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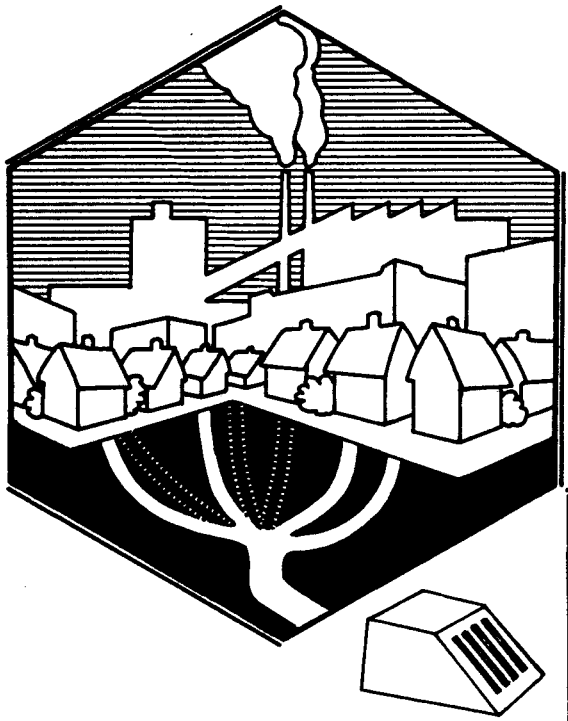

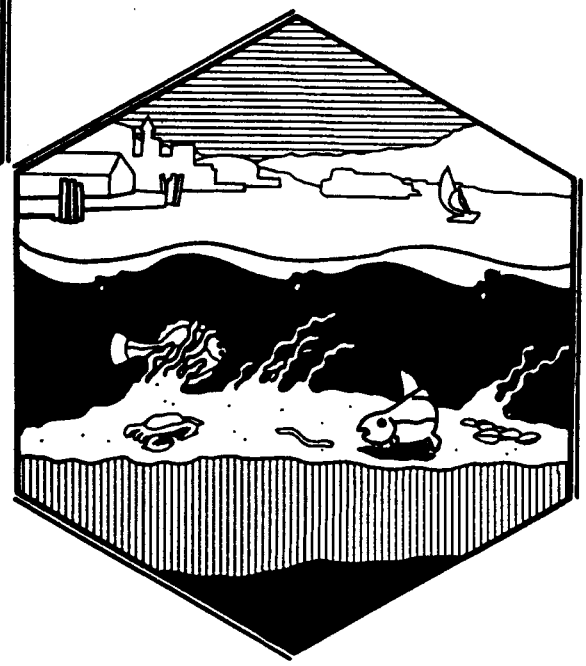

Toxicant Reduction in the Denny Way Combined Sewer System

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Municipality of Metropolitan Seattle

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TOXICANT REDUCTION IN THE DENNY WAY COMBINED SEWER SYSTEM

By
G. Patrick Romberg
Denise Healy
Keith Lund (Environmental Intern)

Municipality of Metropolitan Seattle
821 Second Avenue
Seattle, Washington 98104

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STUDY RESPONSIBILITIES

Study Design and Planning	Metro - Marine Group, Industrial Waste, Environmental Services, Water Resources, Facility Planning, Engineering Services Contract - Environmental Interns
Questionnaire Survey	Metro - Industrial Waste Contract - Environmental Interns
Site Visits	Metro - Industrial Waste
Sample Collection	
Collection System	Metro - Industrial Waste
Environmental Sediments	Metro - Environmental Services, Marine Group
Sample Analysis	
Wastewater & Inline Sediment for Metals	Metro - Metals Lab
Wastewater & Inline Sediment for Organics	Metro - Organic Lab
Environmental Sediment for Metals	Contract - Weyerhaeuser Lab
Environmental Sediment for Organics	Contract - AM TEST
Environmental Cores for Metals and Radioactive Lead-210	Contract - Battelle Northwest
Data Analysis and Draft Report	Metro - Industrial Waste, Marine Group, Water Quality Planning, Data Management Contract - Environmental Interns
Final Report	Metro - Technical Publications, Water Quality Planning, Print Shop

PARTICIPATING PERSONNEL

Metro CATAD Coordinator	Bill Nitz
Metro Management and Data Control	Ron Woo, Janet Condon, Lucy Woo
Metro Engineering Services	Ed Cox
Metro Environmental Services	Rich Tomlinson, Dan Sturgill, Steve Aubert, John Blaine, Lisa Beineke, Bob Dutton, Jody Heintzman, Sue Hennig, Steve Joyce, Marc Patten, Gary Yoshida
Metro Facilities Planning	Gunnar Sreibers, Doug Houck, Laura Wharton
Metro Industrial Waste	Doug Hilderbrand, Cathy Foss, Denise Healy, Bruce Burrow
Metro Marine Assessment	Bob Matsuda, Pat Romberg, Ralph Domenowske, Tom Hubbard, Villamor Gamponia, Tim Sample
Metro Metals and Conventional Lab	Raymond Dalseg, Rocky Wells, Ann Peacock, Romeo Aquino, Lester Laris, Brian Mazikowski,
Metro Trace Organic Lab	Lyn Faas, David Fada, George Parker, Joseph Weikel, Susan Dino
Metro Technical Publications	Cynthia Bischak, Alexandra Stone
Metro Water Resources	Bob Swartz, Lori Nye
Metro Water Quality Planning	Rodney Proctor, Jan Lonn
Environmental Intern Program	Keith Lund, Brant Gutermuth
AM TEST	John Hicks
Battelle Northwest Lab	Eric Crecelius
Weyerhaeuser Lab	Kari Doxsee

they can be cleaned out on a regular basis. The Computer Augmented Treatment and Disposal (CATAD) System controls could be modified to maximize containment of flows from the Denny Lake Union Basin since this basin contributes the largest loading. Total flow volume from the Denny Lake Union Drainage Basin could be significantly reduced if flows from about one-third of the service area could be diverted back into the Dexter Tunnel without overloading that drainage basin.

Offshore sediment samples from a grid of 29 stations showed that surface sediment concentrations for organic pollutants were far more variable than metals values both in terms of the overall concentration range and distribution patterns. Sediment concentration values decrease more rapidly with distance offshore (increasing depth) than they do with distance along shore. Despite certain anomalies, the general distribution pattern tends to be fairly symmetrical both north and south of the outfall structure. Cluster analysis of metals data was used to define groups of stations with similar conditions. There was still so much variability within the groups that concentrations of metals in these sediments would need to change 20-30 percent before this change could be verified statistically. Because organics data was more variable than metals data, there would need to be an even larger change in organics level before the difference could be detected with a sample size of 5 to 15 stations.

Sedimentation rate is an important factor that influences how fast pollutants build up in the environment and also how fast concentrations decline when the pollutant source is removed. Four sediment cores were collected and used to determine sedimentation rate and historic trends in pollutant levels. Vertical profile plots of stable lead and copper show large subsurface peaks; this change in concentration appears to be linked to construction of the Denny Way Regulator in 1969. When this peak is used to age date the two sediment cores closest to the outfall, the calculated sedimentation rates are 1.4 cm/year and 0.7 cm/year. Natural sedimentation rate without the outfall may only be about 0.25 cm/year. At this rate of natural sedimentation, it would take 10 years to accumulate only 1 inch of new overlaying sediment and 60 years to accumulate one-half foot of sediment.

One method of speeding up that natural "capping" process is to artificially spread clean sediment over the area. Ideally it would be preferable to eliminate the pollutant source before capping, but in some cases it may still be practical to cap sediments before the source is eliminated. The two primary benefits of capping at the Denny Way CSO would be to:

1. Provide immediate environmental improvement in sediment concentrations that should continue to remain better than existing conditions for a long time even if pollutants begin to accumulate.

2. Eliminate confusing historic conditions, so it is easier to identify current pollutant inputs and thus help focus control efforts more effectively.

EXECUTIVE SUMMARY

Combined sewer overflows (CSOs) are sources of pollution to receiving waters and need to be controlled. A new Facilities Plan adopted by the Municipality of Metropolitan Seattle (Metro) includes many large construction projects that will provide secondary treatment and reduce discharge volumes for CSO sites. However, it may take years before a major project can be implemented to control the Denny Way CSO which discharges large volumes of untreated wastewater into Elliott Bay.

As an interim approach to improving environmental conditions at this site, a trial study was conducted to see if the level of toxic chemicals in the discharge could be reduced by locating and eliminating toxicant sources upstream in the sewer system.

The study focused on commercial businesses and involved a questionnaire survey and site visits to obtain information about the use and disposal practices for toxic chemicals. Separate sampling programs were conducted, both in the sewer system to identify chemicals and their sources, and in the offshore sediments to define existing conditions that can document future changes.

Nearly all the wastewater that overflows at Denny Way CSO originates from two drainage basins with a total area of 1,885 acres. The Denny Lake Union Basin is about seven times larger than the Denny Local Basin and has more commercial sources. A total of 530 businesses were identified as potential toxicant sources to these basins and included a large number of print shops and photo/design businesses. Response to questionnaires was especially good and showed that only a small portion of these businesses have any nonsanitary discharges and the combined volume of these discharges is only about 4 percent of the average base sanitary flow of 12.6 million gallons per day.

Site visits were conducted at 96 businesses and verified the discharge volumes. A need for better storage and housekeeping practices to prevent spills was identified at many sites and 40 businesses were sent letters with specific directions. Site visits also helped identify a couple of unknown sources that were indicated by the collection system samples. These sources have either been eliminated or required to obtain a Metro industrial waste permit.

Two industrial laundries, which are already regulated through permits, were the most identifiable sources of metals and volatile organics in the collection system samples. Installation of new pretreatment equipment has produced documented improvements in discharge concentrations, but the large discharge volumes from these sources allows their influence to be easily identified. A large accumulation of sediments in the Lake Union Tunnel was found to contain high concentrations of metals which appear to be linked to historic inputs from these laundries. These sediments also may be responsible for high metals levels in the offshore environment and may need to be removed. PCBs were found in one tunnel sediment sample, but in no other location. Street runoff appears to be the major source of combustion hydrocarbons (polyaromatic hydrocarbons) with very little coming from industrial laundries.

Besides controlling commercial sources, there may be a few changes in the collection system facilities that could reduce the toxicant loading discharged from the Denny Way CSO. Special catchment structures could possibly be used to increase inline sedimentation of the heavier contaminated particles at preferred locations where

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SECTION 1
INTRODUCTION

Combined sewer overflows (CSOs) are a source of pollution to receiving waters and need to be controlled. One of the major problems with CSOs is that they contain toxic chemicals that contaminate the environment. A new Facilities Plan adopted by the Municipality of Metropolitan Seattle (Metro) in July 1986 includes many large construction projects that will provide secondary treatment and reduce discharge volumes and frequencies for CSO sites. However, it may take years before a major project can be implemented to control the Denny Way CSO which discharges large volumes of untreated wastewater into Elliott Bay.

In May 1986, Metro began a trial program aimed at identifying and reducing toxicant inputs into the sewer system tributary to the Denny Way CSO. Denny Way was chosen because it is the largest CSO discharging to Elliott Bay and has been identified as the major source of substantially elevated levels of toxicants in bottom sediments near the overflow site.

Major activities conducted in this study include the following:

1. Identification of all commercial businesses that potentially use toxicants and are tributary to Denny Way CSO.

2. Mailed questionnaire survey designed to provide information about the type and volume of wastewater discharged from these commercial sources.

3. A sampling program to detect chemicals and identify sources in the sewer system.

4. Site inspections of representative businesses in the study area.

5. Offshore sediment sampling to document existing contamination levels for future comparison of change over time.

This report describes the results of Metro's trial program and identifies potential areas where toxicant loading can be reduced.

SECTION 2
DESCRIPTION OF STUDY AREA

SEATTLE METRO COMBINED SEWER SYSTEM

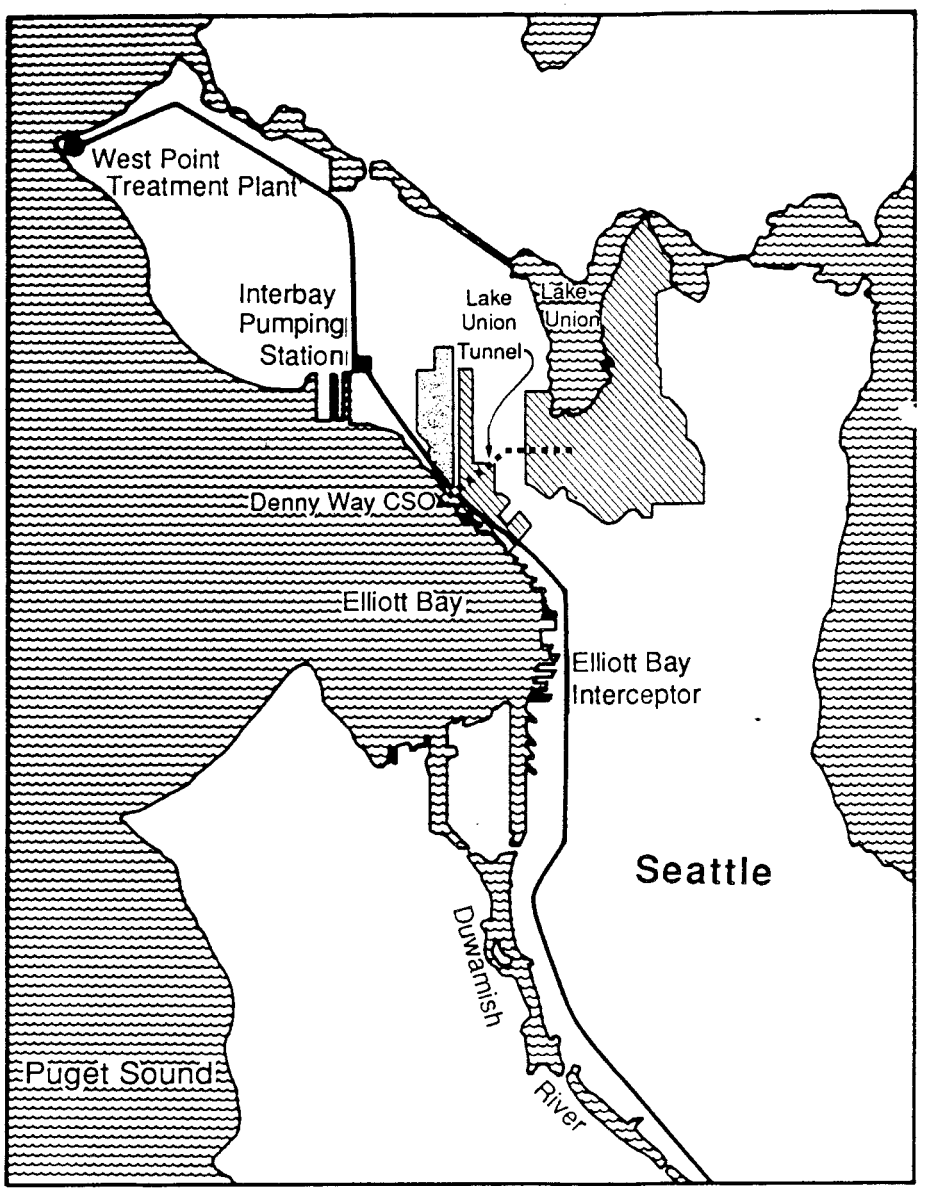
A combined sewer is one that receives both sanitary sewage plus stormwater runoff from streets and other impervious surfaces. Combined sewer systems were built in Seattle (and most other large cities) at a time when the primary objective in wastewater control was to simply collect and transport these flows to nearby water bodies without providing any treatment. However, when these receiving waters developed severe pollution problems, it became necessary to build facilities to intercept and transport wastewater flows to treatment plants. Due to the cost and various practical limitations, these facilities were designed to handle only the projected sanitary flow rather than peak combined flows. Since runoff from large storms could overload the system, a series of relief points, called combined sewer overflows, were included along the lines so excess volumes could be diverted directly to receiving waters without treatment.

During the 1960's, Metro built the present system of interceptors and treatment plants that collect, transport, and treat wastewater in the greater Seattle area. The West Point primary treatment plant receives wastewater flows from these large interceptors and discharges the treated effluent to Puget Sound (Figure 2-1). West Point is designed to handle a base flow of 124 million gallons per day (mgd) with a peak wet weather capacity of 325 mgd. There are approximately 100 relief points in the system, with 25 Metro CSO sites that overflow at least once per year. The average total overflow volume from these sites was originally estimated at about 1.8 billion gallons per year (bgy) (Cooley, 1984). and was more recently revised to 2.4 bgy (CWC/Ott, 1986). This volume is equivalent to about 5 percent of the total annual plant flow

During high flow conditions, a Computer Augmented Treatment and Disposal (CATAD) system maximizes inline storage and regulates where overflows occur. This system is programmed to minimize overflows to the more sensitive freshwater bodies and gives priority to discharging into marine waters. As a result, over 50 percent of the total overflow is discharged into Elliott Bay and 20 percent goes into the Duwamish River estuary, while another 20 percent is discharged to Lake Union and the Ship Canal, and less than 1 percent overflows into Lake Washington.

DENNY WAY CSO AND DRAINAGE BASIN

The largest and most frequent overflow site on Elliott Bay is the Denny Way CSO. During wet years (1981-1983) there can be 30 to 60 overflow events that produce a total average overflow volume of 500 million gallons per year. About 99 percent of this volume originates from two specific drainage basins called



Denny Lake Union Drainage Basin = 1653 acres
(11.0 million gallons/day base flow volume)

Denny Local Drainage Basin = 232 acres
(1.5 million gallons/day base flow volume)

In Seattle, a series of interceptor lines carry sewage flows to West Point Treatment Plant; but when storm runoff exceeds capacity of this system, untreated wastewater is diverted into Elliott Bay at the Denny Way Combined Sewer Overflow site. Heavy metals and organic chemicals contained in this discharge flow originate from two drainage basins which were studied in an attempt to locate any toxicant sources that can be controlled.

Figure 2-1. Location of Denny Way CSO and the Two Drainage Basins that Contribute Flows

TABLE 2-1. OVERFLOW FREQUENCY AND VOLUMES (1981-83)

	1981 DL / DLU*	1982 DL / DLU	1983 DL / DLU
number of overflow events	31 / 34	52 / 50	61 / 60
total volume discharged (million gallons)	58 / 370	66 / 551	39 / 395
average volume per event (million gallons)	1.8 / 10.9	1.3 / 11.0	0.6 / 6.6
max. single event (million gallons)	12.6 / 65.1	17.6 / 131.7	12.1 / 52.3

*DL=Denny Local area
*DLU=Denny Lake Union area

Denny Way Local and Denny Way Lake Union. The location of these basins is shown in Figure 2-1 and information on the frequency and volume of overflow that originates from each basin is presented in Table 2-1 and Appendix A. Prior to 1969, these two basins each had a separate discharge line that carried untreated wastewater directly into Elliott Bay. Construction of the Elliott Bay interceptor line in 1969 resulted in these two discharges being plumbed into the Denny Way Regulator. Here, flows from each area can be controlled separately and routed either into the interceptor or into Elliott Bay when the interceptor is full. CATAD control closes the regulator gates during certain storms to store as much volume as possible in the local lines before diverting this flow into Elliott Bay. Diversion here and at other regulators allows the interceptor to be maintained at a full level without backing up and overflowing. When levels in the interceptor begin to drop, CATAD adjusts regulator gates to start redirecting local flows back into the interceptor.

A general diagram of the pipes connected to the Denny Way Regulator is shown in Figure 2-2. Lake Union Tunnel is the conveyance line that defines the Lake Union Drainage Basin. Several smaller sub-areas are also tributary to the tunnel, but most of the flow in this basin originates from the large area at the upper end of the tunnel. Originally, flow from about one-third of this area traveled to the West Point Plant along a different route through the Dexter Tunnel, but later, a weir was installed to direct this flow into the Denny Way Lake Union Drainage Basin. Base sanitary flows from the Denny Way Lake Union area are about seven times larger than those from Denny Way Local (11.0 vs. 1.5 mgd) and the size of the drainage basins differs by a similar amount (1,650 vs. 232 acres). Both areas have similar land usage, consisting of residential and commercial. Three businesses in the Denny Lake Union Basin have Metro industrial waste permits, and there are none in the Denny Local Basin. Additional statistics regarding the two basins are included in Table 2-2.

CHANGE IN PRIORITIES

Assessment of environmental problems has played a key role in decisions about discharging untreated wastewater from Denny Way. Over 100 years ago, problems with sewage in Lake Union and sewage overflowing in streets during rainstorms prompted construction of the two diversion lines to Elliott Bay in 1895 (see Figure Al in Appendix A). Subsequent concern over high fecal bacteria levels in Elliott Bay and even greater bacteria and nutrient problems in Lake Washington led to major construction projects that eliminated all continuous untreated wastewater flows from Elliott Bay in 1969. This action greatly improved conditions, but in a few years a new concern developed over whether CSO discharges were causing toxic effects in the environment.

For several years, various studies were conducted around Denny Way CSO to look for effects on the environment. (Armstrong, et. al., 1978; Tomlinson, et al, 1980; Malins, et al, 1980; Chapman, et. al., 1982; Cominskey, et al, 1984; and Romberg, et

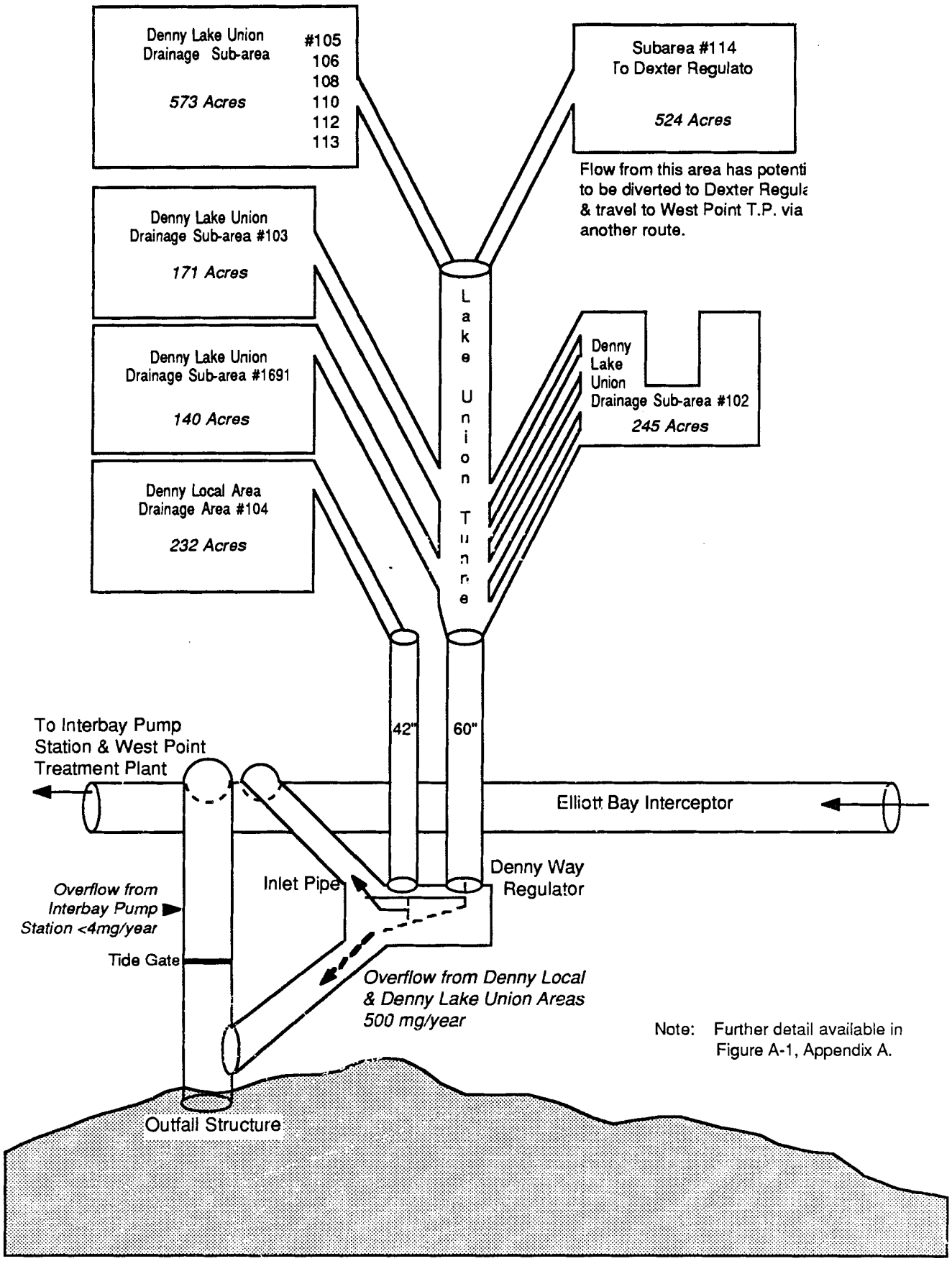


Figure 2-2. Pipes Connecting to the Denny Way Regulator

TABLE 2-2. DRAINAGE BASIN CHARACTERISTICS

PARAMETER	DL*	DLU*	TOTAL
total area (ac)**	232	1653	1885
combined area (ac)	232	1067	1299
separated area (ac)	0	0	0
partially sep. area (ac)	0	586	586
impervious surfaces (ac)	158	744	902
% impervious	68%	45%	48%
average base flow (MGD)***	1.5	11.0	12.5

*DL/DLU = Denny Local Area/Denny Lake Union Area
**(ac) = acres
***(MGD) = million gallons/day

al,1984). These studies showed that bottom sediments near the outfall contained substantially elevated levels of heavy metals and organic toxicants and that there were detectable biological effects in the form of altered benthic communities. While these studies were unable to establish a clear "cause/effect" relationship between elevated chemical and biological effects, the strong correlation was convincing enough to indicate a need for change.

In 1986, Metro adopted a new Facilities Plan with a total cost of around 1 billion dollars to provide secondary treatment and to substantially reduce CSO discharge volumes. Because construction of secondary treatment has both the highest priority and highest cost, implementation of CSO projects will be distributed over time. Control options for Denny Way CSO are very expensive and will be difficult to site, so it could take years before a major construction project can be implemented for this site. However, in the meantime Metro is exploring other ways of reducing toxicant loading from this CSO source.

SECTION 3
IDENTIFICATION OF TOXICANT SOURCES

DISCHARGE QUESTIONNAIRE

In October 1986, a questionnaire survey was sent by mail to those businesses that were considered potential toxicant sources to the Denny Way CSO. This survey was designed to accomplish the following items:

1. Provide an estimate of how much wastewater originates from commercial sources.

2. Identify what types of chemicals are currently being discharged or stored by these businesses.

3. Serve as a basis for selecting those businesses that should be investigated more closely through site visits and those that can be designated as having no significant discharge.

4. Increase public knowledge about the CSO discharge problem and the steps that must be taken to improve the situation.

The first step in conducting this survey was to develop an appropriate mailing list. Various business categories that were considered potential toxicant sources were selected based on Standard Industrial Classification (SIC) codes and included everything from services and light manufacturing to more industrial activities like electroplating and industrial laundries. A computer data base containing addresses of all Seattle area businesses with the selected SIC codes was purchased. This master data base was then sorted by address to yield a list of 530 target businesses tributary to the Denny Way CSO.

Due to the large number of printing and photographic operations found in the study area, target businesses were divided into three separate groups consisting of 138 printers, 94 photo and graphic shops, plus an assortment of 298 other general businesses. Specific questionnaires were developed for each of the three different groups and copies were sent with a cover letter explaining the CSO problem and the toxicant reduction project. Copies of the cover letter, the three different questionnaire forms, and the mailing list are included in Appendix B.

A summary of the questionnaire response statistics is presented in Table 3-1. Total response level reached 54 percent, which was exceptionally high since anything over 10 percent is generally viewed as a good return for a mail survey. Nearly all businesses that failed to respond were visited or contacted by phone and in all but a few cases, none of these had any discharge and had felt there was no need to respond.

TABLE 3-1. SUMMARY OF QUESTIONNAIRE RESULTS

	GENERAL BUSINESS	PRINTERS	PHOTO/ GRAPHICS	TOTAL
# sent	295 **	138	94	527 **
# responding	170	75	39	284
% response	58%	54%	41%	54%
# no response	118	58	54	230
balance*	7	5	1	13
discharge vol (gallons/day)	111,015 **	282	15,010	126,307 **

*Those which were returned undelivered
**Does not include the three businesses with a Metro industrial waste permit

Few printers or graphics shops have any discharge because their cleaning operations primarily involve the use of solvents on cloth rags that are then sent to the industrial laundries to be washed. Some printing and graphic shops that do silk screening, rinse rollers or screens after they have been wiped clean with solvent. Since most of the ink has been wiped off and the solvent evaporates, these washes are not likely to be highly contaminated. Both printers and graphic shops discharge small amounts of photo waste, such as developer, which contains no metals but some organics. Encouragement from Metro's Industrial Waste Section has nearly stopped the input of silver from these sources; now they either conduct silver reclamation on site or send their fixer solutions out for reclamation. About one-quarter of those businesses in the general category had any discharge, but most of these were small volumes of less than 50 gallons per day. By far, the largest discharges were from the two industrial laundries with average daily flows of about 100,000 gallons each. Both these businesses already have a Metro-issued industrial waste permit that sets discharge limits for metals, and oils and grease. There is one other business in the drainage basin that has a Metro industrial waste permit. This is an electroplating operation with a discharge volume of about 3,000 gallons per day.

These survey results indicate that only a portion of the many commercial businesses in the area have any discharge other than sanitary flow, and that the total nonsanitary flow from these businesses is about 4 percent of the combined average base flows for the two drainage basins (12,600,000 gallons per day). The two laundries and electroplating business have Metro industrial waste permits and have a combined discharge volume of about 203,000 gallons per day (gpd) which represents slightly less than 2 percent of the total base flow. Discharge volumes reported by the nonpermitted businesses responding to the questionnaire totaled 126,307 gallons per day (as listed in Table 3-1) which is equivalent to 1 percent of the total base flow. Even if this value is increased to 2 percent (because only half of the businesses responded), the combined nonsanitary flow from all the target businesses is only 3 to 4 percent of the entire average base flow.

SITE VISITS

Selected businesses were visited during December 1986 by a Metro industrial waste investigator. Limited staff and time constraints made it impossible to inspect each business in the study area, so inspections were carried out at a number of companies representing various business categories including dry cleaners, print shops, photo processors, medical laboratories, auto repair shops, and various manufacturing operations.

Results of the questionnaire survey were extremely useful in selecting the most appropriate businesses to visit.

Objectives of the inspections include the following:

- Obtain a better understanding of actual discharge volumes and types.
- Determine the presence of any processes or discharges that were not included in the questionnaire responses.
- Indicate the presence of any unreported hazardous chemicals on the site that could possibly enter the sewer system.
- Aid in the assessment of the feasibility and effectiveness of implementing source control strategies (such as retention of wastewater during overflow periods).

The site visits revealed several small-volume discharges that did not meet existing Metro regulations. For example, the discharge source that produced an elevated level of chromium and mercury during the sampling program was identified. Several businesses had inadequate storage of chemicals that would allow spills to reach the sewer system. Discharge volume figures reported on the questionnaire forms were not always clear and had to be adjusted after further inquiry. Visits to companies failing to respond to the survey indicated that most of these businesses contributed little or no wastewater to the system other than normal sanitary flows.

A total of 96 site visits were conducted; Table 3-2 summarizes results from these investigations and details are included in Appendix C. Seventy-one percent of the companies visited had discharges to the sanitary sewer. Letters requesting improvements (including three requesting permit applications) were sent to 42 percent of the companies. Storage problems were observed at 20 percent of the locations visited. Site visits were successful in locating the sources of chromium and mercury spikes and one low-level source of toluene. But site visits were inconclusive in defining the sources of phenol and dichlorobenzene.

Site visits confirmed that most discharge volumes were small, as was reported in the questionnaire survey. Table 3-2 lists the number of these 96 businesses that fall into four different ranges of flow volumes. A total of 70 businesses were in the lowest discharge category of less than 50 gpd while 19 were in the 50 to 100 gpd category and only 3 were in the more-than-500 gpd category.

Based on observations during the site visits and on the questionnaire results, it would be possible for the majority of the small dischargers to retain their wastewater flows during overflow events because the volumes discharged by these companies appear to be insignificant compared to the volumes from other sources.

TABLE 3-2. SITE INVESTIGATION SUMMARY AND VOLUME ESTIMATE

a) SITE INVESTIGATION SUMMARY

	#	%
TOTAL NUMBER OF INVESTIGATONS	96	100
COMPANIES WITH DISCHARGES	68	71
COMPANIES WITHOUT DISCHARGES	28	29
ACTIONS TAKEN (letters/permit)	40	42
STORAGE PROBLEMS	18	20

b) VOLUME ESTIMATE

NUMBER OF COMPANIES	VOLUME	TOTAL gpd
3	>500gpd	6,000*
4	100-500 gpd	2,000
19	50-100 gpd	1,900
70	<50 gpd	3,500
	Total	13,400

*Assume 2,000 gpd/company

COLLECTION SYSTEM SAMPLING

Wastewater and in-line sediment deposits were sampled during May and October of 1986 at those collection system sites identified in Figure 3-1. Wastewater samples were taken at nine locations (Sites 1, 2, 3, 4, 5, 6, 7, 11, and 12). Sediment samples were collected at six sites (Sites 2, 7, 8, 9, 10, and 11). Samples were analyzed for both metals and organic priority pollutants.

A combination of composite and grab sampling techniques was used to characterize wastewater and sediment quality in the Denny Way collection system. In Figure 3-1. Metals Concentrations in Collection System Samples comparing contamination levels, it is important to remember that the composite samples approximate the average conditions, while grab samples give an instantaneous or "snapshot" picture of the wastewater. Since sediments remain in the line for a considerable length of time, they indicate the nature of some of the historical dischargers.

Automatic samplers (ISCO brand) were used to collect composite samples at Sites 1, 2, and 7. Collection tubes for these samples were inserted into PVC pipes to prevent debris from collecting over the opening and filtering out the solids as wastewater samples were collected. All three composite samplers were set to draw one sample every hour during the 24-hour composite period.

