminous document. References to specific information available in earlier reports have been incorporated into the final plan to enhance readability, however.

23. Figure 2-1 is referenced on page 4-1 rather than repeated. To maintain the goal of a concise document, the page numbers of detailed descriptions of projects presented in the 1985 and 1986 plans are noted on page 4-1 where each project is listed.

24. Table 4-1 has been incorporated into the final plan to show the effect of project implementation (in phases) on CSOs in the NSA and SSA.

25. The CSO projects directly affected by the schedule and major elements of the 1986 secondary facilities plan are the Alki and Carkeek storm-weather treatment plants, the parallel Fort Lawton tunnel and the University regulator (Green Lake/Portage Bay Improvement project). Predesign for the West Point Treatment Plant includes consideration of increased flows from the addition of Alki and Carkeek sanitary flows (average wet weather flows times 2.25). The West Point plant is scheduled to be on line by the year 1995. Conversion of the Carkeek plant to treat storm-weather flows will be completed by 1992. At that time, Carkeek basin sanitary flows will be routed to West Point. When the West Point plant is upgraded to provide secondary treatment, the Carkeek basin sanitary flows will receive secondary treatment. The Alki conversion will be completed by 1995. As with Carkeek, Alki sanitary flows will be transported to West Point and will receive secondary treatment when the West Point plant is on-line in 1995. (Note: The increase of West Point sanitary flows from Alki will be offset by diverting an equal amount of flow from the Norfolk regulator station south to Renton.) The parallel Fort Lawton tunnel is scheduled for completion in 1993. This will provide additional reliability for the main conveyance system for influent going to West Point. The tunnel will be sized to accommodate flows in excess of the base requirements to achieve CSO control benefits. Development of predesign/design specifications will more

accurately predict if CSO benefits are attainable upon completion of the parallel tunnel or when the West Point plant upgrade is completed.

26. The University regulator (Green Lake/Portage Bay Improvement project) was scheduled for completion in the year 2005 in the draft plan. At that time, approximately 5 mgd of outflow from Green Lake, the Densmore drain and Ravenna Creek that currently go to the West Point plant will be diverted to a new storm drain and discharged into Union Bay. Metro has accelerated the schedule for the University project in its final CSO plan. West Point plant sizing will not be affected. In the event that a delay in the project occurs, and it is not completed until 2006, there would be an additional 5 mgd of flow from Green Lake going to West Point that was not anticipated in the 1986 secondary facilities plan. If no alternative provisions are made to transfer or reduce other flows or expand the plant, capacity might be exceeded after the year 2000 until the North Creek connection is completed in 2004. Other options would include construction of the clarifiers reserved as future facilities at West Point earlier than originally planned or offsetting the additional flows by routing more SSA flows to the Renton plant. The issue should be looked into carefully after 1995 in as much as flows may not increase as rapidly as currently forecast, increased water conservation may reduce flows below forecast, and/or the new treatment facilities may provide substantially greater capacity than indicated in design. These factors will be much more clear after 1995.

27. To comply with the sampling requirement of WAC 173-245, Metro has incorporated CSO sampling with requirements for the West Point NPDES permit. The sampling program currently collects data for five CSO sites per year. Following negotiation and clarification of Ecology requirements, the NPDES program will be modified to collect data for sediment adjacent to CSO sites.

Specific Comments 28, 29 and 30

The following comments were made at the public hearing.

28. Metro has not been able to unequivocally assure us that health risks as posted at the Carkeek Park beach are not coming from the sewage treatment plant.

29. After Metro has completed the University regulator project, they should begin working on the next step and put in oil and grease separators for the I-5 runoff or store the runoff in storage tanks. A site in the University area was identified for locating storage tanks.

30. Are hospital wastes being discharged in the University regulator CSO?

Responses to Specific Comments 28, 29 and 30, Respectively

28. Metro has three sampling and monitoring programs on-going in the Carkeek area designed to measure fecal coliform levels in Piper Creek, on the nearshore beaches and at the outfall. Results indicate that during the summer months, when use of the park and beaches are highest, the effluent plume does not reach surface waters offshore and effluent from the Carkeek Treatment Plant has little influence on the nearshore area. During the winter months, the effluent plume may reach surface waters but this has not yet been confirmed. Metro has a quarterly offshore monitoring program at three stations in Puget Sound as part of the NPDES compliance program for the Carkeek Treatment Plant. Virtually all data from the offshore stations show fecal coliforms at or below background levels.

29. Metro is committed to a sampling and monitoring program for sewer separation projects in the CSO plan in an effort to identify any problems caused by increasing storm-water discharges. If runoff from I-5 is shown to have an adverse impact on beneficial uses in Union Bay, Metro will take action to mitigate those impacts.

Once the separation project is completed Metro will study the sites proposed in the University area for locating storage facilities for CSO remaining at University regulator. This study will be conducted during the five-year assessment process required by Ecology.

30. Sanitary sewage wastes from Children's Hospital may be present in CSO discharges from University regulator. Upon completion of the University regulator project, overflow volumes will be reduced by 50 percent and will occur less than ten times per year.

APPENDIX D

RATE ANALYSIS

BASED ON THE PHASING AND CASH FLOW TABLES

PRESENTED IN APPENDIX B

RATE ANALYSIS

Purpose

This appendix provides an analysis of wholesale sewer rates resulting from the Combined Sewer Overflow (CSO) Control Plan costs shown on the phasing and cash flow tables presented in Appendix B. The intent of this section is to provide the following information:

1. A comparison of CSO program projected rates, capital costs and present worth values based on Metro Council Resolution 4780 adopted July 17, 1986 for Secondary Treatment and CSO Control Facilities and the current proposal as described in the Final 1988 CSO Control Plan.

2. A sensitivity analysis of the projected sewer rate to show the impact of high and low economic assumptions in comparison to current economic assumptions.

Highlights

Highlights of the analysis show that the portion of the sewer rate attributable to the 1988 CSO Control Plan would be $1.05 in 1995 compared with $.88 for CSO costs adopted in CR 4780. Capital costs for CSO (1986 through 1995) are $84 million in the current plan compared with $58 million for CSO capital costs in CR 4780. The present worth value of costs set forth in the CSO Control Plan (to the year 2030) is $123 million compared with $71 million of CSO costs in CR 4780.

Despite the higher capital costs of the CSO control program from 1986 levels, the projected sewer rate for 1995 is $19.62 (using 5% general inflation, and 8% bond rate). This is 18% lower than the 1995 projected sewer rate of $23.98 based on the economic assumptions used in CR 4780 (6% general inflation, 10% bond rate).

Changes in economic conditions could raise or lower the projection of the wholesale sewer rate. Current conditions predict a rate of $19.62 in 1995 given a 5% general inflation rate and 8% bond rate. Higher inflation and bond rates could raise the rate to $23.36 by 1995 (7% general inflation, 10% bond rate). Lower inflation and bond rates could lower the rate to $17.71 by 1995 (3% general inflation, 6% bond rate).

Presentations

The following is a brief description of the tables and figures that follow in the rate analysis in Appendix D.

Table D-1. This table provides capital cost, wholesale sewer rate and present worth values for the CSO program adopted in CR 4780 in 1986 and the CSO program as proposed in this Plan. To allow for clear comparisons, the table is structured to show cost information in a similar way to that presented in the backup documents for Resolution 4780.

Figure D-1. This graph shows a comparison of the projected sewer rate schedule of the 1986 adopted Secondary/CSO program (CR 4780) and the projected rate schedule including the 1988 CSO Control Plan.

Figure D-2. This graph shows the impact on the projected sewer rate of high and low economic assumptions. These are contrasted with the projected sewer rate based on assumptions used in the 1989 Proposed Budget.

