Annual Stormwater Monitoring Report

for

Seattle-Tacoma International Airport

for the period July 1, 1996 through May 31, 1997

Port of Seattle

September 29, 1997

prepared by Scott Tobiason

Port of Seattle Environmental Services

Introduction

This report is submitted to the Washington Department of Ecology (WDOE) pursuant to Special Condition S.9 of the NPDES permit. This report collects and analyzes stormwater data collected in the past 4 quarters. Water quality data from STIA's stormwater discharges is compared to relevant regional and national data on both a concentration and unit load basis. Because many capital BMPs were instituted during the current data collection period, improvements in water quality will be discussed in more detail in the next annual report.

Figure 1 shows the individual stormwater drainage basins and the STIA Stormwater Management Boundary. Note that only colored subbasins drain to the storm system, white or blank areas near the terminals and gates drain to the Industrial Waste System (IWS) which drains runoff to the Industrial Waste Treatment Plant (IWTP). Monitoring data from the IWTP are not included in this report.

Sources of Reported Data

Data reported and analyzed in this annual report are limited to discharges from stormwater outfalls only and include:

- Quarterly and annual monitoring required by the NPDES permit;
- Sampling specified by the Stipulated Agreement (Brasher, et. al., 1995);
- Stormwater Receiving Environment Study (SRES, Condition S.8 of the STIA NPDES permit), and
- The runway deicing washoff study described in last year's annual report.

Note that data previously submitted to Ecology in the monthly discharge monitoring reports (DMRs), was data for only those storms and sampling routines

Acknowledgments

reviewed by Tom Hubbard, Port of Seattle

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Glossary

Acronym	Definition
AMA	Aircraft Movement Area (mainly runways, taxiways)
AOA	Airport Operations Area (includes AMA, ramps, etc.)
BMP	best management practice
BOD_5	5-day biochemical oxygen demand
BTEX	benzene, toluene, ethylbenzene, and xylenes
DMR	discharge monitoring report
FOG	fats, oils and grease
GSE	ground support equipment
IWS	industrial waste system (including the piping)
IWTP	industrial waste treatment plant
LC_{50}	concentration proving lethal to 50% of test poulation
MDL	method detection limit
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
ppb	parts per billion, same as µg/l or ppm/1000
ppm	parts per million, same as mg/l
SRES	Stormwater Receiving Environment Study, Permit condition S8
SRP	soluble reactive phosphorus
STIA	Seattle-Tacoma International Airport
SWPPP	Stormwater Pollution Prevention Plan
TDP	total dissolved phosphorus
TPH	total petroleum hydrocarbons
TSS	total suspended solids
WAC	Washington Administrative Code

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Executive Summary

This report is provided to the Department of Ecology as required in Special Condition S9 of the NPDES Permit (WA-002465-1) for the Seattle-Tacoma International Airport (STIA). The report presents and reviews data collected from STIA stormwater outfalls only for the period of July 1996 through May 1997. This report does not cover the airport's Industrial Waste System (IWS). Permit-required data that describe the storms sampled in the period appear in Appendix A. All analytical data are summarized in figures in the ensuing report and are tabulated in Appendix B.

The Port of Seattle complied with all stormwater monitoring requirements specified in the STIA airport NPDES permit. In early 1997, the Port completed and concluded all sampling required by the Stipulated Agreement (Brasher, et. al., 1995). A permit modification in August 1996 added sampling requirements for three additional outfalls, SDN4 (011), B (013), and D (015). The Port completed three consecutive quarters of monitoring for outfalls B and D and will reduce future monitoring to an annual basis as allowed by the NPDES permit.

Consistent with the previous Annual Report (POS, 1996a), the current results continue to show very positive results for STIA stormwater runoff. Runoff from the airfield (runways and taxiways) is cleaner than comparable regional areas and landuses. Copious data show that most metals, petroleum hydrocarbons and glycols were consistently not detected. This is true particularly for the 8 airfield outfalls where discharges are cleaner than the terminal and "landside" outfalls. Several public roadways drain to the landside and terminal outfalls, and consequently, bias the STIA results for metals, petroleum hydrocarbons, and other vehicle-based pollutants.

As mentioned in the previous Annual Report (POS, 1996a), 9 metals, petroleum hydrocarbons and glycols were consistently not detected. This is true particularly for the 8 airfield outfalls.

In samples taken at the outfall before stormwater mixes with the receiving waters, data for total copper appear at concentrations above toxic criteria for the receiving waters (WAC 173-201A). A direct comparison, however, is not appropriate without allowing for the inevitable mixing of the stormwater discharge with the receiving water. A wealth of regional data show that copper in urban stormwater in the Puget Sound region regularly exceeds these criteria without mixing in the receiving water. The most conservative total copper concentrations used to compare to STIA results in this report, were actually receiving water (instream) data. These results for a Bellevue stream's stormflow samples exceeded the acute total copper criterion by a factor of two (Bellevue, 1996). Even *baseflow* samples in other urban creeks in the Seattle metropolitan area exceed the acute total copper criterion.

Fecal coliforms continued to show occasionally elevated levels in runoff from subbasins SDE4, SDS1, and SDS4. However, recent BMPs and other projects may eliminate some potential sources. The Port believes wild animals or birds to be a possible, yet unmanageable source. Ongoing investigations aim to continue vigilance and take appropriate actions where necessary.

Estimates of stormwater unit-loads show that the Port discharges considerably less than typical roadways and commercial areas on an annual basis. Suspended sediment and metals unit loads were more than 2 orders of magnitude (100X) less than for commercial areas. Copper, lead and zinc unit loads were 10 to 100 times less than from commercial areas.

In the past year, the Port completed 5 capital BMPs at a total of more than $450K designed to reduce or eliminate pollutants in STIA stormwater. Each BMP reroutes drainage from the SDS to the IWS. Three aircraft service areas were completely eliminated from storm drains SDS1 and SDE4. Another aircraft cargo/service area in SDN2 was connected to a pump station designed to operate during the wet season. These four areas were previously sources of aircraft deicing glycols found in stormwater. In addition, the Port's maintenance shop yard drainage was re-routed to the IWS. Data collected in the next winter season should show dramatically reduced glycols in SDN2 and SDE4 discharges, and elimination of glycols in SDS1 discharges.

Through recent stormwater monitoring, the Port discovered and eliminated several inappropriate stormdrain connections. Washwater from a food service loading dock drain elevated BOD_5 and surfactants in SDN1 baseflow and runoff. Overflow discharges from IWS pump station #283 in the terminal parking area caused elevated BOD_5 and surfactants in SDE4 baseflow and runoff. The Port has eliminated both of these inappropriate connections from the storm drains. Automatic landscape irrigation sprinklers caused mysterious, but innocuous early morning discharges in SDN1 during dry weather.

With Ecology permission, the Port moved the sampling station for SDN1 so that it is now above offsite inputs from more than 3 acres of SR 518 and public roadways. Upstream and downstream samples show that these roadways have been responsible for elevated FOG and TPH that biased samples at the previous SDN1 sampling location.

The Port completed the Stormwater Receiving Environment Study (SRES) in June of 1997 (POS, 1997a). Because that report discusses mostly instream stormwater issues, no further discussion appears in this annual report.

Two snowfall episodes occurred in late 1996. An extreme winter-weather sequence over more than a week during the Christmas holiday period resulted in extensive runway and aircraft deicing. Snowfall of more than 16 inches, plus more than 5 inches rainfall on the accumulated snow caused many regional runoff problems. Certain amounts of the Port's plowed snow contained aircraft and runway deicers. The Port monitored runoff from select outfalls during the two winter-weather periods.

Elevated BOD_5 was attributable to glycols and runway deicers in snowmelt monitored at the north storage area within the SDN2 subbasin. It took only about 4 days for BOD_5 concentrations to drop below 1000 mg/l in the snowmelt. Concentrations of both BOD_5 and glycols dropped below 100 mg/l about one week after the snow was originally plowed and began melting. Even though the snowpile remained for three months, glycols from the snowmelt remained at low levels below 100 mg/l after the first week. By the end of November this year, the Port will construct three snow storage facilities that drain snowmelt to the IWS.

Aircraft deicing was very intense during the two winter-weather periods, with nearly 600 aircraft deiced during the 4-day December episode. The number of aircraft deiced in each episode was similar to the two 1995-96 winter events, but due to the severity of the weather, airlines applied nearly as much glycol during these two periods as they reported during the previous year. As a result, glycols and BOD_5 concentrations were higher in the severe December event.

During these two severe winter weather episodes, runways and taxiways were deiced multiple times. Deicing chemical application resulted in stormwater pollutants generally below any toxic levels, although no standards exist. No urea was applied and the data reflect low ammonia concentrations except those attributable to the limited urea used to keep roadway sand stockpiles from freezing. Concentrations of ammonia were more than an order of magnitude (10X) less than the receiving water toxic criterion. More than 80% of the BOD_5 attributable to acetate-based deicers washed off in the first inch of rainfall after deicing. Less than the 6-month, 24-hour storm (1.3 inches) washed off more than 90% of the total runway pollutant load caused by the deicers. These washoff functions agree with conclusions reached in last year's Annual Stormwater Report.

Aircraft deicing glycols in STIA stormwater appeared only in subbasins where aircraft were deiced or glycols dripped or sheared-off during taxi and takeoff. Glycol shear from aircraft is not regulated in stormwater. Glycols continue to be rarely present: they were undetected in 73% of all 163 samples analyzed over the past three years. Glycols were never detected at SDN4, and detected only once in more than 25 samples from the SDN1 and SDN3 outfalls, with each detection barely 1 mg/l above the detection limit. Monitoring over the next winter season will show the effectiveness of three major capital BMPs completed in 1996-97 that eliminate or reduce glycols in stormwater in subbasins SDE4, SDS1 and SDN2.