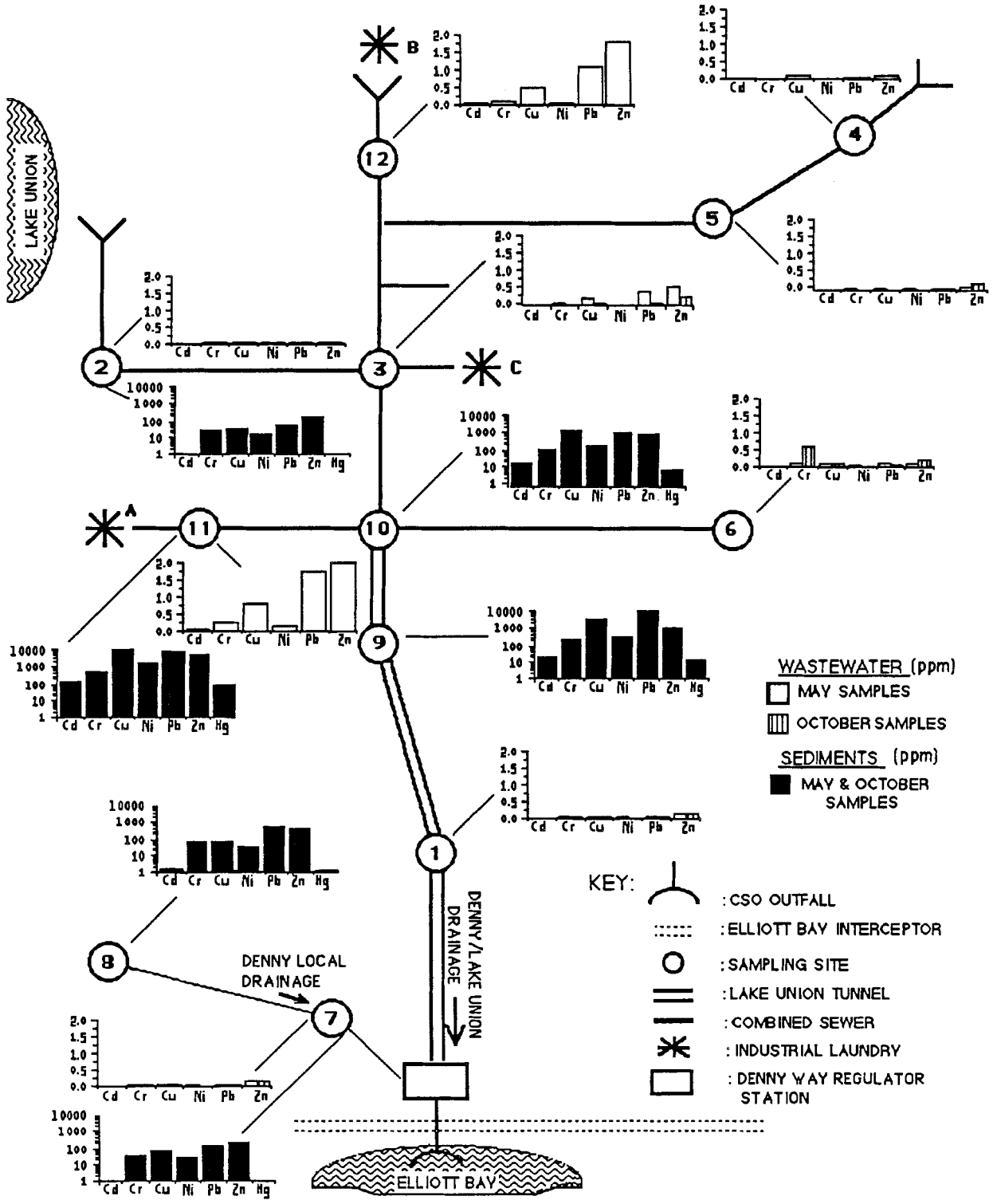
Wastewater samples were manually collected and composited from Sites 3, 6, Il, and 12 in October 1986. At these sites, grab samples were collected twice a day over a two-day period and mixed to form the composites that were analyzed. (Volatile samples were stored without air space prior to compositing.) In May 1986, single grab samples were collected at Sites 3, 4, 5, and 6 and analyzed.

Sediment samples at Sites 2, 7, 8, and 11 were collected by dragging a bucket connected to a telescoping pole, on the bottom of the sewer line. The bucket was retrieved and excess water was decanted until enough solids were collected to fill the sample containers. A new bucket was used at each sample site to prevent cross-contamination:

Sediment samples from the Lake Union Tunnel (Sites 9 and 10) were collected when manholes were entered by Metro Engineering Services personnel. Sediment was collected from several sites near the manhole entry point and mixed to form the sediment samples that were analyzed.

Heavy Metals Data

Metals data are presented in Table 3-3 and these results are summarized in Figure 3-1. Wastewater samples at the nine sampling locations had relatively low metal concentrations that were similar between sites and represented a fairly uniform baseline condition. Three sites (3, 11, and 12) had higher levels of most



1	Denny Lake Union	4	Melrose and Olive	7	Denny Local	10	Tunnel and Ninth
2	Valley and Boren	5	Minor and John	8	Elliott and Harrison	11	Westlake and Ninth
3	Republican and Boren	6	Westlake and Denny	9	Tunnel and Sixth	12	Republican and Pontius

Figure 3-1. Metals Concentrations in Collection System Samples

TABLE 3-3. DETAILED METALS DATA FROM COLLECTION SYSTEM SAMPLING

Site		Cd	Cr	Cu	Ni	Pb	Zn	Hg
(Wastewater)				ppm (mg/liter)				
1 Denny Lake Union	(May)	<0.004	<0.02	0.07	<0.02	0.06	0.145	-
	(Oct)	0.005	0.027	0.073	<0.01	0.06	0.163	0.0003
2 Valley & Boren	(May)	<0.004	<0.02	0.05	<0.02	0.04	0.077	-
3 Republican & Boren	(May)	0.018	0.08	0.20	0.03	0.42	0.574	-
	(Oct)	0.010	<0.005	0.079	<0.01	0.07	0.259	0.0004
4 Melrose & Olive	(May)	<0.004	<0.02	0.11	<0.02	0.06	0.119	-
5 Minor & John	(May)	<0.004	<0.02	0.04	<0.02	0.05	0.105	-
	(Oct)	<0.002	0.009	<0.007	<0.01	<0.03	0.159	0.0005
6 Westlake & Denny	(May)	<0.004	0.07	0.06	<0.02	0.11	0.122	-
	(Oct)	<0.003	0.592	0.065	<0.01	0.05	0.184	0.0056
7 Denny Local	(May)	<0.004	<0.02	0.04	<0.02	0.07	0.101	-
	(Oct)	0.002	<0.005	0.018	<0.01	<0.03	0.077	0.0002
11 Westlake & 9th	(May)	0.042	0.261	0.779	0.15	1.74	1.950	0.0019
12 Republican & Pontius	(May)	0.067	0.106	0.524	0.06	1.12	1.830	0.0024
(Sediments)				ppm (wet weight)				
2 Valley & Boren	(May)	0.7	27.0	35.0	17.0	57.0	162.0	0.16
7 Denny Local	(May)	0.6	32.0	67.0	23.0	111.0	164.0	0.24
8 Elliott & Harrison	(Oct)	1.41	45.8	48.5	26.6	400.0	281.0	0.14
9 Tunnel & 6th	(Oct)	23.0	195.0	3790.0	353.0	9480.0	1120.0	13.2
10 Tunnel & 9th	(Oct)	25.8	187.0	1910.0	292.0	1820.0	1390.0	11.5
11 Westlake & 9th	(Oct)	151.0	524.0	16900.0	1570.0	8520.0	5360.0	94.0

metals that appear to be due to inputs from upstream industrial laundry sources, labeled A and B in Figure 3-1 Two metals (chromium an mercury) were found to be high at Site 6. A second sampling event showed an even higher chromium level. Site investigations traced the chromium source to a movie film developing operation. This source has been directed to use proper disposal practices and the input should be eliminated or greatly reduced. Sites 1 and 7, located Just upstream from the the Denny Way Regulator, showed overall low concentrations that were similar during the two sampling events.

Inline sediment samples contained much higher metals values than wastewater samples. This is expected since sediments represent a concentrated sample of the particulates that are present in the wastewater sample. Highest metals values in sediments were found at Site 11, which is a short distance downstream from an industrial laundry discharge. Other high metals concentrations were found at Sites 9 and 10, which are located farther downstream from the laundries at the upper end of a 6 foot-diameter conveyance tunnel called the Denny Lake Union Tunnel. Sediments in the upper portion of this tunnel are a couple of feet deep and taper down to less than a foot deep in the first 700 feet of the tunnel. Concentrations at both tunnel sites were fairly similar, except for lead and copper which were higher at the downstream site. Although these concentrations in the tunnel were relatively high, they were substantially lower than those values, found near the laundry at Site 11. zinc, lead, nickel, copper, and cadmium were all four to six times higher at site 11, and chromium was twice as high.

Sediment concentrations at Sites 2, 7, and 8, were much lower than those found in the tunnel (Sites 9 and 10) and appear to represent a baseline condition for sediments. The sample at Site 8 was taken from a catchbasin and had slightly higher concentrations than inline sediments collected at Sites 2 and 7. In general, inline sediments taken from sites isolated from the laundries had concentrations many times lower than those found in the tunnel (7 times lower for zinc and chromium; 35 to 90 times lower for cadmium, copper, and lead).

These results strongly indicate that particulates from the laundries (which are reflected in the tunnel values) have a much greater influence on offshore sediments than do particulates from the Denny Local system. This conclusion is further supported by the fact that concentrations of lead and mercury in the Denny Local sediments (Sites 7 and 8) are lower than values found in offshore sediments. While industrial laundries appear to be the major source of metal-laden sediments that have accumulated in the past, institution of new pretreatment equipment was implemented in 1986 which should reduce these inputs in the future. Only a preliminary estimate of these reductions is possible since the new pretreated discharges have only been sampled once. Based on this data, estimated average daily loadings for lead, copper, and zinc were calculated for the two laundries presently in operation and compared with their average loadings for 1980 through 1985 before pretreatment. This comparison is presented in Table 3-4. Lead showed an exceptionally large reduction of 77

TABLE 3-4. DISCHARGE OF METALS FROM THE INDUSTRIAL LAUNDRIES

DISCHARGE OF METALS FROM THE INDUSTRIAL LAUNDRIES
(1980-85 data vs. 1986 data to show influence of pretreatment)
(loading values are in pounds per day)

Laundry	Copper 80-85 / 86	Lead 80-85 / 86	Zinc 80-85 / 86
A	0.6 / 0.2	2.5 / 0.3	1.1 / 0.9
B	1.4 / 0.8	4.2 / 1.2	3.4 / 2.5
Total	2.0 / 1.0	6.7 / 1.5	4.5 / 3.4
Reduction	50%	77%	24%
C*	0.3 / ---	1.1 / ---	0.8 / ---
Total (including C)	2.3 / 1.0	7.8 / 1.5	5.3 / 3.4
Reduction (including C)	56%	81%	36%

*Laundry C went out of business in mid-1985

percent, while copper and zinc also show substantial reductions of 50 percent and 24 percent respectively. These figures do not include the loading attributable to Laundry C, which ceased operation in mid-1985. When Laundry C's pre-1985 load is included in the calculation, load reductions for laundry sources are even greater--81 percent for lead, 56 percent for copper, and 36 percent for zinc.

Organic Volatiles Data

A summary of organic volatiles data is given in Figure 3-2, and the detailed data is included in Appendix D. The industrial laundries appear to cause the Denny Lake union wastewater to have higher concentrations of toluene and ethyl benzene than those found in the Denny Local drainage area. Pretreatment systems installed at the industrial laundries appears to be reducing this input. In addition, lesser amounts of toluene and ethyl benzene are contributed from the area upstream of Site 6. Paint booths observed during the site visits are one potential source of the input to this site.

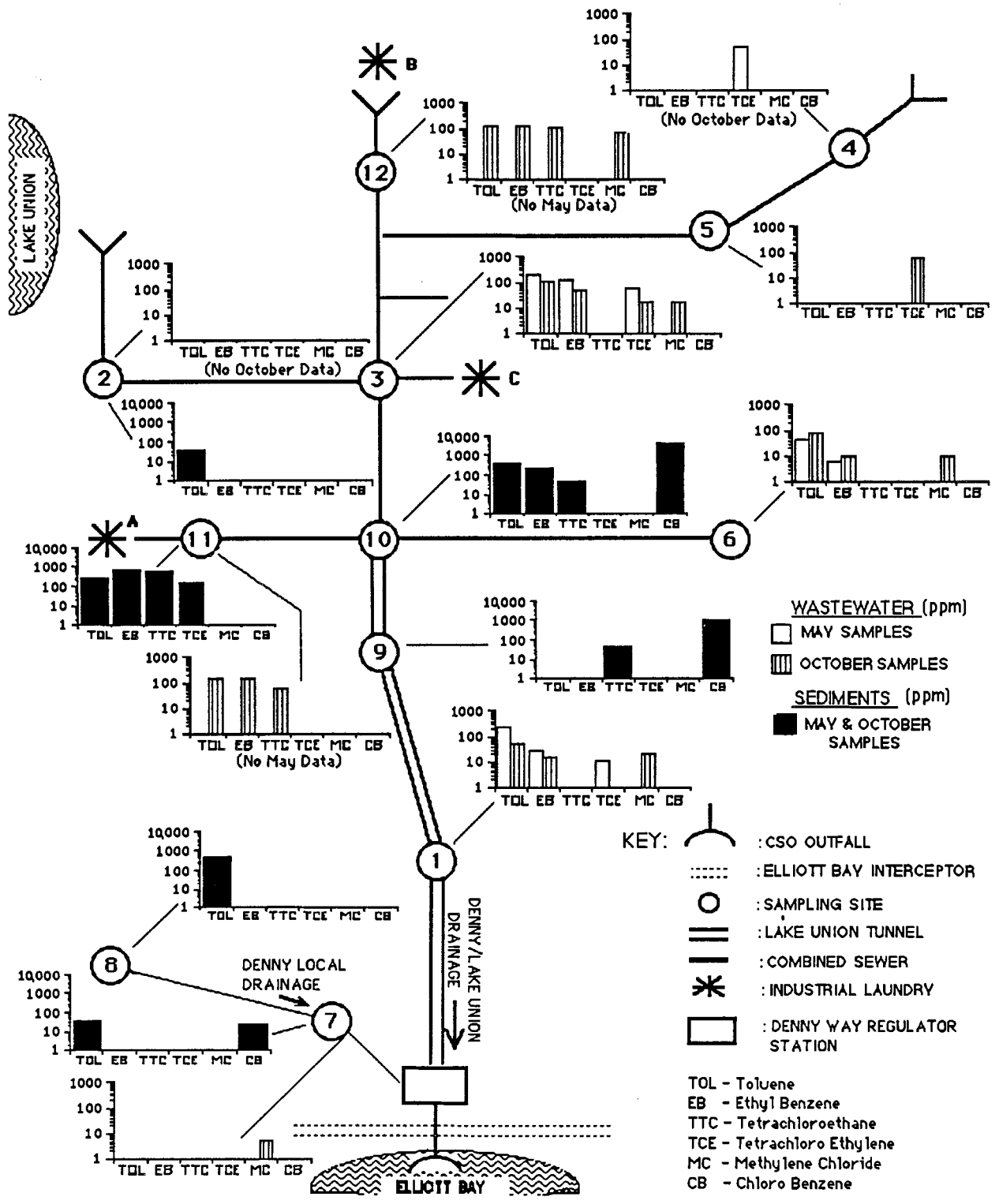
Although tetrachloroethylene had a high concentration of 140 parts per billion in the laundry discharge, it only appeared at two of four sites downstream of the laundries. It was not detected at the two sites closest to the laundries. Concentrations at sites not influenced by laundry discharges were similar to those levels at sites located in the Lake Union Tunnel. Tetrachloroethylene is a common dry cleaning solvent and there appears to be significant inputs in addition to the industrial laundries. Data from laundry effluents indicate that the installation of pretreatment systems at the laundries has reduced the discharge concentrations from these sources.

Both methylene chloride and 1, 1, 2, 2-tetrachloroethane appear in laundry effluents, but only appeared downstream of the laundries. Methylene chloride is commonly used as a paint solvent and in printing operations. The questionnaire survey showed that the majority of print shops send their cleaning rags to the industrial laundries, which may account for a sizeable portion of the input of methylene chloride to the system.

Sediment samples from Site 11 showed high levels of ethyl benzene and tetrachloroethane. Toluene showed up in every sediment sample except at Site 9. Site 10 contained a very high concentration of chlorobenzene.

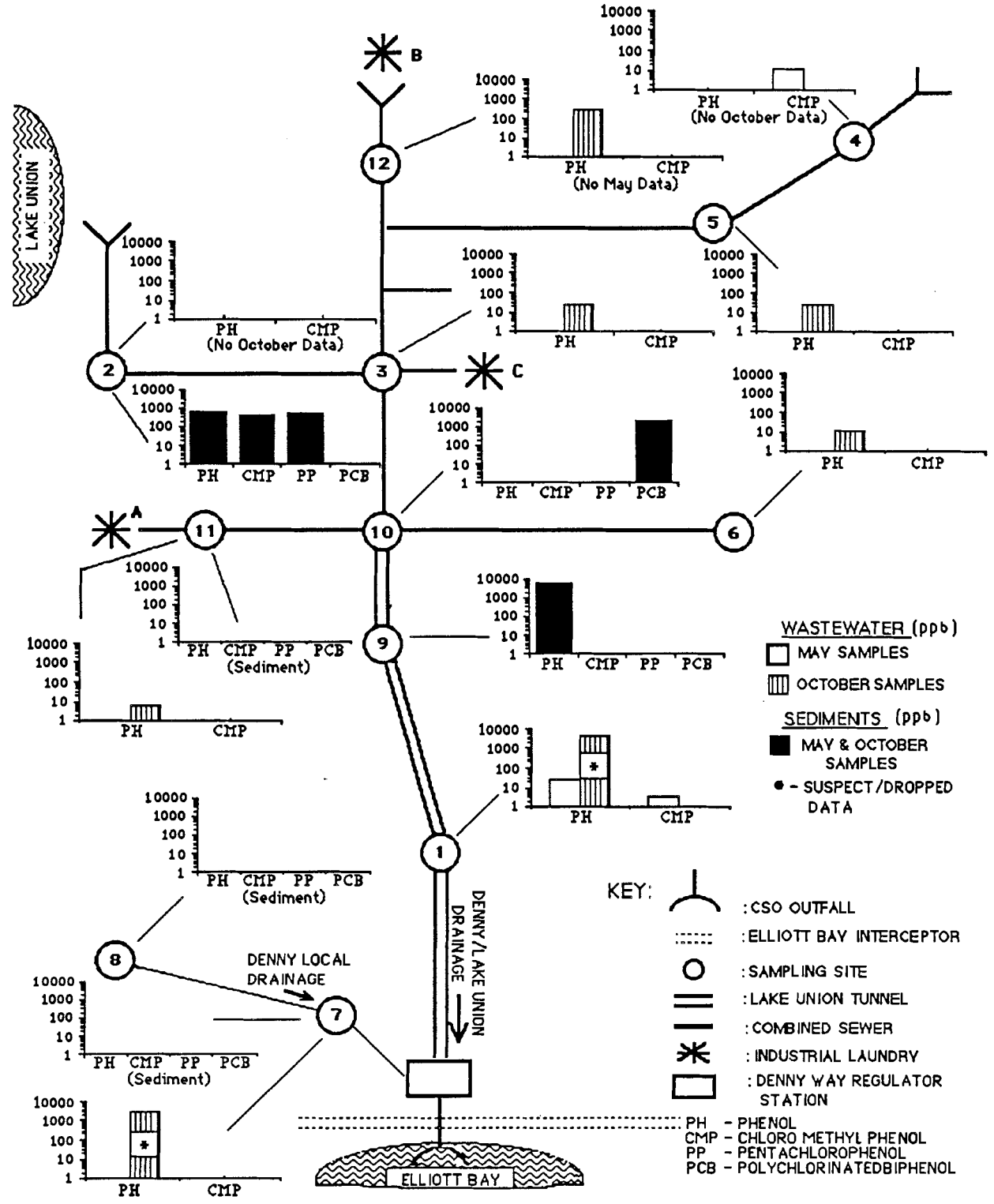
Organics Acid Extractables and PCBs Data

Wastewater samples were found to contain only two acid extractable compounds (phenol and 4-chloro, 3-methyl phenol) and no pesticides or PCBs. One sediment sample contained a maximum of six acid extractable compounds (Site 11) and one sample contained PCBs (Site 10). A summary of acid extractable and PCB data is given in Figure 3-3, with detailed data included in Appendix D.



1	Denny Lake Union	4	Melrose and Olive	7	Denny Local	10	Tunnel and Ninth
2	Valley and Boren	5	Minor and John	8	Elliott and Harrison	11	Westlake and Ninth
3	Republican and Boren	6	Westlake and Denny	9	Tunnel and Sixth	12	Republican and Pontius

Figure 3-2. Organic Volatile Compounds in Collection System Samples



1	Denny Lake Union	4	Melrose and Olive	7	Denny Local	10	Tunnel and Ninth
2	Valley and Boren	5	Minor and John	8	Elliott and Harrison	11	Westlake and Ninth
3	Republican and Boren	6	Westlake and Denny	9	Tunnel and Sixth	12	Republican and Pontius

Figure 3-3. Organic Extractable Acid and Pesticide Compounds in Collection System Samples

In May, phenol was found in only one wastewater sample, but in October it was present in all wastewater samples. Concentrations of phenol were typically low in wastewater, except for a higher value directly downstream from one laundry (Site 12) and two unusually high values at Sites 1 and 7, located at the bottom of each drainage basin. These two very high values are suspect and are believed to be a sampler contamination problem because they occur at sites where samples were obtained with a composite sampler instead of grab sampling. A composite sampler could catch a slug discharge of phenol, but it is questionable that this would occur in both drainage basins at similar levels without any indication in grab samples from upstream.

Phenol was found in two sediment samples (Sites 2 and 9), but there was no correlation with sites where it was found in wastewater. Pentachlorophenol and 4-chloro, 3-methyl phenol were found in only one sediment sample (Site 2) and PCBs were found in one sediment sample from the tunnel (Site 10). None of the acid compounds or PCBs occurred in both the sediment and wastewater samples from the same site.

Organic Base and Neutral Extractables and PCB Data

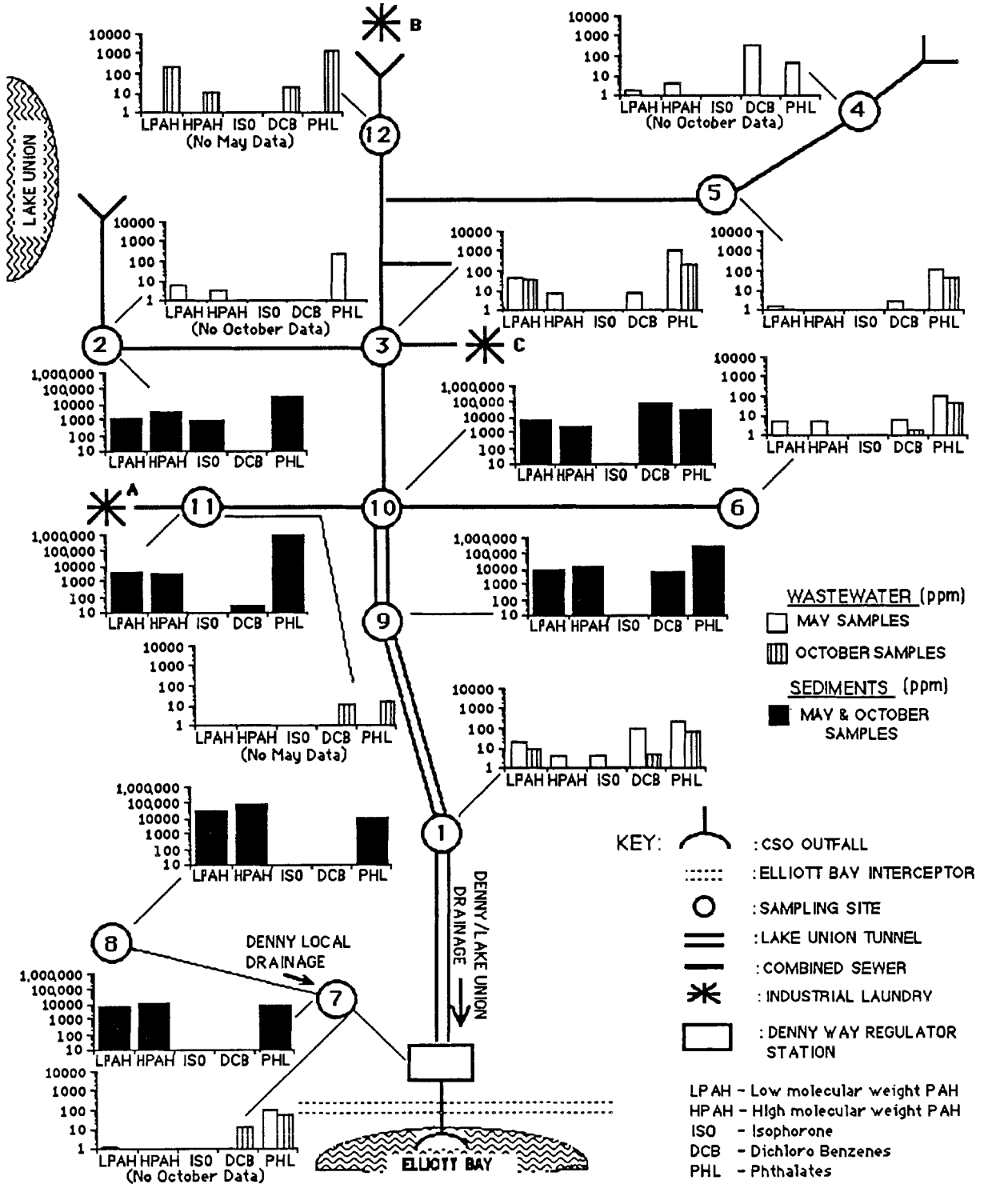
Concentrations of most base-neutral organics were relatively low in wastewater samples and much higher in sediment samples. Wastewater samples from most sites contained more LPAH compounds than they did HPAH compounds, but the reverse was true for most sediment samples. Phthalates were found in all wastewater and sediment samples. A summary of base and neutral extractable data is given in Figure 3-4, with detailed data included in Appendix D.

Except for napthalene and dichlorobenzene, the water samples showed very low levels of base-neutral extractable compounds. Napthalene only appeared at sites influenced by the laundries, most notably Sites 12 and 3. The level at Site 3 was lower in October after the installation of pretreatment systems. The sediments downstream from the laundries also showed enriched napthalene concentrations.

Dichlorobenzene showed very high concentrations in the May sampling at Site 4. This high level did not appear at Site 5, but it seems to have raised the level in the composite sample at Site 1.

Sediment collected in the tunnel also showed high levels of dichlorobenzene. The dichlorobenzene spike did not reappear in October, and the levels in the composite samples taken at Sites 1 and 7 were similar. The sediment collected at Site 2 had the lowest levels of base-neutral extractables, even lower than Site 7 (which is also not influenced by the laundry inputs).

The amount of stormwater entering the drainage system tributary to Site 7 is much larger than that entering the system tributary to Site 2. Much of the stormwater tributary to Site 2 drains to Lake Union instead of to the combined



1	Denny Lake Union	4	Melrose and Olive	7	Denny Local	10	Tunnel and Ninth
2	Valley and Boren	5	Minor and John	8	Elliott and Harrison	11	Westlake and Ninth
3	Republican and Boren	6	Westlake and Denny	9	Tunnel and Sixth	12	Republican and Pontius

Figure 3-4. Organic Extractable Base and Neutral Compounds in Collection System Samples

sewer system. It is interesting to note that the ratio of low-to high-weight PAHs at both sites is the same. This seems to support the idea that stormwater contributes PAHs at both sites, but more stormwater reaches the Denny Local system.

The sample collected at Site 8 consisted of sediment taken from three stormwater catch basins near the intersection of Elliott Avenue and Harrison Street. This sample showed significantly higher concentrations of all base-neutral extractables except napthalene and chlorobenzene. Concentrations at Site 8 were up to 10 times as high as those found in sediments from the Denny Lake Union system. This sample indicates that sediments that have accumulated in catch basins should be removed periodically to reduce the release of contaminated sediments into the sewers during wet weather.

TOXICANT LOADING ASSESSMENT

It is beyond the scope of this study to perform any detailed assessment of the total annual toxicant loading that is discharged at the Denny Way CSO or to determine source contributions. Due to the variable nature of CSO wastewater, such an assessment would require chemistry data from a sufficiently large number of actual CSO events to calculate representative average concentration values for each pollutant. Wastewater samples analyzed during this study were not taken during CSO events and in most cases were taken at locations upstream in the collection system for the purpose of identifying sources. Despite this lack of chemistry data during CSO events, there is good evidence that toxicant loading from the collection system has been decreasing in recent years.

The Metro Toxicant Pretreatment Planning Study, conducted in the early 1980's, provided estimates of toxicant loading at Denny Way and also predicted future decreases in toxicant loading at the West Point Treatment Plant as a result of industrial pretreatment activities and corrosion control of the Seattle water supply. Heavy metals are monitored daily in the West Point effluent and a plot of the monthly averages over an 8-year period shown in Figure 3-5, reveal a steady decline in concentrations of zinc, copper, chrome, and lead. Although this reduction in metals loading applies to the total West Point Collection System, there have obviously been reductions in the Denny Way Drainage Basins as a result of specific industrial pretreatment activities previously discussed.

To assess the relative importance of different sources and predict the maximum toxicant reduction, it is necessary to know how much of the actual overflow volume is stormwater and how much is municipal wastewater from different land use types. The computer model of CSO volume, developed as part of the Metro Facility Plan for secondary and CSO control, incorporates runoff and wastewater input from residential, commercial, and industrial areas. This model was subsequently expanded to project pollutant loadings for comparison purposes between basins. However, since these pollutant projections are generic in nature,

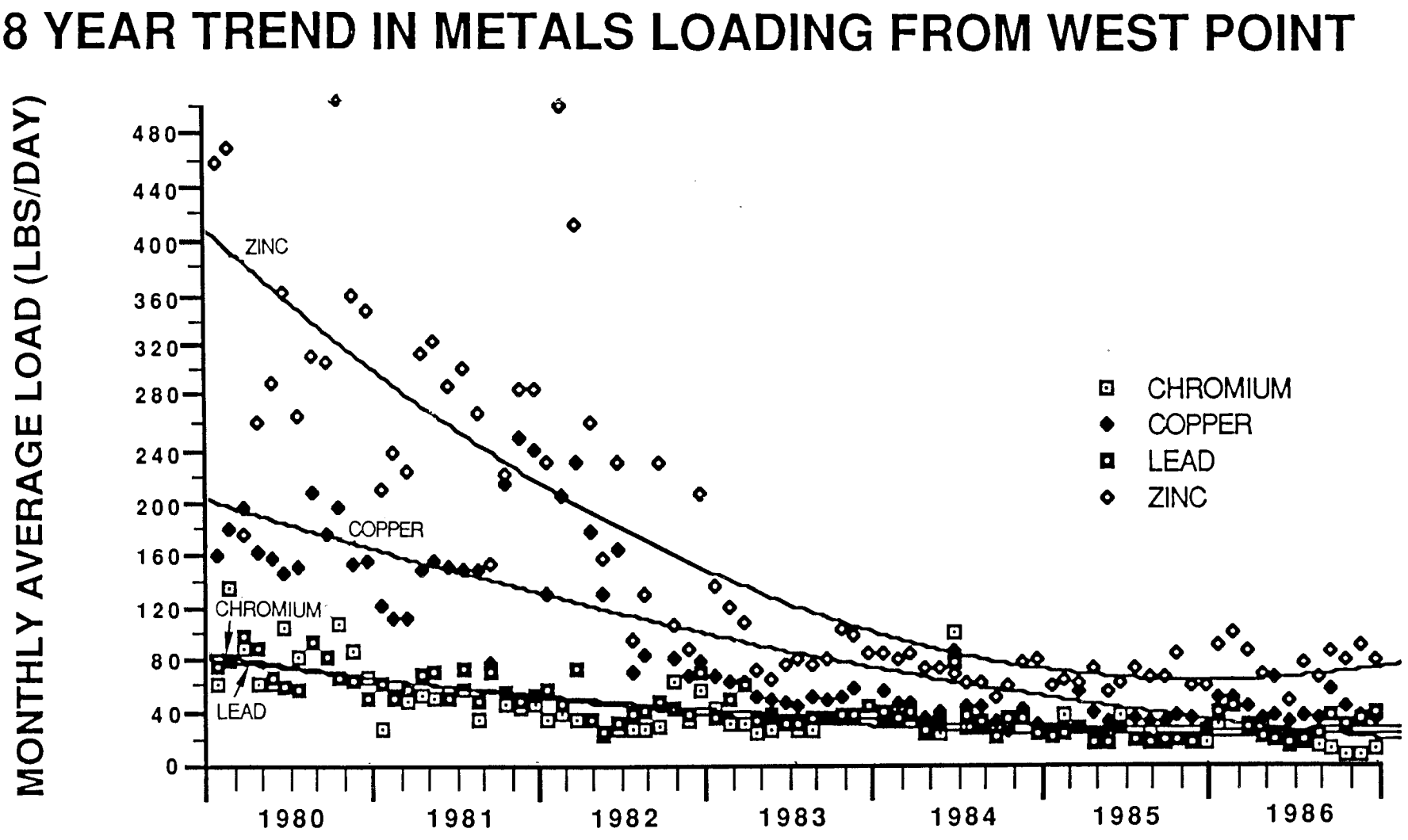


Figure 3-5. Eight-Year Trend in Metals Loading from West Point Treatment Plant

they are not intended to accurately reflect the true toxicant loadings at Denny Way nor can they be used to accurately extrapolate the stormwater input. It is necessary to use the original flow data to obtain a true assessment.

SECTION 4
ENVIRONMENTAL SEDIMENT QUALITY

OFFSHORE SEDIMENT SAMPLING

Since the late 1970's, numerous investigators have collected offshore bottom sediments from near the CSO and analyzed them for chemical content or biological effects (Malins, et al, 1980; Tomlinson, et al, 1980; Comiskey, et al, 1984; and Romberg, et al, 1984). While past studies indicate that toxicants from the Denny Way CSO are accumulating in the environment and causing biological effects, these data bases are too sparse to answer the following important questions:

1. How big an area is affected by the high concentrations previously reported and what is the spatial variability and distribution pattern.

2. What is the minimum amount of change that one can reasonably expect to measure statistically given the environmental variability?

3. Have sediment conditions offshore from the Denny Way CSO historically been getting better, getting worse, or staying the same over time?

4. How soon would natural sedimentation reduce pollutant concentrations in surface sediments if inputs from the CSO were stopped?