TABLE D-1

COST COMPARISONS OF
1988 CSO CONTROL PLAN (WITH SECONDARY PROGRAM)
AND 1986 SECONDARY/CSO PLAN (CR4780)

	Sec/CSO Plan (CR4780)*	1988 CSO Control Plan (with Secondary Program)**
Capital Cost 1986-1995 ($ Millions inflated to year of expenditure)		
Secondary	$ 832	$ 822
CSO	58	84
Subtotal	$ 890	$ 906
Other Capital Program	278	357
Total	$ 1,168	$ 1,263
Rates 1995 ($/Month)		
CSO	$ .88	$ 1.05
Secondary and Other Capital Program (including operating expense)	23.10	18.57
Total (assuming $300M grant)	$ 23.98	$ 19.62
Total (assuming $0 grant)	$ 29.27	$ 23.82
Present Worth to 2030 ($ Millions)		
Secondary	$ 1,116	$ 1,136
CSO	71	123
Total	$ 1,187	$ 1,259

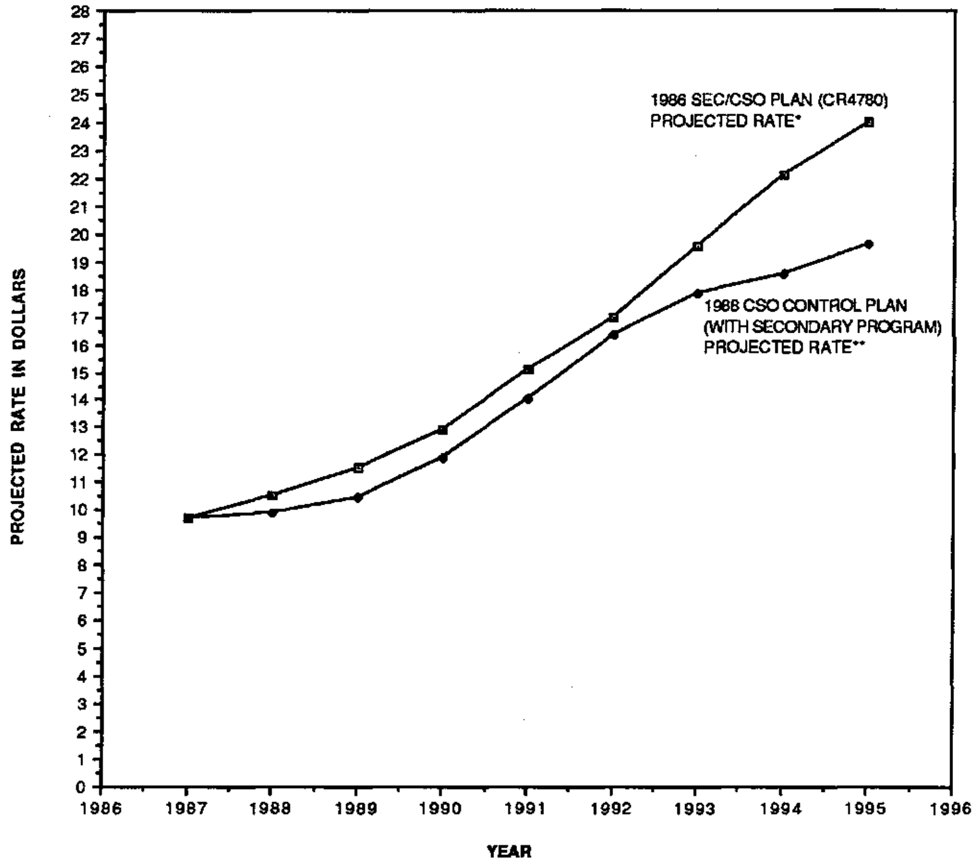
ECONOMIC AND BUDGET ASSUMPTIONS

	1986*	1989 P**
CSO Reduction Level	60-65%	75%
Grants	$300M	$300M
General Inflation	6%	5%
Construction Inflation	7%	6%
Energy Inflation	8%	6%
Revenue Bond Rate	10%	8%
Residential Customer Equivalent Growth Rate	1.6	1.6[1]
Debt Service Coverage Ratio	1.20	1.25

[1] Based on historical trends

FIGURE D-1

COMPARISON OF PROJECTED RATE SCHEDULE FOR 1988 CSO CONTROL PLAN (WITH SECONDARY PROGRAM) AND 1986 SECONDARY/CSO PLAN (CR4780)



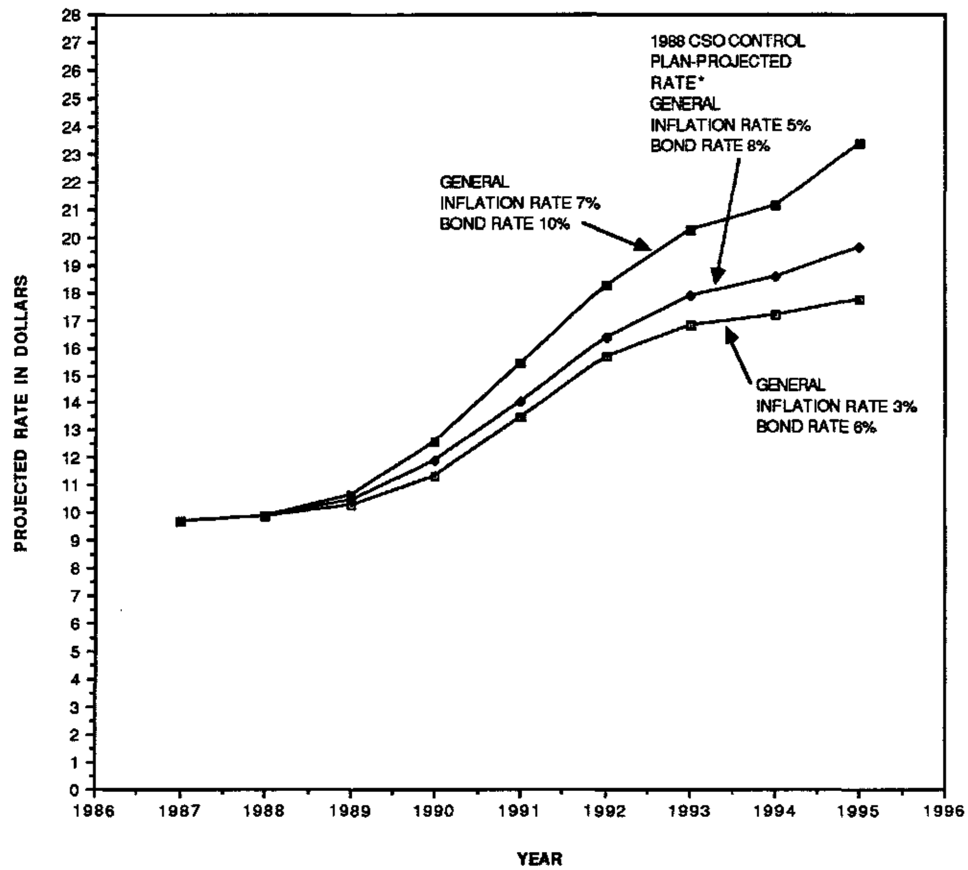
ECONOMIC AND BUDGET ASSUMPTIONS

	1986*	1989 P**
CSO Reduction Level	60-65%	75%
Grants	$300M	$300M
General Inflation	6%	5%
Construction Inflation	7%	6%
Energy Inflation	8%	6%
Revenue Bond Rate	10%	8%
Residential Customer Equivalent Growth Rate	1.6	1.6[1]
Debt Service Coverage Ratio	1.20	1.25

[1] Based on historical trends

FIGURE D-2

SENSITIVITY ANALYSIS OF PROJECTED RATES FOR 1988 CSO CONTROL PLAN (WITH SECONDARY PROGRAM) WITH VARIABLE INFLATION AND BOND RATES



ECONOMIC AND BUDGET ASSUMPTIONS

	1989 P*
CSO Reduction Level	75%
Grants	$300M
General Inflation	5%
Construction Inflation	6%
Energy Inflation	6%
Revenue Bond Rate	8%
Residential Customer Equivalent Growth Rate	1.6[1]
Debt Service Coverage Ratio	1.25

[1] Based on historical trends

APPENDIX E

INDEMNIFICATION STATEMENT
THAT MAY BE APPLIED TO SEPARATION PROJECTS
THAT RESULT IN NEW STORM DRAIN SYSTEMS
FOR THE CITY OF SEATTLE

INDEMNIFICATION

Metro will ensure that the Seattle storm drain discharge resulting from construction of a Metro sponsored storm drainage separation project will maintain or enhance existing beneficial uses of the receiving water body as established jointly by Metro and the City of Seattle. If the discharge from the storm drain should adversely impact an existing beneficial use(s) and the quality and quantity of the discharge has not significantly changed from base conditions jointly established by Metro and the City of Seattle at the time the project was implemented, Metro will assume the responsibility to make improvements necessary to restore the beneficial use(s) to their original values.