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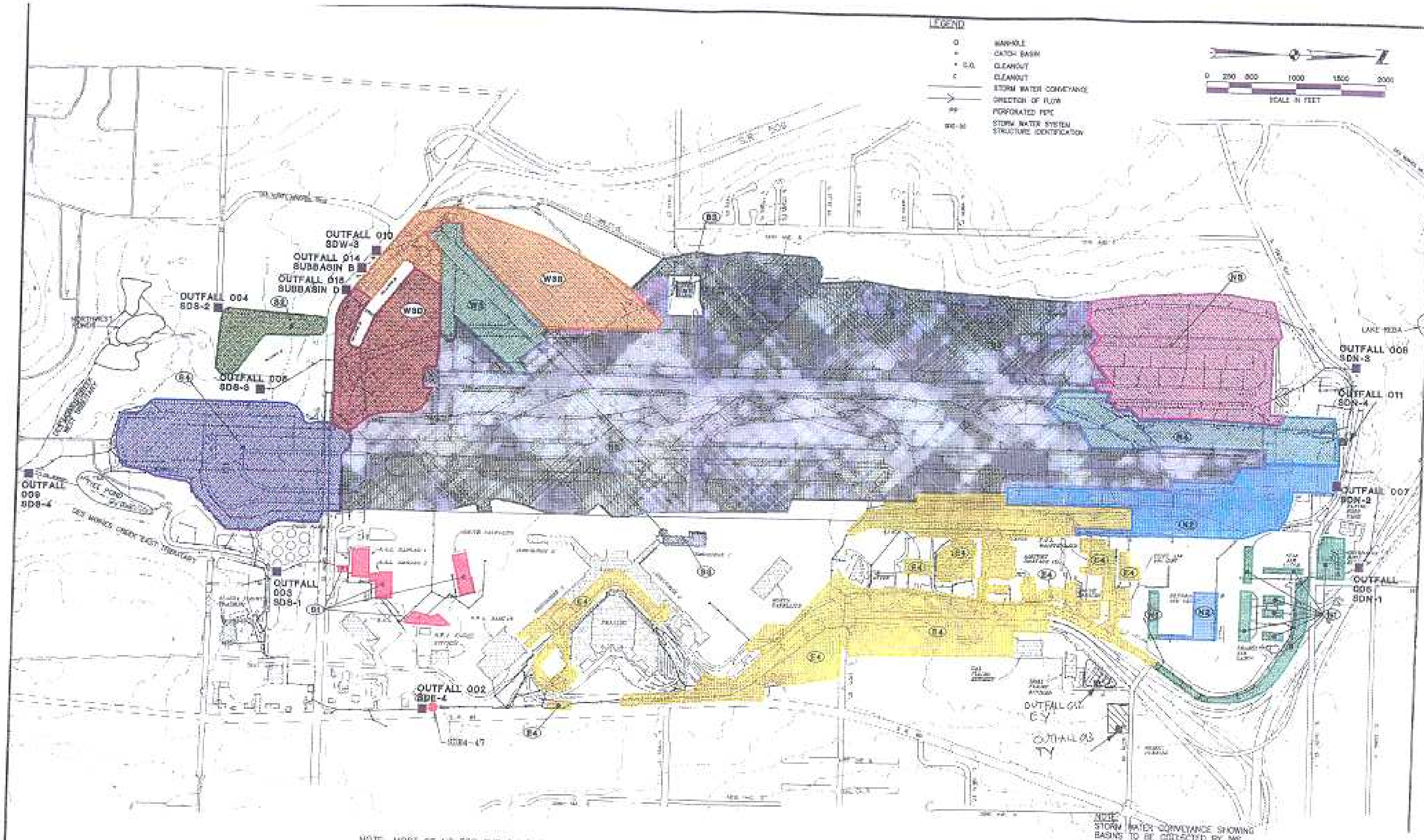
Requirements for the Annual Report

Special Condition S.9 of the permit states:
"On or before August 1 of each year of this permit cycle, the Permittee shall submit a report to the Department summarizing the stormwater monitoring results obtained during the preceding twelve (12) month period from July 1 through June 30. The report shall present the analytical data, the Port's conclusions as to what is being learned from the data, and any new initiatives to be undertaken as part of the Stormwater Pollution Prevention Plan required in condition S10." Ecology authorized the 11-month reporting period (and an October 1 submittal date) for this report because it comprises four complete quarters, two of which are under the "new" quarter system (POS, 1997c, 1997f).

Further, the permit requires in Special Condition S3C that: "The permittee ... submit the following data for the storm event used: date, duration, the number of dry hours preceding the storm event, total rainfall during the storm event (inches), maximum flow rate during the rain event (gallons per minute), and the total flow from the rain event". This hydraulic and hydrologic information is provided in Appendix A.



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STORMWATER DRAINAGE BASIN COLOR CODES:

N1 SDN1	S1 SDS1	W3 SDW3	STORM FLOW MONITORING LOCATION
N2 SDN2	S3 SDS3	S3 SDW3B	
N3 SDN3	S4 SDS4	S3 SDW3D	OUTFALL LOCATION
N4 SDN4	E4 SDE4	S2 SDS2	

PROJECT ENGR./ARCH. W. MOSS
DESIGNER R. UTLEY
DRAWN BY G. OFFERMANN
SCALE AS NOTED
DATE DECEMBER 1996
FILE NAME HDBFIG1.DWG

PORT OF SEATTLE

SEATAC INTERNATIONAL AIRPORT

COMPREHENSIVE STORM DRAINAGE SYSTEM PLAN AND DESIGN

STORM WATER CONVEYANCE SYSTEM
JUNE 1997 PLANNED CONDITIONS

C-3258

94066

FIGURE 1

Background

Stormwater Monitoring Program

The Port conducts a comprehensive stormwater monitoring program that fulfills a considerable array of substantial and unique requirements contained in:

- Quarterly and annual monitoring required by NPDES permit condition S3;
- the runway deicing washoff study described in last previous annual reports, and
- other special studies.

The stormwater monitoring program has been in place since 1993 pursuant to the NPDES permit number WA-002465-1, issued June 30, 1994. The Port conducts specific monitoring activities described in the Procedures Manual (POS, 1997b). The Port submitted the first and second annual reports on August 30, 1995 (POS, 1995a), and November 18, 1996 (POS, 1996a). In 1996, the Port concluded additional monitoring that was part of the SRES and the Stipulated Agreement.

Subbasin categories

Table 1 shows that STIA stormwater subbasins fall into three general categories: "landside", terminal, and airfield. Subbasins SDS3, SDS4, SDW3, SDN2-SDN4, B and D drain the airfield, officially designated the Aircraft Movement Area (AMA), containing the airport runways, taxiways, and open space.

The SDS1 "terminal" subbasin, which was dramatically reduced from 40 to 6 acres in the past year by two capital BMPs, now drains mostly rooftops on the aircraft side of the terminal. However, because the majority of data for SDS1 predates these BMPs, this subbasin will continue to be treated as "terminal" for this report.

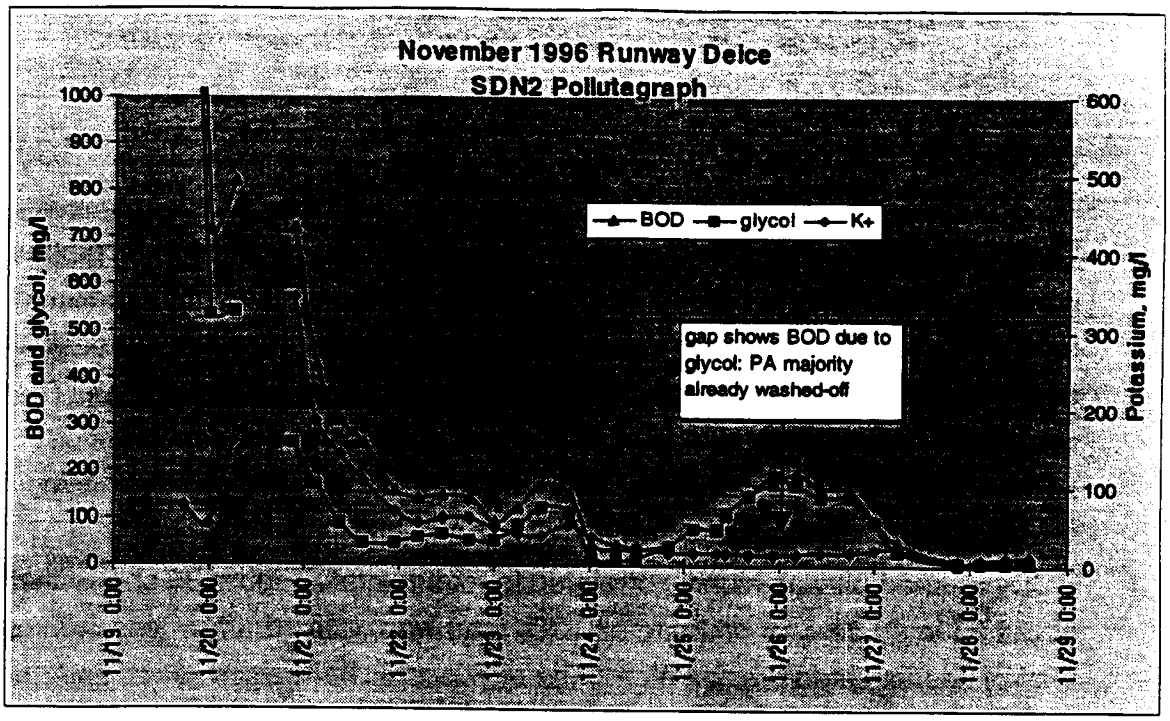


Figure 33 November 1996 Event Pollutagraph for SDN2

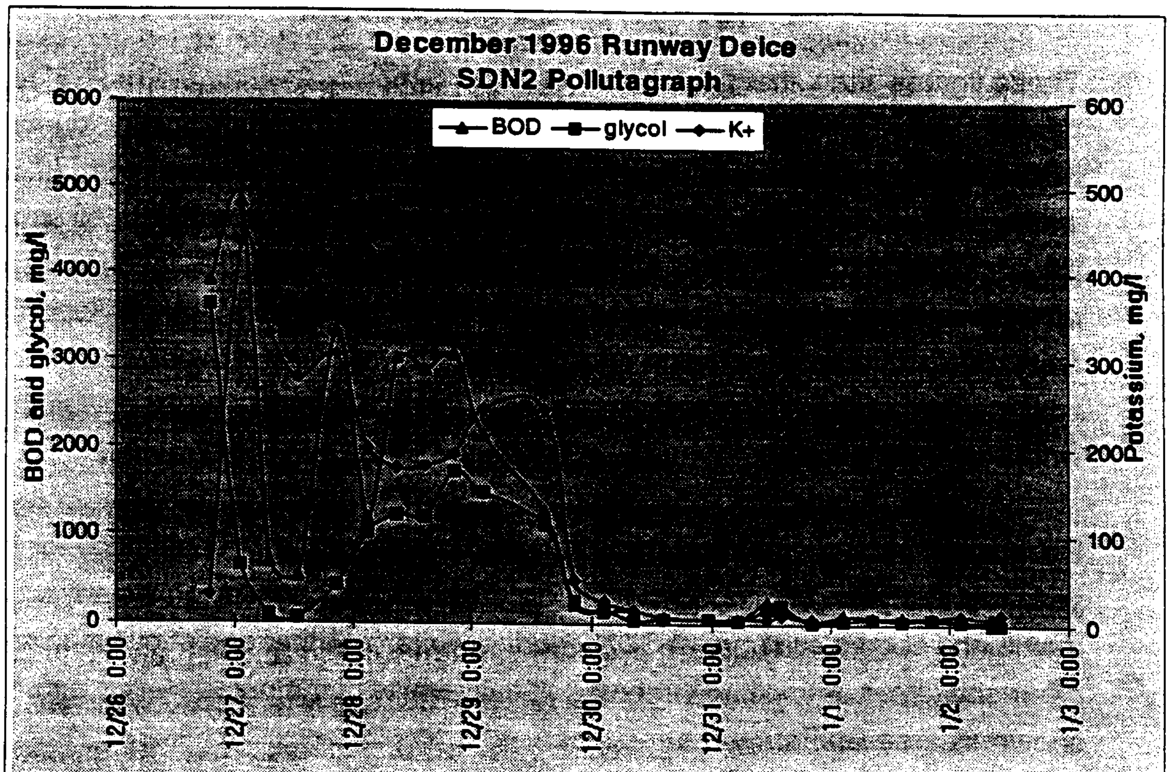


Table 1 Outfall Nomenclature Cross Reference

Outfall number in permit	Port nomenclature	Principal Activity
002	SDE4	landside
[illegible]	SDS1	terminal
[illegible]	SDS2	open space
[illegible]	SDS3	airfield
[illegible]	SDN1	landside
007	SDN2	airfield
008	SDN3	airfield
009	SDS4	airfield
[illegible]	SDW3	airfield
[illegible]	SDN4	airfield
012	EY	landside
013	TY	landside
014	B	airfield
015	D	airfield

The Port selected sampling locations in a manner that minimizes the sampling of runoff from areas *outside* the Port's SWPPP boundary. The Port achieved this objective for subbasins SDN2, SDN3, SDS4, SDW3, B and D. In contrast, non-Port off-site stormwater enters upstream from the sampling points for subbasins SDE4, SDS1, SDS2, SDS3, and SDN1:

- The total area draining to SDE4 (outfall 002) contains a limited non-Port area of commercial property and public roadway along the International Boulevard corridor producing runoff from the City of SeaTac.
- In addition to the Port's SDS1 subbasin, a portion of South 188th Street drains to the outfall sampling point. Because two recent BMPs reduced the Port's SDS1 area dramatically from 40 to 6 acres, runoff from South 188th Street is now a more dominant fraction of the total. This non-Port runoff could upwardly bias monitoring results for vehicle-source pollutants such as

metals and petroleum products. Trends will be identified in subsequent annual reports.