5. How do most offshore sediment concentrations compare with local sediment quality levels for biological effects?

Two types of offshore sediment samples were collected in this study in an effort to answer the above questions. Sediment cores were collected at four locations to provide information on sedimentation rate and historic changes in pollutant concentrations. Surface grab samples were- collected from a grid of 29 stations to establish spatial variability in the area and the amount of change that can be detected. Sampling locations are shown in Figure 4-1 along with a key indicating the type of chemical analyses performed for each site. Detailed chemistry data for these samples are presented in Appendix E.

Only the top 2 centimeters of surface grab samples were used for analysis since this was assumed to represent the most recently deposited sediments. At most stations, three separate grabs were collected and a composite sample prepared. Each of these samples was analyzed for five selected metals (cadmium, copper, mercury, lead, and zinc).

Key for Sample Type and Analysis

- 19 -Location and station number for the 29 sites where surface grab samples were taken.
  - -Typically a composite of 3 grabs were used for analysis.
  - -Five metals (Cd, Cu, Hg, Pb, Zn) measured at all 29 stations.
  - -An additional field replicate was also collected at Station 19.
- 19 -Those 20 stations where surface grabs were analyzed for extractable organics (acids, base, nuetral, pesticides, and PCBs).
- 19 -Those 4 stations where seperate boxcores were collected.
  - -Pb and Cu measured in 20 sections of each core. Radioactive Lead-210 dating attempted at Station 14A.

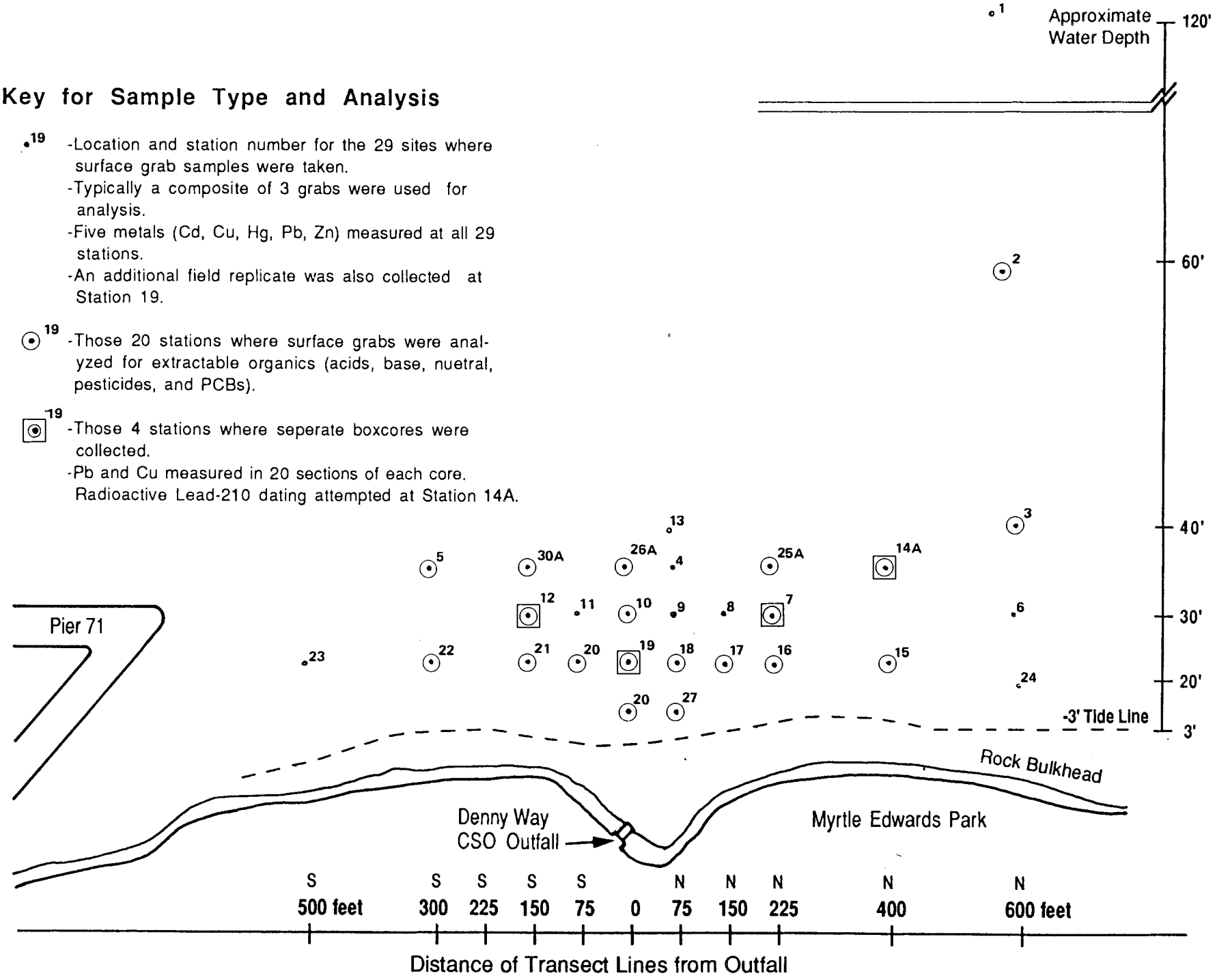


Figure 4-1. Location of 29 Stations Sampled for Offshore Sediments

A review of past sediment chemistry data from the area (included in Appendix E) indicated that concentrations of these five metals were sufficiently elevated and that they would be the ones most capable of showing a change over time. Extractable organic priority pollutants (acids, bases, neutrals, pesticides, and PCBs) were measured at 20 of the 29 sites.

SPATIAL VARIABILITY IN SURFACE SEDIMENTS

Nineteen of the 29 stations sampled for surface sediments were located in a tight grid pattern (75-foot spacing, as described in Appendix E) to better define the areas of higher concentration and to obtain enough data points for statistical analysis. Another 10 stations were spread out offshore and in directions up and down the shoreline. Chemical concentrations in surface sediments (Tables 4-1 and 4-2) were plotted on station maps to show spatial distributions. Examples of these plots are shown in Figures 4-2 through 4-5 for two metals (lead and copper) and two organic compounds (HPAH and PCBs). A distribution plot of total solids values is presented in Figure 4-6 because this parameter provides an indication of sediment textures. Other distribution plots are included in Appendix E for reference.

As expected, the two stations closest to the outfall (Stations 27 and 28) have the highest concentrations for nearly all metals and organics. These stations are located in a shallow depression that extends offshore to the west of the outfall structure. All inshore stations near the outfall were positioned as close to shore as possible without getting into the coarser sand and gravel substrate that extends below the intertidal areas. Finer grained sediments extend further inshore right in front of the outfall because of this depression, but on either side of this depression the finer grained sediments were located further to the west and just outside a band of bullwhip kelp that runs parallel to shore. Total solids values for most stations fell within the range of 39 to 59 percent. The closest inshore station just north of the outfall (Station 22) had a much higher solids value at 71 percent, which indicates it contained much coarser sediment.

Metals values have a smaller range in concentrations than do the organics, and metals also show a much more uniform decrease in concentration with distance from the outfall. The station closest to the outfall (Station 29) had the highest concentrations for all metals while the station furthest offshore (Station 1 typically had the lowest concentrations. Because the lowest observed metals values approximated background conditions, a simple concentration factor could be calculated by dividing the lowest concentration value into each of the other metals values. Maximum concentration factors occur at the stations closest to the outfall and range from a high of 30 for cadmium, to 10 for lead and mercury, 9 for copper, and 4 for zinc.

Distribution plots for metals show that only a very small area is affected by these maximum values and that for most stations near the outfall, the concentration

TABLE 4-1. METALS DATA FOR OFFSHORE SEDIMENT SAMPLES

Station Number	Lab Code	Cd	Cu	Pb	Zn	Hg	TS	TVS
			mg/kg, O.D. Basis			--->	%	%
1	87701	0.2	35	48	150	0.49	56.17	3.99
2	87702	0.6	60	78	232	0.59	51.95	5.23
3	87703	1.0	68	111	205	0.66	52.35	5.72
4	87704	1.1	73	147	179	0.69	55.42	5.53
5	87705	2.4	72	176	376	0.76	49.43	6.60
6	-87706	1.1	72	136	234	0.88	48.33	7.78
7	87707	2.4	102	256	271	0.97	48.88	8.33
8	87708	2.0	109	246	271	1.2	56.04	5.18
9	87709	1.7	101	199	260	1.2	49.14	7.22
10	87710	2.3	92	196	294	1.0	50.40	6.83
11	87711	1.6	70	124	319	0.58	57.94	5.47
12	87712	1.9	86	193	224	1.2	49.88	6.08
13	87713	0.5	58	84	187	0.42	27.81	13.1
14A	87714	0.6	55	97	143	0.47	40.15	8.27
15	87715	0.5	42	95	165	0.23	62.77	5.13
16	87716	1.7	116	241	241	0.57	57.52	7.52
17	87717	2.6	132	398	273	1.8	59.27	9.63
18	87718	3.2	140	398	374	0.99	54.83	8.81
19	87719	2.8	212	340	248	2.2	50.83	9.48
20	87720	2.7	162	267	257	1.1	51.02	7.41
21	87721	2.3	112	304	268	1.7	48.91	9.35
22	87722	2.4	106	148	262	1.1	54.53	7.38
23	87723	2.3	94	260	258	0.98	49.95	7.13
24	87724	1.9	70	149	188	0.74	54.86	5.90
25	87725	1.6	90	178	295	0.72	43.39	7.91
26A	87726	0.8	60	109	170	0.44	59.57	4.57
27.	87727	3.2	264	350	445	0.70	70.86	3.84
28	87728	6.1	302	478	472	2.2	41.02	14.5
19*	87729	3.4	147	407	307	1.1	48.36	11.2
30A	87730	1.8	87	186	272	1.0	38.61	8.63

NOTE: O.D. = Dry Weight Basis
TS = Total Solids
TVS = Total Volatile Solids
* = Replicate Sample

TABLE 4-2. EXTRACTABLE ORGANIC BASE NEUTRAL DATA FOR OFFSHORE SEDIMENT (UNITS = ug/gm dry wt = ppm)

LPAH/Concentrations

Station Number	Fluorene	Naphthalene	Acenapthene	Acenaphthylene	Anthracene	Phenanthrene	Total LPAH
2	ND	ND	ND	ND	ND	ND	ND
3	ND	0.12	ND	ND	0.21	0.58	0.91
5	0.13	0.14	ND	ND	0.36	1.05	1.68
7	0.18	0.50	0.12	ND	0.58	1.90	3.28
10	0.13	0.17	0.14	ND	0.40	1.20	2.04
12	ND	0.11	ND	ND	0.25	0.55	0.91
14	ND	0.11	ND	ND	ND	0.40	0.51
15	ND	ND	ND	ND	0.24	0.45	0.69
16	1.50	0.13	0.12	ND	0.24	1.22	3.21
17	ND	0.17	0.20	ND	1.17	4.40	5.94
18	0.30	0.14	ND	ND	1.17	2.28	3.89
19	0.64	0.25	0.17	ND	0.26	3.70	5.02
20	0.15	0.15	0.13	ND	0.25	1.47	2.15
21	0.16	ND	ND	ND	0.21	0.80	1.21
22	0.26	0.12	0.12	ND	2.26	1.81	4.57
25	ND	ND	0.14	ND	ND	0.35	0.49
26	ND	ND	ND	ND	ND	0.24	0.24
27	31.50	1.34	12.80	ND	40.70	98.60	184.94
28	0.90	0.35	0.41	ND	3.51	6.40	11.57
30	ND	ND	ND	ND	0.20	0.55	0.75
ND Limit	0.1	0.08	0.1	0.18	0.1	0.27	

HPAH/Concentrations

Station Number	Fluoranthene	Pyrene	Chrysene	Benzo(a)-anthracene	Benzo(a) pyrene	Benzo(b & k) flouranthene	Indeno(1,2,3-cd) pyrene	Dibenzo(ah) anthracene	Benzo(ghi) perylene	Total HPAH
2	0.25	2.62	0.36	0.19	0.36	0.48	ND	ND	ND	4.26
3	0.90	1.00	1.13	0.61	0.85	1.20	0.56	ND	0.72	6.97
5	1.59	1.60	ND	1.07	ND	2.40	0.61	ND	0.71	7.80
7	2.17	2.02	2.40	1.73	1.70	2.40	ND	ND	0.74	13.16
10	1.46	1.83	1.4	1.06	1.06	1.68	0.56	ND	ND	9.05
12	0.88	0.89	1.20	1.10	0.85	1.50	0.61	ND	0.68	7.71
14	0.30	0.26	0.51	0.25	0.34	0.52	ND	ND	ND	2.18
15	0.43	0.37	0.59	0.37	0.78	0.95	ND	ND	ND	3.49
16	1.73	1.45	1.19	1.06	0.95	1.53	0.79	ND	0.62	8.80
17	6.80	5.20	5.00	4.00	2.40	4.50	1.30	ND	1.40	30.60
18	3.23	2.75	2.86	2.18	1.76	2.70	0.80	ND	0.80	17.08
19	4.80	4.00	4.00	3.20	1.74	3.50	0.70	ND	ND	21.94
20	1.90	2.00	1.53	1.20	0.82	1.98	ND	ND	ND	9.43
21	0.69	0.64	0.47	0.83	0.56	1.12	ND	ND	0.70	14.94
22	2.50	1.84	3.14	2.72	0.87	2.37	0.80	ND	ND	2.49
25	0.46	0.44	0.48	0.29	0.28	0.54	ND	ND	ND	1.43
26	0.24	0.24	0.28	0.15	0.17	0.35	ND	ND	ND	158.80
27	61.50	36.20	26.50	10.70	7.50	16.40	ND	ND	ND	24.07
28	6.73	5.00	4.00	3.14	1.90	3.30	ND	ND	ND	3.78
30	0.66	0.63	0.68	0.39	0.49	0.93	ND	ND		
ND Limit	0.11	0.1	0.13	0.39	0.13	0.24	0.50	0.50	0.50	

Phthalate/Concentrations

Station Number	Dimethyl phthalate	Di-n-buty	Butyl Benzyl	Di-n-octyl	Bis (2-ethylhex1)	Total Phthalates
2	ND	ND	ND	ND	1.34	1.34
3	ND	1.67	0.22	0.25	1.09	3.23
5	ND	1.42	0.38	1.16	17.30	20.26
7	ND	0.79	0.65	ND	15.6	17.04
10	ND	1.00	0.50	ND	0.40	1.90
12	ND	0.70	0.25	0.45	2.24	3.64
14	ND	ND	ND	ND	12.10	12.10
15	ND	ND	0.71	ND	8.80	9.50
16	ND	0.40	0.41	ND	22.50	23.31
17	ND	0.94	0.87	ND	37.00	38.80
18	ND	1.03	0.31	ND	12.40	13.74
19	0.10	1.02	0.68	ND	18.20	19.90
20	ND	0.81	0.81	ND	20.80	22.42
21	ND	0.59	0.23	ND	4.30	5.12
22	ND	0.61	0.54	ND	34.1	35.25
25	ND	0.91	0.16	ND	53.70	54.77
26	ND	ND	ND	ND	0.80	0.80
27	0.18	0.34	1.10	ND	1.20	2.64
28	0.12	0.28	1.83	ND	0.40	2.51
30	ND	ND	0.52	ND	0.50	1.02
ND Limit	0.08	0.13	0.13	0.13	0.13	

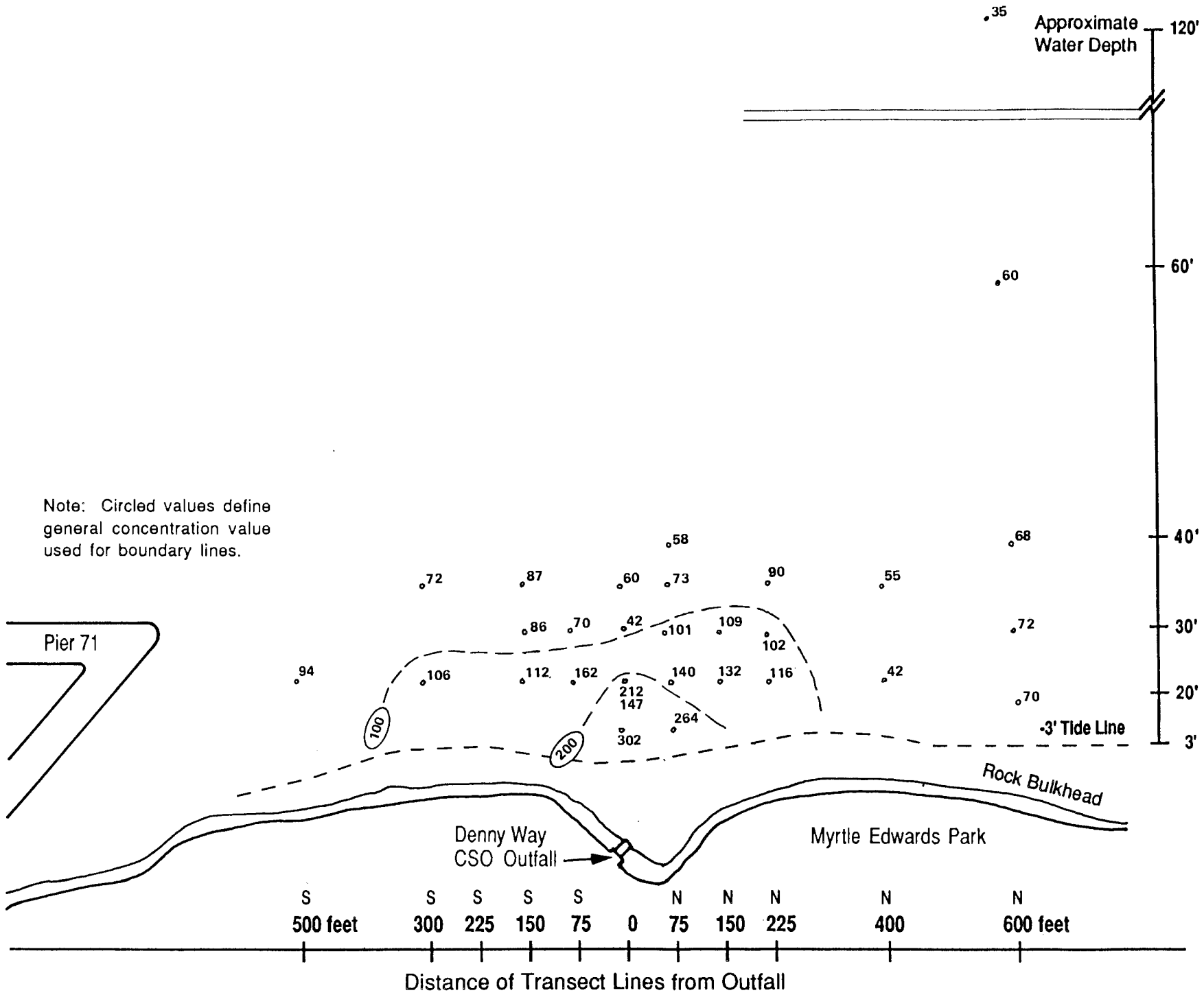


Figure 4-2. Distribution of Copper Concentrations (ppm) in Surface Sediment

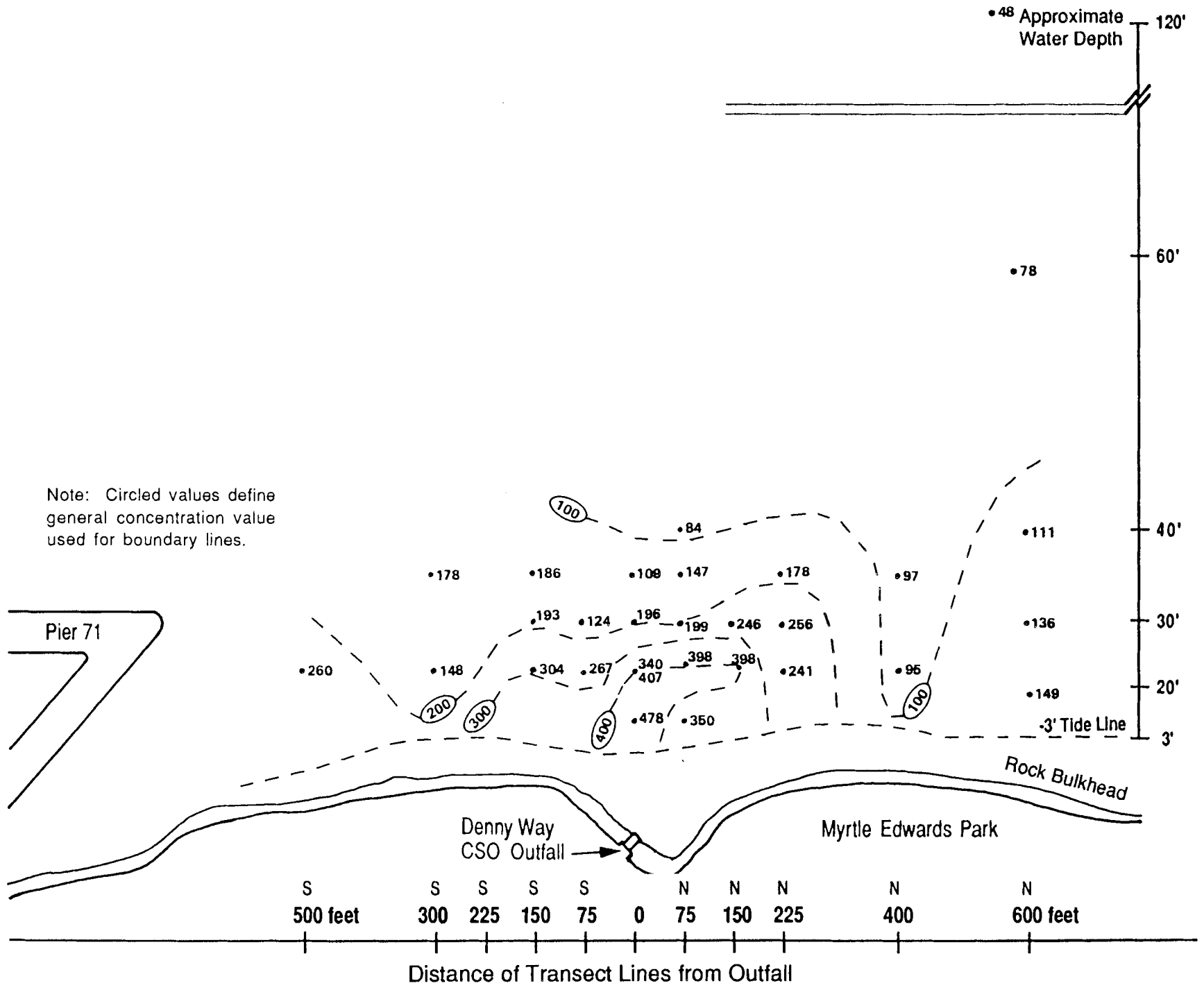


Figure 4-3. Distribution of Lead Concentration (ppm) in Surface Sediments

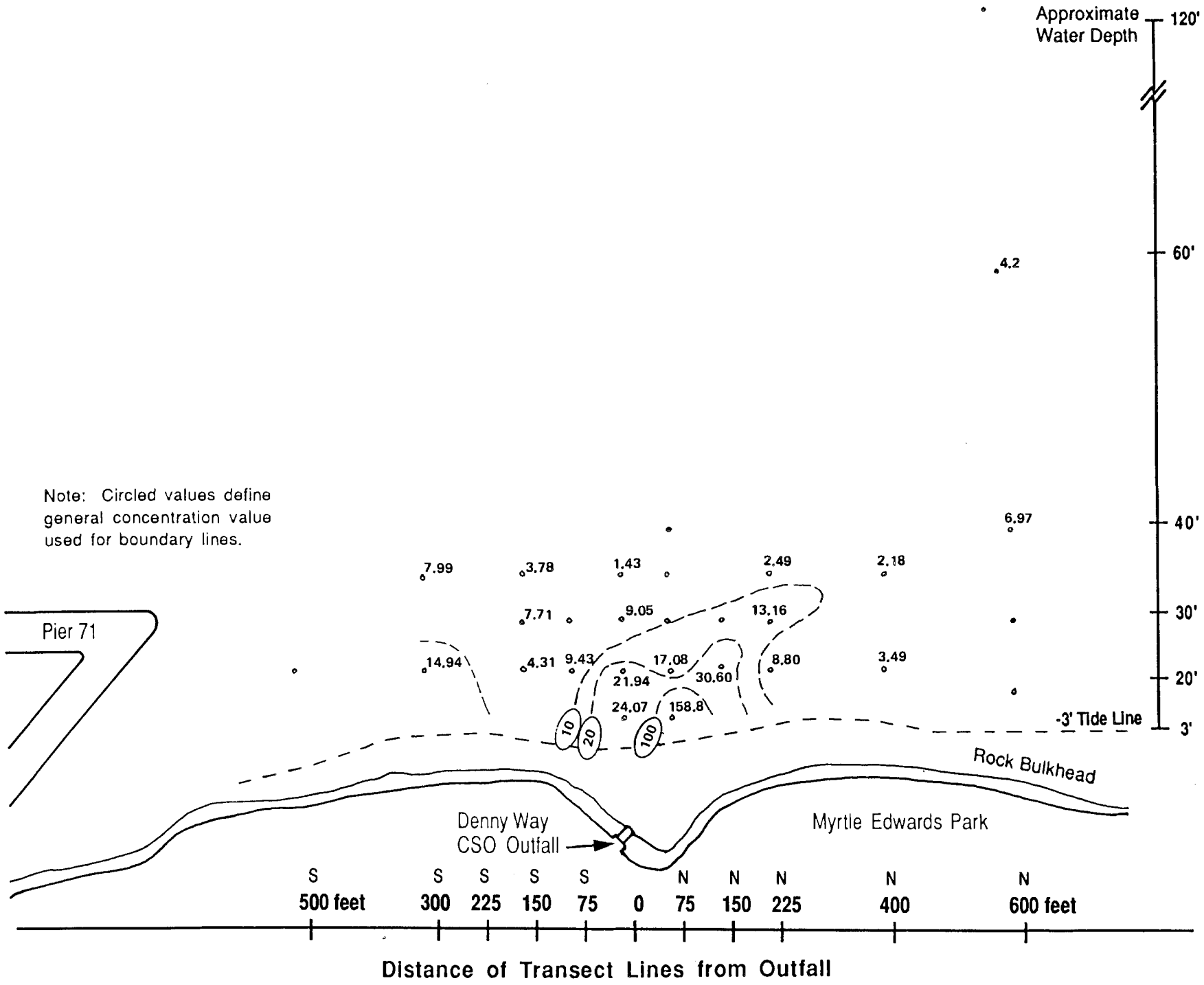


Figure 4-4. Disbribution of HPAH Concentrations (ppm) in Surface Sediments

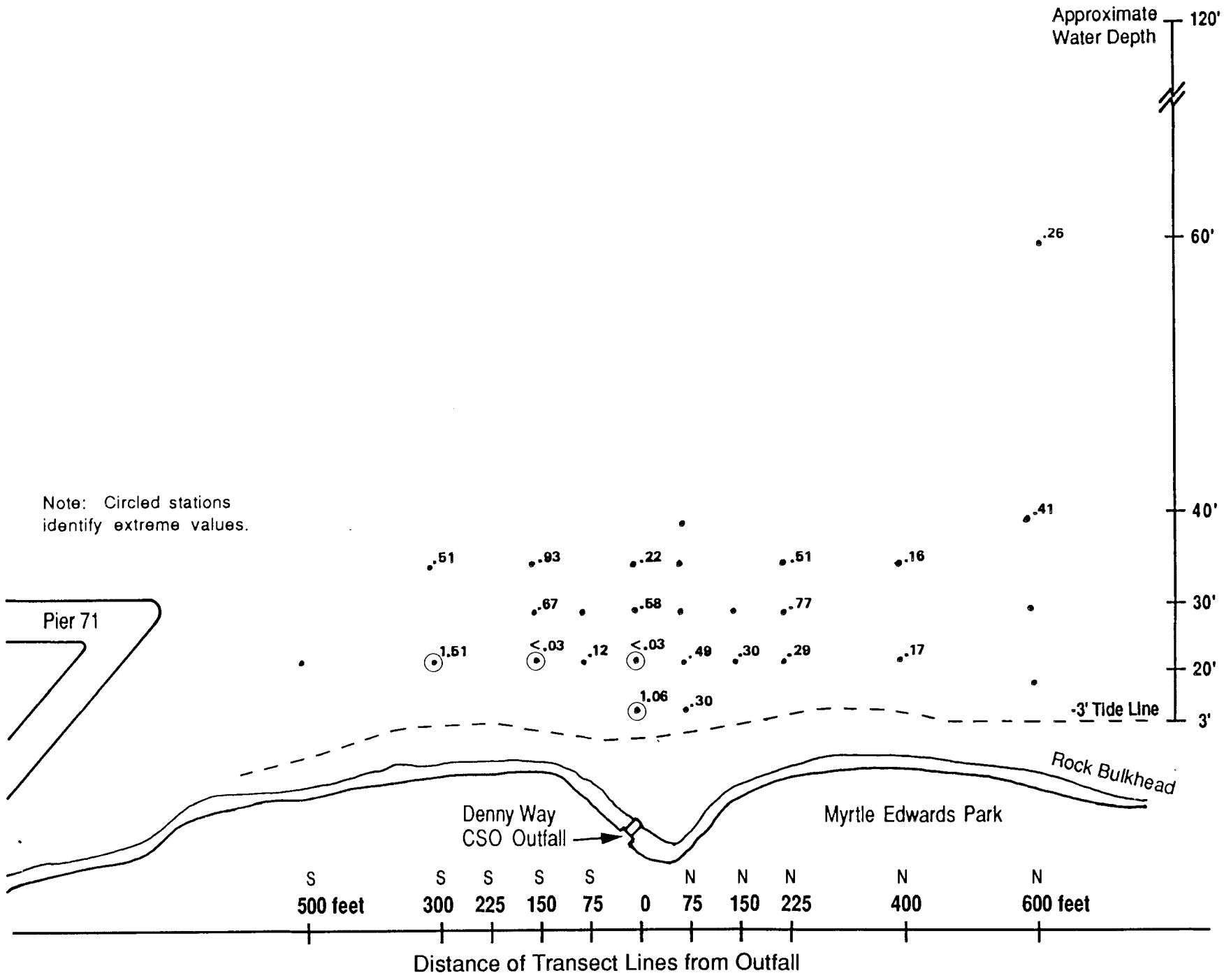


Figure 4-5. Distribution of PCB Concentrations (ppm) in Surface Sediments

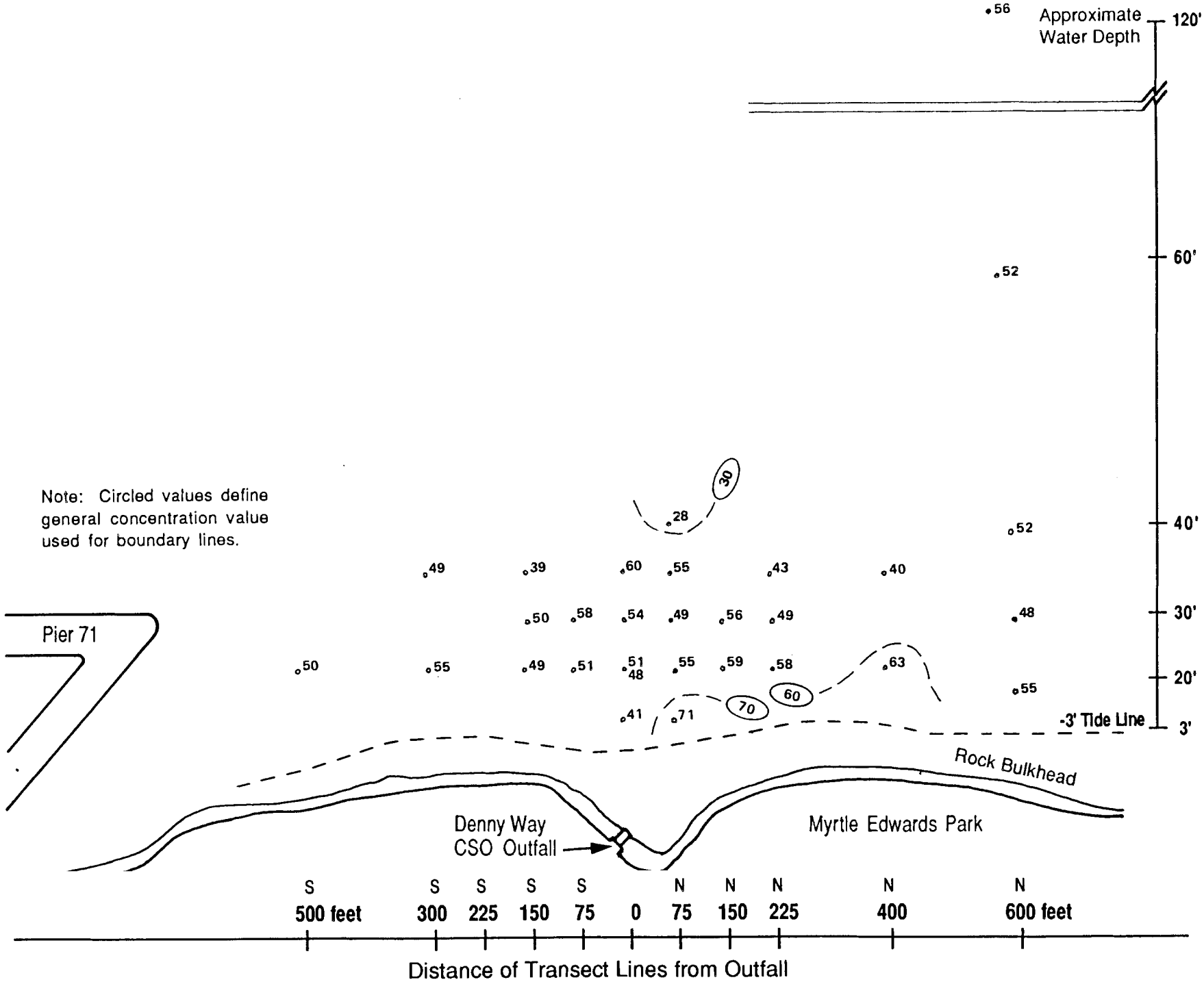


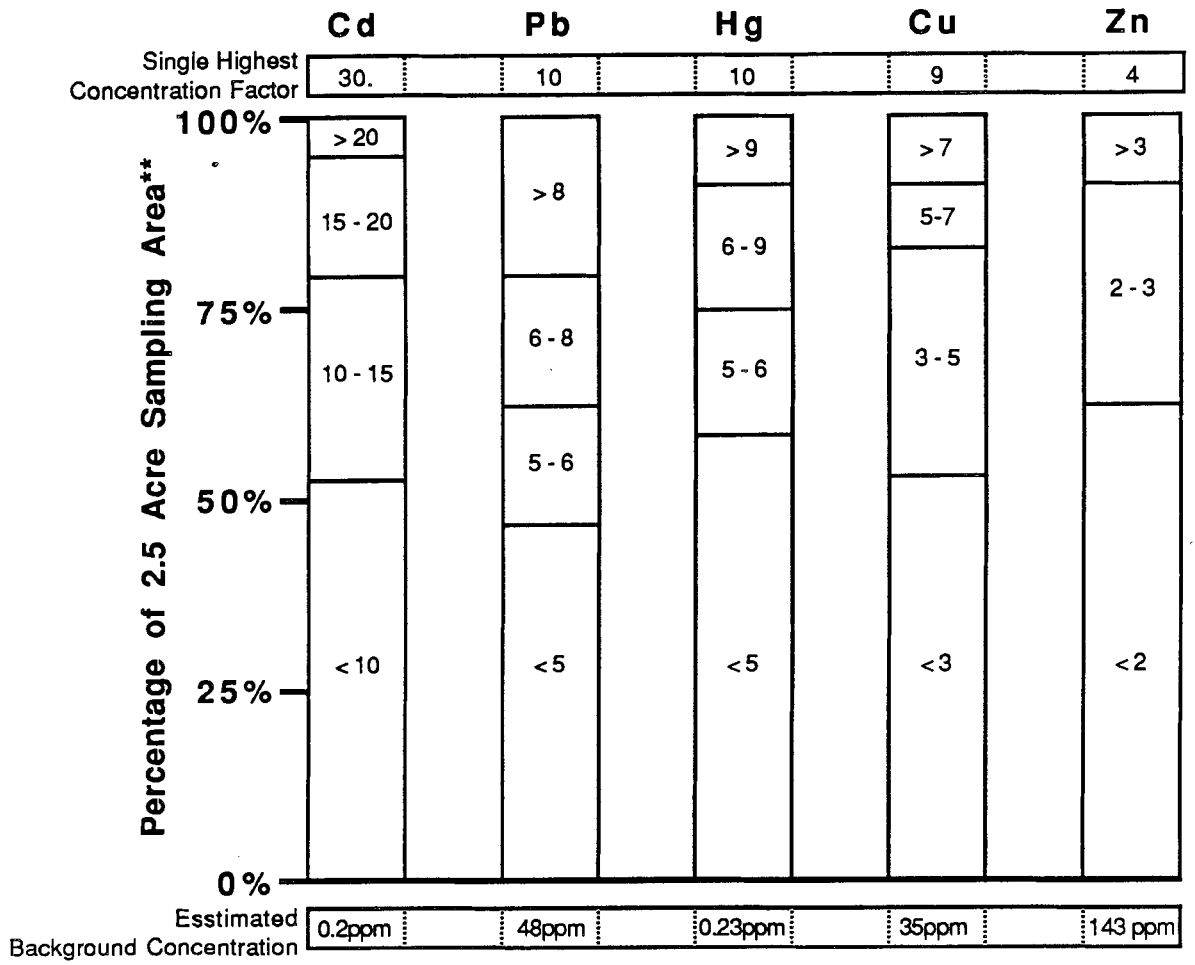
Figure 4-6. Distribution of Total Solids Concentrations (gm dry wt./gm wet wt.) in Surface Sediments

factors are only about one-third to one-half of these maximum values. This situation is illustrated in Figure 4-7 which shows the percentage of area represented by various concentration factors. For simplicity, only the 19 stations located in a tight grid immediately in front of the outfall were used in this analysis. Together, they represent a combined area of about 2.5 acres (assuming each station defines an area 75 feet X 75 feet). Figure 4-7 shows that for cadmium, the concentration factor is less than 10 in about 50 percent of the grid area despite a maximum concentration factor of 30. For lead and mercury, the maximum concentration factor is 10, but for about 50 percent and 60 percent of the area respectively, the concentration factors for both metals were less than 5 Copper has a maximum concentration factor of about 9, but about half the grid area has concentration factors of less than 3. Maximum concentration factor for zinc is only 4 and about 70 percent of the grid area has values of less than 2.