As a condition of obtaining Seattle permit approval for a project, Metro will establish and characterize the existing status of beneficial uses within the receiving water. Metro will also establish both the quantity and quality of the discharge and assess its potential impacts on beneficial uses.

Metro assumes no liability for future regulatory requirements which may be established for storm drains or impacts resulting to beneficial uses attributable to changes in the storm drainage quality or quantity from base conditions.

APPENDIX F

URBAN STORM WATER AND COMBINED SEWER OVERFLOWS
A SUMMARY OF WATER QUALITY ISSUES

URBAN STORM WATER AND COMBINED SEWER OVERFLOWS--
A SUMMARY OF WATER QUALITY ISSUES

Many water quality problems result from the urban environment, including human pathogens from untreated sewage, stimulation of algae from excess nutrients, destruction of salmon habitat in streams from excess storm-water flows and buildup of toxic chemicals from a variety of sources. This paper presents a brief overview of two major pathways for urban water problems and their interrelationship: combined sewer overflows and urban storm-water runoff. This paper provides: (1) a summary of the types of problems encountered with CSOs and urban runoff as they affect the various receiving water environments; (2) the alternative methods of managing these problems; and (3) a summary that describes how CSO control can be combined with a responsible program to manage potential urban runoff problems on a site-specific basis.

Combined Sewer Overflows

Background

Seattle's combined sewer system dates from the 1890s. Sanitary engineers of that period were trained to deal with all aspects of streets and with sewage, drainage and water supply. Combined sewers were the inevitable result. Since the streets were then visibly coated with manure, it seemed logical that they should also drain into the same single pipe network that carried human wastes.

Combined sewers moved the problems of sanitary wastes, horse manure and rainwater away from the immediate vicinity of houses and streets out into an appropriate body of water, where dilution was assumed to (and initially did) take care of it. Overflows of the combined sewers (storm water combined with raw sewage) were designed to occur in these systems because pipes large enough to store or carry all the rainwater to its ultimate destination were too expensive to put in and because treatment of these combined wastes was not an issue--just getting them to the nearest lake or bay was considered an improvement.

Since the early 1950s the construction of separate systems for sanitary sewage (which is now treated before disposal) and storm water (which is discharged directly to the nearest water body) has been the standard environmental and engineering practice for drainage and wastewater utilities locally as well as nationwide. The City of Seattle is the only jurisdiction with combined sewers in the Metro service area, as shown in Figure 1.

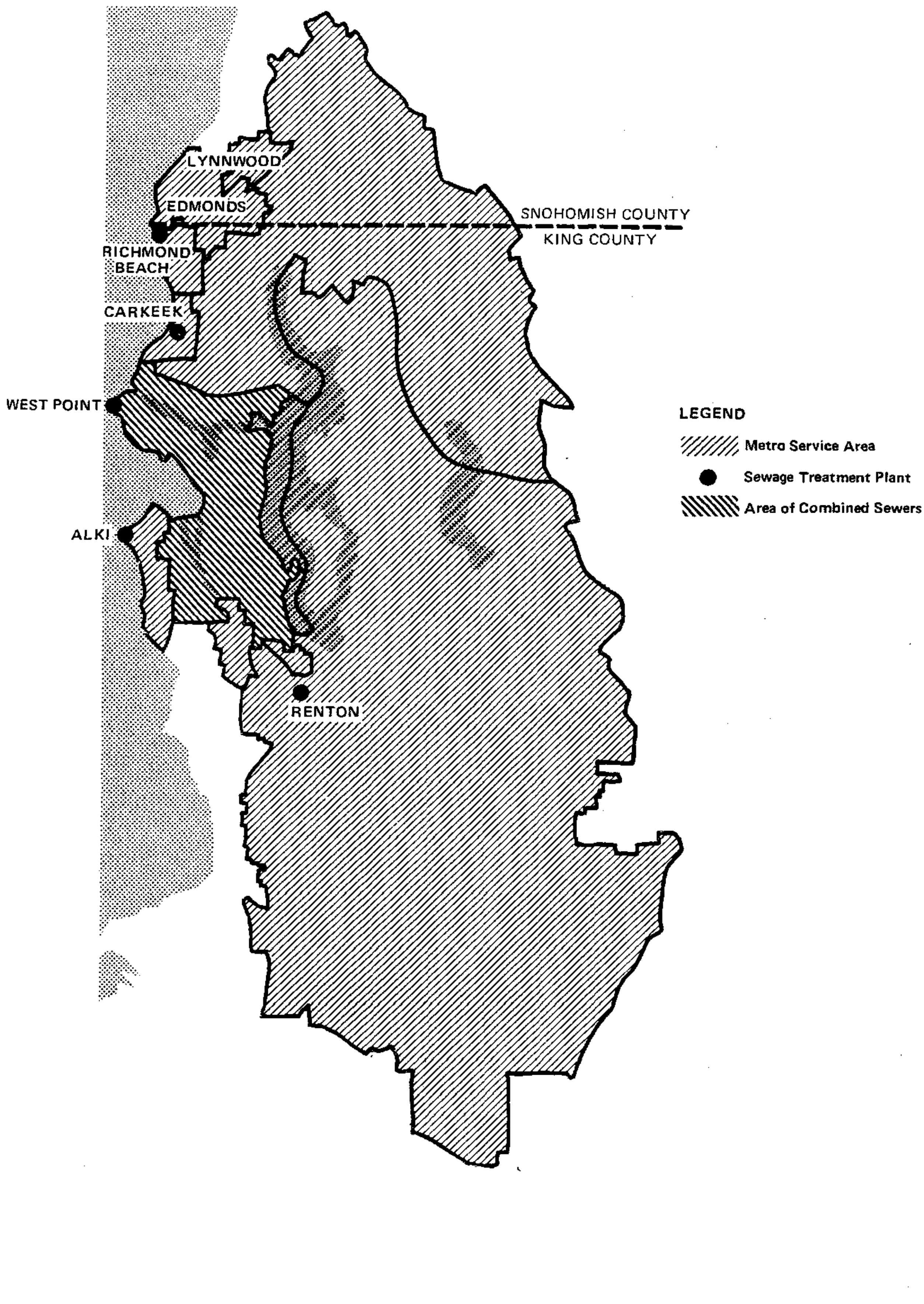


FIGURE 1. Combined sewers exist only in the older parts of the City of Seattle, representing eight percent of the Metro service area.

When Metro was formed in 1958 to provide a regional wastewater treatment system for the entire metropolitan Seattle area, the existing combined sewers and trunk lines from Seattle were incorporated into the regional system with the separated sanitary sewers from more recently developed parts of Seattle and other areas. A treatment plant was constructed at West Point in proximity to the existing North Trunk combined sewer outfall which had discharged untreated sewage and storm water from north and central Seattle into Puget Sound south of Shilshole Bay. The Elliott Bay interceptor was built to intercept the numerous untreated sewer outfalls from the central Seattle waterfront and transport these flows for treatment at West Point. Dry weather discharges of raw sanitary sewage and industrial wastewater were eliminated as a result.