- In addition to the Port's SDS2 subbasin, non-Port commercial property along 16th Avenue South, 1,200 linear feet of 16th Avenue South roadway itself plus at least 300 linear feet of westbound South 188th St. also drain to the sampling point. Therefore, non-Port runoff comes from at least 1.3 acres of City of SeaTac public roads and parking (10% of the subbasin area). The sampling point cannot be relocated to exclude this non-Port runoff because the first point of accumulated Port runoff from the entire basin lies downstream of the non-Port stormwater inputs. Furthermore, because the non-Port runoff originates from impervious surfaces, it will reach the sampling point before the Port's runoff. There is dense, regular non-Port vehicle parking activity along the gravel shoulders of 16th Avenue South. As a consequence, the offsite runoff may upwardly bias the Port's sample results for total suspended solids (TSS), turbidity, and petroleum products.

- The outfall and sampling point for subbasin SDS3 is downstream from 2,000 linear feet (approximately 3 acres) of South 188th Street that also drains to the Port's SDS3 outfall. Though this City of SeaTac roadway drainage area is less than 1% of the total Port SDS3 subbasin, it could upwardly bias sample results attributable to vehicle-source pollutants. Because this non-Port drainage area is highly impervious and immediately upstream from the sampling point, grab samples for FOG and TPH taken early in a storm hydrograph could reflect this bias.

- Until December 1996, the sampling point for subbasin SDN1 (Outfall 006) was in manhole SDN1-27 on the shoulder of SR 518. This sampling point receives runoff from at least 3 acres of public roads including SR 518, South 154th Street, 24th Avenue South, plus abandoned stormdrains along South 154th Street that carry groundwater baseflow. Total Port property in

SDN1 is about 14 acres. Paired upstream/downstream samples in the current reporting period show that the offsite runoff from SR518 elevates FOG and TPH concentrations sampled in SDN1-27. As a result, with Ecology permission, the Port moved the sampling location to manhole SDN1-22 which eliminates the offsite runoff. Ecology concurred with moving the monitoring location.

Storm Sampling procedures and analytes

The Port targets storms of at least 0.20" preceded by 48 hours with no rainfall events greater than 0.10". The Port's Procedures Manual (POS, 1997b) describes the criteria for sample storm events, and describes all relevant sampling, programming and handling necessary to comply with requirements of the permit. The reader is referred to this document for additional sampling details.

Sampling frequency and pollutant analytes

The Port samples storms quarterly at 10 of 14 permitted outfalls. Sampling at two of these outfalls (B and D) will be reduced to an annual basis as allowed by the NPDES permit condition S3.4 footnote c. At two other permitted outfalls, SDS2 and SDW3, one storm is sampled per year. Table 2 lists required pollutant analytes, methods and detection.

Sampling procedure and protocols

The Port uses ISCO automatic samplers paired with ISCO flowmeters for the stormwater monitoring program. Model 4150, 4230, or 3230 flowmeters measure discharge and trigger Model 3700 automatic samplers. Samplers first collect a one-gallon grab sample taken after the "enable" conditions are satisfied, and then continue to collect a 3-gallon flow-weighted composite sample during the storm discharge hydrograph. Fecal coliforms, pH, FOG, and TPH are analyzed from the grab sample, while remaining pollutants are analyzed from the composite sample.

The Port employs staff to monitor stormwater. Safety reasons preclude manual grab sampling below grade in the confined spaces of manholes at SDE4, SDN2, SDN1, and the Taxi Yard. The Port utilizes automatic samplers to take all samples. Samplers use Teflon sample tubing and glass containers at all locations to minimize losses of FOG and TPH in the sampling apparatus. The WDOE has reviewed and approved the Port's Procedures Manual (POS, 1997b).

Table 2 Pollutant Analytes, Methods and Detection Limits

Analyte	Method[1]	Detection limit (mg/l)	Subbasins (refer to Table 1_			
			Airfield outfalls[2]	EY TY	SDS2 SDW3	Miller Creek Outfalls[3]
pH	150.1	0.10	X	X	X	
FOG (Oil and Grease)	413.1	1.0	X	X	X	
TPH (total petroleum hydrocarbons)[4]	418.1 mod	1.0	X		X	
Fecal coliforms	9221 E	2	X		X	
TSS (total suspended solids)	160.2	0.50	X	X	X	X
Turbidity	180.1	0.10	X		X	X
BOD_5	405.1	4.0	X		X	X
Total Ammonia	350.2S	0.010	X*			X
Total Glycols[5]	GC FID	5	X*			X
Total Recoverable Priority Pollutant Metals[6]	200	varies, see Table 7	X*			
Surfactants	425.1	0.10	X*	X		

1. Method refers to EPA-600/4-79-020, March 1979. Fecal coliform method refers to 18th edition of Standard Methods for the Examination of Water and Wastewater, or as revised.
2. Includes SDE4, SDS1, SDS3, SDS4, SDN1, SDN2, SDN3, and SDN4
3. SDN1, SDN2, SDN3, L. Reba outlet For Stipulated Agreement
4. Washington Department of Ecology method WTPH-418.1 Modified.
5. Analyzed by Gas Chromatograph, Flame Ionization Detector.
6. Total recoverable metals analyzed by atomic absorption (AA) furnace, unless quantifiable by ICP, Mercury analyzed by Cold Vapor method.

* except outfalls B and D. ** Total recoverable copper, lead and zinc only for outfalls Band D.

Results and Discussion

This section separates the presentation and discussion of results into two parts: stormwater monitoring data and SWPPP activities. The data for the current reporting year, July 1996 through May 1997 are compared to the data for the entire three-year period (to July 1994). The data are compared on the basis of concentration, annual loading, and unit loading among the outfall categories. These metrics are also compared to relevant regional and national data.

This Report discusses differences in stormwater data for the airfield, "landside", and terminal outfall categories when a distinction is merited:

- the airfield subbasins are: SDS3, SDS4, SDW3, SDN2, SDN3, SDN4, B and D,
- the landside subbasins are: SDE4, SDN1, EY, and TY, and
- the terminal subbasin is SDS1.

Stratified Data Set for Stormwater Discharges

Because stormwater discharge data represent different and distinct conditions, a stratified analysis approach is appropriate. These strata are:

1. Discharges from storms and samples that meet criteria of the Procedures Manual (POS, 1997b), including:
   a) regular quarterly NPDES monitoring,
   b) extra full-suite NPDES samples for the Stipulated Agreement,
   c) certain Miller Creek outfall samples for the Stipulated Agreement, and
   d) certain events monitored by the SRES
2. Samples analyzed for glycols during aircraft anti-icing and deicing operations

3. Other monitoring not required by the NPDES permit:

   a) Runway deicing events (runways, taxiways, and ramps inside the AOA)

   b) Stipulated agreement sampling at the Miller Creek outfalls

   c) Special investigations

Stratum 1: NPDES samples

Stratum 1 includes samples taken for at least four different objectives (1a, 1b, 1c, and 1d). Sampling for each of these objectives took place on a similar basis: a flow-weighted composite sample taken during a storm that met criteria. Because these samples share this common basis, they are examined together.

Results from flow-weighted composite samples approximate an average value of a particular pollutant during the portion of the hydrograph sampled. Results from composite samples are relatively comparable storm-to-storm, and site-to-site. In addition, composites give more representative results than discrete grab samples despite the difficulty in composite sampling.

Because sampling over the *entire* event hydrograph is neither required by the permit, nor practical, most of the Port's data in Stratum 1 represent a "sample mean concentration" or SMC. The SMC may be different from an event-mean concentration (EMC) represented in turn by composite samples taken over the *entire* duration of the hydrograph. The City of Bellevue also made this distinction in their recent report (Bellevue, 1996). All data reported in stratum 1 represent SMCs, with the exception of pH, fecal coliform, FOG, and TPH data which are from grab samples as required by the permit.

Stratum 2: Glycols

Stratum 2 data are from a variety of samples where glycols were analyzed. Per the Procedures Manual (POS, 1997b) these samples may be either flow-weighted composite or time-composite samples. These samples were from storm events in strata 1, 3 and 4 whenever glycol was analyzed. This stratum therefore aggregates all glycol data. Multiple time-series samples taken during runway deicing events are aggregated into average glycol values for each event at a particular outfall.

Stratum 3: Other monitoring not required by the NPDES permit

Stratum 3 segregates data from

1. monitoring during runway deicing events (the "washoff study"),
2. Stipulated Agreement monitoring data,
3. snowmelt montioring study,
4. special investigations, and
5. Quality control field samples.

Washoff study

For the past three seasons, the washoff study has been monitoring water quality from two outfalls during winter-weather runway-deicing. These samples monitored runoff during and after periods of deicing chemical application to the runways, taxiways, and terminal areas inside the AOA. The monitoring scheme provides data for "pollutagraphs" and "loadagraphs" which depict variation in BOD_5 concentration and load over the course of the runoff. These metrics identify when the majority of the BOD_5 load washes off as a function of accumulated rainfall, or "washoff function". This monitoring project and sampling is not required by the NPDES permit.

Monitoring took place over several days on a time-composite basis which is different from Stratum 1. Because they cause atypical stormwater quality occurring on the average twice per year at STIA, data analysis for runway deicing events requires a special stratum. Some samples in the other strata were also taken during a runway deicing event and included here as applicable.

Miller Creek samples for the Stipulated Agreement

This group of stormwater data includes a summary of samples taken at the Miller Creek outfalls for the Stipulated Agreement. These samples were generally flow-weighted composites, yet some were discrete samples, or time-composites depending upon the situation. The Stipulated Agreement did not require particular sampling and storm criteria. Several samples share data with other strata.