The most prominent organic priority pollutants found in surface sediments were the HPAH and LPAH (high and low molecular weight PAH compounds) and PCBs, which were found at most of the 29 stations. All but one of the 10 HPAH compounds and one of the 6 LPAH compounds were detected, but not all compounds were present at each station. Only 3 of 11 acid extractable priority pollutants (phenols and cresols) were detected and these were only at a few stations. Phenol was found at 12 stations while pentachlorophenol and nitrophenol were only found at 2 and 5 stations respectively. None of the 18 priority pollutant pesticides or any of the 10 base extractable priority pollutants (nitrosamines and other nitrogen compounds) were detected in any of the surface sediments. Volatile organics have a limited residence time in sediments and were not measured because low values were anticipated since the samples were collected in July which is several months after the winter CSO season.

Distribution plots show that organic pollutants have a much wider range of concentrations than metals and that there is more variability in the distribution patterns for organics. The wider concentration ranges occur partly because the natural background concentrations of organics is very low and even zero for the manmade compounds like PCBs. Also, certain concentrations of HPAH and LPAH compounds are unusually high at Station 27. Because Station 27 has much higher PAH values and coarser sediment texture than the other inshore station, it appears that the high PAH values may be due to pieces of asphalt or tar in the sample.

Concentrations of organics exhibit a much less uniform decrease with distance from the outfall than do metals. The PAH groups have a more uniform decrease than PCBs but several stations show anomalies for these compounds. Station 22, located 300 feet south of the outfall, and Station 3, located 600 feet north of the outfall, had higher than expected concentrations for many organics. Station 22 was unique since it had the highest concentrations of PCBs, phenol, and the wood preservative pentachlorophenol which was only found at one other location to the west (Station 5). These higher values at further distances from the outfall suggest



**Values in histograms represent concentration factor above background (measured value/background value).

** Sampling grid of 19 stations closest to outfall represent an area of about 2.5 acres (assuming 75' X 75' per station).

Figure 4-7. Amount of Sampling Grid Area Within Certain Concentration Factors for Metals

that either the particulates containing these materials have been transported greater distances or that somehow more contaminated sediments were dumped at these sites. The common practice of washing excess sediment over the side during sampling operations is one way that higher concentrations could be redistributed in the surface sediments. Pier 71 is an old fuel dock located south of the sampling grid and has not been used for many years, but runoff from the dock may still be a source of particulates containing organics.

There is some similarity in the distribution patterns for related groups like LPAH and HPAH compounds, which both tend to contain a decreasing number of compounds with distance from the outfall. PCB values varied entirely independent of PAH values and failed to show any consistent distribution pattern. The two highest PCB concentrations were on either side of two stations where no PCBs were detected. It is tempting to attribute this difference to analytical error but the chromatograms were reviewed and the chemist confirmed that no PCBs were detected at these two locations (Stations 19 and 21) which are both near the outfall.

The outfall structure is pointed in a northwesterly direction, but the concentration ranges for most chemicals tend to extend about the same distance both north and south of the outfall. Two stations located 400 feet north of the outfall tend to interrupt this symmetrical pattern because they have slightly higher concentrations than expected. There is no immediate explanation for these lower values, but the station closest to shore (Station 15) appeared to have coarser sediments since the total solids value was 60 percent.

ABILITY TO DETECT CHANGE IN SURFACE CONCENTRATIONS

To document a change in surface sediment concentrations, it is necessary to show a statistically significant difference between two representative mean values. Since there is large spatial variability near point sources, the best mean value to represent an area would be the one that describes the largest area, but has the lowest variability. The statistically appropriate relationship can be rearranged to provide the following formula that describes the minimum statistical difference than can be detected from a given set of data.

$$k = t_{\alpha} \, cv \sqrt{\frac{2}{n}} \times 100$$

where
- k = percentage change in mean concentration
- t = critical value at significance level α, (in this case = .05)
- cv = coefficient of variation defined as the standard deviation divided by the mean ($s/\bar{x}$)
- n = sample size

when the confidence level is set at 95 percent, the percent change (k) depends only on the sample size and coefficient of variation.

A statistical technique called cluster analysis was used to define groups of stations that are most similar. Results of a cluster analysis on metals data for all 29 stations showed that the 55 stations closest to the outfall grouped together as did another 15 stations a little further from the outfall. Two smaller subgroups were selected from the 15 stations in order to test the effect of sample size on statistical sensitivity. These subgroups were defined based on their proximity to the outfall and the location of each group is shown in Figure 4-8.

The mean concentration and coefficient of variation was calculated for each group and then used in the above equation to calculate the smallest amount of change that could be detected. These results are presented in Table 4-3 Group 1 located closest to the outfall, has the highest average concentration for each metal. However, this group typically also has the highest coefficient of variance which makes it the least sensitive group for detracting change. Copper and mercury, for example, would need to have a change of 66 percent and 73 percent respectively to be detected. Lead is an exception in this group and exhibits the lowest sensitivity of being able to detect an 18 percent change. Station Group 2, and Subgroups A and B, are located a little farther from the outfall and have both a lower average concentration and a lower coefficient of variance, which makes these groups more sensitive for detecting change (except for lead).

In general, the sensitivity for detecting change increases as the size of each group increases from 6 to 15 stations. However, even with 15 stations, the percent change in zinc, copper, lead, and mercury concentrations would need to be 11 percent, 18 percent, 19 percent, and 23 percent respectively, before this difference could be verified statistically. It may be possible to improve this sensitivity by collecting even more samples, but this becomes less practical.

Visual inspection of the organics data for surface sediments showed that concentrations were far more variable than the concentrations of metals. Frequently, organics concentrations at some stations were reported as undetectable, but there may be one station where concentrations are high. No statistical evaluation was conducted for this organics data, but with a higher variability, the level of sensitivity for detecting change would be less than for the metals.

These results indicate that from a practical sense it may be possible to document a change of 20 to 30 percent in surface sediment concentrations of certain metals; however, the change in organic pollutant concentration would need to be much larger.

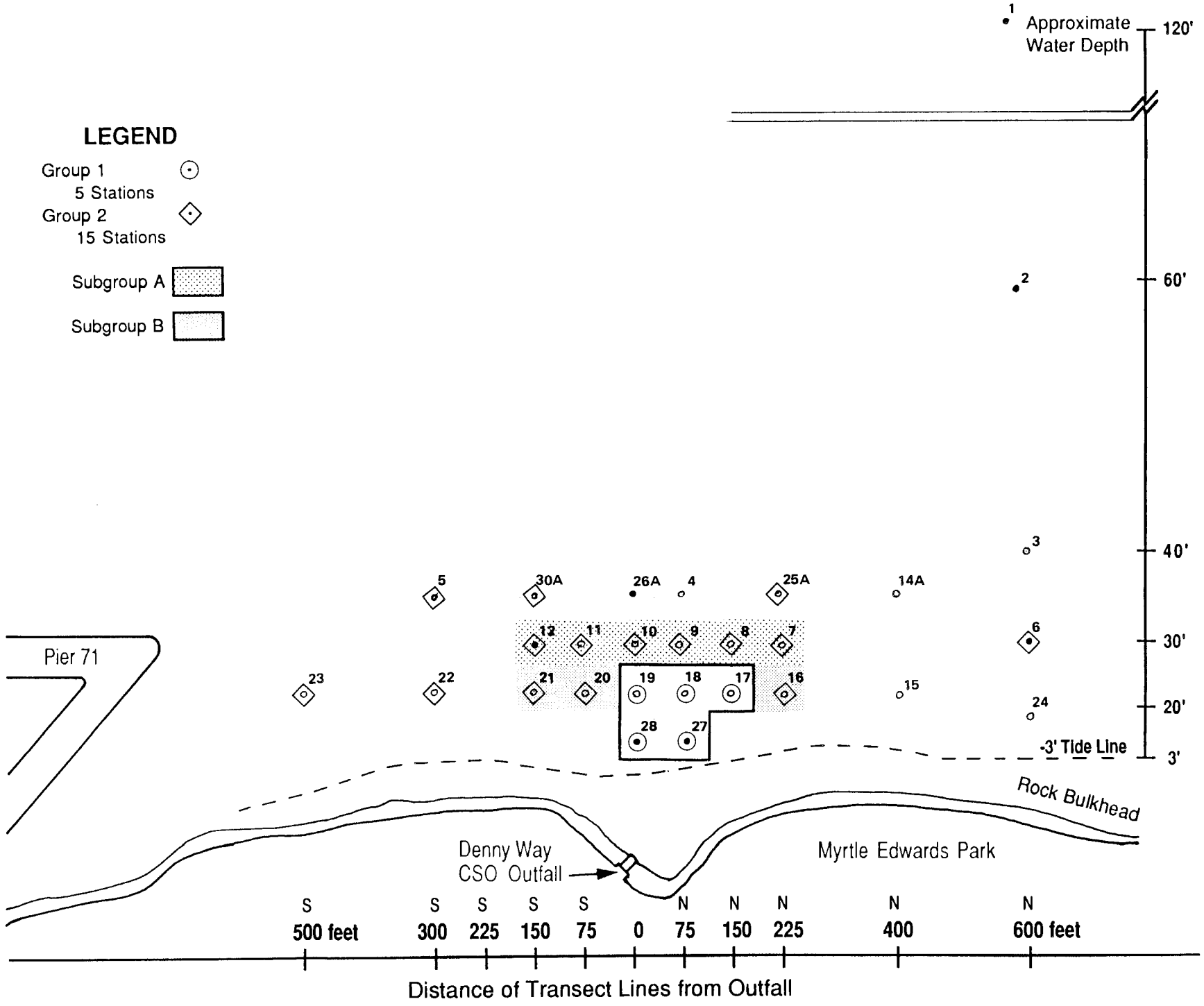


Figure 4-8. Station Groupings Defined by Cluster Analysis of Metals Data

TABLE 4-3. MINIMUM CHANGE IN SURFACE SEDIMENT CONCENTRATION THAT CAN BE DETECTED STATISTICALLY

	Stations Nearest Outfall	Stations slightly farther away from outfall		
Metal	Group 1* n=5	Subgroup A n=6	Subgroup B n=9	Group 2 n=15
Copper				
mean ($\bar{x}$)	197. **	93.	105.	98.
CV	0.41	0.15	0.24	0.23
% change	66.	21.	25.	18.
Lead				
mean ($\bar{x}$)	406.00	202.00	225.	207.
CV	0.11	0.23	0.23	0.25
% change	18.	32.	24.	19.
Zinc				
mean ($\bar{x}$)	374.	273.	267.	273.
CV	0.23	0.12	0.10	0.14
% change	37.	17.	11.	11.
Mercury				
mean ($\bar{x}$)	1.40	1.02	1.05	1.00
CV	0.45	0.24	0.33	0.29
% change	73.	34.	35.	23.

*Each group is composed of the following stations:
Group 1 = Stations 17, 18, 27, 28, 29
Subgroup A = Stations 7, 8, 9, 10, 11, 12
Subgroup B = Stations 7, 8, 9, 10, 11, 12, 16, 20, 21
Group 2 = Stations 5, 6, 7, 8, 9, 10, 11, 12, 16, 20, 21, 22, 23, 25, 30

**Concentration in ppm

SEDIMENT CORE PROFILES

Historic Concentrations

Sediment cores can provide useful information about historical conditions and sedimentation rates, provided that sediment layering is undisturbed and the core is sufficiently long to sample sediments from the period of interest. A box corer was chosen for use in this study because it has been shown to collect undisturbed cores, plus it could be operated from the Metro research vessel and obtained locally from the University of Washington Oceanography Department. Maximum core length for this device is about 50 cm in soft muddy sediments, but penetration and core length are decreased in coarser, sandier sediments. A range of core lengths were obtained from the four sampling stations and went from a minimum of 22 cm to a maximum length of 44 cm.

In each core, a total of 20 sections (each 1 cm thick) were analyzed for stable lead and copper to provide a vertical profile of sediment concentrations over time. These vertical profiles were plotted together in Figure 4-9 to allow comparisons of the patterns and their location relative to the CSO site.

The four coring stations are oriented in a "V" pattern with the point directed at the outfall. Lowest concentrations and the most uniform profiles occur at Station 12 which is located to the southwest. The next lowest values occur at Station 14A which is located to the northwest and the farthest distance offshore. Higher concentrations and prominent subsurface peaks occur at both Station 19 and Station 7. At three of these four stations, the lead values are consistently higher than copper values and the variation with depth tended to be similar for both metals.

The subsurface peaks appear to reflect conditions that existed when raw sewage was being discharged off Denny Way on a continuous basis. Completion of the Elliott Bay Interceptor and Denny Way Regulator in 1969 replaced the continuous discharge with periodic CSO events. A corresponding drop in pollutant loading should be reflected in sediment concentrations and be most obvious near the outfall site.

Station 19 is located closest to the CSO outfall and has the highest surface concentrations, as expected. Station 7 is located further offshore to the northwest and, unexpectedly, has the largest subsurface peaks for both metals which would suggest that this station was closer to the old outfall site. This speculation was confirmed by an old construction drawing (included in Appendix E) which showed that the previous outfall pipes were located to the north of the present CSO site and in the area of Station 7.

It appears that sediment concentrations dropped to a low point shortly after the interceptor was completed, but that these concentrations then gradually increased

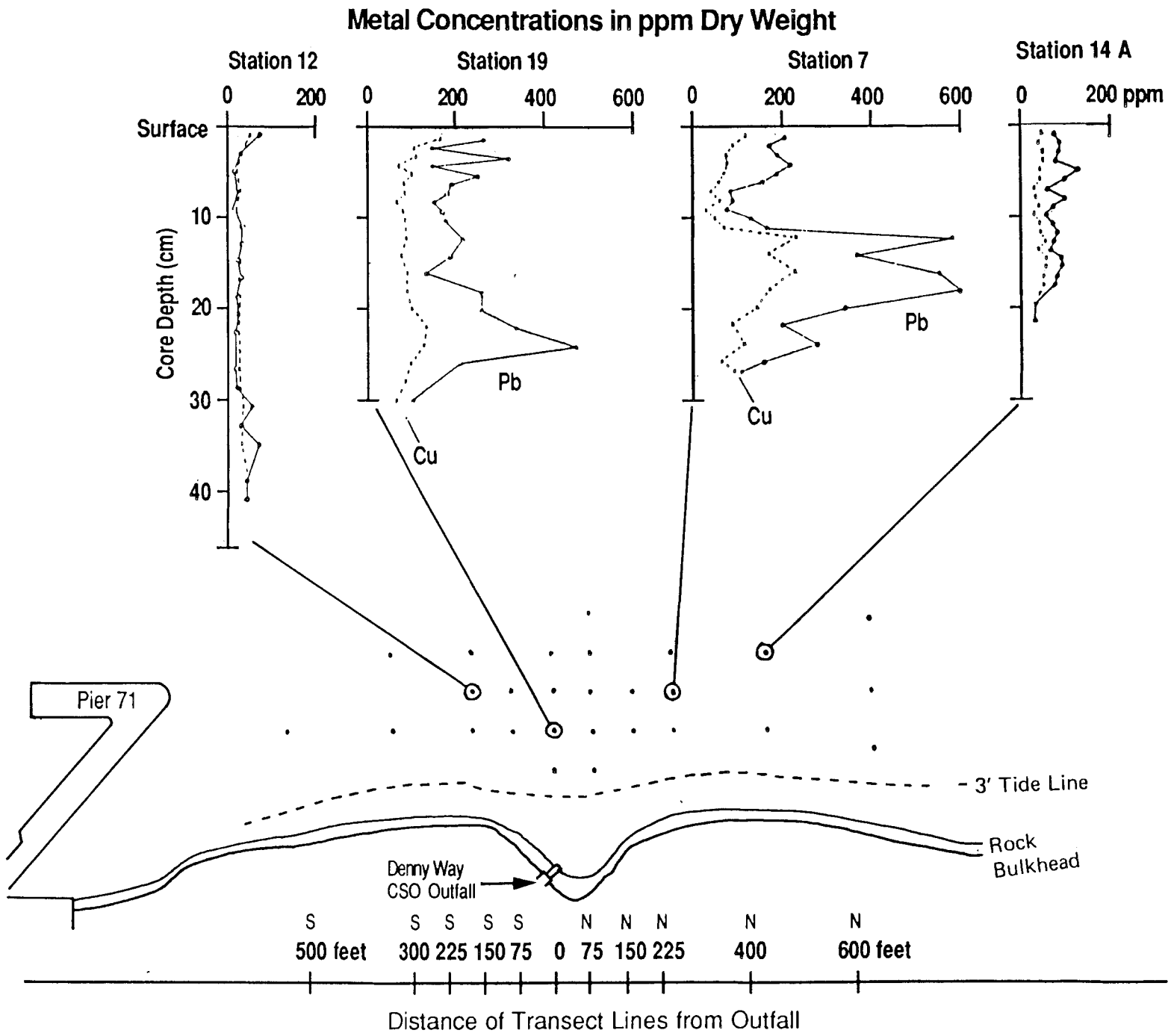


Figure 4-9. Sediment Coring Locations and Vertical Profiles of Lead and Copper Concentrations Showing Change Over Time

again over time. In most cases, the present surface concentrations are less than occurred in previous subsurface peaks. · At Station 7, the present surface concentrations are about one-third the subsurface peak value for lead (199 vs. 569 ppm) and about one-half the subsurface peak for copper (113 vs. 227 ppm). At Station 19, surface concentrations are about one-half the subsurface peak value for lead (260 vs. 463 ppm), but for copper the surface concentration is slightly greater than the subsurface peak.

Station 12 appears to show little influence from either the old outfall or the present CSO. Both metal profiles show uniformly low background concentrations of about 30 ppm that extend from 3 cm down to a depth of 30 cm. If the slight rise in lead concentrations below a depth of 30 cm is related to the old outfall, then nearly a foot (30 cm) of new, cleaner sediment is sitting on top of the older sediment. This deposit appears too large to be natural sedimentation, but could perhaps be related to some past dredging or dumping operation. This theory is further supported by the fact that sediments at this site appear to be less compacted because the core length was 50 percent longer than at other stations (44 cm vs. 30 cm).

Sedimentation Rate

Information regarding sedimentation rate is important because sedimentation is involved with both the accumulation of toxicants and with their burial after the source is stopped. One method for determining sedimentation rate is to age-date the core sections using radioactive lead-210. This approach works well in undisturbed areas like the central basin of Puget Sound where the sedimentation rate has been calculated to be about I.5 cm per year (Romberg, et al, 1984). However, in areas with significant local influence there may be too much interference for the method to work effectively.

To test whether standard age-dating methods work in the area around Denny Way CSO, 10 sections from Station 14A were analyzed for radioactive lead-210 as reported in Appendix E. Station I4A was selected for this test because metal profiles showed more outside influence than Station 12, but far less discharge influence than Stations 7 and 19 Unfortunately, age dating results were inconclusive because lead-210 concentrations were very low even at the surface (only 1.5 disintegrations per minute (dpm) compared to about 10 dpm in central basin sediments), and because lead-210 concentrations did not decrease with sediment depth as they normally should.

Another approach to age dating cores is to establish a calendar year for a distinctive feature in the core. In some cases, a subsurface peak of fallout radioactivity can be used to define the years of maximum nuclear testing. However, in this case, the drop in subsurface metal concentration at Stations 7 and 19 are directly attributed to the completion of the Elliott Bay Interceptor in 1969.

An average sedimentation rate for the period after the interceptor was completed can be calculated by simply dividing the total accumulated distance above the peak by the total elapsed time of 17 years (I986-1969). At Station 7, this calculated sedimentation rate equals 0.7 cm per year (12 cm/17 years) while at Station 19, the rate is double at 1.4 cm per year (24 cm/17 years). These differences seem reasonable since Station 19 is closest to the outfall and would be expected to receive a higher sediment load from the CSO than would Station 7 which is located further offshore.

The background sedimentation rate around Denny Way would probably be less if the CSO were not present, but there is no information on what this background rate would be. The primary sediment source in the area would probably be the Duwamish River, which during high runoff forms a muddy lens several meters thick that travels along the eastern shore of Elliott Bay. Tomlinson (1980) noted that the CSO discharge typically pushed this muddy river plume offshore, which would restrict any inshore influence.

Estimated Effect of Sediment Capping

If the CSO discharge were removed, the river plume should begin to deposit clean sediments on top of the contaminated sediments However, if only 0.25 cm of new sediment are deposited each year, it would take 10 years to accumulate 1 inch (2.5 cm) of clean sediment as a cap and 60 years to accumulate one-half foot of clean sediment. An alternative would be to speed up this capping process by placing clean dredge material on the site.

This accelerated capping process offers several appealing advantages:

- Environmental improvement occurs immediately instead of having to wait for 10-60 years.

- Historic conditions are covered up so it is easier to identify current pollutant inputs and focus on their elimination.

PREDICTED BIOLOGICAL EFFECTS

There is considerable interest in establishing sediment quality criteria values for Puget Sound that can be used as a regulating tool similar to the water quality criteria values. The first step. in developing such values was undertaken in the Puget Sound Dredge Disposal Analysis (PSDDA) study conducted by the U.S. Army Corps of Engineers. As part of this study, existing chemistry and biological data from Puget Sound were used to establish interim guidelines called Apparent Effects Threshold (AET) values. The AET is defined as the concentration above which significant biological effects are predicted to occur. Separate AET values

were developed for each of the following four different biological responses: benthic infauna abundance; amphipod bioassay; oyster larvae bioassay; and Microtox bioassay.

The proposed guideline for evaluating the suitability of dredge material states that if concentrations of chemicals exceed the highest of the four AET values, then the sediments are unfit for disposal at uncontained, open-water disposal sites. Currently, there are no criteria specified regarding acceptability of sediment concentrations in the general Puget Sound environment. Consequently, the AET values cannot be used to specifically characterize sediment quality.

Sediment chemistry and benthic infauna data collected in 1982 as part of the Metro TPPS were included in the data base used to develop the AET values for benthic infauna. Metals data from the 29 offshore sediment stations sampled during this study in 1986 were compared to the AET values to see how many stations might be expected to experience an effect on benthic infauna abundance. Figure 4-10 shows a plot of those stations exceeding the AET values for metals. A total of 18 stations exceeded the AET for fone or more metals. Zinc, mercury, and lead were the metals most responsible for these excesses. The AET value for cadmium was exceeded at only one station and copper values did not exceed the AET value at any station. These stations, where biological effects are predicted to occur, are in a band about 150 feet wide that extends 225 feet north and 500 feet south of the outfall.

For organic pollutants, only two stations exceeded the AET values for benthic infauna. Station 27, located closest to the outfall exceeded the benthic infauna AET values for both LPAH and HPAH. Station 21, located 300 feet to the south of the outfall had the highest PCB value and also exceeded the benthic infauna AET value.

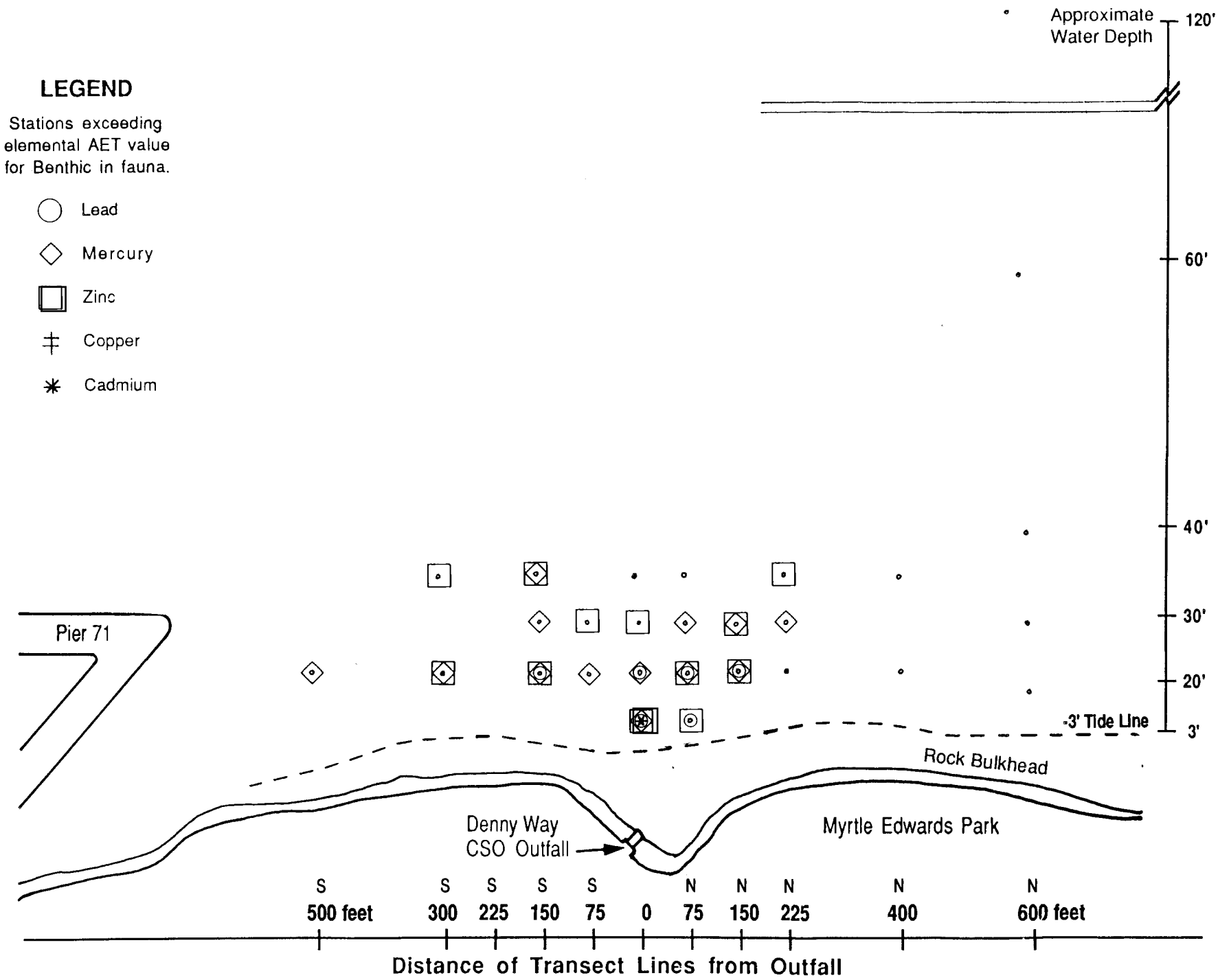


Figure 4-10. Plot of Stations That Exceed the Metals AET Value for Benthic Infauna

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

Metro is implementing a secondary treatment and CSO control plan that will substantially reduce the volumes discharged at all CSO sites. It may take years before the Denny Way CSO is totally controlled. In the meantime, there are toxicant reduction projects that can both reduce the loading of metals and organic chemicals that enter Elliott Bay from the Denny Way CSO, plus speed up recovery of the offshore environment. The following list of 10 potential toxicant reduction projects was generated from this toxicant reduction study.

POTENTIAL DENNY WAY TOXICANT REDUCTION PROJECTS

1. Cap the contaminated offshore sediments with a layer of clean sediment.
2. Remove contaminated sediments from the Lake Union Tunnel to ensure they will not wash into Elliott Bay.
3. Determine whether sewer lines immediately downstream of laundries should be cleaned and establish a schedule.
4. Develop methods to increase in-line sedimentation at convenient clean out sites so contaminated sediment can be removed before reaching the CSO site.
5. Improve maintenance of catch basins to reduce input of street dust into the sewer system.
6. Modify CATAD control at the Denny Way Regulator to reduce overflow from Denny Lake Union Basin.
7. Continue an active pretreatment program that maintains contact with permit holders plus other businesses that are potential toxicant sources.
8. Implement a public education program on toxicants focussed on the two Denny Way Drainage Basins.
9. Accurately apportion the estimated total toxicant loading among probable sources to help determine their relative importance.
10. Evaluate diverting flow from about one-third of Denny Lake Union Basin back into the Dexter Tunnel.

It is possible that not all of these 10 projects are viable; however, there are some that are clearly expected to work. For example, toxicant inputs can be reduced by continued regulation of input sources and removal of contaminated sediments from sewer lines. Also, environmental conditions can be improved by covering over the contaminated sediments with a layer of clean sediment as a cap.