During large storms, however, considerable volumes of sewage diluted with storm water are still discharged from specific relief points in the system. Without these overflow points in a combined system (as shown in Figure 2), some storms would cause wastewater to spill out onto streets and backup into homes and businesses. Metro estimates that about 2.4 billion gallons of combined sewage and storm water overflow from 21 CSO points in Metro's system during an average rainfall year. The City of Seattle estimates that an additional 470 million gallons overflow in an average year from 80 CSOs in the city's local collection system before it can even get to the large trunks in the Metro system. Of the 2.4 billion gallons that overflow from Metro's large trunk and interceptor sewers, 460 million gallons discharge into the Ship Canal and Lake Union and 1.9 billion gallons discharge into the Duwamish River and Elliott Bay. The present capital planning programs of both Metro and the City of Seattle are intended to improve both systems so that fewer overflows occur during rainstorms and significantly smaller volumes of wastewater are discharged.

The Problem

Unlike Metro's treatment plant outfalls which discharge treated effluent through a pipe located in deep water offshore, CSOs generally discharge untreated sewage at or immediately adjacent to the shoreline. These discharges along the shorelines and in freshwater areas pose the greatest potential for human contact with disease-causing bacteria and viruses--clearly the predominant water quality issue associated with CSOs. In addition, elevated levels of toxic chemicals and oxygen-demanding wastes in the nearshore sediments, nutrient enrichment, turbid water, floating materials and other aesthetic impacts also result from CSO discharges.

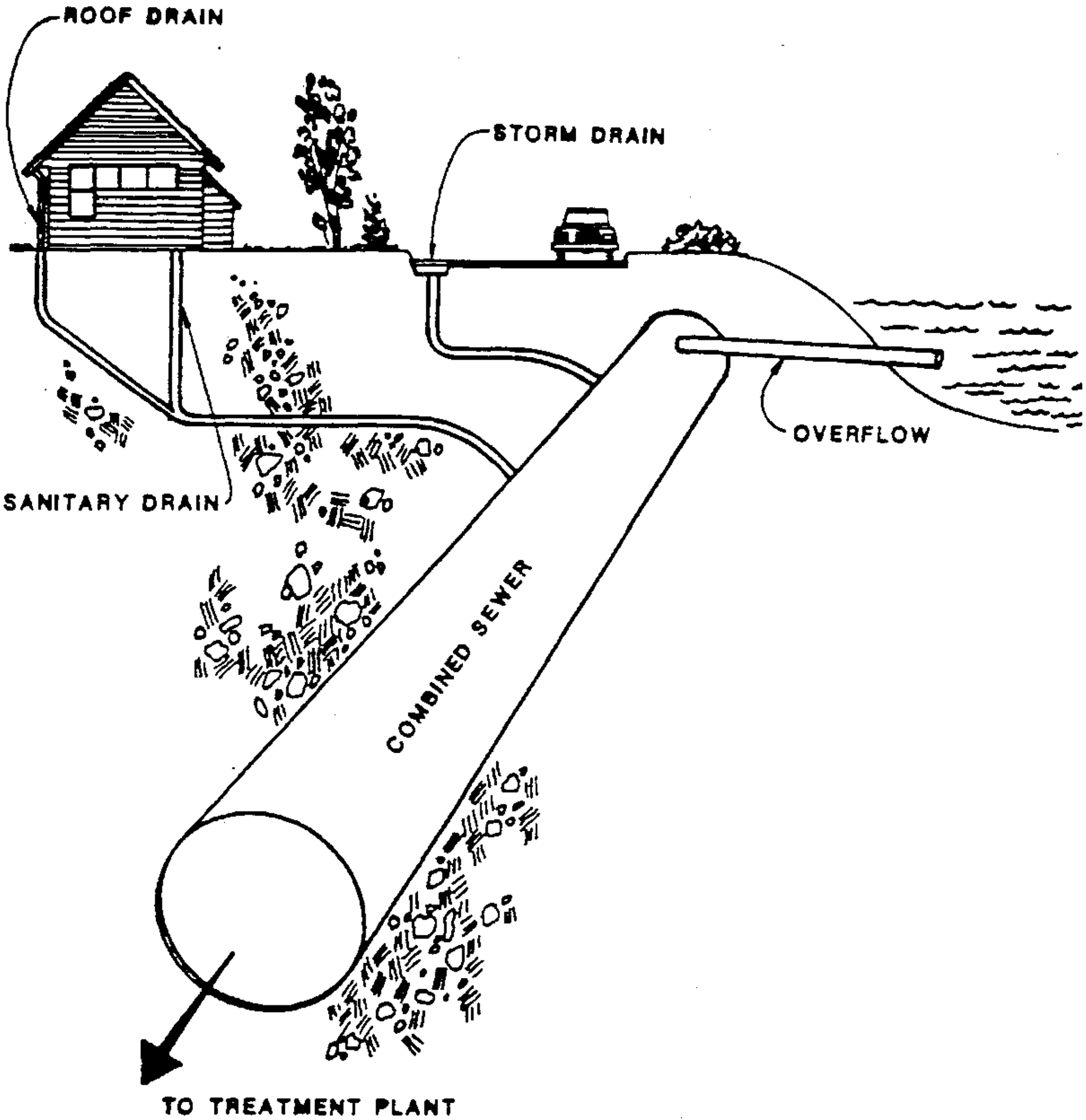


FIGURE 2. Combined sewers, which received both sanitary sewage and storm water, overflow when storm events result in too much volume to fit in the pipes.

Bacteria and viruses. Because CSO discharges include untreated human fecal wastes, it is logical that they result in release of disease-causing micro-organisms into the environment. An EPA-funded Metro project in 1980 documented significant levels of human viruses in the combined sewage in CSOs, while finding none in urban storm water (Tomlinson et al, 1980). Concentrations of the common indicator bacteria called fecal coliforms are very high in CSO discharges and in nearshore water samples during and immediately after storm events that trigger combined sewer overflows. As a result, CSO events have caused periodic closures of public swimming beaches and have contributed to decertification of areas for shellfish harvesting.

Toxicants. The issue receiving the most recent and intense interest, however, is the discharge of toxicants into nearshore waters. In addition to the 1979 study noted above, Metro's Toxicant Pretreatment Planning Study (1980-1984) revealed significant levels of a number of heavy metals and toxic organic compounds in CSO discharges and in the sediments adjacent to CSO outfalls (Cooley et al., 1984; Comiskey et al., 1984; Romberg et al., 1984; Galvin et al., 1984). In fact the biological analyses of the toxicant study concluded that the only area where biological effects to the organisms living in the bottom sediments could be identified and correlated with toxicant loadings into the environment was in the immediate vicinity of a CSO. No comparable effects or correlations could be found near storm drains.

A recent risk assessment (Stuart et al., 1988) of the discharge of lead, copper, polycyclic aromatic hydrocarbons and phthalates into an urban lake by both CSOs and storm drains concluded that for the chemicals studied (selected as the most likely to cause toxic problems), lead is the only toxicant where a potential risk is indicated. Concentrations of lead discharged to freshwater lakes through both CSOs and storm drains may result in (1) chronic toxic effect to some bottom-dwelling organisms and (2) the need to limit the quantity of crayfish or other bottom-dwelling invertebrates eaten by urban children.

Urban Storm Water

Background

In urban areas rainfall hits pavement and buildings instead of fields and trees, and runs off these impervious surfaces instead of soaking in. Rainfall tends to wash dirt and oil and anything else not tied down off the surfaces as well, transporting all of these things through whatever storm-water conveyance system exists, ultimately into the region's waters.

As noted above, storm drainage systems separate from sanitary sewers have been standard engineering practice since the early 1950s. These separate storm drains collect runoff during storm events and route it directly to the nearest stream, river, lake or bay. Separate storm drains have been preferred in order to eliminate the acknowledged problems caused by combined sewer overflows. As shown in Figure 1, most of the developed area in the Seattle-King County region has separate sewers and storm drains, and all new developments throughout the region (including in the City of Seattle) must install separate systems.

The Problem

Separate storm drainage systems are not without their own problems. Primary among them in this region is the increase in peak flows off impervious surfaces, which results in flooding, higher velocity in streams, increased bank erosion, streambed scouring and sediment movement. This "quantity" issue produces "quality" problems such as erosion and sedimentation, destruction of aquatic habitat in streams and rivers, and loading of nutrients into lakes. In addition, runoff washes pet feces, bacteria, oils and greases, heavy metals and organic chemicals off road surfaces and into receiving water environments.