Stormwater Data Reduction

The following subsections present and discuss data obtained as part of the intensive stormwater monitoring program. Stormwater quality data are compared to one another on a sub-basin basis and are compared to certain reference values for the current year and the entire 3 year NPDES permit sampling history. Because objective criteria for stormwater quality do not yet exist, STIA stormwater will be compared to other generally accepted reference comparators. These comparators are:

- Stormwater discharge data from a comprehensive regional study, the City of Bellevue Urban Runoff study (BURP, 1984),
- Stormwater discharge data from the U.S. EPA's National Urban Runoff Program (NURP, 1983),
- Instream stormwater discharge data from Sturtevant Creek (downstream site), a commercial/industrial subbasin monitored by the City of Bellevue (Bellevue, 1996), and
- Receiving water quality standards for Washington State class AA waters as specified by the WDOE in WAC 173-201A.

Table 3 shows the comparator values. The "best" comparison was selected as the more conservative of either of the two City of Bellevue studies, because they were comprehensive, local studies and had similar sampling protocols. In general, using this very conservative approach will help establish that the Port's stormwater is not unusual, and is actually "cleaner" than other urban runoff.

Caution must be exercised in comparing stormwater quality data because the WA State water quality standards for pH, temperature, dissolved oxygen, turbidity, ammonia and certain toxic metal parameters apply strictly to the receiving waters. These criteria apply only to the condition of the receiving water itself, not at the end of the pipe. Dilution factors are allowed and must be computed before applying any standards to stormwater data.

Because many make the direct comparison without dilution anyway, note that all fecal coliform, copper, lead, and zinc comparators exceed the acute criteria. Even though the acute metals criteria in Table 3 were calculated at a rather low hardness of 28 mg/l, the copper lead and zinc comparators still exceed criteria at a hardness of up to 40 to 100 mg/l, which is not unusual for western Washington. Toxicity decreases with increasing hardness. These comparator and WA State criteria values are for total recoverable metals.

Table 3 Stormwater Quality Comparators[1]

Note: Best Comparative Values Shaded

Pollutant	units	Study: NURP, 1983	BURP, 1984	Metro, 1982	Bellevue, 1996[2]	Highway Runoff	WA State Criteria[3] (acute)
pH	std units		[illegible]		7.2 - 7.8		6.5 - 8.5
FOG	mg/l		*2.5*	7.8	[illegible]	30[8]	*no criteria*
TPH	mg/l				[illegible]		*no criteria*
Fecal coliforms	mpn per 100 ml	1000 to 21000	*980*		201		50
BOD_5	mg/l	9	[illegible]				*no criteria*
TSS	mg/l	100	*50*		82.3	106[9]	*no criteria*
Turb	mg/l		19		29.4		based on background
NH3[4]	mg/l		[illegible]		0.58		6.8 - 32.6[5]
glycols	mg/l	*not analyzed in any of these studies*					*no criteria*
Surf	mg/l				<MDL		*no criteria*
Cd (TR)[7]	µg/l			0.7	[illegible]		0.93[7]
Cr (TR)[7]	µg/l			7	[illegible]		612[7]
Cu (TR)[7]	µg/l	34		20	[illegible]	43[9]	5.3[7]
Pb (TR)[7]	µg/l	144	170	210	26.3	466[9]	16[7]
Zn (TR)[7]	µg/l	160	120	110	[illegible]	638[9]	40[7]
As (TR)[7]	µg/l			[illegible]			360[7]
Ni (TR)[7]	µg/l			[illegible]	7.3		483[7]
statistic reported:		median	mean[6], *median*	mean	log-normal median	mean	metals criteria[7] at hardness = 28 mg/l

1. Blank space means no data available, reported, or applicable
2. Bellevue, 1996 data for "Sturtevant Creek, downstream" site
3. Criteria are for class AA receiving waters, see WAC 173-201A
4. Ammonia values and criterion expressed as total ammonia, not as ammonia-nitrogen
5. Ammonia criterion for pH 6.5 to 8.0 and temperatures 5° to 20°C
6. For Turb, Cr, Cu, Pb, and Zn, BURP 1984 data was mean of grab samples, therefore Bellevue, 1996 data are better comparators because they represent median
7. Total recoverable metals. WA State acute criteria expressed as total recoverable, calculated at 28 mg/l hardness using WDOEs "TSDCALC6.XLW" spreadsheet. The hardness value is the 10th percentile for the receiving waters (source: Stormwater Receiving Environment Monitoring Report, POS, 1997)
8. Highway runoff in England (see Booth and Horner, 1995)
9. Highway runoff from an I5 location in Seattle with 57,000 ADT, 43 to 54 storm samples in 1980-81 (Chui, Mar, and Horner, 1982).

Data Interpretation: censored data

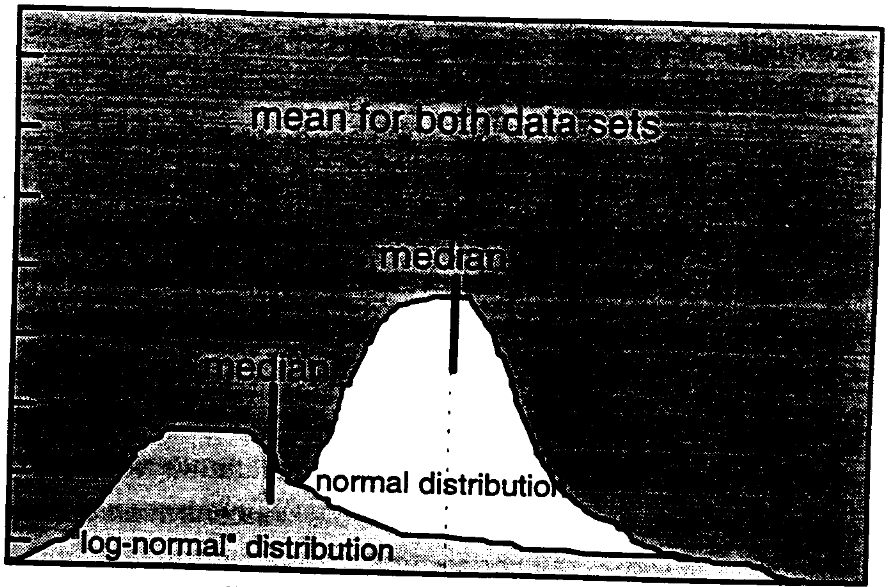
Many studies encounter what is termed "censored data", or results reported as below or above some value. Most analytical laboratories report these results as "<MDL", indicating that the result is below the detection limit for the analytical method specified. Many resort to a simple assumption to convert these censored data to values suitable for mathematical reduction. Others go on to prove an underlying distribution and actually estimate what the censored values should be based upon probability. This approach is beyond the scope of the Annual Report. For purposes of this report, when any pollutants were not detected, one-half the detection limit was assumed to be the concentration present. This approach is a common practice. All censored data values are highlighted in the Appendices.

Data Interpretation: estimators of central tendency

Stormwater discharge data typically fall into what is known as a "log-normal" distribution. Most data fall in the higher or lower ranges, rather than in "the middle" as in the bell-shaped curve of a "normal" distribution. Median values therefore are a better representation of central tendency, or typical value, than are simple arithmetic means.

The median is that value where half of the data fall on either side. An arithmetic mean, or average value, for log-normally distributed data could over or under estimate typical values considerably, which could bias conclusions. Figure 2 illustrates this principal, where both data sets have the same arithmetic mean, but the skewed (log-normal) data set has a median value much less than the mean value.

frequency



pollutant concentration

Figure 2 Median and mean values for data with different distributions

Most studies assume log-normal distributions, though few actually go on to confirm this assumption statistically. The City of Bellevue did so in their recent report of several years' worth of stormwater data (Bellevue, 1996). TSS and BOD_5 for STIA outfalls were found to be log-normally distributed using the regression method described in Supplement S-6 to Statistical Guidance for Ecology Site Managers (WDOE, 1990). Therefore, median data for STIA stormwater are compared, where possible, to the median values in the comparative studies.

"Box" Plots

Box plots efficiently illustrate the central tendency, spread, and skew that a data set might have. The bold line within a box represents the median value, while the bottom and top of a box show the 25th and 75th percentile, respectively. In other words, 50% of the time the data fall within values highlighted by the box. If the median is not in the center of the box, it shows that the data are skewed, further highlighting the log-normal possibility. SPSS software was used to generate the box plots appearing below (SPSS, 1993).

The size of the box shows the variability, and the "whiskers" show the largest values that are not considered outliers. When summarizing data to compare "typical" values, outliers usually represent unusual conditions, atypical of what one could expect on a day-to-day basis.. Thus, the box plots show two separate circumstances. SPSS reports two types of outliers: those more than 1.5 box-lengths from the 75th percentile as "o", and those more than 3.0 boxlengths as "*", each captioned with the date of occurrence (SPSS, 1993).

General box plots showing difference between runoff quality for each of the three subbasin activity types (airfield, terminal, and landside) may have smaller scales than the box plots showing the data for each outfall. The general box plots show the overall difference between the subbasin categories while the outfall boxplots have increased scales as appropriate to show any outlying values.

Loading Estimates

To add more information about STIA's stormwater discharges, this year's report presents an estimate of unit loadings for total suspended solids (TSS) and three principal metals. Loading estimates are not a permit requirement, but provide another degree of sophistication useful in assessing water quality beyond concentration data alone. Throughout this report, the STIA unit loading estimates will be compared to unit loads published for other typical urban land uses. Loading estimates are by no means exact and should be viewed only as general order-of magnitude estimates.

The unit load is a rate term that estimates the annual amount of a pollutant generated or exported per unit of subbasin drainage area. Unit loads can be compared amongst sites and over geographical areas. Unit loads reflect the general extent of activity, land disturbance, or other factors important in characterizing the water quality of a particular drainage area.

Each loading estimate presented in Table 4 is based upon the sampling history for each STIA subbasin, encompassing up to three years and 14 to 23 storm samples. Each estimate is based in turn upon an estimate of total annual runoff for a particular subbasin. Loading estimates use the method of Marsalek (1990), which is summarized in Appendix C. The ranges given reflect the 90% confidence interval.

Table 4 Unit Load Estimates and Comparisons

	Unit Load, kg/ha-yr			Comparative Unit Loads[2], kg/ha-yr								
	STIA outfalls[1]			*Roads*			*Commercial*			*Single-family Res.*		
Parameter	min	median	max	min	median	max	min	median	max	min	median	max
TSS	14	21	30	281	502	723	242	805	1369	60	200	340
BOD_5	12	15	19	na	na	na	na	na	na	na	na	na
Total Copper	0.04	0.05	0.06	0.03	0.06	0.09	1.1	2.1	3.2	0.09	0.18	0.27
Total Lead	0.01	0.03	0.08	0.49	0.78	1.1	1.6	3.1	4.7	0.03	0.06	0.09
Total Zinc	0.13	0.20	0.32	0.18	0.31	0.45	1.7	3.3	4.9	0.07	0.13	0.20

1. 12 outfalls: SDE4, SDS1-SDS4, SDW3, B, D , SDN1-SDN4
2. from Booth and Horner, 1995.