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APPENDIX A

DENNY WAY CSO DRAINAGE BASINS AND OVERFLOW VOLUMES

- Overflow Volumes for 1981 - 1983
- Denny Lake Union Drainage Basin
- Historic Drainage Basins

RANK ORDER OF SSA CSO'S
OVERFLOW IN MILLION GALLONS

STORM DATE	LUN/DEN* R.S.	LOC/DEN** R.S.	KING ST R.S.	CONNECT R.S.	LANDER R.S.	HANF 1 R.S.	HANF2 R.S.	BRANDON R.S.	MICHIGN R.S.	NORFOLK R.S.	CHELAN R.S.	HARBOR R.S.	W MICH R.S.	8TH SO R.S.	INTERBY P.S	STORM TOTALS (MG)***
2 12 82	131.74	17.63	10.38	4.08	15.68	223.40	0.37	2.64	71.40		9.82	7.24	0.40	0.66	0.29	495.73
1 3 83	52.26	0.55	9.05	22.87	68.15		113.82	4.62	50.37	0.13	3.71	8.77	0.97	2.88		338.15
10 5 81	3.44	0.30	14.43	16.80	55.49	31.91	110.41	4.92	64.19	0.16	15.63	6.80	0.76	9.64	2.71	337.59
12 3 82	52.16	9.31	11.13	4.34	106.34	25.85	7.14	8.16		0.35	6.52	11.64	0.89	3.26	4.23	251.32
12 14 82	42.71	1.27	8.28	3.74	76.12	76.22	0.38	1.46		0.59	1.13	5.00	0.11	0.31		217.32
12 7 83	49.22	12.06	0.37	9.16	11.13		71.87		31.08	0.13	9.33	7.54	0.39	0.41		202.69
11 14 83	41.44	7.22	1.54	2.15	2.63		83.65		10.73		3.62	2.36	0.03	3.95		159.32
11 17 82	24.84	0.18	2.74	2.76	58.33	21.54	0.45	2.86	12.95	0.01	1.15	2.88	0.10	0.27	0.64	131.70
1 26 82	15.93	2.02	1.78	5.60	6.74	58.52	0.22	2.54	22.63		3.08	2.82	0.27	1.90		124.05
10 1 81	65.05	12.55	0.88	3.11	5.19		12.01	2.05	5.07		1.62	0.91		0.75		109.19
11 11 81	19.21	3.83	2.74	4.17	13.28	37.71		2.98	15.17		1.83	2.11		0.45		103.48
11 23 83	18.55	3.62		4.24	7.58		36.57		14.85	0.04	4.95	2.79	0.03	1.55		94.77
2 18 81	16.80	2.21	13.29	3.37	11.79	7.06	13.59	2.91	14.64		4.54	2.16	0.05			92.41
12 4 83	88.21	1.00							1.88			0.02				91.11
12 5 81	6.37	3.54	3.87	5.75		15.24	2.13	5.11	23.95	0.02	6.60	4.43	0.11	2.00	0.75	79.87
3 10 82	12.85	1.55	1.22	2.55	5.51	28.40	0.16	1.04	9.27		1.84	0.78	9.27	1.55	1.38	77.37
2 20 82	14.07	2.57	1.80		3.81	30.88		1.08	12.70		4.04	1.71	0.37	0.05		73.08
10 28 82	12.21	2.72	3.48	4.83	11.23	24.64		1.82	0.23		3.08	2.12	0.02			66.38
2 16 83	13.87	0.93	1.10	1.14	2.11		30.39		11.06	0.01	0.44	1.20				62.25
3 7 83	18.23	0.04	1.31	1.92	0.50		21.80		12.45	0.02		1.52		0.33		58.12
3 1 82	13.88	2.01	2.29	0.69		11.12		0.51	11.27			0.70	11.27	0.44		54.18
12 15 81	21.29	4.60	0.54	2.87	1.43	1.50	1.31	0.24	17.83	0.01	0.17	0.75	0.08			52.62
1 22 82	7.74	1.24	1.62	2.80	3.35	20.05		1.18	8.12		2.45	1.83		1.69	0.02	52.09
2 26 82	13.85	1.83	1.93	1.46	3.16	19.81		0.21	8.11			0.83				51.19
12 3 81	1.15	0.11	0.17			48.39	0.07					0.07				49.96
12 13 81	4.86	1.67	0.96	1.00	0.78	31.88	0.39	0.60	3.42		1.37	0.68				47.61
3 8 83	13.67	0.04	1.00	1.43	0.50		17.19		9.96	0.02		0.84		0.33		44.98
2 16 81	16.92	0.93	0.95	0.80	2.12	1.59	12.89	0.63	4.78		1.54	1.19	0.15			44.49
12 9 81	20.96	4.72	0.97	0.54		7.47	0.83	0.05	8.15			0.56			0.07	44.32
12 19 81	14.41	2.29	1.10		4.92	5.11	0.52	0.26	8.95		2.93	0.76		1.54		42.79
11 23 81	12.47	1.21	0.82	1.51			15.40	1.15	5.60		1.59	1.55		0.63	0.05	41.98
2 11 81	18.81	0.77	1.44	0.70	0.77	11.22		1.03	4.61	0.01		0.83				40.19
7 13 81	11.17		2.45	2.86			14.93	0.63	6.14	0.01		0.60			0.69	39.48
10 21 82	12.31	1.95	1.76	1.29		16.60		0.28	1.59		2.57			0.64		38.99
12 5 82	13.13	0.06	0.70			23.90		0.27		0.01		0.31				38.38
4 11 82	7.37	0.47	0.98		12.24	16.56		0.24								37.86
8 29 83	8.39	1.81	2.33	3.42	3.83		12.94		0.40		1.53	1.33		1.00		36.98
10 6 82	9.12	1.32	1.14	1.13	5.81	8.64		0.52	4.00		1.25	0.71		0.38		34.02
1 13 82	13.45	1.41				13.46	1.14	0.52	3.34							33.32
12 20 82	15.51	0.79	1.98	1.28	1.94		5.18	0.98		0.05	2.21	1.85				31.77
6 9 83	8.65	1.54	1.20	0.48	0.39		11.71		6.17			0.39				30.53
1 16 82	11.58	2.50		0.49		6.19	0.92		8.58			0.20				30.46
12 21 82	9.54	4.35	0.08	0.28			15.05	0.09				0.57				29.96
1 7 83	4.24	1.40		0.63			17.49	0.04	5.71			0.30				29.81
2 15 81	5.08	1.07	0.08			1.16	20.06	0.21	0.77			0.49				28.92
11 21 81	6.91	2.29	0.74	0.23	1.76	0.28	12.43	0.53	2.45			0.64				28.26
12 29 83	14.70	2.40	1.50	2.01	2.68				3.33	0.03		0.88				27.53

*LUN/DEN = Lake Union Denny
**LOC/DEN = Local Denny
***MG = million gallons

RANK ORDER OF SSA CSO'S
OVERFLOW IN MILLION GALLONS

STORM DATE	LUN/DEN * R.S.	LOC/DEN** R.S.	KING ST R.S.	CONNECT R.S.	LANDER R.S.	HANF2 R.S.	HANF 1 R.S.	BRANDON R.S.	MICHIGN R.S.	NORFOLK R.S.	CHELAN R.S.	HARBOR R.S.	W MICH R.S.	8TH SO R.S.	INTERBY P.S	STORM TOTALS (MG)***
4 13 82	5.00	0.63	0.71		9.84	10.89		0.19								27.26
12 18 81	1.96	0.16				24.42	0.45					0.06				27.05
3 28 83	7.26	0.88	0.41	0.26			14.77		2.50			0.56				26.64
11 19 82	8.24	0.02	0.76	1.43		11.77			1.69		1.49	0.16		0.38		25.94
2 1 82	12.60	1.99			3.56	3.17		0.02	4.26			0.04				25.64
1 28 81	8.71	1.03	1.56	0.47	1.07	2.60		0.82	4.31		3.27	0.31		0.84		24.99
9 28 81	8.14	1.83	0.84	1.79	1.10	0.38	5.20	0.40	1.05			1.18				21.91
2 10 83	8.19	0.12		0.17			10.80		1.94	0.01		0.52				21.75
10 26 82	5.10	0.64	1.22	1.31		9.76		0.43	0.53		1.25	0.33		0.37		20.94
2 14 81	5.96	0.86	1.85	1.35	2.45	2.28		0.43	2.39		2.09	1.15				20.81
12 12 83	5.39	0.75		0.52	0.13		11.18		2.00			0.50	0.01			20.48
11 17 81	6.16	0.84	1.39	1.20	2.44	1.14	5.17	1.30				0.60		0.22		20.46
12 12 82	12.08	0.05	1.06	1.05	1.87	1.98						0.62				18.71
3 3 82	6.47	0.87				3.88			3.02			0.14	3.02			17.40
3 3 81	5.86	0.93	1.40	0.77	1.05		2.85	0.17	1.18		0.34	0.56				15.11
3 12 83	2.71		0.66	0.79	0.29		8.93		1.37							14.75
9 26 81	4.61	0.40	0.18	0.56	0.45	3.02	0.14	0.91	3.57			0.79				14.63
2 24 81	4.67	0.51	1.05	0.30	0.64	1.61	4.02	0.28	0.50		0.68	0.02				14.28
11 18 82	2.76		0.07	0.02		4.94		0.03	1.35	4.65		0.15				13.97
5 14 83	2.80	0.72	0.92	0.25			8.13		0.32			0.25				13.39
8 31 83	10.02	0.90		0.06					1.27		0.36	0.41				13.02
9 10 83	2.66	0.59	0.51	0.60	0.04		5.67		1.68		0.21	0.58				12.54
11 22 81	4.15	0.28	0.16	0.30		0.99	4.12	0.37	1.76			0.28				12.41
7 7 81	3.54	1.33	0.11		1.32	0.49	4.85					0.17				11.81
6 8 81	3.86	0.41	0.76		0.20	1.75	2.24	0.36	0.94			0.37				10.89
11 13 83	4.07	0.33	0.12				5.41				0.19	0.39				10.51
11 28 82	5.93		0.33			3.55			0.30		0.23	0.03				10.37
3 15 81		0.36	0.56	0.99	0.89	0.25	4.97	0.12	1.04		0.63	0.18		0.12		10.11
11 4 82	3.40	0.46	0.77	0.39		3.08		0.25			1.13	0.35		0.27		10.10
3 5 83	2.78		0.09				6.56		0.36			0.16				9.95
12 1 81	3.11	0.39		0.03		3.79		0.27	1.65			0.25				9.49
10 27 81				0.31			4.89	1.56	1.60		0.68	0.19		0.11	0.01	9.35
1 23 81	2.60	0.33	0.21	0.03			4.62	0.22	0.94			0.18				9.13
3 10 83	1.42	0.15					5.91		1.45			0.14				9.07
11 14 81	4.04	0.82				2.78		0.07	0.95		0.02	0.18				8.86
2 17 81	2.70	0.36	0.36				4.40	0.02	0.48		0.40	0.03				8.75
3 8 82	3.99	0.75				3.85						0.02				8.61
11 11 83	2.54	0.40					5.46					0.09				8.49
3 13 82	1.08	0.34	0.06			5.90			0.47			0.02	0.47			8.34
3 29 82	4.24	1.45	0.40		1.09				0.14			0.41	0.14			7.87
1 21 81	3.40	0.49	0.61	0.16	0.27		2.30	0.07				0.32				7.62
11 30 82	4.63	0.38	0.66			0.46		0.56				0.26				6.95
11 5 82	3.24	0.74	0.38	0.02		2.41						0.11				6.90
11 29 82	3.38	0.19				2.85		0.06	0.07			0.13				6.68
5 7 81	2.02	0.23	0.13	0.02	0.93	2.45						0.16				5.94
11 14 81	2.49	0.21	0.12	0.10	1.03	0.62		0.05	0.96			0.16				5.74
11 16 82	3.64	0.25				1.78						0.06				5.73

*LUN/DEN = Lake Union Denny
**LOC/DEN = Local Denny
***MG = million gallons

RANK ORDER OF SSA CSO'S
OVERFLOW IN MILLION GALLONS

STORM DATE	LUN/DEN* R.S.	LOC/DEN** R.S.	KING ST R.S.	CONNECT R.S.	LANDER R.S.	HANF2 R.S.	HANF 1 R.S.	BRANDON R.S.	MICHIGN R.S.	NORFOLK R.S.	CHELAN R.S.	HARBOR R.S.	W MICH R.S.	8TH SO R.S.	INTERBY P.S	STORM TOTALS (MG)***
9 24 81	4.87	0.80					0.01									5.68
5 11 81	2.30	0.16		0.06		2.41		0.20	0.17			0.09				5.39
2 28 82						0.03					5.16					5.19
2 13 81	3.49	0.26	0.31			0.94						0.05				5.05
9 20 81	2.41	0.29					1.74					0.45				4.89
6 30 82	4.37	0.18				0.13						0.09				4.77
2 15 83	1.21						3.25					0.04		0.24		4.74
8 13 82	3.51	0.04							1.19							4.74
6 26 82	2.91								1.53			0.26				4.70
3 14 83	4.02		0.65													4.67
3 23 81	1.96	0.28					1.21	0.13	0.93		0.13					4.64
3 31 82	2.44	0.16			1.58				0.13			0.14	0.13			4.58
12 21 81	2.22	0.19					0.54	0.04	0.60			0.41				4.00
3 29 81	2.33	0.23	0.41				0.91									3.88
5 19 81	2.76	0.16	0.45	0.09				0.10				0.22				3.78
12 21 81							0.64	2.89								3.53
10 8 81	2.89	0.45							0.16							3.50
5 26 82	3.11	0.31														3.42
4 12 81	1.41	0.10	0.16	0.05			0.94	0.06	0.07		0.37	0.16				3.32
6 9 81	2.62	0.12	0.56									0.01				3.31
3 25 81	2.60	0.25	0.16	0.01				0.01			0.02					3.05
4 28 82	2.41	0.18	0.40								0.04					3.03
12 19 82	2.57	0.14										0.20				2.91
1 26 81	2.41	0.15					0.08					0.10				2.74
12 26 81	2.05	0.15					0.47									2.67
4 1 83	2.18	0.10							0.36							2.64
11 21 83							2.41									2.41
10 7 81	2.18	0.01						0.13				0.05				2.37
2 21 82	1.52								0.71							2.23
9 18 83	1.64	0.42										0.16				2.22
3 10 83	0.62	0.40		0.01			1.08					0.06				2.17
3 13 83							2.15									2.15
3 30 82	1.29	0.13			0.38			0.02				0.25				2.07
6 1 83									1.99							1.99
9 24 82	1.95	0.01														1.96
1 11 82				0.06		1.49						0.11				1.66
3 6 83	1.10		0.13	0.10					0.23			0.07				1.63
5 3 81	1.49	0.10						0.02				0.02				1.63
7 7 82	1.44											0.18				1.62
11 19 81	1.23	0.11					0.04					0.21				1.59
1 25 82	0.72	0.09						0.27				0.45				1.53
5 14 81	1.07	0.38														1.45
5 31 83	1.31	0.12														1.43
6 18 81	0.37	0.54										0.50				1.41
1 10 82							1.38									1.38
6 5 81	1.14	0.01										0.07				1.22
3 31 81	1.09	0.11														1.20

*LUN/DEN = Lake Union Denny
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***MG = million gallons

RANK ORDER OF SSA CSO'S
OVERFLOW IN MILLION GALLONS

STORM DATE	LUN/DEN* R.S.	LOC/DEN** R.S.	KING ST R.S.	CONNECT R.S.	LANDER R.S.	HANF2 R.S.	HANF 1 R.S.	BRANDON R.S.	MICHIGN R.S.	NORFOLK R.S.	CHELAN R.S.	HARBOR R.S.	W MICH R.S.	8TH SO R.S.	INTERBY P.S	STORM TOTALS (MG)***
12 18 82	1.12	0.03										0.02				1.17
5 9 81	0.97	0.05	0.07													1.09
12 2 81	0.31	0.06			0.02		0.07		0.30			0.30				1.06
7 22 82							1.05									1.05
6 16 83	0.89	0.09														0.98
1 27 82	0.86	0.11														0.97
1 30 82									0.77					0.18		0.95
6 21 83									0.95							0.95
11 15 81	0.30	0.02				0.34						0.22				0.88
11 12 81					0.87											0.87
10 28 81			0.36					0.49				0.02				0.87
10 7 82		0.07										0.78				0.85
12 25 83	0.34	0.04							0.29			0.17				0.84
9 28 82									0.83							0.83
5 27 82							0.75									0.75
5 5 83	0.68	0.04										0.02				0.74
4 5 81	0.50	0.02						0.02								0.54
11 1 82												0.53				0.53
11 20 82	0.29									0.22						0.51
10 16 82	0.45	0.03														0.48
12 28 81							0.41									0.41
5 18 81	0.38	0.02														0.40
10 4 83									0.38							0.38
4 12 82					0.36											0.36
7 30 82	0.25											0.07				0.32
12 26 81							0.25					0.05				0.30
4 3 81								0.07	0.05			0.14				0.26
6 12 81												0.24				0.24
9 1 82													0.23			0.23
12 30 81							0.23									0.23
5 28 83		0.22														0.22
4 28 81												0.19				0.19
9 9 82		0.13										0.05				0.18
4 2 82		0.15														0.15
6 3 81	0.08	0.06														0.14
9 1 81												0.11				0.11
7 28 82												0.10				0.10
9 16 81							0.09									0.09
9 12 82		0.09														0.09
11 27 82												0.08				0.08
8 2 82												0.08				0.08
11 10 81							0.07									0.07
3 30 83	0.07															0.07
2 23 82	0.07															0.07
8 27 82			0.07													0.07
4 7 83												0.06				0.06
8 30 82												0.06				0.06

*LUN/DEN = Lake Union Denny
**LOC/DEN = Local Denny
***MG = million gallons

RANK ORDER OF SSA CSO'S
OVERFLOW IN MILLION GALLONS

STORM DATE	LUN/DEN * R.S.	LOC/DEN ** R.S.	KING ST R.S.	CONNECT R.S.	LANDER R.S.	HANF2 R.S.	HANF 1 R.S.	BRANDON R.S.	MICHIGN R.S.	NORFOLK R.S.	CHELAN R.S.	HARBOR R.S.	W MICH R.S.	8TH SO R.S.	INTERBY P.S	STORM TOTALS (MG) ***
2 22 82		0.02										0.01				0.03
7 14 83		0.03														0.03
4 17 82												0.03				0.03
4 27 82		0.02														0.02
1 18 81												0.02				0.02
11 6 82												0.02				0.02
1 17 81												0.02				0.02
3 2 82		0.01														0.01
4 1 81	0.01															0.01
4 7 83		0.01														0.01
8 25 82		0.01														0.01
3YR TOTALS:	1316.7	163.7	142.3	146.1	541.2	950.5	818.2	67.8	577.6	6.5	119.2	115.0	29.3	39.3	10.8	5044.1
AVE/YR:	438.6	54.6													3.6	
NO.: OVERFLOWS	152	145	92	75	58	69	82	76	92	20	48	139	24	35	11	199
AVE.:	8.7	1.1	1.6	2.0	9.3	13.8	10.0	0.9	6.3	0.3	2.5	0.8	1.2	1.1	1.0	25.4
MAX.:	131.74	17.63	14.43	22.87	106.34	223.40	113.82	8.16	71.40	4.65	15.63	11.64	11.27	9.64	4.23	495.73
STD.:	15.84	2.32	2.70	3.45	20.59	29.32	20.85	1.41	11.86	1.00	2.97	1.69	2.81	1.74	1.28	58.83

SSA SELECTED STORM OVERFLOWS
OVERFLOW IN MILLION GALLONS

STORM DATE	LUN/DEN R.S.	LOC/DEN R.S.	KING ST R.S.	CONNECT R.S.	LANDER R.S.	HANF2 R.S.	HANF 1 R.S.	BRANDON R.S.	MICHIGN R.S.	NORFOLK R.S.	CHELAN R.S.	HARBOR R.S.	W MICH R.S.	8TH SO R.S.	INTERBY P.S	STORM TOTALS (MG)
12 3 82	52.16	9.31	11.13	4.34	106.34	25.85	7.14	8.16		0.35	6.52	11.64	0.89	3.26	4.23	251.32
11 17 82	24.84	0.18	2.74	2.76	58.33	21.54	0.45	2.86	12.95	0.01	1.15	2.88	0.10	0.27	0.64	131.70
10 28 82	12.21	2.72	3.48	4.83	11.23	24.64		1.82	0.23		3.08	2.12	0.02			66.38
10 6 82	9.12	1.32	1.14	1.13	5.81	8.64		0.52	4.00		1.25	0.71		0.38		34.02
9 10 83	2.66	0.59	0.51	0.60	0.04		5.67		1.68		0.21	0.58				12.54
TOTALS:	101.0	14.1	19.0	13.7	181.8	80.7	13.3	13.4	18.9	0.4	12.2	17.9	1.0	3.9	4.9	496.0
NO.:	5	5	5	5	5	4	3	4	4	2	5	5	3	3	2	5

*LUN/DEN = Lake Union Denny
**LOC/DEN = Local Denny
***MG = million gallons

METRO LIBRARY
Municipality of Metropolitan Seattle
821 Second Avenue
Seattle, WA 98104

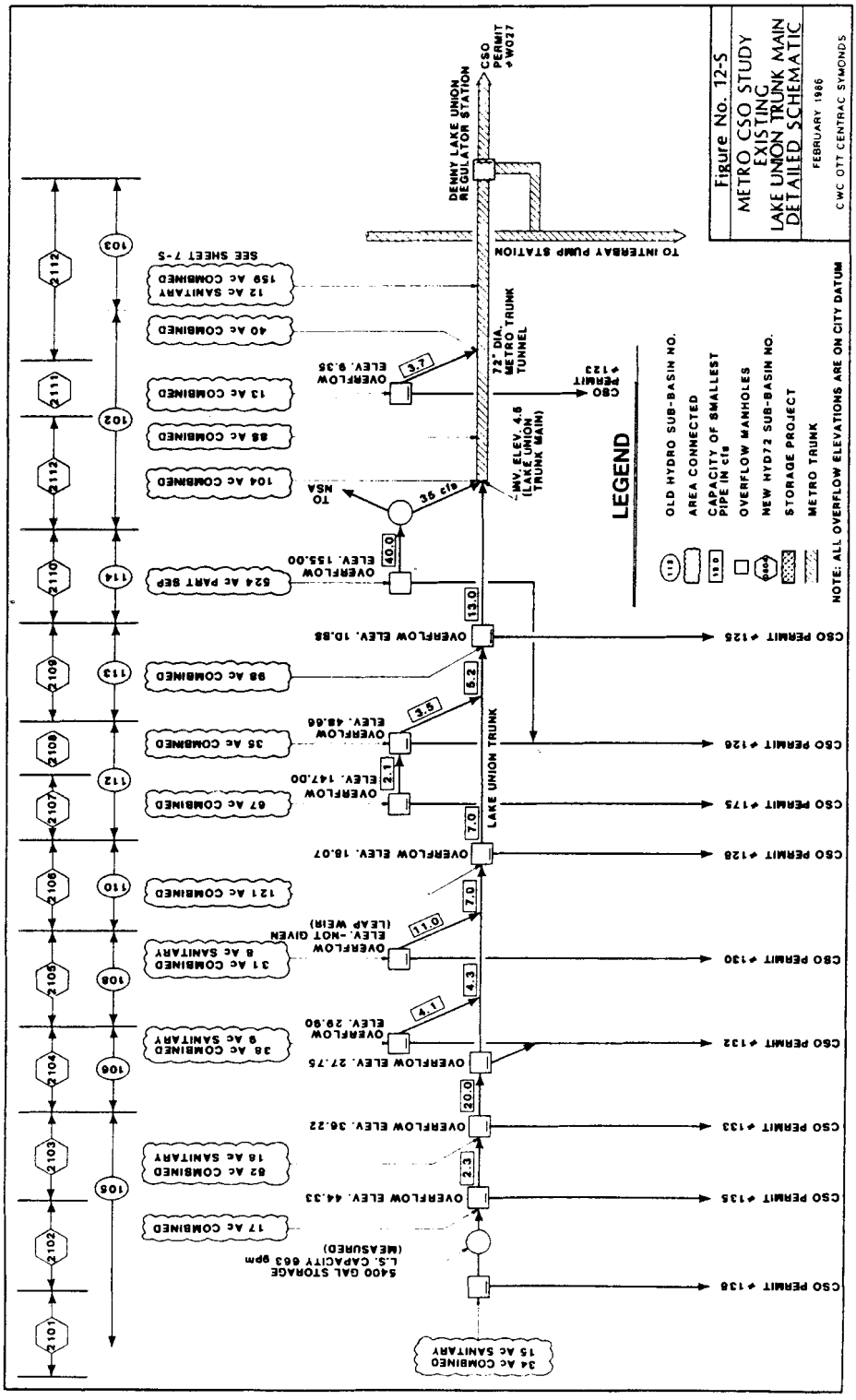
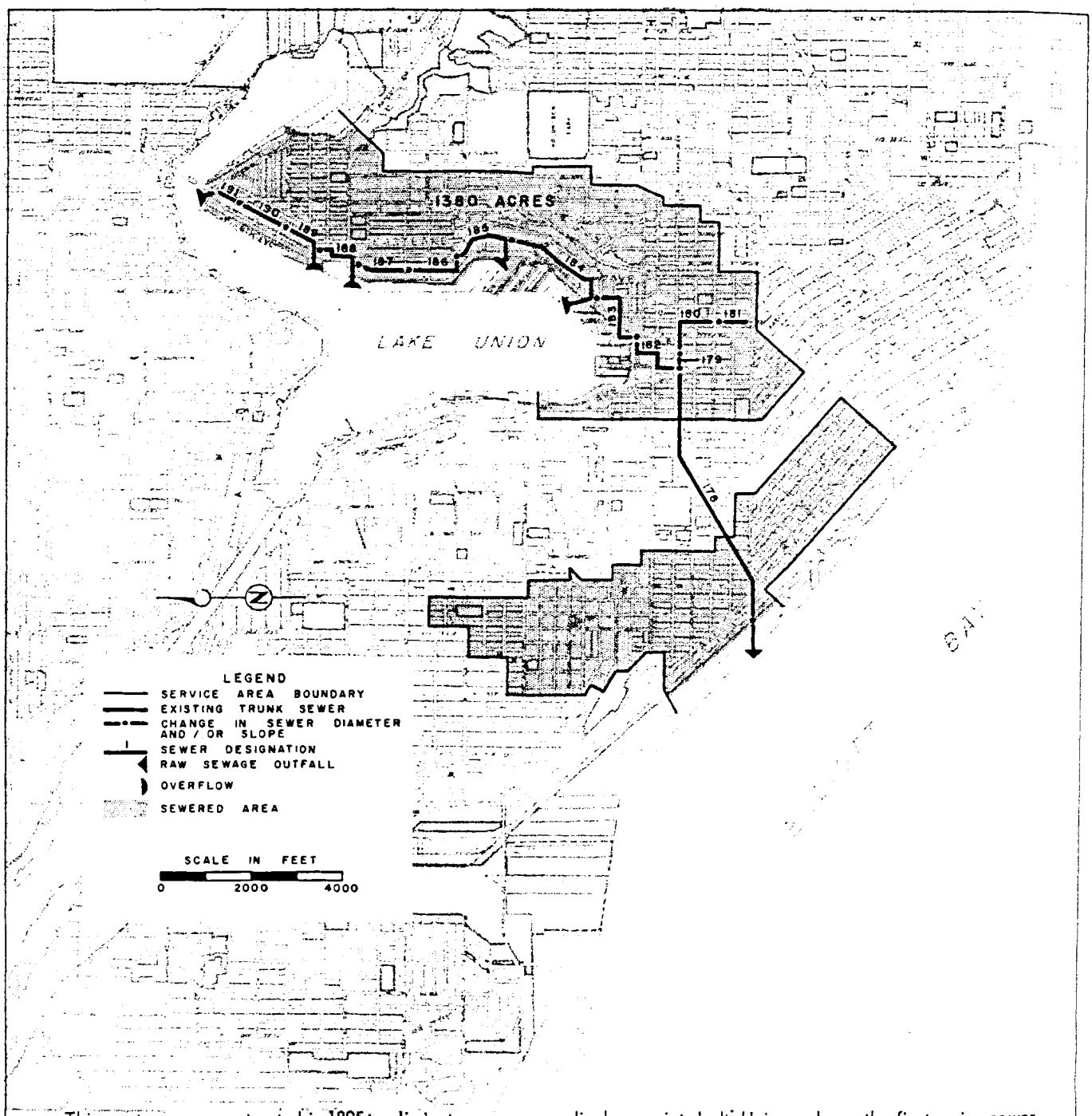


Figure A-1. Lake Union Trunk Main



This system was constructed in 1895 to eliminate raw sewage discharges into Lake Union and was the first major sewer project in Seattle. Initially, it served south Queen Anne Hill, Capitol Hill and a large part of the downtown area, but it soon became grossly overloaded and relief was provided by construction of the central section of the North Trunk sewer (Fig. 6-29). At present, the primary function of the Lake Union tunnel system is to divert sewage from the low areas around the lake and from a small downtown section and to convey it to Elliott Bay through the tunnel (No. 178). This system also serves an area lying along the west slope of the divide between Lake Union and Elliott Bay. In the downtown area, there are interconnections with the central section of the North Trunk system (Fig. 6-29).

Frequent backups of sewage are reported to occur at the south end of Lake Union and in the vicinity of the east end of the tunnel.

From Metropolitan Seattle Sewerage and Drainage Survey, 1958

Figure A-2. Lake Union Tunnel System

APPENDIX B
QUESTIONNAIRE SURVEY

- Transmittal Letter
- Questionnaire Form and Mailing List
  - General Business Category
  - Printer Category
  - Photographic and Design Category

METRO
Municipality of Metropolitan Seattle
Exchange Building • 821 Second Ave. • Seattle, WA 98104-1598

November 10, 1986

Attention: Businesses that discharge wastes to combined sewer system

Questionnaire Regarding Types of Industrial Wastes Discharged

Metro operates the sewage treatment plant that treats wastewater from your business. In your area and most of Seattle, storm and sanitary sewers are combined into one system. During rainstorms, street and roof drains often contribute volumes of runoff large enough to overload the capacity of the sewage conveyance system. When this overload occurs, the excess volume is discharged at relief points called combined sewer overflows (CSOs) that empty into local water bodies. The untreated mixture of raw sewage, industrial wastewater and stormwater runoff contains numerous toxic substances that contaminate the environment and degrade water quality.

A new law requires a reduction in the volumes discharged from CSOs. Metro recently developed a CSO control plan that will achieve these reductions. It will take many years, however, to complete construction of these control facilities. As an interim measure for reducing toxicants in the environment, Metro's industrial waste section is conducting a trial program to control toxicant sources in those areas with major CSO discharges.

Sewer and drain lines from your business are tributary to the Denny Way CSO, which discharges into Elliott Bay at Myrtle Edwards Park. Denny Way, the largest CSO entering Elliott Bay, is the primary source of high toxicant levels in bottom sediments near the CSO. Metro is developing reasonable recommendations for reducing the amount of toxicants discharged at the Denny Way CSO. Information about the major industrial dischargers in your area is already available through Metro's ongoing industrial waste program. However, Metro needs more information about wastewater flows from the general business community. Please help provide this information by completing the attached questionnaire and returning it to Metro by November 17, 1986. Because a number of representative businesses will be visited in November, your prompt reply will be appreciated.

Thank you for your cooperation.

QUESTIONNAIRE FROM METRO REGARDING

DENNY WAY CSO TOXICANT REDUCTION PROGRAM

I. Discharge Potential

Does your company:

...use water for anything other than restrooms? yes___ no___

If yes, please check the uses that apply:

rinsing___ cooling___ product manufacturing___
floor cleaning___ washdown___

What is the approximate volume____ (gallons)
and duration____ (hours) of this use per day?

...have storm drains, catch basins, sumps, or any other outlet to the sanitary sewer in the production or storage areas? yes___ no___

...store or mix liquid chemicals? yes___ no___

If yes, please list them:_____
_____
_____

II. General Information

NOTE: Please make any address label corrections needed here:

Firm name:_____
Address:_____Contact person:_____
City:_____ State:___ Zip code:_____ Phone number: _____

^Firm Name
^Street Address
^City, ^State ^Zip Code ^Phone Number

III. Business Category

Please state the product your company manufactures:_____
_____

OR:

Please state the service your company provides:_____
_____

Please complete this form, fold so that the return address is showing, staple and mail. Postage has been pre-paid.

If you have any questions or need more information, please call Keith Lund in Metro's industrial waste section at 684-2330. Thank you for your cooperation.