Problems with storm water are much more ephemeral and site specific than with CSOs. Problems caused by storm water vary for different receiving waters. Water quality degradation depends upon human activities and land uses in the watershed, the topography of the area, and the beneficial uses of the lake, stream, or Puget Sound at the end of the pipe. For example, phosphorus has been identified as the pollutant in storm water which can stimulate excessive algae growth in lakes. The same loading of phosphorus is not a major concern in an estuary like the Duwamish River. Even within a single watershed, storm water has different effects depending upon the beneficial uses (e.g., drinking water supply, swimming, shellfish harvesting, or commercial navigation) of different sections of the water body.

Metro has consistently identified storm water as the major cause of water quality problems regionwide. The 1978 Areawide Water Quality Plan and the 1987 Update of the Areawide Water Quality Plan both support this conclusion. That does not mean that other causes, such as CSOs, are not of major importance in particular water bodies; in fact, problems from sources other than runoff may be much more serious locally than reflected in the regional perspective of the areawide plan. CSOs in Seattle are a case-in-point.

Flows, erosion and sedimentation. The primary, negative effect of storm water as consistently identified by Metro and others is the increased streambank and bed scouring and related problems caused by the changes in runoff hydraulics. High peak flows result in flooding, erosion, scouring, changes to instream fish habitat, decreased survival of salmonid eggs and fry, decreased stream production of anadromous salmonids such as chinook, coho and steelhead and sedimentation at deltas and in lakes. This is a dominant problem throughout the region as urban development spreads, but is not a major problem in most older parts of Seattle where streams disappeared into pipes decades ago. (Thornton, Longfellow and Pipers Creeks are obvious, important exceptions in Seattle.)

Nutrients. Scouring of soil, stream banks, fertilized urban lawns and disturbed land from farms or new construction results in increased transport of nutrients such as phosphorus and nitrogen in storm drains and streams, with ultimate deposition into lakes or the sound. Phosphorus in particular has been identified as a concern in many of our lakes, where increased levels of this nutrient stimulate algae growth, which in turn can produce problems of cloudy water, floating scum, odors, reduced dissolved oxygen, and general aesthetic nuisance. Water bodies vary greatly as to sensitivity. Marine waters in the Seattle area, including the Duwamish estuary, are not as sensitive to the nutrient impacts from either CSOs or storm water. Nutrient levels are generally lower in storm water than in discharges from CSOs.

Bacteria. Urban storm water often contains high levels of fecal coliform bacteria. While these bacteria could, and sometimes do, come from such sources as leaking or illegally-connected sanitary sewers, failing septic tanks or hobby-farm animals, the general levels of coliforms in urban runoff are attributed to pet feces and, in some specific drainages, to vermin such as rats. The CSO and storm drain studies that documented significant levels of human enteric viruses in CSO samples found no viruses in stormwater samples (Tomlinson et al., 1980). Still, warm-blooded animals such as dogs and cats can occasionally carry human pathogens. Fecal coliform levels in streams throughout western King County consistently exceed state standards.

Toxicants. Storm water carries heavy metals such as lead and zinc and organic compounds such as oil hydrocarbons and PAHs into local streams, lakes and the sound. Studies in Bellevue and Seattle have consistently found the metals in urban runoff, but the organics only sporadically at very low levels (Galvin and Moore, 1982; Cooley et al., 1984). CSOs generally contain higher levels of all toxicants of concern except lead and PAHs. Lead originates from leaded gasoline and has been steadily decreasing in concentration in air particles, street dust and runoff over the last decade as a result of federal gasoline regulations. PAHs originate from incomplete combustion from motor vehicles, oil heating, wood stoves and other sources.

Attempts to document biological effects resulting from toxicant levels in storm water have been unproductive to date. Any potential effects in urban streams are overshadowed by the physical problems such as erosion/sedimentation caused by urban runoff. Detailed and expensive studies off storm drains in Lake Washington as part of Metro's Toxicant Pretreatment Planning Study (McChord et al., 1984) could find no adverse effects correlated with toxicant levels in the sediments there. There are specific exceptions to this general condition, however, as demonstrated in the Duwamish Clean Water Plan where significant toxic sediment concentrations were found directly associated with certain storm drain outfalls. In each case specific sources of these contaminants were located and the pollutants controlled through source elimination.

The recent risk assessment mentioned above (Stuart et al., 1988) that analyzed toxicants discharged into an urban lake concluded that lead from both CSOs and storm drains presents a potential risk. Current lead levels, while decreasing, are still higher in storm water than in CSOs.

Table 1 presents a summary comparison of concentrations of selected pollutants in CSOs and stormwater. Figure 3 shows a general comparison of levels for five parameters in CSOs, storm water and average municipal secondary-treated effluent.

Management Options

Various strategies are available to address the problems caused by CSOs and storm-water runoff. These include structural measures as well as operational or management measures.

CSOs

Reduction in the discharge of untreated wastewater from combined sewers can be accomplished in various ways. These include:

- sewer separation
- storage and treatment
- at-site treatment
- source controls for selected constituents

Separation involves construction of a parallel system of pipes to remove storm-water flows from the pipes carrying residential, commercial and industrial sewage. This has been the preferred approach by the City of Seattle over the past 20 years in many formerly combined areas using

Table 1
Typical Pollutant Levels
In Combined Sewer Overflows
And Storm Water

	CSO[1] (mg/l)	Storm-water[2] (mg/l)	Ratio Storm Water/ CSO
BOD	64	6.6	0.10
Suspended Solids	118	110	0.93
Copper	0.087	0.02	0.23
Lead	0.177	0.20[4]	1.13
Chromium	0.0484	0.007	0.14
Cadmium	0.0038	0.0007	0.18
Zinc	0.2245	0.12	0.53
Nickel	0.0425	0.011	0.26
PAH[3]	0.00271	0.00599	2.21
Phthalates[3]	0.01923	0.01177	0.61

(1) Average concentrations based on Table 8-8, Toxicant Pretreatment Planning Study, TPPS Technical Report A2 (Cooley et al., 1984)

(2) Sources: Metro Toxicants in Urban Runoff (Galvin and Moore, 1982).
Bellevue Urban Runoff Summary Report (Pitt and Bissonnette, 1984).

(3) Average concentrations based on Table A-4, University Regulator Water Quality Impact Analysis (Metro, 1987b)

(4) 0.17 and 0.20 reflect historic average values. Recent lead levels have dropped to around .083 mg/l for storm water and 0.058 mg/l for CSOs. University Regulator CSO Control Predesign Project, Water Quality Impact Analysis (Metro, 1987b).