Stratum 1: all NPDES "Storms"

The following sections and figures present and discuss results within Stratum 1, all NPDES Storms, for each parameter. The tables in Appendix B present the raw data for all Stratum 1 data. Figure 5 through Figure 31 compare results for each subbasin, one to another, using box plots. Comparing outfalls over time and to others using these box plots is expected to show several distinctions: improvement over time and differences between airfield, terminal and "landside" outfalls. Note the reference median parameter concentrations depicted by dashed lines in these figures (BURP, 1984, or Bellevue, 1996). Each figure also shows the method detection limit (MDL), the number "N" of data points for each outfall, and the number of low-censored (<MDL) results replaced with values equal to one-half the particular MDL. All data are from flow-weighted composite samples except FOG, TPH and fecal coliform data are from grab samples as required by the permit.

FOG and TPH in grab samples

Method biases indicated in results

Because FOG and TPH both relate largely to anthropogenic petroleum pollutants, both are discussed concurrently. TPH is a subset of FOG therefore, all TPH values should be less than or equal to the FOG results. Thus, any petroleum hydrocarbons showing up in the TPH analysis should also show up in the FOG procedure. However, TPH exceeded FOG in 18 samples. Minor differences could be attributable to loss of volatile fractions during solvent boil-off in the gravimetric-based FOG analytical method. Differences between TPH and FOG of more than about 1 mg/l show that results from the two methods are not comparable due to this method bias. Eleven of the 18 samples had a difference between TPH and FOG of more than 1 mg/l.

Substantial portions of gasoline through #2 fuel oil (diesel) are lost in the FOG gravimetric method process (APHA, 1995). In contrast, TPH (method 418.1) is analyzed by infrared absorbance without solvent boil-off. The TPH method should not produce a low-biased, or "false negative" result possible with the FOG method. Therefore, TPH is a more reliable indicator of anthropogenic petroleum pollutants, specifically the fuels and lubricants that might be present in STIA stormwater. Because the FOG gravimetric method 413.1 is not equivalent to the infrared FOG method 413.2 (per 40CFR Part 136.3), the Port could not substitute the more reliable FOG method.

In addition, FOG results are subject to interferences from other organic hydrocarbons such as chlorophyll and the biological lipids found in animal and vegetable fats and oils (APHA, 1995). Instances where the FOG results are higher than the TPH results indicate these interferences. These interferences act to high-bias results creating non-representative data and "false positives" if one is concerned primarily with anthropogenic hydrocarbons. Future samples will be analyzed by approved methods less susceptible to such bias.

Also illustrating method biases are unusual FOG results from three samples taken on March 5, 1997[1] It is highly unlikely that the SDE4 and SDN3 outfalls each experienced in the same storm an FOG value that was nearly 10 times the historical maximum. These elevated values were attributed to absorption of water during sample drying and operator error (Aquatic Research, 1997). Standard Methods (APHA, 1995) acknowledges that the FOG method is sensitive to this type of interference. In addition, TPH results for these samples were much less than the FOG results. The SDN3 030597 sample TPH result was non-detected. In these cases the large difference between FOG and TPH results 1) corroborates the laboratory error, 2) indicates the possible FOG interferences, and, 3) shows that petroleum products were absent or at very low concentrations.

STIA general results

The results discussed below demonstrate that the STIA concentrations of both pollutants are consistently less than in stormwater from commercial and residential land uses. Furthermore, airfield stormwater had far less FOG and TPH than the terminal and landside subbasins. Results from the past year continue to indicate the following conclusions stated in the 1996 Annual Report (POS, 1996a).

1. FOG in STIA runoff over the past three years ranged from non-detectable to 21 mg/l, with an overall median of 1.4 mg/l, about fifteen times less than the 30 mg/l mean in a City of Redmond study (Redmond, 1990). Seventy five percent of all STIA FOG (160 samples) was less than 2.9 mg/l, less than the 3.7 mg/l median reported by Bellevue, 1996.
2. FOG and TPH were not detected in 40% and 61% of all STIA stormwater samples, respectively. This means that more than half the samples had no detectable traces of petroleum hydrocarbons. TPH was never detected at outfalls SDS2, SDN4, and B. TPH was also absent in more than 80% of the 16 to 18 samples at airfield outfalls SDS3, SDS4, and SDN3. TPH was absent in 56% of the 16 samples at airfield outfall SDN2.
3. In general, Figure 3 and Figure 4 show that the highest TPH and FOG came from terminal and landside subbasins. These subbasins have large areas of

[1] FOG results for these samples were rejected and the outfalls re-sampled at the next available storm event. Because the problem was rectified in the subsequent month, these elevated FOG results for outfalls SDE4, SDN3, and TY were reported on the March 1997 DMRs.

paved vehicle driving surfaces unlike the airfield subbasins. Only FOG and TPH data from the landside and terminal areas tend to approach the comparative value of 3.7 mg/l. Because 4 out of 5 results for TPH at subbasin D were at or below the MDL, the higher FOG values (shown by comparing Fog in Figure 6 to TPH in Figure 8) can be attributed to non-petroleum interferences as discussed above.

4. Nearly 75 percent of the TPH data for both SDE4 and SDS1 are below the comparator value of 3.7 mg/l. These two subbasins border aircraft service areas in contiguous IWS areas. These data establish that the IWS effectively isolates aviation-related fuel spills and drips from the storm drains.

Trends and outliers

Comparing current year data to the three-year history shows stable or decreasing median values and ranges of both FOG and TPH. The BMPs that recently removed aircraft and GSE service areas from subbasins SDS1, SDE4, and SDN2 will result in further decreases apparent in future data.

As discussed in the last Annual Report (POS, 1996a), Figure 5 and Figure 6 show that the EY had FOG outliers (June 4, 1995, and July 26, 1995). These higher FOG values could be attributable to an occasional leaky vehicle in the area, because FOG was detected in only 57% of the 14 samples at the EY. Current data support the trend of low or non-detectable FOG at the EY.

Note that SDE4 had both FOG and TPH outliers on February 3, 1996 and January 16, 1997. In June 1997, a 10" overflow pipe from an IWS pump station was found to be connected to manhole SDE3-91, part of the SDE4 stormdrain. Occasional overflows are thought to be the source of both elevated FOG, TPH, and surfactants in baseflows and storm discharges. The overflow pipe was permanently plugged in mid June 1997.

As discussed in the last Annual Report (POS, 1996a) an outlying TPH value of 6.6 mg/l for SDW3 was from an August 17, 1995 storm. This TPH value exceeded the 2.9 mg/l FOG result by a factor greater than three, illustrating the bias discussed above. These results suggest that lighter fuel fractions (e.g. gasoline constituents) boiled-off during FOG analysis. This outfall typically has a backwater that forms with the S. 188th Street ditch. Fuels in runoff from the heavily traveled S. 188th Street could have biased results upward in the samples taken in this backwater. Two other samples taken earlier in 1995 do not show detectable TPH, and, FOG was near or below the 1.0 mg/l MDL. Several cleaning attempts to remove accumulated sediments and debris in late summer 1996 were unsuccessful at removing the backwater. Therefore, 1996 samples were taken in manhole SDW3-24 upstream of the backwater at this outfall. Three subsequent TPH samples were at or below the MDL.

Dual upstream/downstream samples showed that public roads generate FOG and TPH that have biased previous STIA results for SDN1. See Table 5. Because these non-Port areas were suspected to bias STIA data, the Port requested approval for moving the monitoring location from SDN1-27 upstream to SDN1-22 in September 1996 (POS, 1996b). Samples were collected at both locations for comparison. In the Spring of 1997, the Port verified[2] that at least 3 acres of public roadway including portions of SR 518, S. 154th Street, several abandoned roadway stormdrains, and the 24th Ave S/S. 154th St. intersection drain to the original SDN1-27 monitoring location. Intersections can be sources of petroleum products from idling and accelerating vehicles. In 1994, SR 518 had six times[3] the annual average daily traffic (AADT) compared to the portion of Air Cargo Road that comprises a more than 50% of SDN1 drainage. Therefore, the Port attributes the relatively high FOG and TPH in SDN1 discharges shown in the last Annual Report (POS, 1996a) to these non-STIA sources.

Table 5 SDN1 upstream/downstream FOG and TPH

date	rain, in.	FOG		TPH	
		up*	down*	up*	down*
10/4/96	0.59	<1.0	**3.8**	0.5	**3.0**
11/3/96	0.14	<1.0	**2.5**	0.39	**1.3**
1/16/97	1.15+	<1.0	n/a	2.1	**3.6**

* upstream point is manhole SDN1-22, downstream is manhole SDN1-27

[2] Verified 4/14/97 by dye testing inlets along SR518, 24th Ave S., and S. 154th St. Earlier remote television inspection in February 1997 did not reveal connections due to equipment limitations caused by complex pipe configurations and vertical relief in several manholes.

[3] Compare 56,750 AADT for SR518 to 9,450 AADT for Air Cargo Road.

Median FOG from the TY continues to remain below the comparative value of 3.7 mg/l. This improvement is probably due to using oil-absorbent media in the catch basin insert "socks" ("Streamguard" units), and increased vigilance by the STITA Taxi Association, which leases this site. On March 5, 1997, there was a an FOG outlier of 18 mg/l similar to that of 19 mg/l on October 16, 1995. The 1995 value was probably due to a defective early design of the "Streamguard" insert (POS, 1996a). The Port replaced the older designs with improved units. The March 5, 1997 outlier was part of a sample batch that was subject to laboratory error discussed above. However, because an elevated TSS result of 188 mg/l accompanied this sample, the catch basin insert may have failed, also contributing to the elevated FOG value.

Comparing FOG results with TY catch basin insert maintenance records in Table 6 shows that the inserts continue to perform well over periods up to 3 1/2 months.

Table 6 Taxi Yard Catch Basin Insert Performance

storm date	last replaced	maint interval[1]	FOG	TSS	comment
22-Mar	3/11/96	11	3.9		3 new bags installed
4/16/96	3/11/96	36	3.7	30	3 new bags installed
4/22/96	4/18/96	4	2	23	2 new bags installed
7/3/96	4/18/96	76	1.4	28	2 new bags installed
7/17/96	4/18/96	90	1.9	13	2 new bags installed
8/2/96	4/18/96	106	1.6	33	2 new bags installed
10/4/96	9/3/96	31	1.4	17	4 new bags installed
2/11/97	12/18/96	55	5.1	29	4 new bags installed
3/5/97	2/15/97	18	18[2]	188[2]	4 new bags installed
	mean	**51.1**	**2.6**	**24.7**	

1. number of days between replacement
2. excluded from calculation because of potential laboratory error or malfunction of insert.