Companies sent GENERAL BUSINESS questionnaire

(those reponding to the survey are denoted by a \)

FIRM NAME	STREET ADDRESS	ZIP	PHONE #	SIC
\Energy Technology Company Inc	1216 Pine #201	98101	6221860	1799
Standard Process Laboratories	1932 1st Ave #930	98101	6226381	2834
Amdahl Corporation	1915 Terry Ave	98101	6822560	3573
Slidecraft Incorporated	1904 3rd Ave #415	98101	6223743	3861
\Tote Vision	1422 Seneca	98101	3254384	3651
Magic 108 Fm	1100 Olive Way #1550	98101	6223251	4832
Sunbelt Communications	1100 Olive Way #1550	98101	6223251	4832
\Boren & Stewart Chevron	1024 Stewart	98101	6237990	5541
\Goodyear Auto Service Center	1105 Stewart	98101	6240984	5531
Metro Imports Incorporated	1124 Pike	98101	6238983	5511
\Motor Sports International	1215 Stewart	98101	6231119	5511
Northwest Stores Group	1100 Virginia #104	98101	4676622	5541
Barg French Cleaners	1929 3rd Ave	98101	6223933	7216
\Bordeaux Photography	1100 Olive Way	98101	3400202	7221
City Custom Tailors	410 Virginia	98101	6226624	7219
Habit French Cleaners	312 Virginia	98101	6237131	7215
Rainbow International	1020 Virginia	98101	6280388	7217
Rainbow International Seattle	1020 Virginia	98101	9382147	7217
\Star Cleaners & Tailors	1118 Howell	98101	6230955	7216
\The Downtown Printing Company	1111 Howell	98101	6821300	7332
Big Dyno Motive	1808 Yale	98101	4677925	7538
\Fat City Volkswagen & Porsche	1726 Minor Ave	98101	6280911	7538
Japanese Auto Clinic	1000 Virginia	98101	4676600	7538
Norelco Service Incorporated	1910 3rd Ave	98101	6245830	7629
\Bedside X Ray	1111 Boren Ave #110	98101	6221900	8071
\Diagnostic Cytogenetics Inc	1214 Boylston Ave	98101	3282026	8071
\Northwest Medical Physics Ctr	1000 Seneca	98101	6250604	8071
\Boilermaker Apprenticeship	1829 Boren Ave	98101	6244707	8249
Puget Sound Institute Of Tech	1116 Summit Ave	98101	3231810	8249
\Marc G Getzen	2010 Broadway E #A	98102	3255811	1721
\Wicklund Woodworking	3241 Eastlake Ave E	98102	3252888	2434
\Aeroquip Corporation	2366 Eastlk Ave E #308	98102	3252720	3728
\Baker Company	3212 Harvard Ave E	98102	3230555	3111
\The Boat Yard Incorporated	3201 Fairview Ave E	98102	3233834	3732
Coolidge Propeller	1608 Fairview Ave E	98102	3255100	3362
Cummins Marine Repair & Refnsh	2925 Fairview Ave E	98102	3256714	3732
\Lake Union Boat Repair	3133 Fairview Ave E	98102	3235945	3732
\Lake Union Drydock Company	1515 Fairview Ave E	98102	3236400	3731
Lightolier Company	1910 Fairview Ave E	98102	3243845	3645
Priest Company	750 Belmont Ave E	98102	2547496	3523
\Remote Measurement Systems	2633 Eastlk Ave E #200	98102	3282255	3573
Ross Laboratories Incorporated	3138 Fairview Ave E	98102	3243950	3679
University Boat Service Inc	2370 Fairview Ave E	98102	3285363	3732
\Cadranell Yacht Landing	2370 Fairview Ave E	98102	3232309	4469

⌃Pacific Marine Charters	2323 Eastlake Ave E	98102	3255450	4469
⌃Thunderbird Marina	2925 Fairview Ave E	98102	3223576	4469
⌃Broadway & Roy Towing	700 Broadway E	98102	3220556	5541
Cascade Marine Incorporated	3245 Fairvw Ave E #103	98102	3233505	5551
⌃Broadway Chevron Station	915 E Roy	98102	3220195	5541
⌃T Kelly Chevron Station	2727 Eastlake Ave E	98102	3291240	5541
⌃Marine Service Center	2370 Fairview Ave E	98102	3232405	5551
⌃Olympic Yacht Center	10 E Allison	98102	3223880	5551
⌃The Truck Yard	3201 Fairview Ave E	98102	3235850	5531
⌃Broadway & Roy Union 76	700 Broadway E	98102	3294635	5541
⌃Wallace Ackerman Photography	1656 E Olive Way	98102	3241111	7221
⌃Apparel Restyling & Alteration	507 E Mercer	98102	3220949	7219
⌃Bellevue Avenue Cleaners	239 Bellevue Ave E	98102	3231500	7216
Four Seasons Cleaners	1800 E Olive Way	98102	3223200	7216
⌃Four Seasons Cleaners	2203 Eastlake Ave E	98102	3244341	7212
⌃Fox Cleaners	1611 E Olive Way	98102	3228218	7216
Floyd R Lee Photography	2837 Eastlake Ave E	98102	3220200	7221
Suds Shop	534 Summit Ave E	98102	2846816	7215
⌃Wandas Tenth Ave Cleaners	2405 10th Ave E	98102	3234370	7216
⌃Copy Mart Copy Centers	2920 Eastlake Ave E	98102	3297900	7332
⌃Mc Mop	2345 Minor Ave E #19	98102	3231934	7349
⌃Rent A Yenta Incorporated	1718 Olive Way E	98102	3258902	7349
Steves Sweep Company	528 11th Ave E	98102	3228216	7349
Television Marketing Corp	2517 Eastlake Ave E	98102	6245959	7391
⌃Ralli Round	1512 Fairview Ave E	98102	3238000	7538
⌃Scott S Sherman Inc	215 E Garfield	98102	3220886	7538
⌃Howisey Brothers Incorporated	1807 Eastlake Ave E	98102	3233010	7641
⌃Industrial Electric Mtr & McHn	1936 Fairview Ave E	98102	3293900	7629
⌃Odegard Upholstery	2203 Eastlake Ave E	98102	3257464	7641
⌃Pro Audio	2022 Fairview Ave E	98102	3622020	7622
Shirzad Jewelers	124 Broadway E #1/2	98102	3236788	7631
⌃TI Fa Typewriter Company	1631 E Olive Way	98102	3224544	7629
Harrison Dental Lab	1627 Eastlake Ave E	98102	3292900	8072
⌃Kong Dental Lab	310 Harvard Ave E	98102	3223996	8072
⌃Cornish Institute	710 E Roy	98102	3231400	8221

⌃Hauge & Hassain Incorporated	416 Dexter Ave N	98109	6224496	1721
Hiroshima Painting Company	411 Westlake Ave N	98109	6226006	1721
Larsson Marine Pnting Inc Arne	2552 Westlake Ave N	98109	2831373	1721
⌃Hollytex Carpet Mills	121 Boren Ave N #601	98109	6226140	2279
Horizon Industries Inc	121 Boren Ave N	98109	6242423	2271
Salem Carpet Mills Inc	121 Boren Ave N #619	98109	2510681	2272
Alexander Smith Carpets	121 Boren Ave N #647	98109	6238987	2279
⌃Artco Sign Company	800 Mercer	98109	6225262	3993
Aupperle Associates Inc	219 1st Ave N #375	98109	7898188	3623
Boyd Sign Company Inc	524 Dexter Ave N	98109	6246755	3993
Commercial Plastics Corp	1012 Fairview Ave N	98109	6824832	3079
⌃Communication Systems Inc	1165 Harrison	98109	6227477	3662
⌃Creations In Gold	9 Mercer	98109	2833614	3915
Expressigns	1308 Stewart	98109	6828242	3993
⌃Gray Design	1011 8th Ave N	98109	2823299	3599

↖ Holiday Fiberglass Marine Inc	1141 Fairview Ave N	98109	6233233	3732
↖ Messenger Signs Incorporated	1167 Mercer	98109	6234525	3993
↖ Meyer Sign Company Inc	512 Minor Ave N #1/2	98109	6244243	3993
↖ National Sign Corporation	1255 Westlake Ave N	98109	2820700	3993
Northwest Fabrication & Repair	120 Broad	98109	4418482	3599
↖ Pioneer Industries	504 Yale Ave N	98109	6824526	3599
↖ Precision Control Mfg Inc	1509 Q. A. Ave N #B	98109	2819380	3662
↖ Rainier Precision Incorporated	1150 Eastlake Ave E	98109	6248258	3079
↖ Seattle Sign Service	421 Minor Ave N	98109	6825771	3993
The Sign Group	1120 Fairview N	98109	6231364	3993
↖ Signpac Northwest	1255 Westlake Ave N	98109	2853090	3993
↖ Sun Supply Northwest Inc	1257 Republican	98109	6232555	3993
↖ Tube Art Displays Incorporated	808 Aloha	98109	2840420	3993
↖ West Earth Incorporated	406 Dexter Ave N	98109	6240013	3914
Midwest Industries Inc	1220 Westlake Ave N	98109	2852566	4469
↖ Rons Fairview Uphostery	1247 Westlake Ave N	98109	2829669	4469
↖ Mike Beasleys Chevron Service	1225 Denny Way	98109	6235723	5541
↖ Queen Anne Chevron	1417 Queen Anne Ave N	98109	2841090	5541
↖ Engel Industries Inc	215 Westlake Ave N	98109	6224804	5531
↖ Firestone Home & Auto	400 Westlake Ave N	98109	6228300	5531
↖ Independent Tire Dealers	215 Westlake Ave N	98109	6243733	5531
↖ Frank Kenney Toyota	731 Westlake Ave N	98109	3822000	5521
William O Mc Kay Company	609 Westlake Ave N	98109	6284711	5511
Pacific Lincoln Mercury Inc	601 Westlake Ave N	98109	6284756	5511
↖ Piston Service Of Westlake	1420 Queen Anne Ave N	98109	2829900	5531
↖ Evs Mercer Avenue Shell	601 Boren Ave N	98109	6230954	5541
Counter Balance Union Service	700 Queen Anne Ave N	98109	2841076	5541
Westlake Union Service	600 Westlake Ave N	98109	6238272	5541
Aarons Dry Cleaners	2 W Roy	98109	2828661	7216
↖ Fuzzy Wuzzy Rug Company	815 Eastlake Ave E	98109	6232957	7217
↖ Helenas Queen Anne Cleaners	537 Warren Ave N	98109	2820873	7216
Leathercare Incorporated	311 Fairview Ave N	98109	6824150	7219
↖ New Richmond Laundries	224 Pontius Ave N	98109	6223600	7213
Kris Renshaw	219 1st Ave N #324	98109	2836974	7221
↖ Superior Service Laundries Inc	1265 Republican	98109	6234700	7213
↖ Aamco Transmissions	900 Fairview Ave N	98109	6232688	7539
Complete Automotive Inc	717 Dexter Ave N	98109	2845500	7538
↖ Foreign Auto Rebuild	421 Eastlake Ave E	98109	6825186	7531
Joes General Automotive	1110 Dexter Ave N	98109	2853198	7538
↖ Marqueen Garage	1506 Queen Anne Ave N	98109	2859100	7538
Queen Anne Auto Body	420 Queen Anne Ave N	98109	2848565	7531
↖ Safelite Auto Glass	410 Terry Ave N	98109	6822263	7539
↖ Softky Brothers	1287 Westlake Ave N	98109	2826224	7539
Standard Auto Rebuild	114 Westlake Ave N	98109	6220085	7531
↖ Continental Auto Company	1405 Dexter Ave N	98109	2829833	7542
Perma Shine Systems	700 Queen Anne Ave N	98109	2829230	7542
↖ Red Carpet Car Wash	1164 Denny Way	98109	6243317	7542
↖ Electromatic Sales & Serv Inc	800 Mercer	98109	6243370	7623
↖ Motoradio Corporation	1231 Westlake Ave N	98109	2825522	7622
Radio One Incorporated	123 Eastlake Ave E	98109	6229777	7629
United Furniture Refinishers	219 Terry Ave N	98109	6825080	7641

G.B. (CONT.)

Drotning Dental Lab Inc	221 Minor Ave N	98109	6240578	8072
Mad Maintenance & Cnstrtn Comp	621 W Galer #100	98119	2852760	1721
Seattle Exhibit	151 Western W	98119	2830955	1799
Christopher & Sons	161 Western Ave W	98119	2824146	3172
Cutting Dies Northwest	117 W Denny Way	98119	2826998	3544
Datacorp	200 1st Ave W #105	98119	2853550	3861
Rainbow Metals Incorporated	501 Elliott Ave W #B	98119	2839727	3499
Skyline Electric Mfg Inc	203 W Thomas	98119	2848420	3613
Stream Associates Inc Ma	400 2nd Ave W	98119	2821311	4469
Pyramid Auto Sales	204 W Highland #304	98119	2831061	5511
Spic N Span Cleaners	127 W Mercer	98119	2847323	7216
Budget Home Services	221 W Republican	98119	2833000	7349
The Cleaning Connection	408 W Republican	98119	2859583	7349
Cynthia L Haavig	520 3rd Ave W #303	98119	2850418	7349
Micro Chem Laboratories Inc	602 Elliott Ave #1	98119	2840862	7397
Barneys Ace Auto Rebuild	600 Elliott Ave W	98119	2832774	7531
Elliott Tire & Service	444 Elliott Ave W	98119	2840600	7538
Hobbs Hilltop Automotive Inc	205 W Galer	98119	2838700	7538
Taylor Brake Service Co	602 Elliott Ave W	98119	2848610	7538
Main Office Machines Company	422 1st Ave W	98119	2820302	7629
Bayview Manor	11 W Aloha	98119	2847330	8051
J K Associates	1000 Lenora #221	98121	4678150	2522
Seattle Envelope Incorporated	3131 Western Ave #524	98121	2842172	2642
Woolridge Woolen Down Products	2609 1st Ave	98121	6246930	2253
A T & T Technologies	2121 4th Ave #1350	98121	3820666	3661
Advance Marking Systems	419 Cedar	98121	7288888	3993
Avanti Plastics	66 Bell	98121	4434644	3079
Azose & Son Incorporated	2018 3rd Ave	98121	6225323	3911
Berts Art & Sign	2131 3rd Ave	98121	6246633	3993
Kenneth L Block	2013 3rd Ave	98121	4419941	3823
Digital Microwave Corporation	2815 2nd Ave #500	98121	4480820	3662
Gem East Corporation	2124 2nd Ave	98121	6238445	3911
Hoy Textiles	3131 Western Ave #417	98121	2837556	3552
Ikon Corporation	2617 Western Ave	98121	6243410	3573
Kaye Smith Productions	2212 4th Ave	98121	6248651	3652
Mobile Communications Company	2131 1st Ave	98121	2853252	3651
Nasty Mix Records	3161 Elliott Ave	98121	2829639	3652
Obie Outdoor Advertising	3161 Elliott Ave	98121	2835577	3993
Quinton Instruments	2121 Terry Ave	98121	2237373	3841
The Sign Company	2600 Western Ave	98121	7281898	3993
Skyway Luggage Company	10 Wall	98121	6235300	3161
Symetrix Incorporated	109 Bell	98121	6245012	3651
Thompson & Thompson Creative	2320 1st Ave	98121	4471971	3652
Zepeda Instruments	2412 2nd Ave	98121	4410220	3841
A Putco	2401 4th Ave #1200	98121	5838100	4469
Kensai Steamship Company Ltd	2701 1st Ave	98121	3821057	4469
Aaron Mc Kiernan	2018 1st Ave	98121	4414020	4833
Evans Auto Sales	2116 Westlake Ave	98121	6241765	5511
Huletz Electric	2017 7th Ave	98121	6227977	5531

G.B. (CONT.)

Kenney Toyota Volvo	2200 Westlake Ave	98121	3821307	5521
Ross Display Fixture Company	3031 Western Ave	98121	6223126	5531
Schucks Auto Supply	2229 7th Ave	98121	6242446	5531
Standard Service Tire Company	2020 8th Ave	98121	6284977	5531
University Chevrolet Company	2121 8th Ave	98121	6822438	5511
University Chevrolet Used Car	2114 Westlake Ave	98121	6233229	5511
Westlake Chevrolet Company	2030 8th Ave	98121	6234122	5511
Carriage House Cleaners	2000 Fairview Ave	98121	4640040	7216
Nick Jahn Photography	3131 Western Ave #517	98121	2818798	7221
Siddoways Dry Clng Elegance	2801 2nd Ave	98121	6827107	7216
Fox Studio	3131 Western Ave	98121	2846597	7332
Printsource	2404 3rd Ave	98121	4415599	7332
Seattle Photocopy Company	111 Battery	98121	4414498	7332
Property Maintenance Company	2101 9th Ave #204	98121	5870707	7349
Alpha Cine Laboratory Inc	1001 Lenora	98121	6828230	7395
Emerald City One Hour Photo	411 Cedar	98121	4417721	7395
Northwest Photographics	2234 1st Ave	98121	4417507	7395
The Slide Company	2419 2nd Ave	98121	4410514	7395
Accu Tran	2408 4th Ave	98121	6242291	7539
Dean Transmissions	2120 4th Ave	98121	6222510	7539
Durham Sunroofs & Upholstery	2227 9th Ave	98121	6823500	7531
Electro Check Auto Diag Center	305 Bell	98121	6231200	7538
European Motors Corporation	2223 9th Ave	98121	6223406	7538
German Autowerke	2801 1st Ave	98121	6259355	7538
Holmans Body & Fender Shop	2324 2nd Ave	98121	6237870	7531
The Import Doctors	211 Bell	98121	6242324	7538
Jules Glass & Upholstery	2116 4th Ave	98121	6220741	7539
Midas Muffler Shops	2331 7th Ave	98121	6828252	7539
Sarco Incorporated	2416 2nd Ave	98121	6825977	7629
Seattle Goldsmith Incorporated	2036 2nd Ave	98121	3401509	7631
Seattle Horological Clinic	307 Broad	98121	4415656	7631
Hundredwaters	2220 1st Ave	98121	6822664	8411
Stonington Gallery	2030 1st Ave	98121	6211108	8411
Arensberg Sons Incorporated	1428 10th Ave	98122	3237111	3131
Foley Sign Company Inc	1205 E Pine	98122	3243040	3993
Form & Function Gallery	516 E Pine	98122	3228175	3269
Foster Music Resources	619 E Pike	98122	3246613	3652
Gerais Pebble Works	1815 18th Ave	98122	3226360	3911
The Music Source	615 E Pike	98122	3236847	3652
National Microcomputer	1705 E Howell	98122	3225114	3573
Phinney Ridge Musical Productn	621 E Pike	98122	3253777	3652
Auto Accessories Incorporated	1520 13th Ave	98122	3222180	5531
British Auto Parts Geon	1325 E Madison	98122	3224366	5531
Lou Rentas Chevron Station	1531 Broadway	98122	3293331	5541
Downtown Nissan Incorporated	420 E Pike	98122	3222800	5511
General Parts Company	1017 E Union	98122	3248457	5531
Grand Prix Motors Limited	1401 12th Ave	98122	3297070	5511
George Grasst Incorporated	905 E Pike	98122	3299650	5531
Broadway Gull	1500 Broadway	98122	3240919	5541
Macready T B A INCORPORATED	1512 11th Ave	98122	3294800	5531

G.B. (CONT.)

Morseth Auto Parts	1222 E Pine	98122	3237668	5531
Motor Specialty Company	620 E Pine	98122	3227700	5531
Rowland Motors Sales & Leasing	517 E Pike	98122	3248488	5511
Phil Smart Incorporated	600 E Pike	98122	3242500	5511
Broadway & Madison Union 76	1100 Broadway	98122	3243344	5541
United Transmission Service Co	1134 Broadway	98122	3242424	5531
The Apparel Production Company	1205 E Pike	98122	3234344	7219
Bonney Watson	1732 Broadway	98122	3220013	7261
Broadway Cleaners & Dyer Corp	1824 Broadway	98122	3253640	7212
Butterworth Manning Ashmore	300 E Pine	98122	6220949	7261
Capitol Hill Cleaners & Lndry	1314 E Pike	98122	3280066	7216
Mars Cleaners	508 E Pine	98122	3226422	7216
Royal Cleaners & Laundry	1406 E Pike	98122	3247401	7216
Joe Spates The Cleaner	1722 E Madison	98122	3250377	7216
Biomed Research Laboratories	1115 E Pike	98122	3240380	7391
Precision Laboratory	1409 E Madison	98122	3282040	7397
Akers Foreign Auto Repair	1414 Broadway	98122	3295253	7538
Auto Battery Electric	1009 E Union	98122	3223905	7539
British Italian Car Center	1527 Harvard Ave	98122	3257233	7538
Callahans Auto Rebuild Inc	1319 E Madison	98122	3229044	7531
Capitol Hill Automotive Servic	1513 Broadway	98122	3250161	7531
The Car Tender Incorporated	1706 12th Ave	98122	3240345	7538
Carburetor Specialty Inc	1517 12th Ave	98122	3237172	7539
Central Auto Rebuild Limited	1514 Broadway	98122	3248736	7531
Davis & Hoffman Incorporated	1406 10th Ave	98122	3228700	7531
Flanagan Auto Incorporated	1117 12th Ave	98122	3251512	7538
Flick & Rash Auto Repair	721 E Pine	98122	3233734	7538
Garlick Manufacturing Company	1419 12th Ave	98122	3258106	7531
Kesslers Foreign Car Repair	1218 10th Ave	98122	3244771	7538
Mecum Collision Repair	1720 12th Ave	98122	3235252	7538
Metro Auto Rebuild	1510 Melrose	98122	6236336	7531
Northwest Frame & Wheel Alignm	310 E Pike	98122	6825727	7539
Prospect Motors	415 E Pike	98122	6829486	7531
Queen City Auto Rebuild Inc	1609 Boylston Ave	98122	3259660	7538
Ruthfords Auto Rebuild	1426 Broadway	98122	3296100	7531
Solomons Automotive	1011 E Pike	98122	3258467	7538
Spray King Auto Painting Inc	1534 11th Ave	98122	3240300	7531
Twelth Avenue Auto Rebuild	1114 E Union	98122	3234094	7538
Madison Street Union 76	1700 E Madison	98122	3253356	7538
Keyes Etc	1114 E Union	98122	3221600	7542
Capital Hill Clock Shop	1205 E Pike #2 E	98122	3226900	7631
The Dovetail Joint	1309 E Olive	98122	3237103	7641
Globe Restoration & Conservatn	1524 E Olive Way	98122	3295666	7641
Kanes Tv & Video	915 E Pike	98122	3255513	7622
Van Lowes Business Equip Inc	1316 E Pine #1/2	98122	3299155	7629
Branch Manor	1103 16th Ave	98122	3249021	8051
Carriveau Dental Lab	1001 Broadway #318A	98122	3237794	8072
Gartin Dental Laboratory	1001 Broadway	98122	3228270	8072
International Clinical Labs NW	1100 E Union	98122	3256100	8071
Jacobsen Nursing Home	1810 11th Ave	98122	3235321	8051
Physicians Medical Laboratory	1001 Broadway	98122	3221280	8071

QUESTIONNAIRE FROM METRO REGARDING

DENNY WAY TOXICANT REDUCTION PROGRAM

I. Discharge Potential

Does your company:

...discharge waste to the sewer from any of the following processes?

____silkscreening ____photography ____dot-etching metal plates
____cleaning of hand tools, mixing vessels, rollers, etc.

If so, what is the approximate volume____(gallons) and duration___(hours) of each discharge per day?

...have storm drains, catch basins, sumps, or any other outlet to the sanitary sewer in the production or storage areas?

How many presses does your company operate?_____

Do you use water based or solvent/oil based ink?_____

What do you do with your waste ink?_____
_____

Do you use blanket wash?_____

If so, how do you dispose of it?_____
_____

II. General Information (Please include corrections if needed)

`Firm Name
`Street Address
`City, `State `Zip Code `Phone Number

Firm name:_____
Address:_____Contact person:_____
City:_____State:_____Zip Code:_____Phone:_____

Please complete this form, fold so that the return address is showing, staple and mail. Postage has been pre-paid.

If you have any questions or need more information, please call Keith Lund in Metro's industrial waste section at 684-2330. Thank you for your cooperation.

Companies sent PRINTERS questionnaire (SIC=27__)

(those responding to the survey are denoted by a \)

FIRM NAME	STREET ADDRESS	ZIP	PHONE #
\Advanced Business Services	1402 3rd Ave #414	98101	6223274
\Auto & Flat Glass Journal	303 Harvard Ave E #101	98102	3225120
\Bear Creek Publications	2507 Minor Ave	98102	3223189
\Coles Directory	2722 Eastlake Ave E #340	98102	3227590
Contact Northwest	801 E Harrison #618	98102	3259405
Farrow Forms Design	3204 Franklin Ave E	98102	3246060
G & H Printing Incorporated	2370 Eastlake Ave E	98102	3299888
\Grawin Publications Inc	303 Harvard E #101	98102	3225120
\One Day At A Time	2022 Fairview Ave E	98102	3225313
\Pica Place	2714 Eastlake Ave E	98102	3239194
\Portage Bay Printing	2917 Fuhrman Ave E	98102	3257885
Travelhost Magazine	2366 Eastlake Ave E #413	98102	3226299
Washington Magazine	1500 Eastlake Ave E	98102	3285000
\A & A Instant Print	320 Queen Anne Ave N	98109	2853883
A B C D	915 Yale Ave N #200	98109	4479511
Advertising Services Inc	325 Westlake Ave N	98109	6236963
\Allied Quick Print	306 Dexter Ave N	98109	6225711
\Athletic Awards Company	817 Republican	98109	6243995
\Automatic Funds Transfer Serv	2040 Westlake Ave N #313	98109	2855658
\Bayless Bindery Incorporated	427 9th Ave N	98109	6226395
Boat Scope	2148 Westlake Ave N	98109	2817447
\Book Publishing Company	201 Westlake Ave N	98109	3435700
\The Business Forms Company	1104 Mercer	98109	6230199
\Color Service Incorporated	509 Fairview Ave N	98109	5870278
Compendium Marketing & Pblshng	1414 Dexter Ave N	98109	2811117
\Contractors Weekly	1213 Valley	98109	6227053
\Craftsman Press Incorporated	1155 Valley	98109	6828800
\Creative Printing & Graphics	216 Westlake Ave N	98109	6251500
Datamac Incorporated	1209 Mercer	98109	6824100
Envelopes Unlimited Inc	409 Yale Ave N	98109	6239333
Fishing & Hunting News	511 Eastlake Ave E	98109	6243845
\Holly Press	217 8th Ave N	98109	6232444
Korea Times	1121 Dexter Ave N	98109	2820022
Latin America Information Line	1219 Westlake Ave N #104	98109	2830181
\Mc Kay Printing Corporation	202 Westlake Ave N	98109	6230650
\Outdoor Empire Publishing Inc	511 Eastlake Ave E	98109	6243845
Pacific Business Forms	1104 Mercer	98109	6232128
Pacific Northwest Magazine	222 Dexter Ave N	98109	6822704
\Pacific Search Press Warehouse	220 Terry Ave N	98109	6825893
\Pacific Search Publications	222 Dexter Ave N	98109	6825044
Pro Litho Printing	119 Yale Ave N	98109	6227371
Puget Sounds Entertainmnt Wkly	975 John #111	98109	6826674
\Rothaus Honey & Associates Inc	1414 Dexter Ave N #316	98109	2849922
\Scanner Graphics Incorporated	325 Minor Ave N	98109	6244469
\Seattle Bindery & Mailing	1016 Republican	98109	6822558

Seattle Lithograph Company Inc	1015 Republican	98109	6822520
Seattle Times Main Office	1120 John	98109	4642460
Service Printing Company Inc	1165 Mercer	98109	6224800
Thompson Printing Corporation	401 Dexter Ave N	98109	6233512
Trade Printery Incorporated	110 Denny Way	98109	2841600
The Type Gallery	1121 Westlake Ave N	98109	2856333
Typehouse	1329 Aloha	98109	6235128
Western Graphics Incorporated	219 9th Ave N	98109	6242010
Windward Press	219 Pontius Ave N	98109	3821117
Adsco Printing Incorporated	315 1st Ave W	98119	2848220
Arctic Printing & Graphics	501 2nd Ave W	98119	2817600
Cats Away Printing	401 Elliot Ave W	98119	2832715
Clearing Up	1015 1st Ave W	98119	2852332
Colonial Typesetting	508 2nd Ave W	98119	2825858
Cornerstone Company	401 Elliot Ave W	98119	2833508
Custom Press	114 W Denny Way	98119	2818115
Diers Bindery Incorporated	310 W Republican	98119	2844243
Emerald City Letter Press	401 Elliot Ave W	98119	2833512
Graphic Arts Center	200 1st Ave W #305	98119	2843410
Janco Printing	401 Elliott Ave W	98119	2833745
L & H Engraving Company Inc	100 Elliott Ave W	98119	2850146
Masonic Tribune	225 W Galer	98119	2851505
Master Press Incorporated	505 3rd Ave W	98119	2831560
The Mountaineers Books	306 2nd Ave W	98119	2852665
Newsdata	1015 1st Ave W #1/2	98119	2854848
Nfl Hotline	120 W Harrison	98119	2854651
P I P Printing	201 Elliott Ave W #130	98119	2826066
Phils Custom Bindery	100 Elliott Ave W	98119	2851523
Pickup Printers	312 2nd Ave W	98119	2844820
Pioneer Newspapers Inc	221 1st Ave W #405	98119	2844424
Queen Anne Magnolia News Inc	225 W Galer	98119	2820900
James G Scripps Newspapers Inc	221 1st Ave W #405	98119	2844424
Springs Litho Printing Inc	425 3rd Ave W	98119	2823511
Sudden Printing	513 Queen Anne Ave N	98119	2851006
Trinity Galleries Ltd	428 2nd Ave W	98119	2837421
Turman Publishing	200 W Mercer #508	98119	2826900
Two Dimensions	501 Elliott Ave W	98119	2831742
Tahoma Press Incorporated	123 W Harrison #300	98119	2832729
U S Sports Publications	120 W Harrison	98119	2823725
Vernon Publications Inc	109 W Mercer	98119	2852050
Viking Press	130 Elliott Ave W	98119	2833650
Van Dyke Agency Press	2815 2nd Ave #506	98121	4641550
Art Foto Typography	2026 2nd Ave	98121	6220218
Binder Products Incorporated	2323 3rd Ave	98121	6240385
Comp Shop	2224 1st Ave	98121	4410156
Compu Type	2706 3rd Ave	98121	6227845
Consolidated Press Printing Co	2228 1st Ave	98121	4411844
Orrin F Drew Fine Printing Inc	2015 2nd Ave	98121	4414243
Evergreen Publishing	901 Lenora	98121	6248400
Frayn Printing Company	2518 Western Ave	98121	4414222
G M R Printing	3124 Elliott Ave #Bay 12	98121	2818366
The Grange News	3104 Western Ave	98121	2841753
Graphic Impressions	3018 Western Ave	98121	4413645

SIC= 27__ (CONT.)

Graphicolor Incorporated	3018 Western Ave	98121	4415700
William R Johnson Company	3130 Elliott Ave	98121	2847755
Keystrokes	115 Cedar	98121	6235236
Kroll Map Company Incorporated	2700 3rd Ave	98121	6228172
The Litho House	63 Clay	98121	4419800
Lithographics	2107 9th Ave	98121	6229016
Modern City Printing Company	2022 2nd Ave	98121	6235471
Murray Publishing Company	2314 3rd Ave	98121	6823560
Frank Potter & Associates	2101 9th Ave	98121	6238844
Quality Press Incorporated	2208 2nd Ave	98121	5830639
Rocket Type	2322 2nd Ave	98121	4430477
Save On Printing	2017 2nd Ave	98121	6231720
Scanner	2800 1st Ave #114	98121	6827102
Seattle Magazine	2815 2nd Ave #508	98121	6232848
Serigraphics	3135 Western Ave	98121	2844454
Sir Speedy Printing Center	2012 3rd Ave	98121	4419047
Camerart	820 E Pike	98122	3243840
Columbine Printing	1205 E Pike	98122	3238007
Copy Mart Copy Centers	11th & E Madison	98122	3255900
Data Print	616 E Pine	98122	3233632
Edds Printing Company	1507 Belmont Ave	98122	3259934
Heath Printers	1617 Boylston Ave	98122	3233577
Industrial Printers	1724 17th Ave	98122	3246282
Interchecks Incorporated	1428 Harvard Ave	98122	3231234
K C M S Printing	1507 Belmont Ave	98122	3259988
New Method Printing Inc	1515 14th Ave	98122	3240173
Our Town Publications	211 E Denny Way	98122	3252008
Peoples Daily World	1408 18th Ave	98122	3299505
The Richmark Company	1110 E Pine	98122	3228884
Rogers Printing Company	1507 Belmont Ave	98122	3259938
The Real Comet Press	500 E Pike	98122	3281801
S G N Graphics	910 E Pike #A	98122	3237882
Storefront Press	514 E Pine	98122	3223150
Sudden Printing	1618 Broadway	98122	3231142
Teller Printing Company	1518 E Olive Way	98122	3254300
United Graphics Incorporated	1401 Broadway	98122	3254400
Waterlines	1631 Belmont Ave	98122	3241333
VALCO GRAPHICS	3104 WESTERN AVE.	98121	2841755
WESTERN TYPOGRAPHERS, INC.	2403 2ND AVE.	98121	6243642

QUESTIONNAIRE FROM METRO REGARDING

DENNY WAY TOXICANT REDUCTION PROGRAM

I. Discharge Potential

Does your company engage in any of the following processes?:

_____photography _____silkscreening _____dot-etching metal plates

photographic processes

-how many cameras/processors do you use?_____
-what type and size are they?_____
-what kind of development process do you use?_____
_____
-do you have a silver recovery system?_____, or, do you use a silver reclamation service?_____ what materials are reclaimed?_____
_____

silkscreening

-what solvents are used to clean your screens?_____
_____
-what kinds of inks or pigments do you use?_____
_____

*how do you dispose of your waste chemicals (developer, inks, solvents, etc.)? _____sanitary sewer _____storm drain _____dumpster _____other

*If you discharge wastes to the sewer, what is the approximate volume _____(gallons) and duration_____ (hours) of this discharge per day?

II. General Information (please include any corrections if needed)

^Firm Name
^Street Address
^City, ^State ^Zip Code ^Phone Number

Firm name:_____
Address:_____ Contact person:_____
City:_____ State:_____ Zip code:_____ Phone:_____

Please complete this form, fold so that the return address is showing, staple and mail. Postage has been pre-paid.

If you have any questions or need more information, please call Keith Lund in Metro's industrial waste section at 684-2330. Thank you for your cooperation.