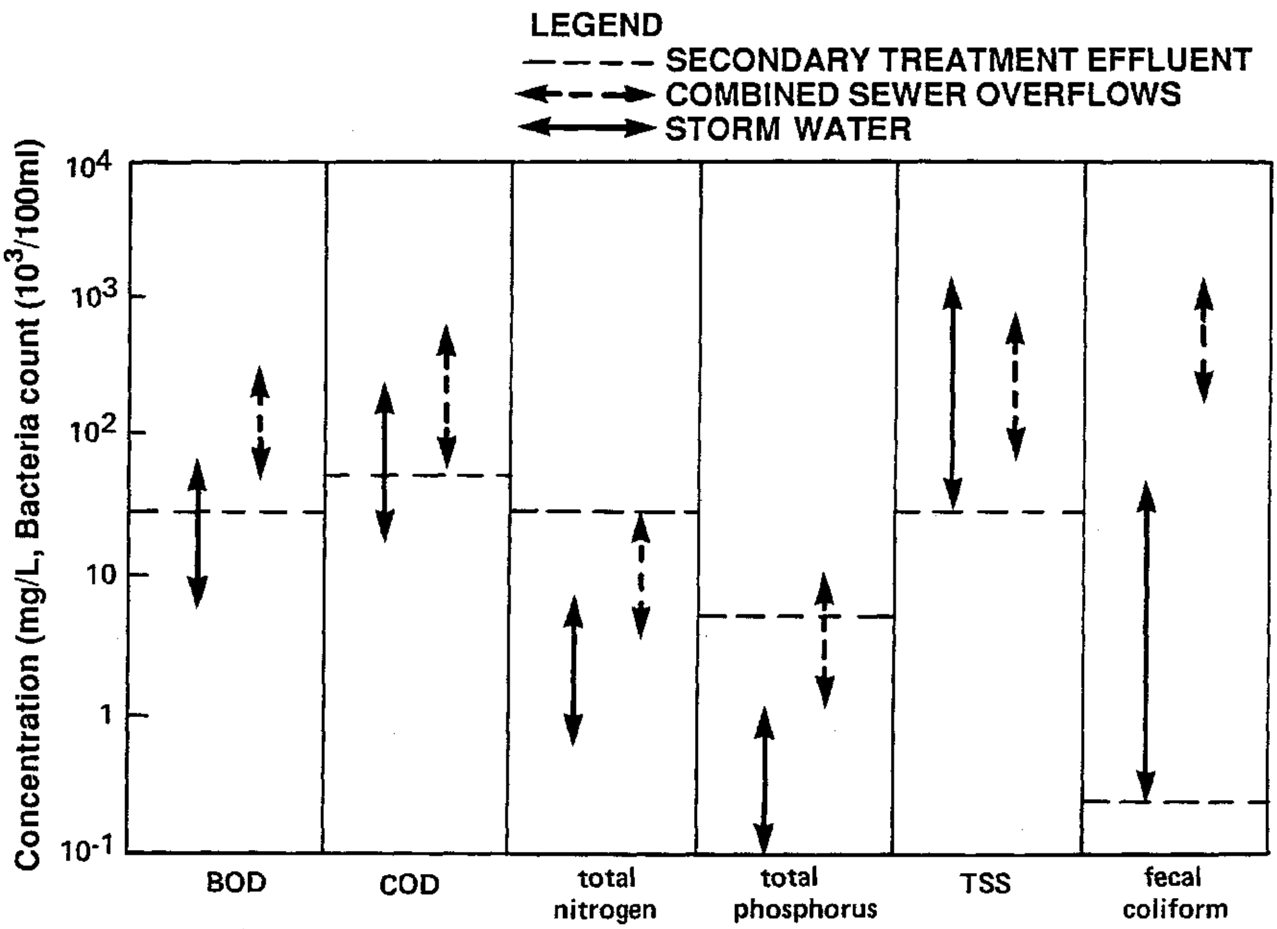


FIGURE 3. Concentrations of conventional parameters in storm water are usually less than those in CSOs but are often comparable to or greater than those in secondary-treated municipal effluent. (From Hvitved-Jacobsen, 1986.)

Forward Thrust bond funds. As has been mentioned, separate storm drainage systems have been the norm throughout the nation for the past 40 years.

Storage involves using excess capacity in existing pipes or construction of special storage tanks or oversized pipes to hold onto the excess storm flows that would otherwise overflow, and then pumping or metering the stored wastewater back into the collection system for treatment at the municipal treatment plant. This strategy reduces peak flows in the system, but prolongs the duration of increased and diluted storm-related flows at the treatment plant. Metro has implemented a Computer Augmented Treatment and Disposal System and provided oversized pipes in the Metro system whenever possible to implement this technique.

At-site CSO treatment involves some form of special treatment for the combined wastewater before discharge at the CSO point. Various types of physical treatment plus disinfection would be the most effective methods of treating the intermittent CSO events. This approach has not been implemented in the Seattle area to date.

To address reduction of particular pollutants in CSO discharges, source controls in the contributing sewered area are possible. Industrial pretreatment, limits to type or times of discharge, in-line cleaning and other methods can be used to reduce the levels of toxicants or other constituents in the overflows. These methods are being employed by Metro in the system tributary to the Denny Way CSO particularly to reduce toxicant loadings at that location into Elliott Bay in advance of major structural measures for that overflow point.

Storm Water

Reduction in the negative effects of urban storm water discharges is in many ways more complex than for CSOs because of the combination of flow-related and pollutant-carrying character of the storm-water problem. However, there are many more options available that can be targeted to site-specific issues. Structural and storm water control measures include:

- o erosion and sedimentation controls;
- o extended detention ponds;
- o wet (permanent) detention ponds;
- o infiltration basins;
- o porous pavement;
- o oil-water separators;
- o vegetated or grass-lined swales;
- o stream setbacks/vegetated filter strips; and
- o wetland treatment.

In addition, non-structural or operational measures can be applied. Source controls, management practices and house-keeping measures can be relatively inexpensive and can control water quality and water quantity before runoff is discharged into municipally-owned systems. Source controls are designed to control or capture pollutants before they can contaminate storm water. For example, storage of petroleum products or solvents in bermed and covered areas will isolate them from the rain, and any leaks or spills can be contained before drains or ditches are polluted. Other institutional options include control of pet wastes, changes in use of fertilizers or pesticides, changes in maintenance practices and public education. These kinds of management practices focus on prevention rather than treatment of pollution problems with emphasis on changing the activity which is generating the pollution.

Each of these control measures has advantages and disadvantages and the use of one in a particular situation is site-dependent. Parameters such as benefits, cost (construction and maintenance), performance, site conditions, adverse or positive impacts on local habitat, safety, recreation and aesthetics must be considered in choosing a particular control measure for a site.

As was shown in Figure 1, most of the metropolitan region has separate sanitary sewer and drainage systems. Increased awareness in recent years of the flooding and property damage caused by urban storm water as well as other water quality concerns has resulted in the formation of surface water management programs in much of the region, with dedicated utility funding. Figure 4 shows the extent of currently operating SWM utilities. (In addition to those areas shown on the map, the cities of Seattle and Redmond are in the process of developing SWM utilities but are not yet operating with drainage utility-based revenues.) These utility-based programs have been and will continue to be able to focus attention on urban storm-water management, with both structural and non-structural controls.

Metro's CSO Control Plan

Since the 1970s several studies on CSO control for the Metro and Seattle systems have been conducted and substantial progress has been made in reducing local CSOs through a series of separation and storage projects, as shown in Figure 5. All CSOs along Lake Washington and West Seattle beaches have been controlled to at least the one-year storm level and major reductions in overflows have been realized elsewhere. In January 1987, the state Department of Ecology issued new CSO control plan requirements that identify a long-term planning goal of one untreated CSO discharge per CSO site per year. Based on specific guidance from the state, Metro