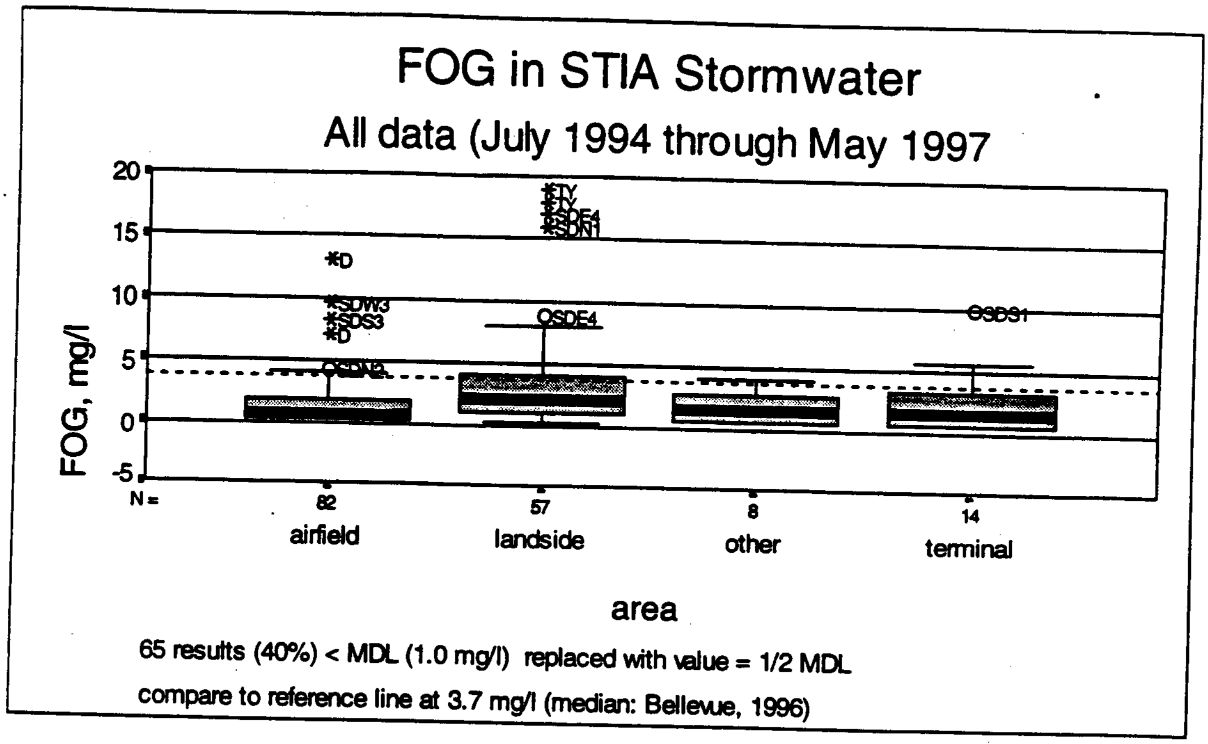


Figure 3 FOG compared by subbasin activity

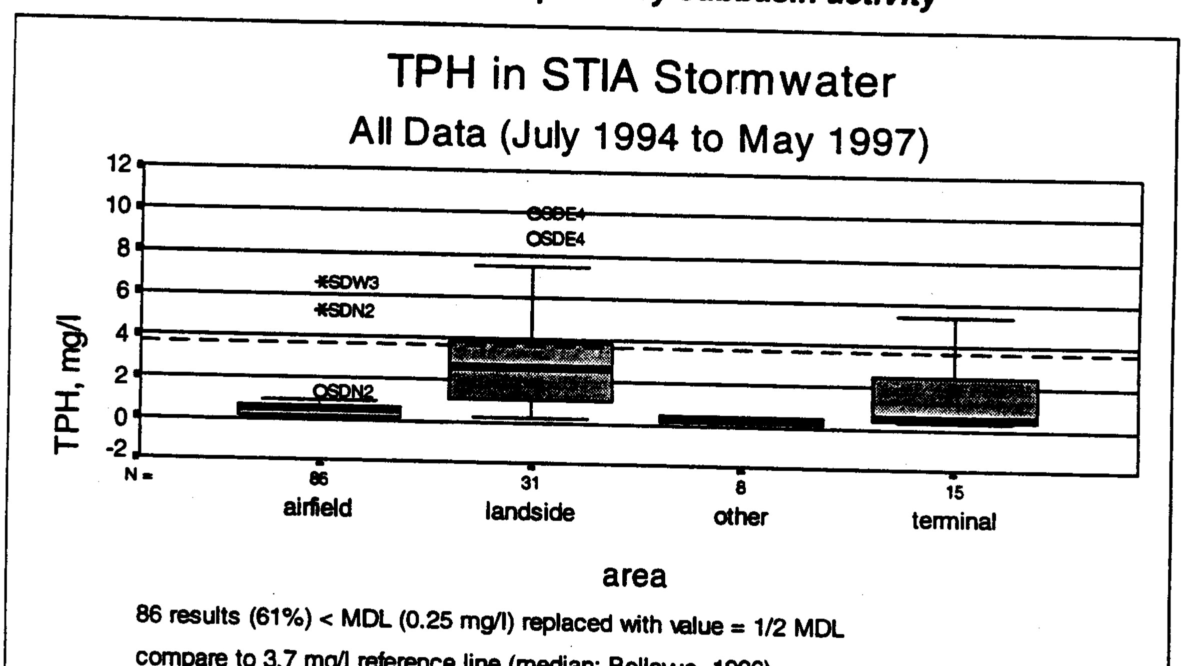


Figure 4 TPH compared by subbasin activity

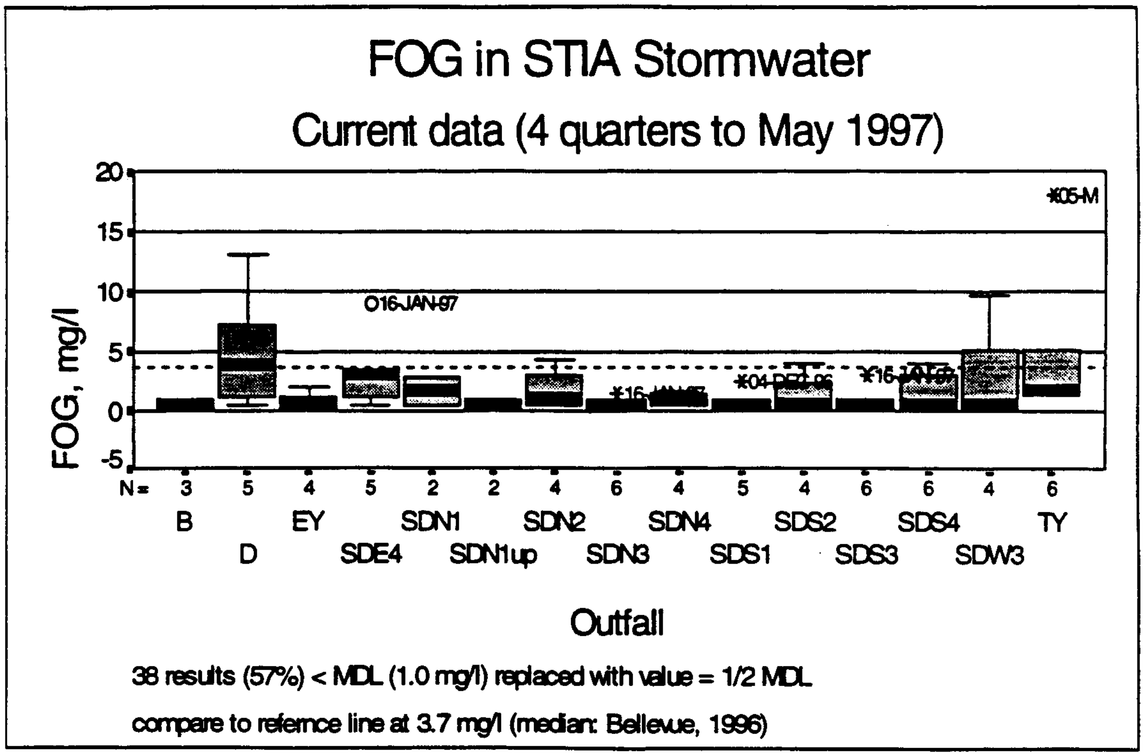


Figure 5 FOG compared in box plot for current year

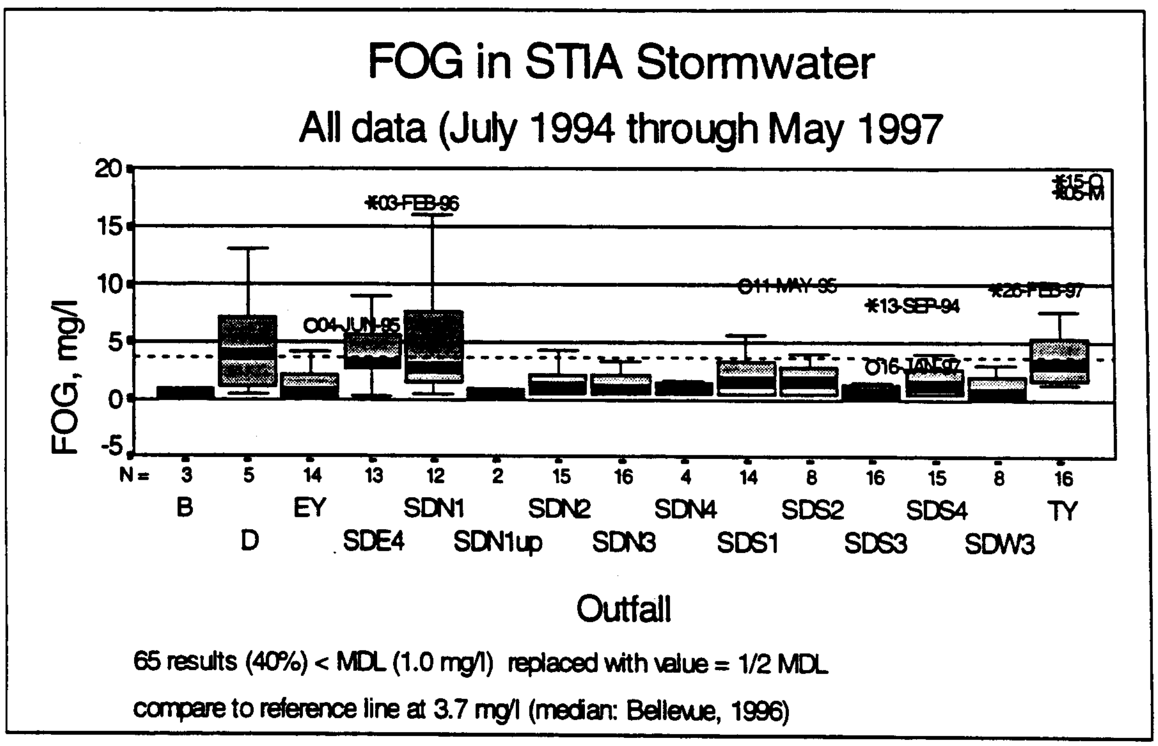


Figure 6 FOG compared in box plot for permit history

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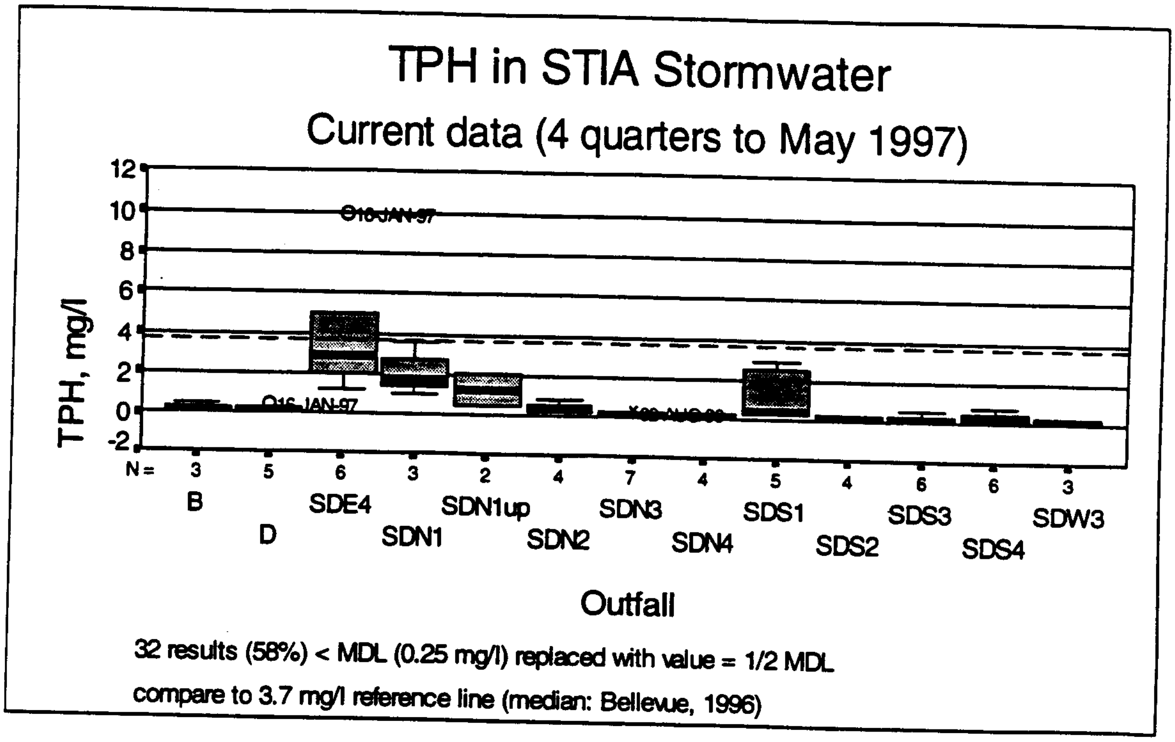

Figure 7 TPH compared in box plot for current year

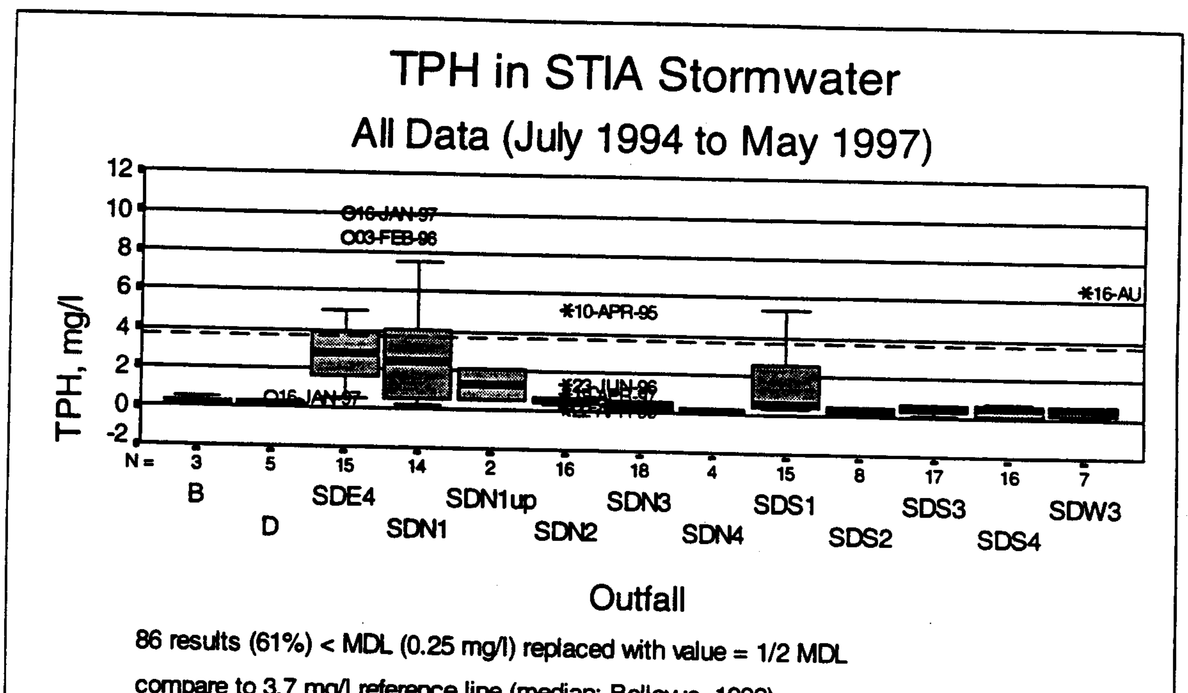

Figure 8 TPH compared in box plot for permit history

Suspended Solids and Turbidity

STIA general results

Both total suspended solids (TSS) and turbidity (Turb) are measures of suspended material. In stormwater runoff, TSS and turbidity generally appear proportional to one another. Turbidity generally indicates finer suspended material such as colloidal clays and fine silts.

In general, Figure 9 and Figure 12 show that airfield subbasins produced less TSS and turbidity than either the landside or terminal subbasins. Both median TSS and turbidity values for all subbasins were below the comparative values of 50 mg/l and 29 NTUs, respectively. The 75th percentile for all grouped subbasins was below these median reference values as shown by the dashed lines on these figures. Therefore, this concentration-based data confirms that suspended material in STIA runoff is much lower than in comparable regional urban areas.

Furthermore, unit loading estimates for TSS indicate that STIA runoff overall is more than an order of magnitude (10X) less than typical roads, commercial areas, and even single-family residential areas. The 90% confidence interval for the STIA estimates does not even come close to overlapping that for single-family residential areas. See the annual and unit load estimates presented in Table 4.

Trends and outliers

Comparing current year data to the three-year history shows stable or decreasing median values and ranges of both TSS and turbidity. IN the past year, there were only two aberrations in TSS data, the outlying values shown on Figure 10 for outfalls SDE4 and TY.

The SDE4 TSS outlier on January 16, 1997 was probably due to the large amounts of roadway sand applied during the freezing conditions in the prior weeks. The Port applies sand to ensure public safety. This is similar to the TSS and turbidity outliers for SDE4 and SDN1 in the February 3, 1996 storm that followed roadway sanding. See Figure 10 through Figure 14.