Companies sent PHOTO/GRAPHIC DESIGN questionnaire (SIC=7333)

(those responding to the survey are denoted by a \)

FIRM NAME	STREET ADDRESS	ZIP	PHONE #
\Alyson Burns Design	1212 Minor Ave	98101	6243252
Magicmation Incorporated	1100 Olive Way #1560	98101	6828235
Stanton Burns & Bondo Inc	1212 Minor Ave #500	98101	6249592
Wear On Earth	1108 Pike	98101	6231632
Phototron Northwest	315 Virginia	98101	6248501
Claudine Graphics	747 Bellevue Ave E	98102	3245967
\M P Curtis Photography	233 Summit Ave E	98102	3231230
Doely Commercial Photographers	1058 E Harrison	98102	3224876
Ruth E Draheim	732 Belmont Pl E	98102	3298008
\David C Ensley & Associates	615 Bellevue Ave E #210 F	98102	3291384
\Lisa Farin Design	223 E Boston	98102	3223108
\Glenn Garner Designers	2366 Eastlake Ave E	98102	3237788
\Graphic Reactions	301 E Thomas #A4	98102	3281002
\Vern L Green Photographers	2218 Broadway E	98102	3293269
\Hamlin Pier Communication	2727 Fairview Ave E #F	98102	3222085
Doug Hansen Design Inc	3123 Fairview Ave E #C	98102	3220998
Illustration Design	2018 Franklin Ave E	98102	3221935
\Bud Johnson Graphic Design	123 Boylston Ave E	98102	3296993
Jorgensen Artists Rep	609 Summit Ave E	98102	2845080
\Adrian Kalar & Friends	1604 Lakeview Blvd E	98102	3241775
Ben Kerns Photography	233 Summit Ave E	98102	3231230
Chris Maple Design	2727 Fairview Ave E	98102	3280691
Martin & Cox	3123 Fairview Ave E	98102	3245167
Milkie Studio	127 Boylston Ave E	98102	3243000
Pacific Marine Center	1801 Fairview Ave E	98102	4427656
Alan Tenuta Graphic Design	2727 Fairview Ave E #F	98102	3248934
Watermark Company	2712 Eastlake Ave E	98102	3225200
Film Stop	617 Broadway E #1/2	98102	3224086
\Advertising Graphics Inc	2306 4th Ave	98121	5830190
\Art Attack	2606 3rd Ave	98121	3430428
Camera Craft Incorporated	2312 2nd Ave	98121	6820996
\Chroma Copy	2720 3rd Ave	98121	5870840
Corporate Design	2030 1st Ave #201	98121	2929403
Cliff Fiess Photography	3131 Western Ave #517	98121	2818798
Richard S Gibbs	2916 Western Ave	98121	6226791
\Genesis One Design	3028 Western	98121	4439005
David Hampton Corporate Design	2030 1st Ave #201	98121	4439362
Scott Herren Designs	3131 Western Ave #417	98121	2829330
Imagic Color Incorporated	417 Vine	98121	6230237
Randal Jacoby Photography	115 Bell #100	98121	4410954
\Menu Workshop	2815 2nd Ave #460	98121	4439581
\Northwest Architectural Co	303 Battery	98121	4414522
Carl Smool Miscellaneous Artwk	101 Wall	98121	5870513
Alpha Cine Laboratory Inc	1001 Lenora	98121	6828230
\Emerald City One Hour Photo	411 Cedar	98121	4417721
Northwest Photographics	2234 1st Ave	98121	4417507
The Slide Company	2419 2nd Ave	98121	4410514

Company Stiles	2315 10th Ave E	98112	9326288
\Bruce Carroll Photographer	517 Dexter Ave N	98109	6232119
Commercial Displayers	429 Eastlake Ave	98109	6228039
George Costa & Associates	300 Fairview Ave N	98109	5870505
J Curtis Photography	1022 Yale Ave N	98109	6228848
\George King Design Associates	158 Thomas #11	98109	4484488
\Carl Le Jon Associates	419 Queen Anne Ave N #107	98109	2838586
\Roger Schreiber Photographer	429 Boren Ave N	98109	6223525
\Shooting Gallery	1121 Westlake Ave N	98109	2856444
\Slide Gallery Incorporated	1121 Westlake Ave N	98109	2856600
\Werrbach Studios Incorporated	534 Westlake Ave N	98109	6226282
\Westlake Graphics	507 Yale	98109	6821515
White Sign & Graphic Design	601 Eastlake Ave E	98109	4479671
Zeppelin Studio	423 Minor Ave N	98109	5830606
Medrecs Copying Service Inc	701 Dexter Ave N #205	98109	2851420
\Ivey Seright Incorporated	424 8th Ave N	98109	6238113
\Tokyo Photo	766 Thomas	98109	6237479
Advertising & Commercial Photo	1507 Belmont Ave	98122	3223377
Common Line Communication Svc	1833 Nagle Pl	98122	3228800
\Conrad & Company	719 E Pike	98122	3242208
Jim Cummins Studio Inc	1527 13th Ave	98122	3224944
Effective Design Studio	1418 Bellevue Ave	98122	6218989
\Jim Fagiolo	700 E Pike	98122	3223580
Dave Hagyard Photography	1205 E Pike	98122	3228419
Insight Photography	1418 Broadway	98122	3234985
Perimeter Graphic & Sign Co	1605 12th Ave	98122	3291881
Pisano Archtctrl Photography	911 E Pike #301	98122	3246092
Visual Communications	1605 12th Ave #12	98122	3291750
Willitts Design	417 E Union #206	98122	6237686
\Woodfin Design	1516 Melrose Ave	98122	3821516
\Marketplace Photo	426 Broadway	98122	6242551
Superposter	1814 Bellevue Ave	98122	3223700
\Carl Bennett Design	105 W John	98119	2823137
Ben Dennis & Associates	107 W John	98119	2853171
\Graphic Chromatics	129 1st Ave W	98119	2824683
\Barry Gregg Photography	300 2nd Ave W	98119	2858695
L Hamrick Design Photography	159 Western Ave W #484	98119	2840920
Kip Kaufman Photography	524 4th Ave W #3	98119	2829150
\Latona Productions	159 Western Ave W	98119	2855779
David Marty Design	425 3rd Ave W	98119	2826250
\Jeff Miller Photography	300 2nd W	98119	2855975
\N W Graphics Schroeder & Assoc	306 W Republican	98119	2832143
Rabbit Stat	3131 Western #23	98119	2846591
\David Turrill Creative	300 Elliott Ave W #420	98119	2836200
Upstream Productions	420 1st Ave W	98119	2819177
\Ellen Ziegler Graphic Design	114 W Denny Way #250	98119	2856300
Film Stop	508 3rd Ave W	98119	2852111

APPENDIX C
SITE INSPECTIONS

- o Name and Address of each Company Visited
  - Companies with Discharges
  - Companies without a Discharge
- o Business Category and Discharge Volume for companies visited

Denny Way Site Investigations
Companies With Discharge

COMPANY	ADDRESS	ZIP	VOLUME *
International Clinical Laboratories	1100 E Union	98122	4
The Richmark Company	1110 E. Pine	98122	2
Corey Sign Co.	1492 Crawford Place	98122	2
Downtown Nissan	420 E. Pine	98122	2
United Transmission Specialists	1134 Broadway	98122	2
Rowland Motors	517 E. Pike	98122	2
United Graphics	1401 Broadway	98122	1
Foley Sign Co	1205 East Pine	98122	1
Gartin Dental Laboratory	1001 Broadway	98122	1
5 Point Cleaners	1001 Madison	98122	1
Butterworth Manning Ashmore	300 E. Pine	98122	1
Otto's Radiator	953 East Union	98122	1
Phil Smart,Inc	600 E. Pike	98122	1
Flanagan Automotive/A-1 Imports	1117 12th Ave.	98122	1
Flick and Flash auto Repair	721 East Pine	98122	1
Carburetor Specialty,Inc.	1517 12th Ave.	98122	1
Car Tender Incorp	1706 12th Ave	98122	1
Alpha Cine	1001 Lenora Street	98121	4
Reflections Auto Detailing	305 Bell Street	98121	3
Frank Potter & Ass,Inc. Printers	2101 Ninth Avenue	98121	2
Auto Detail	1915 2ond Ave	98121	2
Valco Graphics	3104 Western	98121	1
Week end	2312 3rd Ave.	98121	1
Ikon Corporation	2617 Western Ave	98121	1
Hundredwaters	2220 1st Ave.	98121	1
Standard Service Tire	2020 8th Ave.	98121	1
Quinton Instruments Co.	2121 Terry Ave.	98121	1
European Motors	2223 9th Ave	98121	1
Import Doctor	211 Bell Street	98121	1
Seattle Auto Glass	2217 9th	98121	1
Frank Kenny Toyota Service	731 Westlake	98121	1
Two Dimensions	501 Elliot	98119	1
Graphic Chromatics	129 1st West #208	98119	2
Data Corp./Kalvar Corp.	200 1st W # 105	98119	2
Westours Printshop	204 W. Republican	98119	1
Artic Graphics and Printing	501 2ond Ave.	98119	1
Seattle Exhibit	151 Western	98119	1
Hoy Textiles	3131 Western Ave#417	98119	1
Ivy Sergight, Inc	424 8th Ave. No.	98109	4
Forde Motion Picture Lab	306 Fairview North	98109	4

*1 = <50 gpd
2 = 50-100 gpd
3 = 100-500 gpd
4 = >500 gpd

Denny Way Site Investigations
Companies With Discharge

COMPANY	ADDRESS	ZIP	VOLUME *
Western Graphics, INc.	219 9th	98109	3
Fuzzy Wuzzy Rug Co.	815 Eastlake	98109	3
Greyhound Lines, Inc.	1250 Denny Way	98109	3
Craftsman Press	1155 Valley	98109	2
Seattle Lithograph Co.	1015 Republican	98109	2
Drothing Dental Lab	221 Minor Ave. N.	98109	2
West Earth Incorporated	406 Dexter	98109	2
Gray Design	1011 8th Ave North	98109	2
Pacific Lincoln Mercury	601 Westlake No	98109	2
Brad's Machine - Regalia Auto Parts	401 Westlake North	98109	2
Auto Service Company	630 Westlake Ave. No	98109	2
The Type Gallery	1121 Westlake Ave.	98109	1
Service Printing	1165 Mercer	98109	1
Creative Printing and Graphics	216 Westlake Ave. N	98109	1
Outdoor Empire Publishing	511 Eastlake Ave. E	98109	1
Envelopes Unlimited	409 Yale	98109	1
Windward Press	219 Pontius Ave. No.	98109	1
Zeppilin	423 Minor Ave. N	98109	1
Tube Art Displays Incorporated	808 Aloha	98109	1
Westlake Graphics	507 Yale	98109	1
Boyd Sign Company, Inc.	524 Dexter Ave. No.	98109	1
Pioneer Industries	504 Yale North	98109	1
Howisey Brothers Upholstry	1807 Eastlake E	98102	2
Messenger Signs, Inc	1167 Mercer	98102	1
AAMCO Transmission	900 Eastlake	98102	1
Fat City VW & Porsche	1726 Minor Ave	98101	2
Big Dyno Motive	1808 Yale	98101	1

*1 = <50 gpd
2 = 50-100 gpd
3 = 100-500 gpd
4 = >500 gpd

Denny Way Site Investigations
No Discharge Companies

COMPANY	ADDRESS	ZIP	STORAGE
Metropolitan Savings and Loan	1000 Olive Way	98101	ok
Pacific Marine Center NOAA	1801 Fairveiw Ave.E	98102	ok
Laser Graphics	1605 12th E.	98102	ok
Antique Liquidators	503 Westlake Ave.N.	98109	ok
Seattle Sign Service	421 Minor Ave. N.	98109	ok
Commercial Plastic Corp	1012 Fairveiw North	98109	ok
Graffix	505 Yale North	98109	ok
Pacific NW Bell	900 Terry Ave.	98109	ok
University Chev Body and Paint	114 Westlake N	98109	ok
People's Choice Vending	411 Westlake	98109	ok
Aupperle Associates,inc	219 1st Ave N. #375	98109	ok
Nelson truck and Equipment Co.	128 Westlake Ave. N.	98109	ok
Express Signs	1308 Stewart	98109	ok
Financial Systems	321 Minor North	98109	ok
Leathercare Inc.	901 Elliot Ave w	98119	ni
The Sign Company	2600 Western Ave	98121	ok
Crecent Arms Dry Cleaning	2801 2ond Ave.	98121	ni
Johnny's Machine	2121 Westlake	98121	ok
Durham Sunroofs	2227 9th	98121	ok
Seattle Goldsmith	2036 2ond Ave. 98121	98121	ok
Spectrum Ink Company	1430 Summit Ave	98121	ok
Brithish Italian Car Parts	1527 Harvard Ave.	98121	ok
Huletz Auto Electric	2017 7th Ave	98121	ok
Capital Hill Auto Rebuild	1513 Broadway	98122	ok
Rutherfords Auto Rebuild	1426 Broadway	98122	ok
Prospect Motors	415 E. Pine	98122	ok
Royal Cleaners	1406 E. Pike	98122	ok
Central Auto Rebuild Limited	1514 Broadway	98122	ok

Denny Way Site Investigations
Categories, Volumes

COMPANY	VOLUME*	CATEGORY	HOLD**
International Clinical Laboratories	4	general	n
The Richmark Company	2	print	y
Corey Sign Co.	2	graphic	y
Downtown Nissan	2	auto-e	y
United Transmission Specialists	2	auto-e	y
Rowland Motors	2	auto-b	n
United Graphics	1	print	y
Foley Sign Co	1	graphic	y
Gartin Dental Laboratory	1	General	n
5 Point Cleaners	1	general	n
Butterworth Manning Ashmore	1	general	n
Otto's Radiator	1	auto-e	y
Phil Smart,Inc	1	auto-e	y
Flanagan Automotive/A-1 Imports	1	auto-e	y
Flick and Flash auto Repair	1	auto-e	n
Carburetor Specialty,Inc.	1	auto-e	y
Car Tender Incorp	1	auto eng	y
Alpha Cine	4	photo	n
Reflections Auto Detailing	3	auto-b	n
Frank Potter & Ass,Inc. Printers	2	Print	y
Auto Detail	2	auto-b	y
Valco Graphics	1	print	y
Week end	1	print	y
Ikon Corporation	1	general	y
Hundredwaters	1	general	h
Standard Service Tire	1	general	y
Quinton Instruments Co.	1	general	y
European Motors	1	auto-e	y
Import Doctor	1	auto-e	y
Seattle Auto Glass	1	auto-b	y
Frank Kenny Toyota Service	1	aauto-e	y
Two Dimensions	1	Graphic	y
Graphic Chromatics	2	print	y
Data Corp./Kalvar Corp.	2	photo	n
Westours Printshop	1	print	y
Artic Graphics and Printing	1	print	y
Seattle Exhibit	1	graphic	y
Hoy Textiles	1	graphic	y
Ivy Sergight, Inc	4	phto	n
Forde Motion Picture Lab	4	photo	n

*1 = <50 gpd
2 = 50-100 gpd
3 = 100-500 gpd
4 = >500 gpd

**Y = yes
N = no

Denny Way Site Investigations
Categories, Volumes

COMPANY	VOLUME*	CATEGORY	HOLD**
Western Graphics, INc.	3	graphic	y
Fuzzy Wuzzy Rug Co.	3	genral	y
Greyhound Lines, Inc.	3	auto-b	y
Craftsman Press	2	print	y
Seattle Lithograph Co.	2	print	y
Drothing Dental Lab	2	general	n
West Earth Incorporated	2	general	y
Gray Design	2	general	y
Pacific Lincoln Mercury	2	auto-e	y
Brad's Machine - Regalia Auto Parts	2	auto-e	y
Auto Service Company	2	auto-b	y
The Type Gallery	1	print	y
Service Printing	1	print	y
Creative Printing and Graphics	1	print	y
Outdoor Empire Publishing	1	print	y
Envelopes Unlimited	1	Print	y
Windward Press	1	photo	y
Zeppilin	1	graphic	y
Tube Art Displays Incorporated	1	graphic	y
Westlake Graphics	1	graphic	y
Boyd Sign Company, Inc.	1	graphic	y
Pioneer Industries	1	general	y
Howisey Brothers Upholstry	2	general	y
Messenger Signs, Inc	1	graphic	y
AAMCO Transmission	1	auto-e	y
Fat City VW & Porsche	2	auto-e	y
Big Dyno Motive	1	auto-e	y

*1 = <50 gpd
2 = 50-100 gpd
3 = 100-500 gpd
4 = >500 gpd

**Y = yes
N = no

APPENDIX D

COLLECTION SYSTEM SAMPLING DATA

- Organic Pollutant Data
  - Volatiles
  - Acid Extractables and PCB
  - Base and Neutral Extractables
  - Phthalates

WASTEWATER VOLATILES (ppb)

COMPOUND	TOLUENE	ETHYL BENZENE	TETRA CHLORO ETHYLENE	1,1,2,2,-TETRACHLORO ETHANE	METHYLENE CHLORIDE	1,1,1,-TRICHLORO ETHANE	1,2-DICHLORO ETHYLENE
1 DENNY LK UNION (MAY)	230	29.0	11	–	–	–	–
(OCT)	54	14.0	–	–	21.0	–	–
2 VALLEY & BOREN (MAY)	–	–	–	–	–	9.8	–
3 REP & BOREN (MAY)	200	120.0	52	–	–	–	–
(OCT)	110	50.0	17	–	11.0	–	–
4 MELROSE OLIVE (MAY)	–	–	48	–	–	–	–
5 MINOR & JOHN (MAY)	–	0.0	0	–	–	–	–
(OCT)	–		57	–	–	–	–
6 WESTLAKE & DENNY (MAY)	43	6.1	0	–	–	–	–
(OCT)	83	9.7	–	–	8.5	–	–
7 DENNY LOCAL (MAY)	–	0.0	–	–	–	–	–
(OCT)	–	–	–	–	5.3	–	–
11 WESTLAKE & 9TH (OCT)	140	150.0	–	54	–	–	6.4
12 REP & PONTIUS (OCT)	130	120.0	–	100	66.0	20.0	–
BLANK	–	0.0	–	–	–	–	–

SEDIMENT VOLATILES (PPB WET WEIGHT)

COUMPOUND	ETHYL BENZENE	1,1,2,2, TETRACHLOR ETHANE	TOLUENE	CHLORO BENZENE	1,2 DICHLORO ETHYLENE	1,1,2 TRICHLOR ETHYLENE	TETRA CHLORO ETHYLENE	VINYL CHLORIDE	BENZENE	1,1 DICHLORO ETHYLENE
2 VALLEY & BOREN (MAY)			33.2							
7 DENNY LOCAL (MAY)			66.2	40.4						
8 ELLIOT & HARRISON (OCT)			550.0							
9 TUNNEL 6TH (OCT)		38.9		1055.6						
10 TUNNEL 9TH (OCT)	233.3	45.0	388.9	4277.8						
11 WESTLAKE & 9TH (OCT)	750.0	691.2	305.9		161.8	89.7	39.7	32	26.5	7.4

Note: 0.0, blanks, and -- mean that the compound was not detected (below detection limits).

WASTEWATER
ACID EXTRACTABLES (ppb)

COMPOUND	PHENOL	4-CHLORO-3-METHYL PHENOL
1 DENNY LK UNION (MAY)	26.0	2.9
(OCT)	4400.0	
2 VALLEY & BOREN (MAY)	0.0	0.0
3 REP. & BOREN (MAY)	0.0	0.0
(OCT)	25.0	
4 MELROSE & OLIVE (MAY)	0.0	11.5
5 MINOR & JOHN (MAY)	0.0	0.0
(OCT)	32.0	
6 WESTLAKE & DENNY (MAY)	0.0	0.0
(OCT)	12.0	
7 DENNY LOCAL (MAY)	0.0	0.0
(OCT)	3800.0	
11 WESTLAKE & 9TH (OCT)	7.8	
12 REP & PONTIUS (OCT)	400.0	
BLANK	0.0	0.0

SEDIMENT ACID EXTRACTABLES AND P.C.B. (PPB WET WEIGHT)

COUMPOUND	PHENOL	2-NITRO PHENOL	2-4 DIMETHYL PHENOL	2-4 DICHLORO PHENOL	4-CHLORO 3 METHYL PHENOL	PENTA CHLORO PHENOL	AROCLOR 1260
2 VALLEY & BOREN (MAY)	616.8	130.8	672.9	130.8	467.3	532.7	
7 DENNY LOCAL (MAY)							
8 ELLIOT & HARRISON (OCT)							
9 TUNNEL 6TH (OCT)	5800.0						
10 TUNNEL 9TH (OCT)							2354
11 WESTLAKE & 9TH (OCT)							

WASTEWATER
BASE NEUTRAL EXTRACTABLES (ppb)

COMPOUND	NAPTHALENE	1,2 DICHLORO BENZENE	PHENANTHRENE	ANTHRACENE	FLUORENE	PYRENE	FLUORANTHENE	ACENAPTHENE	BENZO (A) ANTHRACENE
1 DENNY LK UNION (MAY)	10.9	85.1	3.9	1.2	1.2	1.4	1.6	0.6	0.5
(OCT)	9.0	5.2							
2 VALLEY & BOREN (MAY)			4.7	0.0	0.7	1.2	1.9	0.6	0.0
3 REP. & BOREN (MAY)	35.1	3.9	6.6	0.0	2.5	4.2	2.6	0.0	0.0
(OCT)	8.5			26.0					
4 MELROSE & OLIVE (MAY)	0.0	290.9	2.0	0.0	0.0	1.0	1.3	0.0	0.5
5 MINOR & JOHN (MAY)	0.0	1.5	1.2	0.2	0.0	0.0	0.6	0.0	0.0
(OCT)									
6 WESTLAKE & DENNY (MAY)	0.0	3.7	3.7	0.6	0.7	1.6	1.9	0.4	0.0
(OCT)									
7 DENNY LOCAL (MAY)	0.0	0.0	1.2	0.0	0.0			0.0	0.0
(OCT)		12.6							
11 WESTLAKE & 9TH (OCT)		9.7							
12 REP & PONTIUS (OCT)	170.0	17.0	14.0	10.0	5.2	5.0	3.0	2.4	2.0
BLANK	0.0	0.0	2.1	0.0	0.0	1.0	0.0	0.4	0.0

COMPOUND	CHRYSENE	1,3 DICHLORO BENZENE	1,4- DICHLOR BENZENE	ISOPHORONE	1,2,4 TRICHLORO BENZENE
1 DENNY LK UNION (MAY)	1.1	0.0	1.8	4.4	0.0
(OCT)					
2 VALLEY & BOREN (MAY)	0.0		0.7		
3 REP. & BOREN (MAY)	0.0	0.0	3.0	0.0	0.0
(OCT)					
4 MELROSE & OLIVE (MAY)	0.8	0.7	19.4	1.0	0.8
5 MINOR & JOHN (MAY)	0.0	0.0	1.0	0.0	0.0
(OCT)			0.6		
6 WESTLAKE & DENNY (MAY)	0.7	0.0	2.3	0.0	0.0
(OCT)			1.6		
7 DENNY LOCAL (MAY)	0.0	0.0	0.0	0.0	0.0
(OCT)					
11 WESTLAKE & 9TH (OCT)			1.1		
12 REP & PONTIUS (OCT)	2.0				
BLANK	0.0	0.0	0.0	0.0	0.0

SEDIMENT EXTACTABLES (PPB WET WEIGHT)

COUMPOUND	PHEN-ANTHRENE	PYRENE	FLUORENE	FLUOR-ANTHENE	ANTHRACENE	CHRYSENE	BENZO(A) ANTHRACENE	NAPHTHALENE	1,4 DICHLORO BENZENE	1,2-DICHLORO BENZENE
2 VALLEY & BOREN (MAY)	523.4	495.3	84.1	579.4	84.1	308.4	186.9	252.3		
7 DENNY LOCAL (MAY)	3119.3	2568.8	449.5	3578.0	623.9	1192.7	862.4	1926.6		
8 ELLIOT & HARRISON (OCT)	20394.7	16447.4	2763.2	21710.5	5394.7	8552.6	7236.8	723.7		
9 TUNNEL 6TH (OCT)	3700.0	2700.0	1000.0	2300.0	1500.0	1100.0	1400.0	1900.0	5400.0	1300.0
10 TUNNEL 9TH (OCT)	1400.0	740.0	370.0	740.0	590.0	440.0	440.0	3600.0	85000.0	
11 WESTLAKE 9TH (OCT)	2200.0	1100.0	1000.0	880.0	760.0	530.0	350.0	32.3	19.3	7.8

SEDIMENT EXTACTABLES (PPB WET WEIGHT) CONT.

COUMPOUND	ISOPHORONE	ACENAPTHENE	BENZO(B) FLOUR-ANTHENE	BENZO(K) FLOUR-ANTHENE	BENZO(A) PYRENE	DIBENZO (A,H) ANTHRACENE	IDENO 1,2,3-CD-PYRENE	BENZO (G,H,I) PERYLENE
2 VALLEY & BOREN (MAY)	878.5	65.4	215.0	224.3	233.6		252.3	215.0
7 DENNY LOCAL (MAY)		394.5	862.4	1192.7	1009.2		587.2	660.0
8 ELLIOT AND HARRISON		2697.4	6315.8	5921.1	6250.0	1315.8	3289.5	4342.1
9 TUNNEL 6TH			910.0	1100.0	2500.0		1500.0	2000.0
10 TUNNEL 9TH								
11 WESTLAKE 9TH								

WASTEWATER PHTHALATES (ppb)

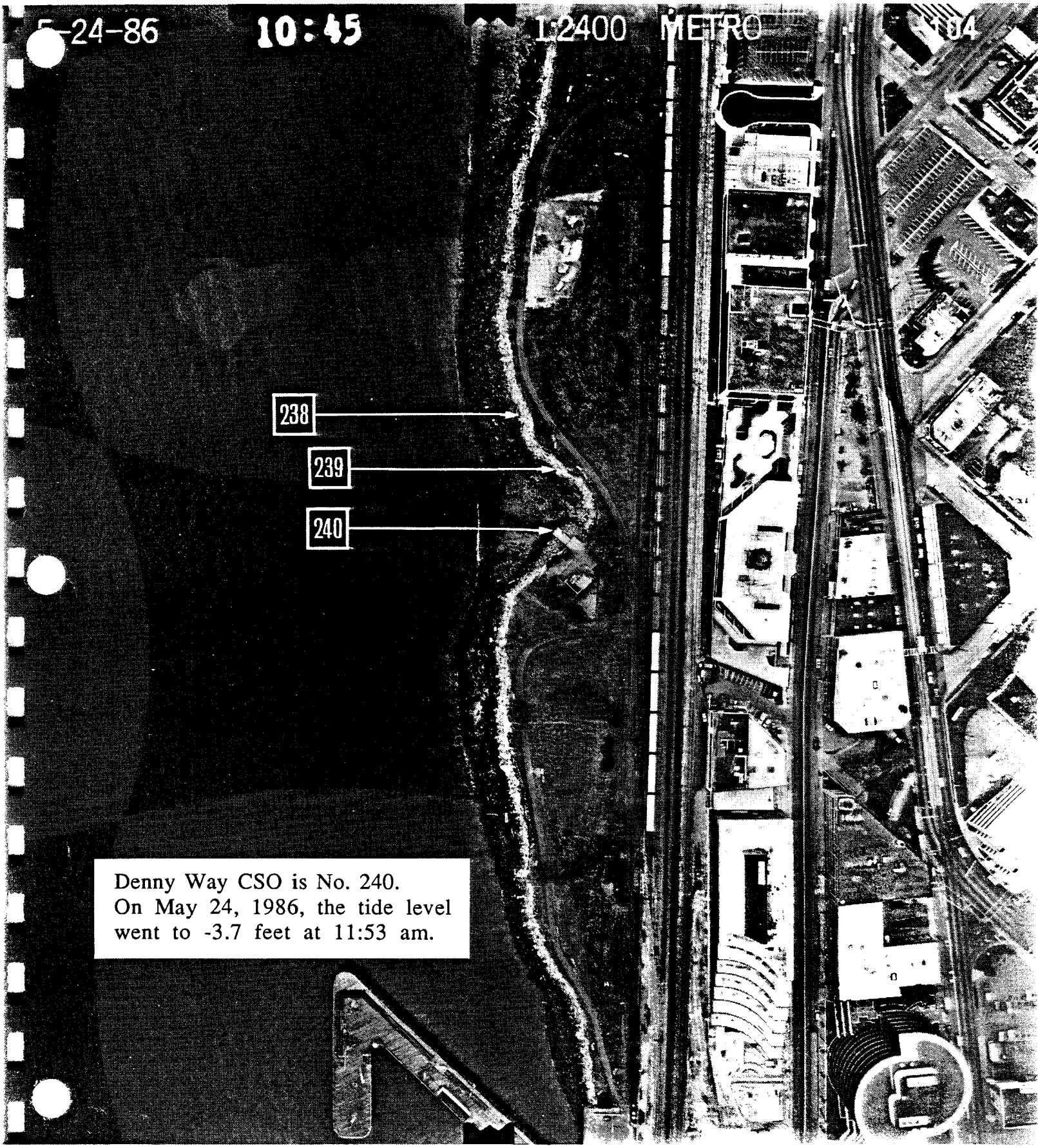
COMPOUND	DIETHYL PHTHALATE	DI-N-BUTYL PHTHALATE	BENZYL BUTYL PHTHALATE	BIS (2-ETHYLHEXYL) PHTHALATE	DI-N-OCTYL PHTHALATE
1 DENNY LK UNION (MAY)	43.4	19.3	13.7	178.6	4.8
(OCT)		7.8	3.0	60.0	
2 VALLEY & BOREN (MAY)	5.5	9.9	10.7	172.2	2.2
3 REP. & BOREN (MAY)	15.0	44.2	122.3	783.5	20.2
(OCT)	2.0	10.0	10.0	220.0	4.0
4 MELROSE & OLIVE (MAY)	8.6	13.5	5.7	13.2	2.3
5 MINOR & JOHN (MAY)	8.5	9.3	4.6	98.2	2.2
(OCT)	6.2	5.9	8.4	24.0	1.3
6 WESTLAKE & DENNY (MAY)	4.0	8.6	4.0	77.5	1.6
(OCT)	1.4	4.0	5.9	30.0	4.0
7 DENNY LOCAL (MAY)	8.0	7.8	1.4	67.5	0.8
(OCT)		2.8		12.8	40.0
11 WESTLAKE & 9TH (OCT)	0.0	3.9	1.7	9.0	1.1
12 REP. & PONTIUS (OCT)	0.0	70.0	160.0	1300.0	29.0
BLANK	1.0	7.7	0.7	108.3	0.7

SEDIMENT PHTHALATES (PPB WET WEIGHT)

COUMPOUND	DIETHYL PHTHALATE	DI-N-BUTYL PHTHALATE	BENZYL BUTYL PHTHALATE	BIS (2-ETHYLHEXYL) PHTHALATE	DI-N-OCTYL PHTHALATE
2 VALLEY & BOREN (MAY)		486.0	84.1	28598.1	1102.8
7 DENNY LOCAL (MAY)		724.8		7889.9	256.9
8 ELLIOT & HARRISON		1381.6	723.7	9868.4	513.2
9 TUNNEL 6TH		4100.0	3800.0	280000.0	6600.0
10 TUNNEL 9TH	290	2400.0	3500.0	27000.0	800.0
11 WESTLAKE 9TH		16000.0	20000.0	930000.0	7100.0

APPENDIX E
ENVIRONMENTAL SEDIMENT DATA

- Aerial Photo of Sampling Area
- Survey Data for Sampling Grid
- Station Coordinates and Depths
- Previous Metals Data from 1982
- New Metals Data from 1986
- New organic Data
  - Acid Extractable and PCBs
  - Base Neutral Extractables
    LPAH, HPAH, Phthalates
- Sediment Core Data
- Location of Historic Outfalls



Denny Way CSO is No. 240.
On May 24, 1986, the tide level went to -3.7 feet at 11:53 am.

DISCHARGE DATA
PHOTOGRAPH 104

DISCHARGE IDENTIFICATION CODE ---------- 238
DISCHARGE LOCATION COORDINATES (lat/long)---------- 47 37 8.39 / 122 21 35.6
DISCHARGE LOCATION COORDINATES (state plane in feet)---------- N 229525 / E 1623525
PIPE/CHANNEL SIZE (diameter/height x width, dimensions in inches)--- 4
PIPE/CHANNEL TYPE (composition)---------- black corrugated plastic
PIPE/CHANNEL PHYSICAL CONDITION---------- fair
TYPE OF DISCHARGE (storm drain,sewer,creek,seep,other)---------- seep
ESTIMATION OF VISUALLY IMPACTED AREA (square feet)---------- 8
ESTIMATION OF HIGH WATER MARK (from bottom of discharge in inches)-- 1
OBSERVATIONS (debris,odor,discoloration,other)---------- no odor
LOW FLOW DISCHARGE ---------- trickle
SUBTIDAL DISCHARGE LOCATION (depth in feet)---------- (derived from mean lower low water or zero tide level)

DISCHARGE IDENTIFICATION CODE ---------- 239
DISCHARGE LOCATION COORDINATES (lat/long)---------- 47 37 8.22 / 122 21 34.21
DISCHARGE LOCATION COORDINATES (state plane in feet)---------- N 229505 / E 1623620
PIPE/CHANNEL SIZE (diameter/height x width, dimensions in inches)--- 4
PIPE/CHANNEL TYPE (composition)---------- black corrugated plastic
PIPE/CHANNEL PHYSICAL CONDITION---------- good
TYPE OF DISCHARGE (storm drain,sewer,creek,seep,other)---------- storm drain
ESTIMATION OF VISUALLY IMPACTED AREA (square feet)---------- 24
ESTIMATION OF HIGH WATER MARK (from bottom of discharge in inches)-- 1
OBSERVATIONS (debris,odor,discoloration,other)---------- no odor
LOW FLOW DISCHARGE ---------- trickle
SUBTIDAL DISCHARGE LOCATION (depth in feet)---------- (derived from mean lower low water or zero tide level)

DISCHARGE IDENTIFICATION CODE ---------- 240 (Denny Way CSO)
DISCHARGE LOCATION COORDINATES (lat/long)---------- 47 37 7.54 / 122 21 33.17
DISCHARGE LOCATION COORDINATES (state plane in feet)---------- N 229435 / E 1623690
PIPE/CHANNEL SIZE (diameter/height x width, dimensions in inches)--- 72 (2 pipes)
PIPE/CHANNEL TYPE (composition)---------- concrete
PIPE/CHANNEL PHYSICAL CONDITION---------- good
TYPE OF DISCHARGE (storm drain,sewer,creek,seep,other)---------- storm drain/CSO
ESTIMATION OF VISUALLY IMPACTED AREA (square feet)---------- 420
ESTIMATION OF HIGH WATER MARK (from bottom of discharge in inches)-- no evidence
OBSERVATIONS (debris,odor,discoloration,other)---------- strong petroleum and hydrogen sulfide smell
LOW FLOW DISCHARGE ---------- 0.1 cfs
SUBTIDAL DISCHARGE LOCATION (depth in feet)---------- (derived from mean lower low water or zero tide level)

Reference: An Inventory of Shoreline Discharge Sources, Metro, Publication Number 158, May 1987.

DENNY WAY CSO SEDIMENTS

PROJECT: B53417

COLLECTION DATES: Sept. 10, 11, 18, 1986

!DENNYWAYGRABSAMPLES 29R x 6C

0 sta	1 descripl	2 bdeep*	3 lat	4 long	5 xplan	6 yplan
1 LTBC09	TRANSECT STATION # 1	38	473702.00	1222151.0	1622457	228898
2 LTBC33	TRANSECT STATION # 2	27	473707.86	1222146.1	1622805	229465
3 LTBC26	TRANSECT STATION # 3	20	473709.00	1222144.0	1622935	229600
4 LTBC19	TRANSECT STATION # 4	16	473705.00	1222139.0	1623315	229230
5 LTBD17	TRANSECT STATION # 5	12	473703.00	1222135.0	1623555	228940
6 LTBC25	TRANSECT STATION # 6	12	473710.00	1222143.0	1623045	229690
7 LTBC30	TRANSECT STATION # 7	10	473707.00	1222139.0	1623275	229390
8 LTBC22	TRANSECT STATION # 8	12	473707.00	1222138.0	1623335	229345
9 LTBC18	TRANSECT STATION # 9	14	473706.00	1222138.0	1623375	229280
10 LTBC16	TRANSECT STATION # 10	13	473705.00	1222137.0	1623425	229225
11 LTBD13	TRANSECT STATION # 11	15	473705.00	1222136.0	1623470	229165
12 LTBD10	TRANSECT STATION # 12	14	473704.00	1222136.0	1623517	229105
13 LTBC28	TRANSECT STATION # 13	18	473705.00	1222139.0	1623260	229180
14 LTBC32	TRANSECT STATION # 14A	13	473708.00	1222142.0	1623110	229475
15 LTBC23	TRANSECT STATION # 15	8	473709.00	1222140.0	1623225	229575
16 LTBC29	TRANSECT STATION # 16	6	473708.00	1222138.0	1623335	229440
17 LTBC21	TRANSECT STATION # 17	5	473707.00	1222138.0	1623390	229390
18 LTBC17	TRANSECT STATION # 18	9	473706.00	1222137.0	1623435	229325
19 LTBD15	TRANSECT STATION # 19	10	473706.00	1222136.0	1623485	229270
20 LTBD12	TRANSECT STATION # 20	12	473705.00	1222135.0	1623530	229215
21 LTBD09	TRANSECT STATION # 21	12	473705.00	1222135.0	1623575	229150
22 LTBD08	TRANSECT STATION # 22	7	473704.00	1222133.0	1623675	229040
23 LTBD07	TRANSECT STATION # 23	9	473702.00	1222131.0	1623810	228885
24 LTBC24	TRANSECT STATION # 24	11	473711.00	1222141.0	1623130	229755
25 LTBC31	TRANSECT STATION # 25A	14	473707.00	1222140.0	1623330	229345
26 LTBC27	TRANSECT STATION # 26A	15	473705.00	1222138.0	1623385	229175
27 LTBD16	TRANSECT STATION # 27	2	473707.00	1222136.0	1623495	229375
28 LTBD14	TRANSECT STATION # 28	3	473706.00	1222135.0	1623540	229320
29 LTBD18	TRANSECT STATION # 30A	14	473704.00	1222136.0	1623455	229050

* All bdeep values have been corrected to Mean Low Low Tide which = 0.00 feet.