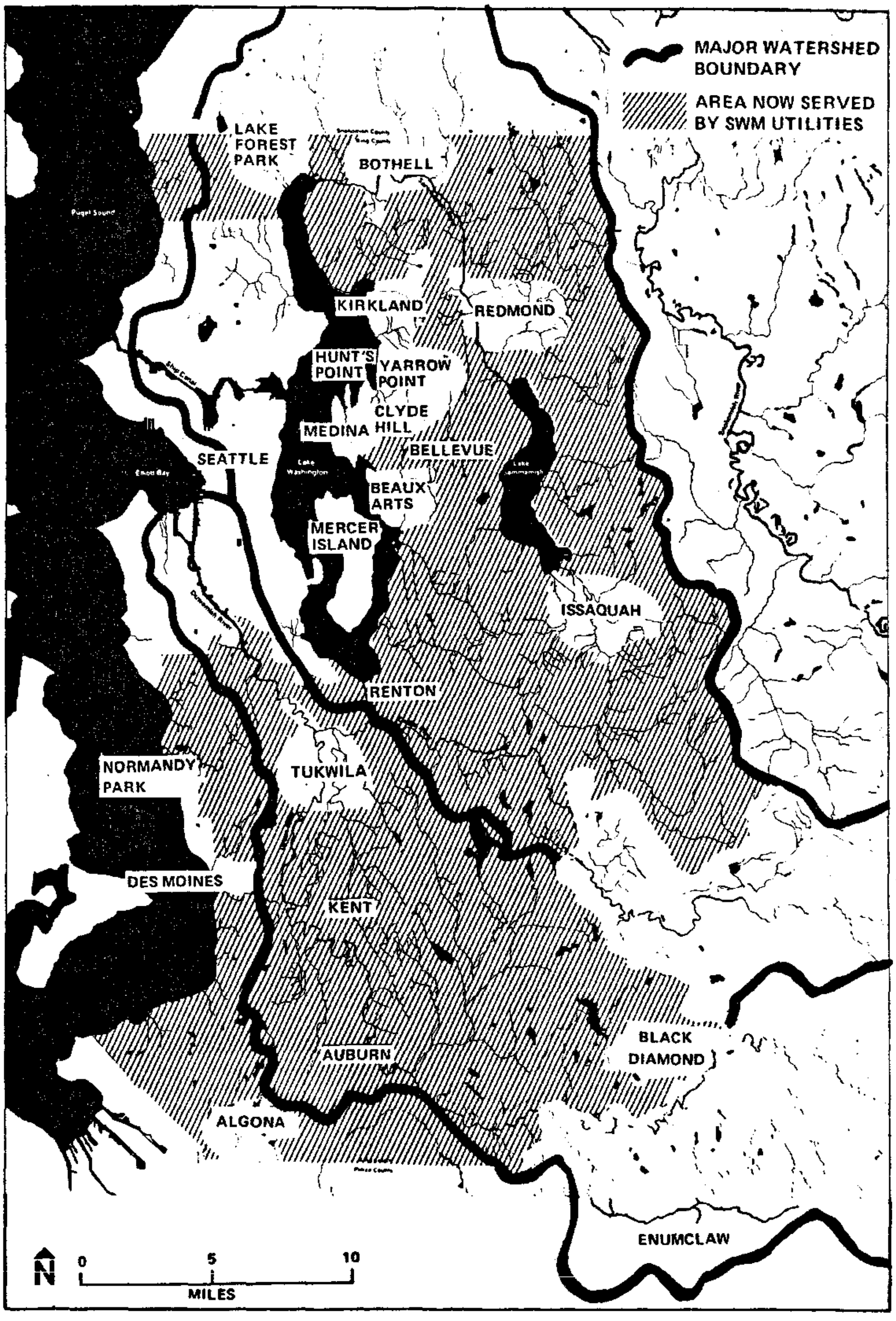


FIGURE 4. Much of the Cedar-Green basin and adjacent shorelines is now served by surface water management programs that are funded by dedicated utility revenues. (In addition to those areas shown, the cities of Seattle and Redmond are in the process of developing surface water management utilities but are not yet operating with drainage utility-based revenues.)

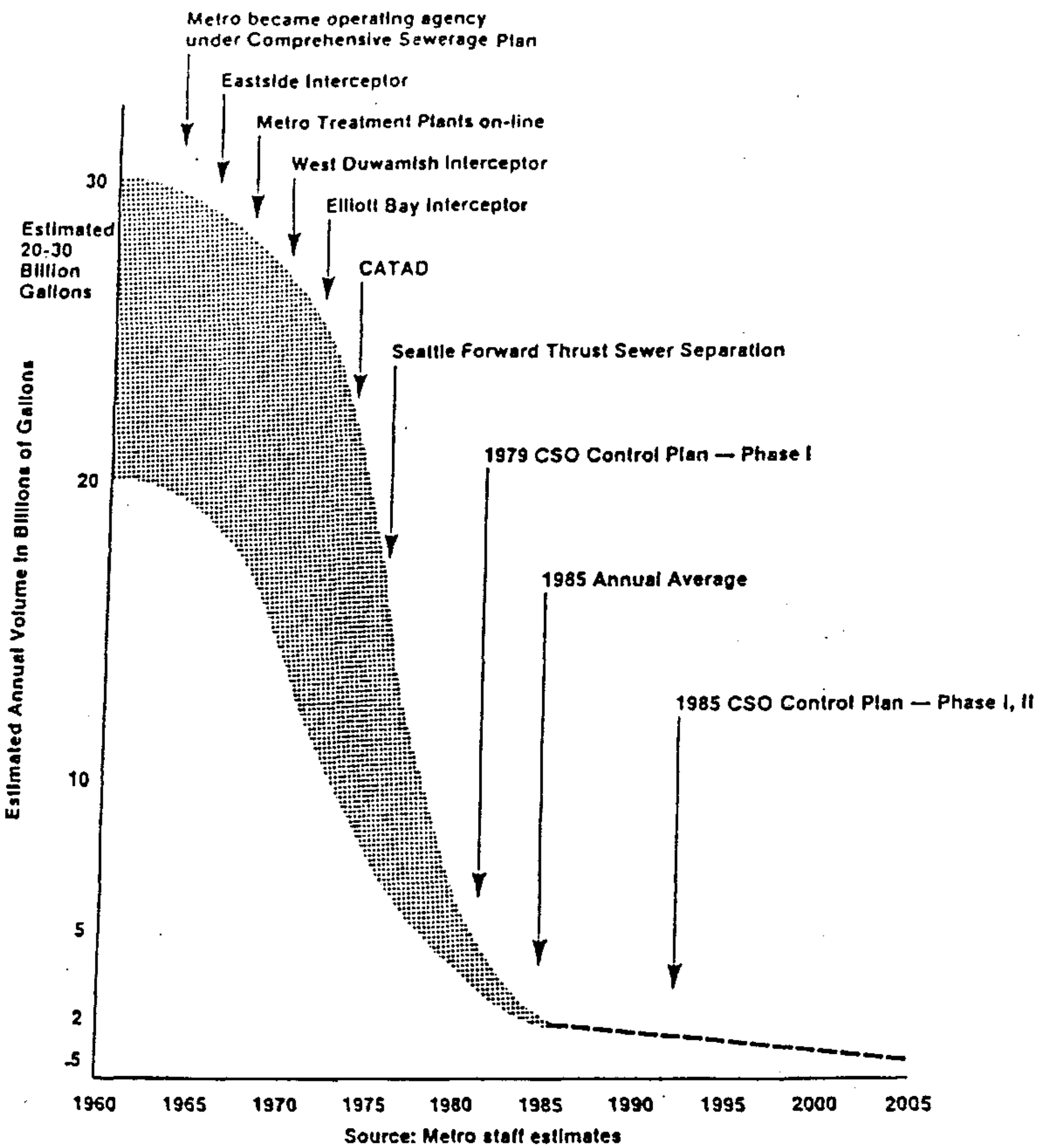


FIGURE 5. Untreated sanitary and combined sewer overflows in the Seattle area have been significantly reduced since 1960.

issued a facility plan to reduce the 2.4 billion gallons of remaining CSO by 75 percent. The plan looked at a number of CSO control alternatives including sewer separation, storage and treatment, centralized CSO treatment facilities, and improvements to Metro's computer control system.

Because of concerns expressed regarding increased storm-water discharges that would result from sewer separation projects, Metro initially looked at control alternatives that emphasized storage facilities. It became evident, however, that to rely on storage alone was impractical because of the enormous volumes Metro would have to deal with. Several hundred million gallons of storage would be needed at a cost of more than $1 billion to achieve the long-range goal of one event per year throughout Metro's system. The local site impacts of building these storage facilities would be substantial. Siting constraints and their impact on storage project efficiency is evident with regard to controlling the University regulator CSO. A 20-mg storage tank (larger than any storage facilities currently in the Seattle area) would cost twice as much per million gallons of CSO reduction while achieving only half the volume reduction possible with separation.

Metro's plan therefore recommends a combination of alternatives to obtain the most efficient and cost-effective CSO control program.

In the plan Metro has identified three projects that collectively provide approximately 27.5 million gallons per year of CSO storage (CATAD, Parallel Fort Lawton Tunnel, Bayview tunnel rehabilitation), six sewer separation projects covering about 5,500 acres within the city of Seattle (University Regulator, Hanford/Lander, Denny Way, Diagonal, Michigan and the Kingdome/Industrial area) and two stormweather primary treatment plants (located at Alki and Carkeek).