On March 5, 1997 there was a TSS outlier of 188 mg/l at the taxi yard (TY). The Port utilizes flexible catch basin inserts as a BMP in the TY. This value may have been due to malfunction of an insert where one of the fabric corners slipped into the inlet, spilling accumulated sediments. The Port frequently inspects and replaces these inserts as necessary. Table 6 shows that the Port's maintenance intervals are adequate and that the inserts continue to reduce TSS below 30 mg/l over periods as long as 3 months.

Subbasin B showed elevated TSS and turbidity in a December 4, 1996 sample. A minor construction project in near the perimeter road was responsible for the elevated results. Appropriate perimeter BMPs were already in place during this storm event. A gap in the filter fabric fence was fixed immediately and wood chip mulch applied as a cover practice to prevent further erosion. Because this sample was one of 4 taken in the first year at this outfall, the elevated results skewed the data. The low position of the median line in the relatively large box in Figure 10 and Figure 13 indicate this skew. Subsequent samples showed TSS and turbidity similar to other airfield subbasins and near the comparative values. Therefore, the elevated values are not representative of typical runoff, though they indicated the need to repair several BMPs already in place.

As stated in last year's Annual Report, current data show that the gravel shoulder of 16th Ave South continues to contribute sediments and turbidity to the SDS2 samples. Current data show turbidity values of 19 to 39 NTUs. Though the median of these values is less than the comparative value of 29.4, the data are skewed by non-Port runoff. Many vehicles park on this shoulder on a daily basis disturbing the gravel-surfaced shoulder on the east side of this road. Turbid runoff was observed draining in rills and gullies along this shoulder during the past year's storm events. The Port has no jurisdiction of these public roadways.

In summary, the main airfield outfalls SDS3, SDS4, SDN2, SDN3 and SDN4 produced less than the comparative values for either TSS or turbidity. STIA runoff had less suspended material and turbidity than comparable regional areas.