PROJECT COORDINATOR: PAT ROMBERG

TECHNICAL COORDINATOR: LISA BEINEKE

TABLE E-1. SURVEY DATA USED TO LOCATE SAMPLING STATIONS

Transect lines south and north of outfall	Distance offshore (measured from top of bulkhead at edge of grass)				
	Station line 325′ from fence	Station line 400′ from fence	Station line 475′ from fence	Station line 550′ from fence	
S 500′		#23 - 220′			
S 300′		#22 - 180′		#5 - 330′	
S 225′					
S 150′	to rocky - 100′	#21 - 175′	#12 - 250′	#30A - 325′	
S 75′	wood chips - 140′	#20 - 215′	#11 - 290′		
00 - outfall	#28 - 185′	#19 - 260′	#10 - 335′	#26A - 410′	
N 75′	#E27 - 220′	#18 - 295′	#9 - 370′	#4 - 445′	#13 - 520′
N 150′	to rocky - 135′	#17 - 210′	#8 - 285′		
N 225′		#16 - 185′	#7 - 260′	#25A - 335′	
N 300′					
N 400′		#15 - 173′		#14A - 325′	
N 600′		#24 - 165′	#6 - 275′		#3 - 415′, #2 - 60′ depth, #1 ~1200′

TABLE E-3. PREVIOUS METALS DATA FROM OFFSHORE SEDIMENTS COLLECTED IN 1982

Station	Metal/Concentration					
	Antimony		Arsenic		Beryllium	
	3/22/82	7/21/82	3/22/82	7/21/82	3/22/82	7/21/82
1603**	3.3	2.40	15.0	16.0	0.21	0.24
1406	3.2	1.50	8.8	15.0	0.33	0.35
1606	1.3	0.46	12.0	9.1	0.41	0.16
1706	3.2	0.60	15.0	12.0	0.40	0.20
1512	2.3	0.87	12.0	13.0	0.30	0.37
1612	3.7	1.00	16.0	14.0	0.30	0.11
1810	1.0	0.94	12.0	11.0	0.37	0.18
1230	0.5	0.67	13.0	14.0	0.36	0.40
1630	0.8	0.53	12.0	8.0	0.45	0.07*
1830	1.0	0.67	10.0	11.0	0.44	0.24
Will Metal Show Change?	Yes		Doubtful		No	

Station	Metal/Concentration					
	Cadmium		Chromium		Copper	
	3/22/82	7/21/82	3/22/82	7/21/82	3/22/82	7/21/82
1603	0.46	2.20	63.0	57.0	120	120
1406	0.99	2.10	60.0	61.0	130	87
1606	0.15	0.34	63.0	45.0	57	34
1706	0.86	0.63	59.0	53.0	61	54
1512	0.32	0.39	48.0	57.0	52	55
1612	0.70	0.36	60.0	59.0	62	54
1810	0.47	0.33	54.0	49.0	82	58
1230	0.25	0.46	54.0	47.0	62	50
1630	0.23	0.05*	37.0	11.0*	55	13*
1830	0.30	0.14	47.0	47.0	50	46
Will Metal Show Change?	Yes		No		No	

*Suspect data

**Water depth given by adding one zero to last two values of station number (Station 1603 = 030′ deep)

TABLE E-3. PREVIOUS METALS DATA FROM OFFSHORE SEDIMENTS COLLECTED IN 1982 (Continued)

Station	Metal/Concentration					
	Lead		Mercury		Nickel	
	3/22/82	7/21/82	3/22/82	7/21/82	3/22/82	7/21/82
1603	670	430	1.6	1.30	41	49
1406	89	210	0.98	1.00	44	44
1606	88	49	0.77	0.22	56	50
1706	95	100	0.62	0.72	49	58
1512	54	94	1.60	0.34	40	51
1612	90	98	0.72	3.60	48	50
1810	82	120	0.65	0.61	39	45
1230	55	81	0.43	0.29	32	38
1630	68	30*	0.63	0.06*	27	13*
1830	62	72	0.53	0.34	31	43
Will Metal Show Change?	Yes		Yes		No	

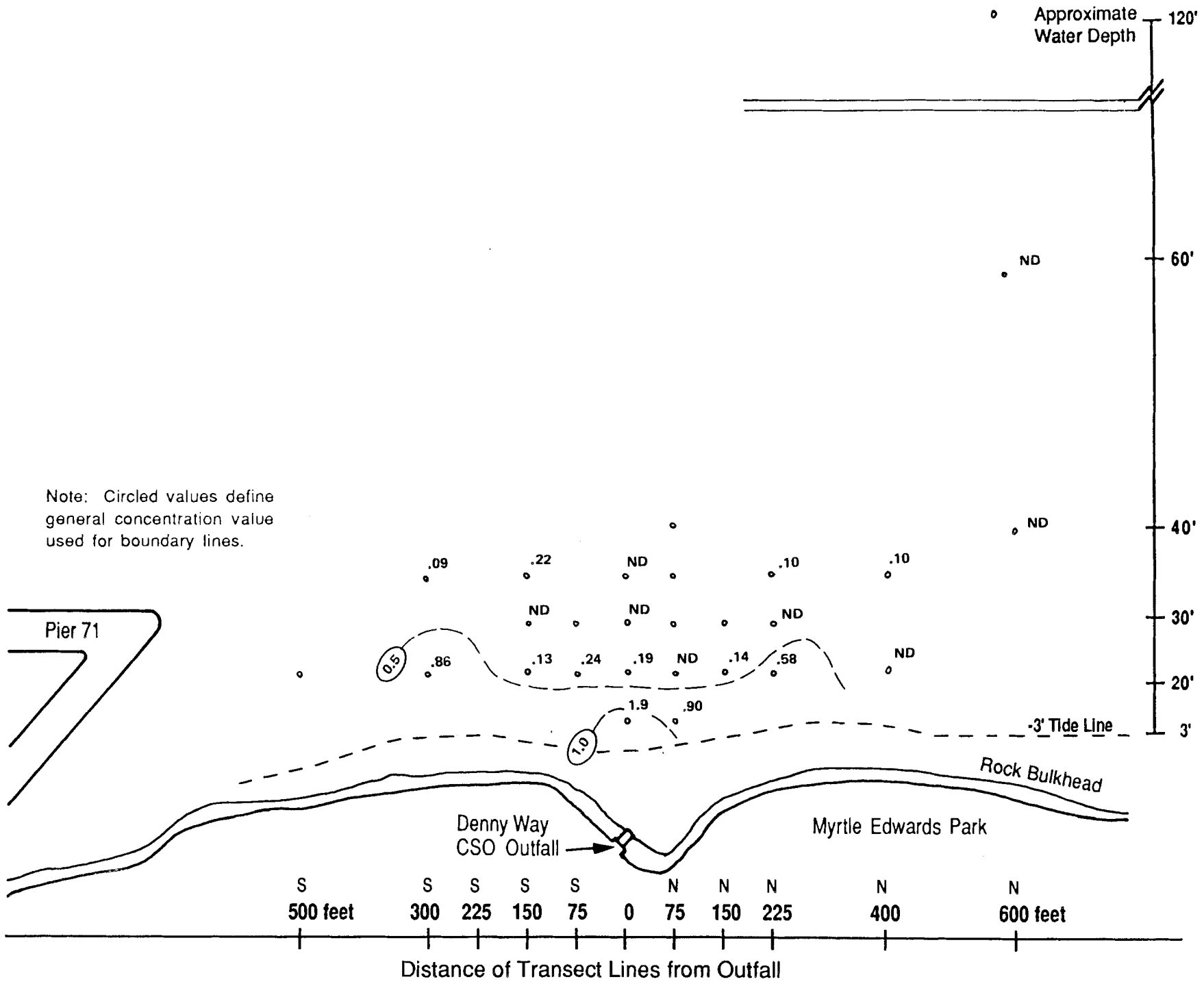
Station	Metal/Concentration					
	Selenium		Silver		Zinc	
	3/22/82	7/21/82	3/22/82	7/21/82	3/22/82	7/21/82
1603	<0.20	<0.20	4.1	0.94	300	260
1406	0.48	<0.20	4.6	1.10	140	170
1606	0.40	<0.20	5.4	1.30	150	86
1706	0.48	<0.20	5.2	2.20	130	110
1512	0.56	<0.20	3.4	2.10	100	110
1612	0.78	<0.20	3.4	2.10	120	110
1810	<0.20	<0.20	2.1	2.40	120	120
1230	<0.20	<0.20	3.9	0.24	100	100
1630	0.33	<0.20	3.6	0.05*	120	50*
1830	<0.20	0.34	2.3	0.74	110	100
Will Metal Show Change?	No		No		Yes	

*Suspect data

ACIDS EXTRACTABLES AND PCBs IN SURFACE SEDIMENTS
(units = ug/gm dry wt. = ppm)

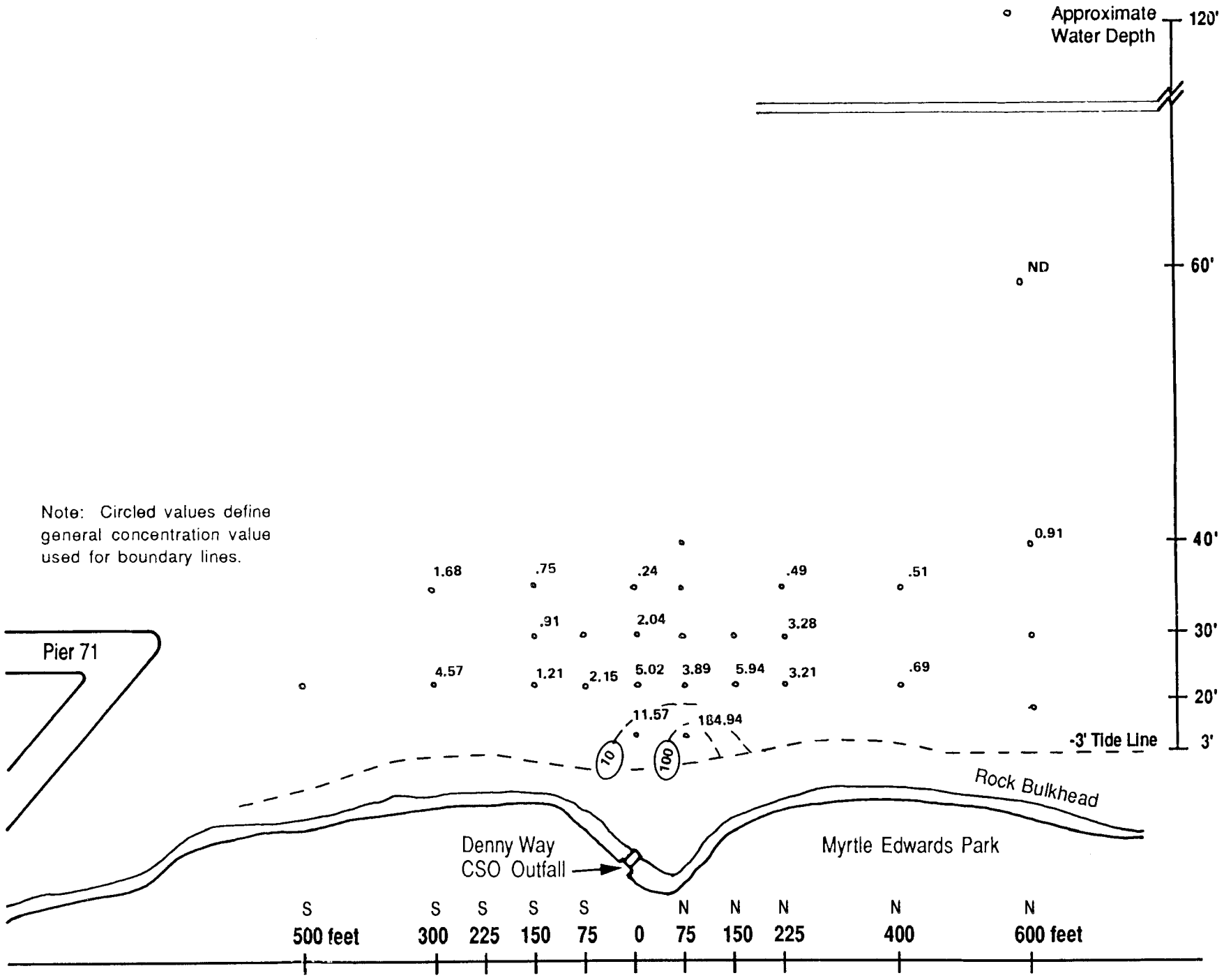
	Compound*			
Station Number	Phenol	Penta-Chlorophenol	Nitrophenol	PCBs (1254)
2	ND**	ND	ND	0.26
3	ND	ND	ND	0.41
5	0.09	0.79	0.38	0.51
7	ND	ND		0.77
10	ND			0.58
12	ND			0.67
14	0.10			0.16
15	ND			0.17
16	0.58			0.29
17	0.14			0.30
18	ND			0.49
19	0.19			<0.03
20	0.24			0.12
21	0.13			<0.03
22	0.86	0.56		1.51
25	0.10			0.51
26	ND			0.22
27	0.90			0.30
28	1.90			1.06
30	0.22			0.93
Detection Limit	0.08	0.18	0.12	0.03

* No other acids, PCBs, or pesticide compounds were detected.
**Both ND and a blank mean levels were non-detectable.

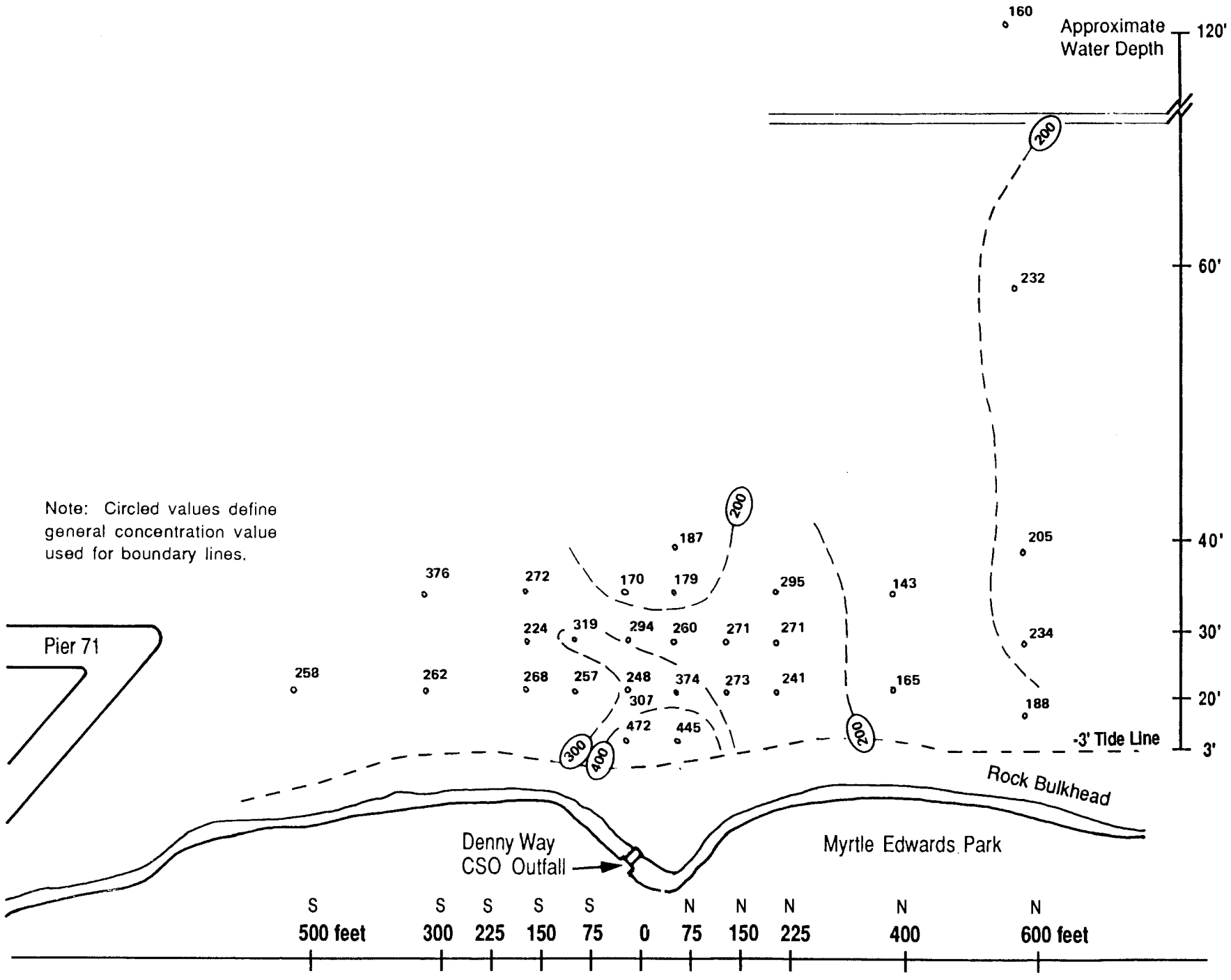


Note: Circled values define general concentration value used for boundary lines.

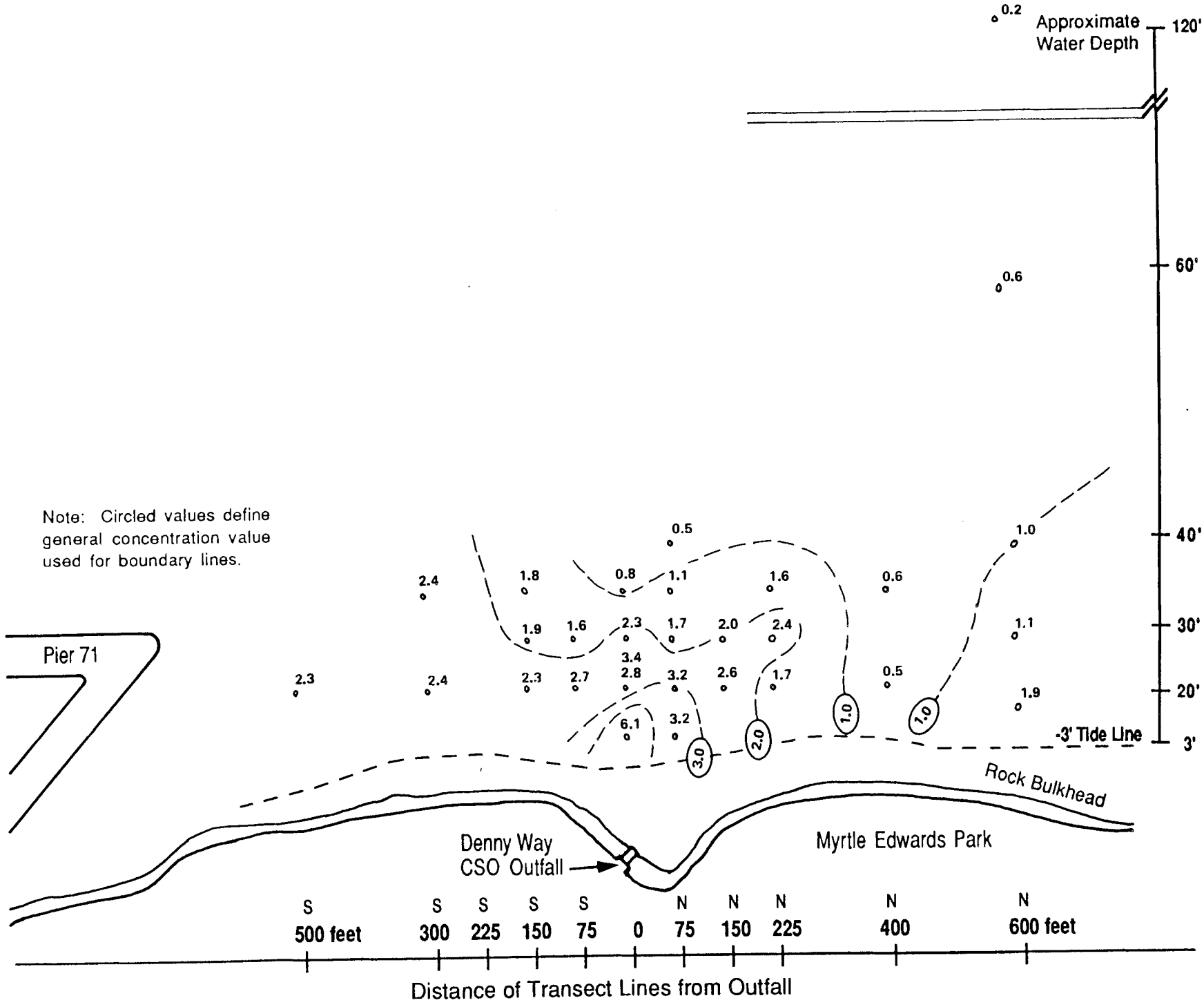
Distribution of Phenol Concentrations (ppm) in Surface Sediments



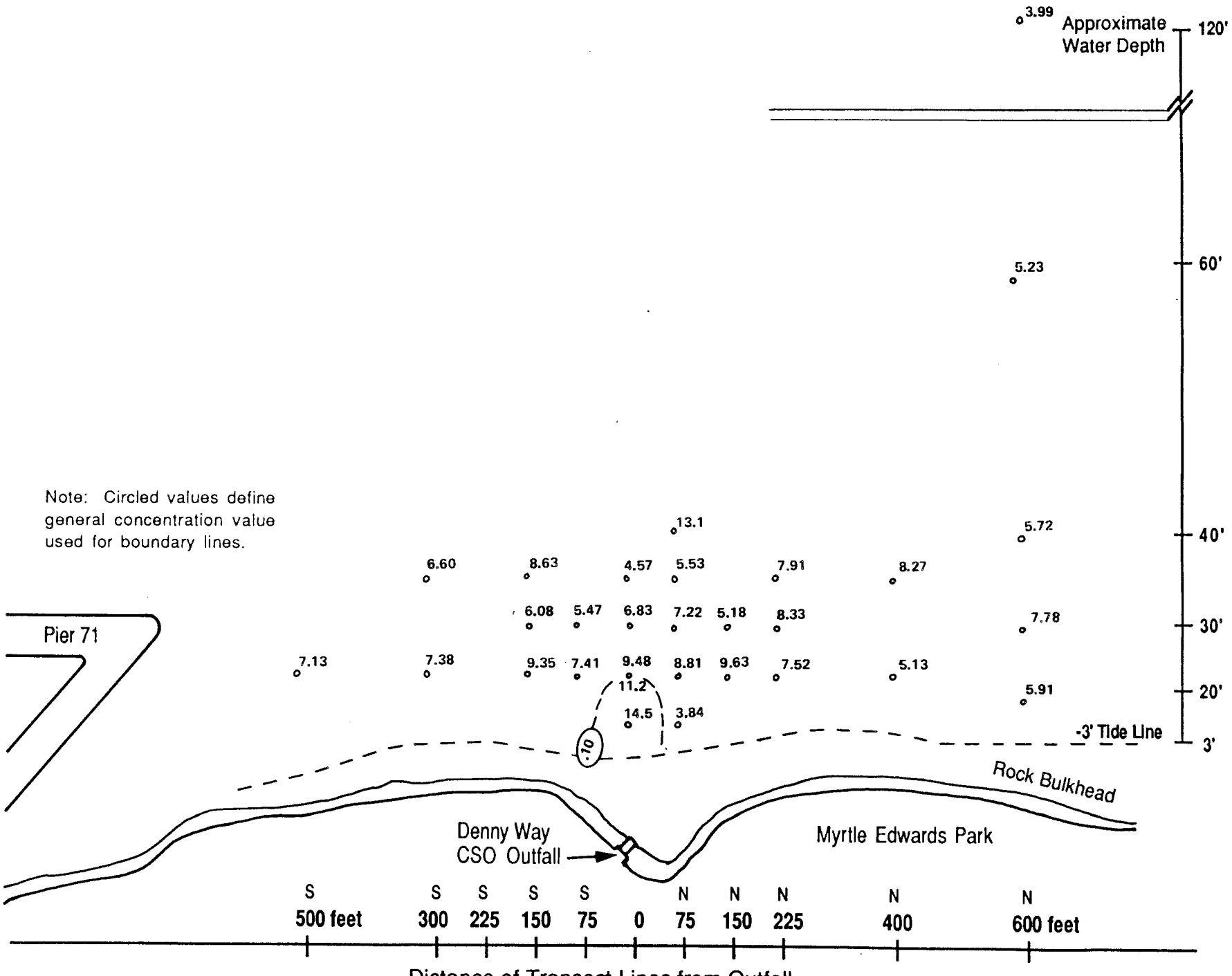
Distribution of LPAH Concentrations (ppm) in Surface Sediments



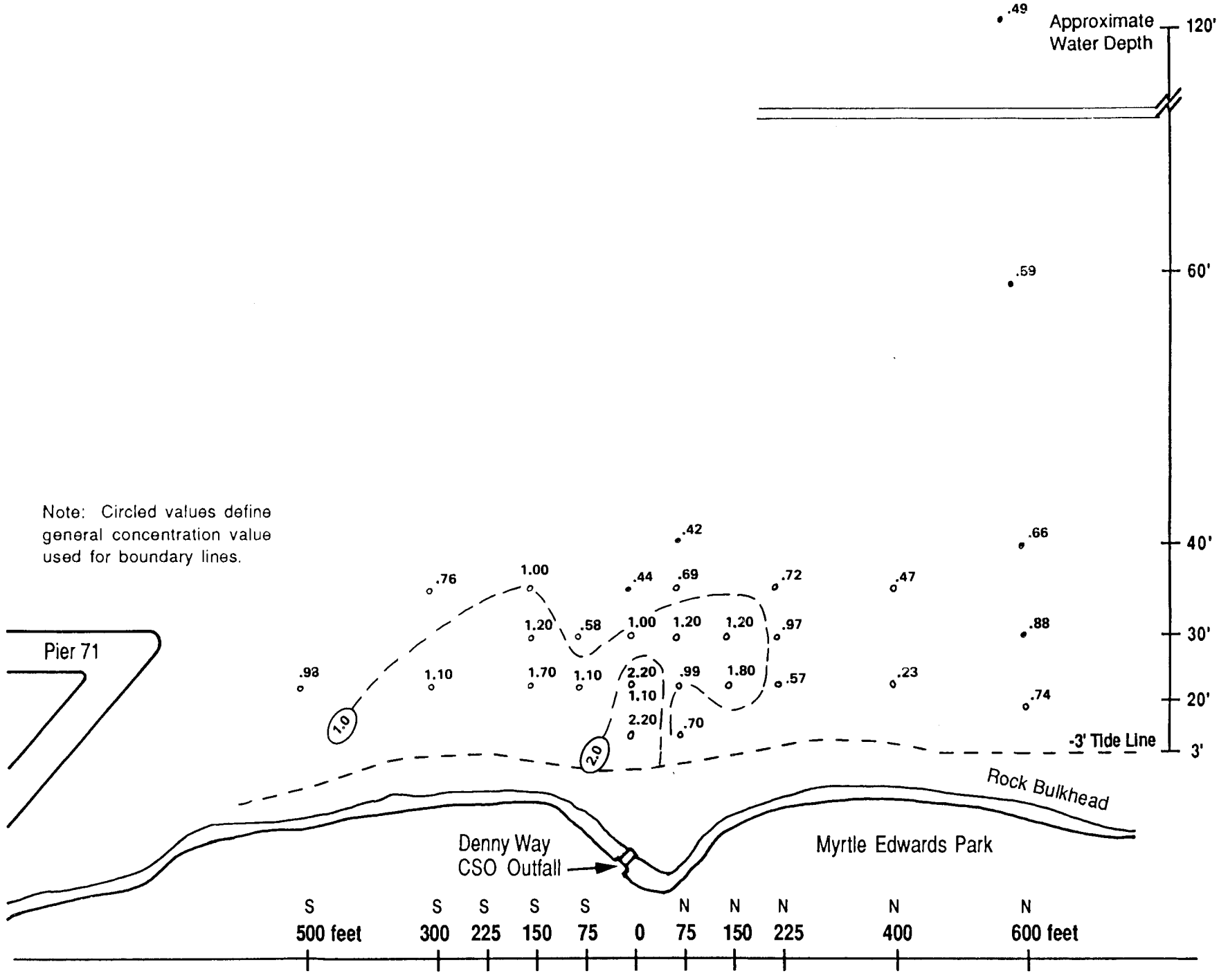
Distribution of Zinc Concentrations (ppm) in Surface Sediments



Distribution of Cadmium Concentrations (ppm) in Surface Sediments



Distribution of Total Volatile Solids (%) in Surface Sediments



Distribution of Mercury Concentrations (ppm) in Surface Sediments

Sediment Core Data

Listed are the concentrations of Cu and Pb in box cores collected near the Denny Way COS on November 24, 1986. The sediments were oven dried to constant weight, then leached with hot nitric acid and analyzed by flame AA. Standard reference sediment, MESS-1 certified for Cu 25 µg/g and Pb 34 µg/g was also analyzed. Our results were Cu 22 and Pb 25.

Concentration of Pb µg/g dry wt.

(depth) cm	STA 19 D-15	STA 12 D-10	STA 7 C-30	STA 14A C32
1 Rep 1	260	73	199	81
Rep 2		69		73
Rep 3		62		70
2	147		164	87
3	314	30	181	84
4	147		209	77
5	248	17	181	128
6	190		147	98
7	181	26	77	58
8	151		86	98
9	171	17	70	73
10	177		126	57
11		36	160	70
12	216		568	81
13		26		72
14	188		358	66
15		23		89
16	133		540	89
17		32		79
18	256		585	75
19		21		
20	258		331	32
21		25		
22	331		190	28
23		19		
24	463		269	
25				
26	209		151	
27		19	100	
28				
29		23		
30	105			
31		57		
33		29		
35		72		
39		43		
41		43		

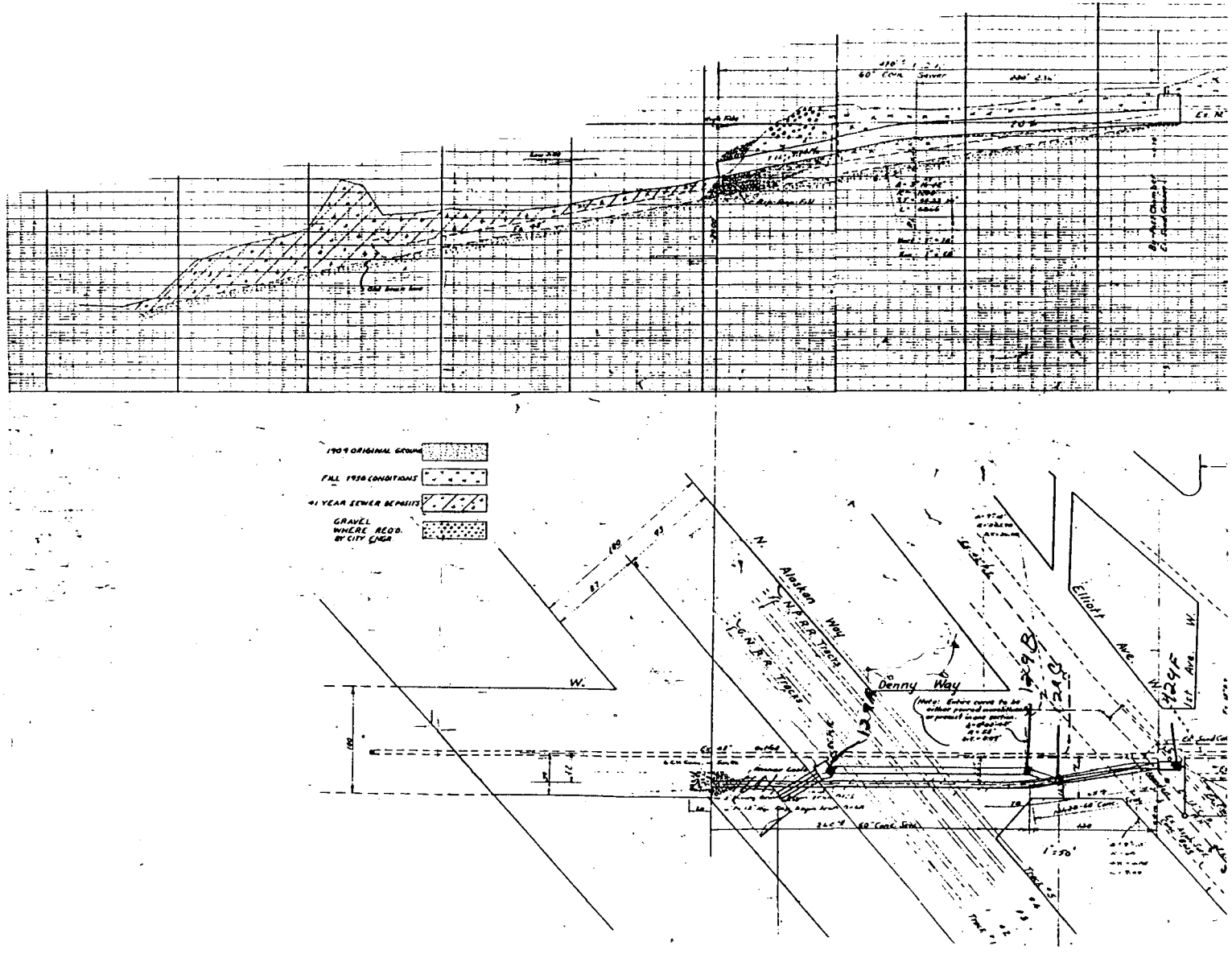
Concentration of Cu µg/g dry wt.

(depth) cm	STA 19 D-15	STA 12 D-10	STA 7 C-30	STA 14A C32
1 Rep 1	166	49	113	47
Rep 2		51		46
Rep 3		48		42
2	107		84	40
3	110	31	71	48
4	69		73	48
5	100	26	66	42
6	82		53	42
7	85	30	34	30
8	66		56	33
9	79	23	26	40
10	84		44	29
11		31	63	42
12	88		227	44
13		32		55
14	74		162	39
15		29		58
16	89		219	55
17		27		52
18	90		164	47
19		27		
20	102		134	27
21		25		
22	133		82	32
23		28		
24	128		109	
25		32		
26	97		59	
27		26	86	
28	85			
29		33		
30	63			
31		37		
33		36		
35		32		
38		45		
41		40		

CONCENTRATION OF LEAD-210 IN CORE 14A

Core Segment (cm)	Lead-210 Value (dpm)	Total Solids (%)
0-1	1.53*	47
2-3	1.25	56
4-5	1.22	62
6-7	0.77	64
8-9	0.89	65
10-11	0.81	66
13-14	0.96	50
16-17	0.98	44
19-20	1.22	32
21-22	0.65	29

*Values are not corrected for the supported lead-210. Fine-grained (30%) solids) surface sediments from the central basin of Puget Sound typically have lead-210 values of 10-12 dpm and a supported lead-210 concentration of about 1 dpm. The supported lead-210 was not determined because the lead-210 values in the core were too low to be useful.



Source: Metro Technical Services Department