Both Metro's and the City's current or proposed CSO control plans call for separation as the technology of choice for the majority of CSO corrections within the metropolitan area.

Considering the total service area, the fate of stormwaters will be altered by Metro's 75 percent CSO control program as follows:

	Volume (MG/Year)	
	Existing	**At 75% CSO Reduction**
Direct Storm Discharges	12,338	14,398
Treated Storm water	4,447	3,894
Storm-water Portions of CSO	1,927	420
Subtotal, Storm water	18,712	18,712
Sanitary Portion of CSO	482	182
	19,194	18,894

When Metro's program is completed, direct storm-water discharges will be increased by about 17 percent over existing conditions. The relatively minor regional significance of these increased discharges from proposed new storm drainage systems is evident. The great bulk of regional storm-related discharges into local water bodies is from existing direct storm drainage systems rather than from the increases resulting from proposed sewer separation projects. Figure 6 graphically presents the information from the previous table showing the effects of the 75 percent reduction program on regional volumes of storm water and CSOs.

Both the City's and Metro's CSP control plans call for detailed investigation at the project specific level before the implementation of any separation project to ensure that necessary source controls or other management practices are in place in order to ensure net overall water quality improvement as a result of any projects implemented.

Conclusions

1. Combined sewers, which carry both sanitary wastes and urban storm water, are historical relics that still cause water quality problems today. Combined sewer overflows occur during storm events in both the city of Seattle's local sewer lines and in Metro's large trunk and interceptor lines. Overflows release untreated sewage, human pathogens, toxic chemicals and other pollutants into nearshore waters. CSOs are an acknowledged problem and are the focus of past and current control programs by both Metro and the City.

2. Separate sanitary sewers and storm drainage systems have been the standard engineering practice for the past 40 years. Many parts of the City of Seattle as well as all other areas in the metropolitan region are served by separate systems. Separate storm drains are the norm. Surface water management utilities have been formed in much of the region to dedicate local revenues to address storm and surface water issues.

3. Municipal wastewater treatment plants have been designed to treat domestic sewage, not storm water. They not only are inefficient at treating storm water, but their overall efficiency of removal of settleable solids, biochemical oxygen demand and other pollutants in wastewater is decreased by peak storm-related flows and by the dilute nature of those flows.

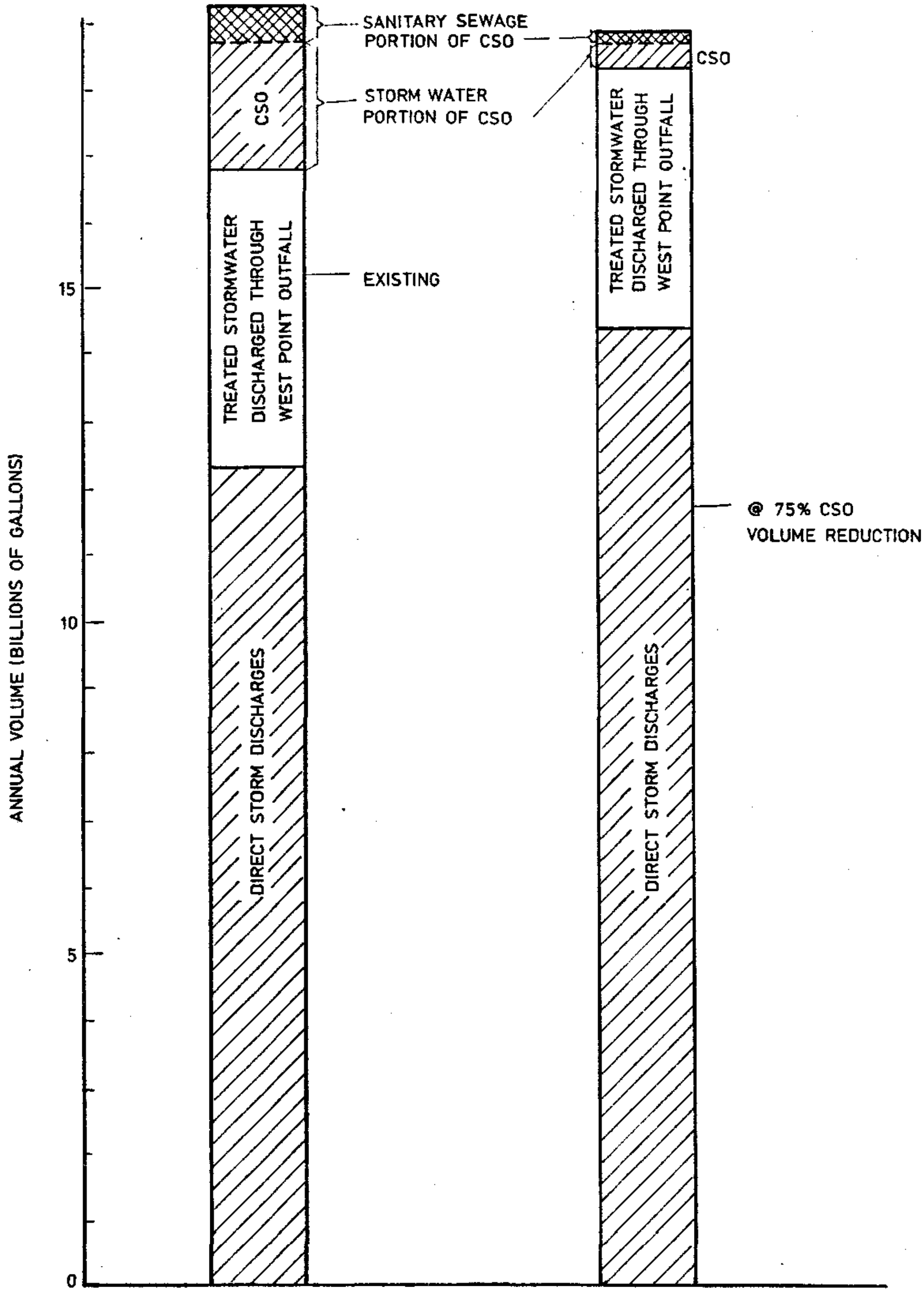


FIGURE 6. Regional volumes of storm water and CSOs will be reduced as a result of Metro's 75 percent CSO reduction program.

4. Urban storm water presents water quality problems, too, and has been consistently identified as one of the primary causes of problems in our local water bodies. The dominant problem characteristic of storm-water runoff is its physical, hydrologic effect on drainage systems, with resulting scour, erosion, sedimentation, habitat loss, nutrient transport and related problems--primarily in urban streams. Storm water also carries some toxic chemicals into receiving waters, with lead being identified as the most likely pollutant to present risks in urban waters. Effects of storm water vary with receiving water; for example, while nutrients can cause problems in some freshwater lakes, they are not currently a concern in the Duwamish estuary or central Puget Sound. In a report to Congress in 1984, EPA stated that the Nationwide Urban Runoff Program was unable to find extensive impairment or denials of approved water uses because of chemical pollutants borne by urban runoff (U.S. EPA, 1984).

5. Structural controls and management practices can be applied to both combined sewer overflows and storm drainage systems to address water pollution concerns. Source control is considered to be the most efficient and effective means of controlling pollutants in storm water. Control at the source prevents pollutants from entering the storm water and thereby assures protection of the receiving waters.

   An important example of the effectiveness of source control is the significant reduction of lead found in urban storm water since the mid-1970's. This reduction is directly attributable to regulations regarding the use of leaded gasoline.

6. Control plans for CSOs should consider all available options, including system separation, and select preferred options on a site-specific basis.

7. Where separation is found to be the most efficient and cost-effective control measure, detailed investigations should be performed at the project specific level before implementation in order to ensure that necessary source controls, structural measures or other management practices are in place. This commitment to appropriate application of storm-water controls will insure net overall water quality improvement as a result of any projects implemented.

8. Such an approach will result in the best water pollution control program for the region: significant reductions in CSOs, less storm water in the sanitary sewerage system, and appropriate focus on storm drainage systems throughout the region to insure the best possible water quality protection.

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