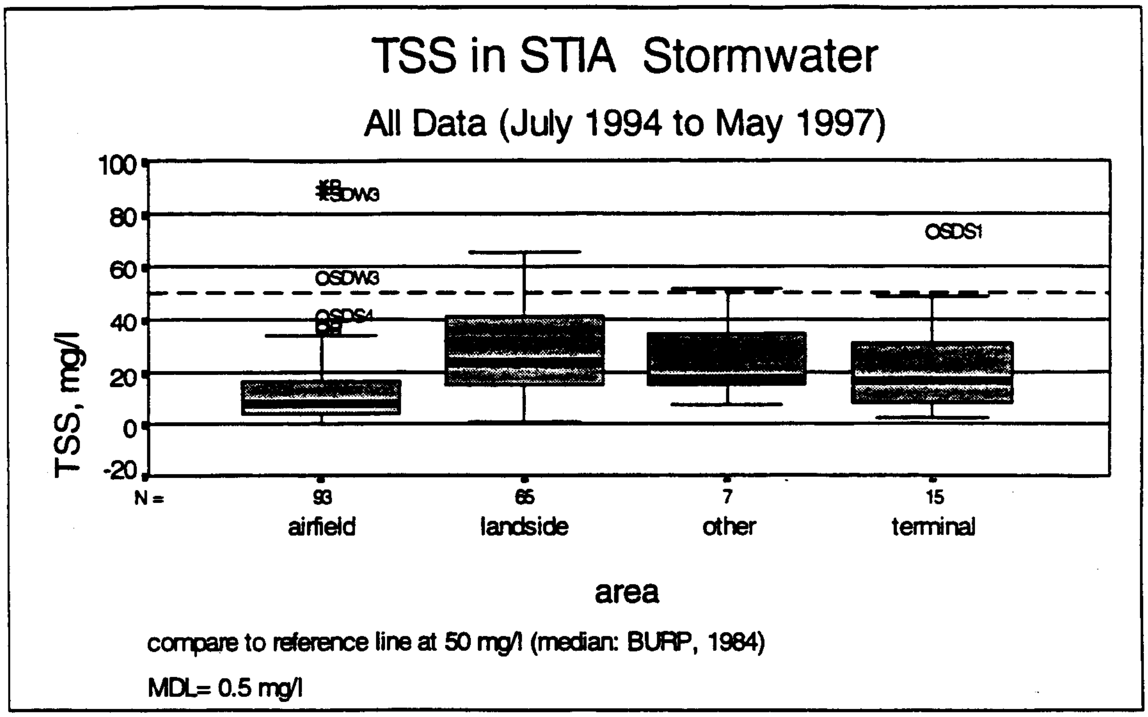

Figure 9 TSS compared by subbasin activity

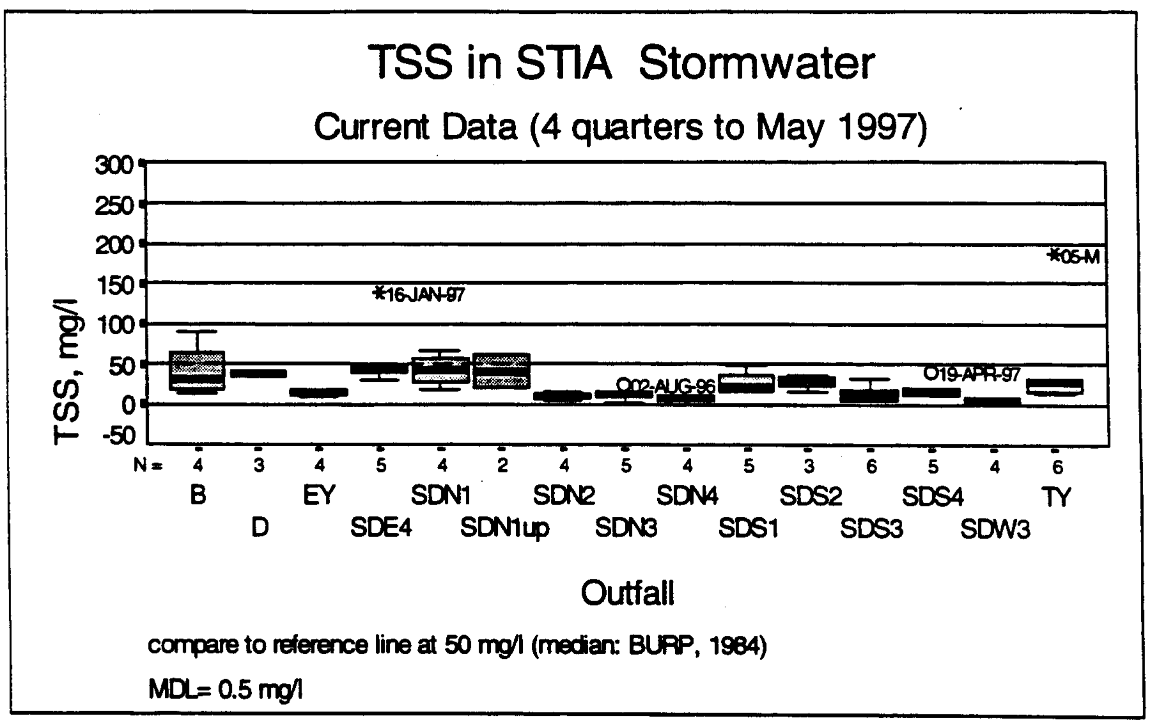

Figure 10 TSS compared in box plot for current year

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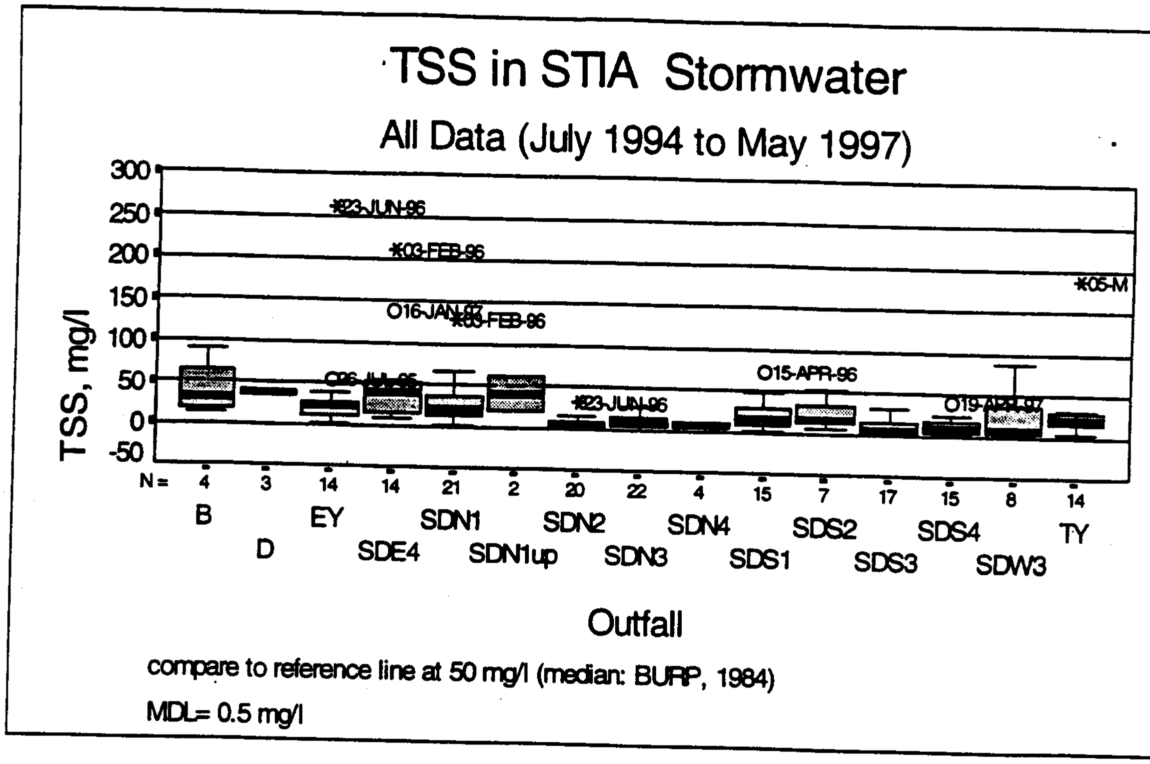

Figure 11 TSS compared in box plot for permit history

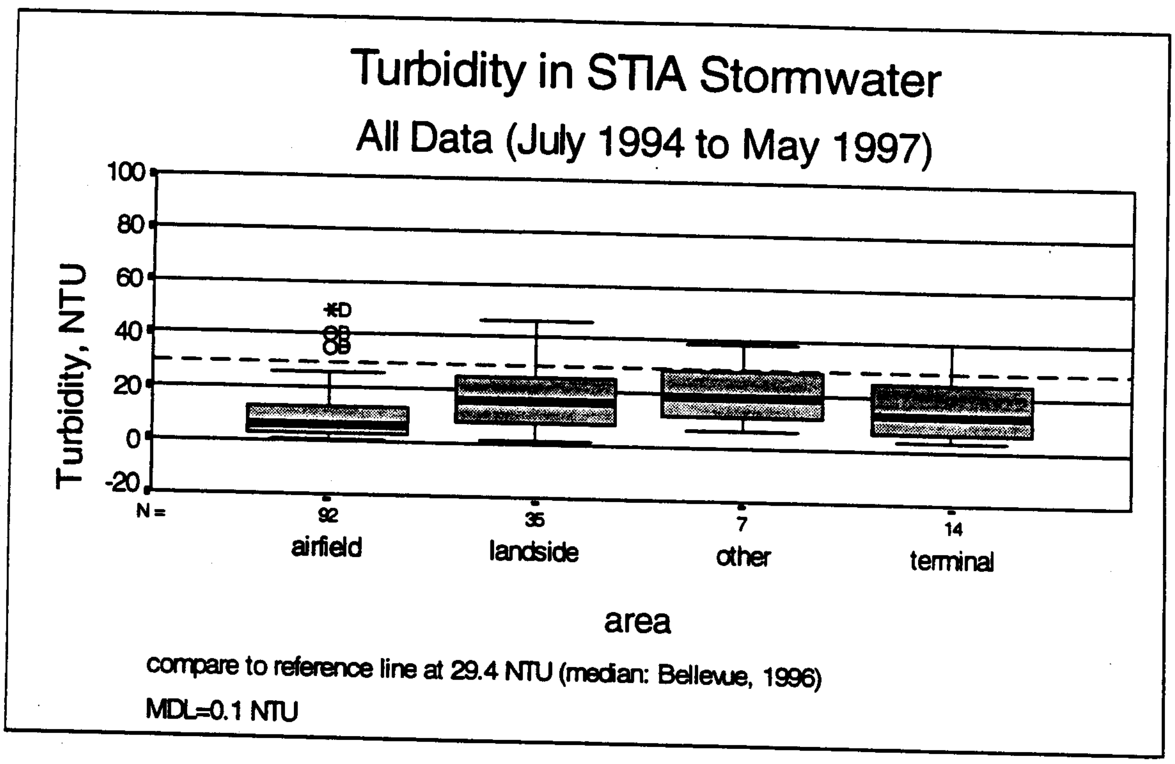

Figure 12 Turbidity compared by subbasin activity

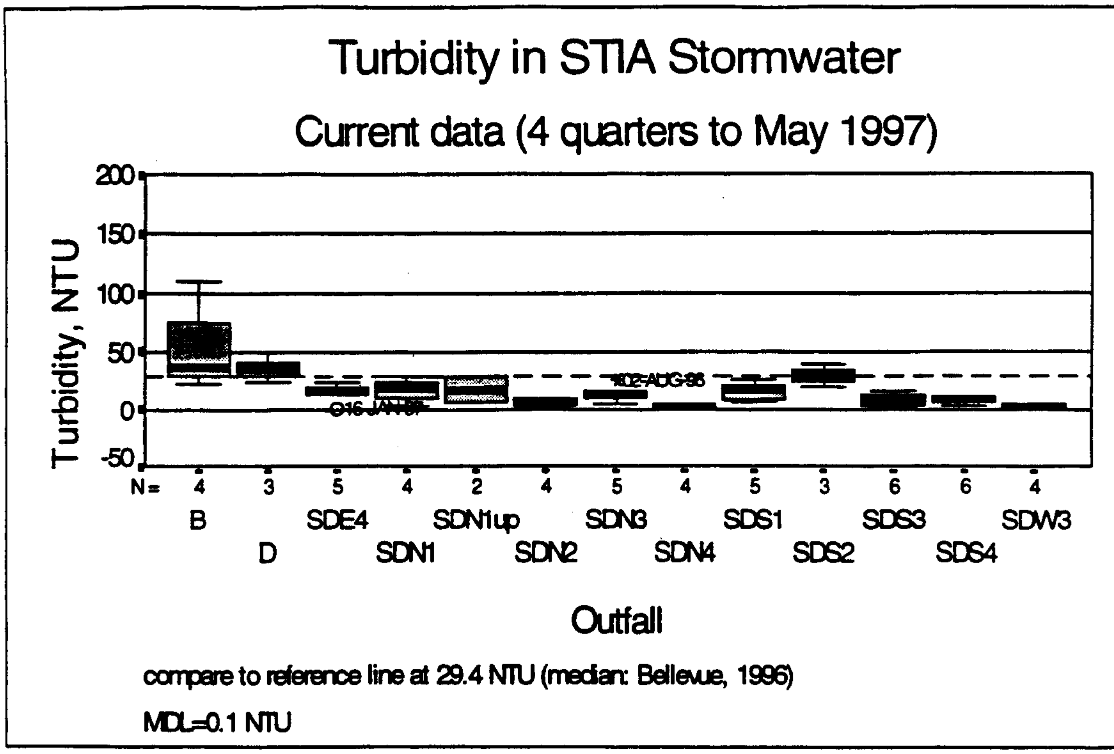

Figure 13 Turbidity compared in box plot for current year

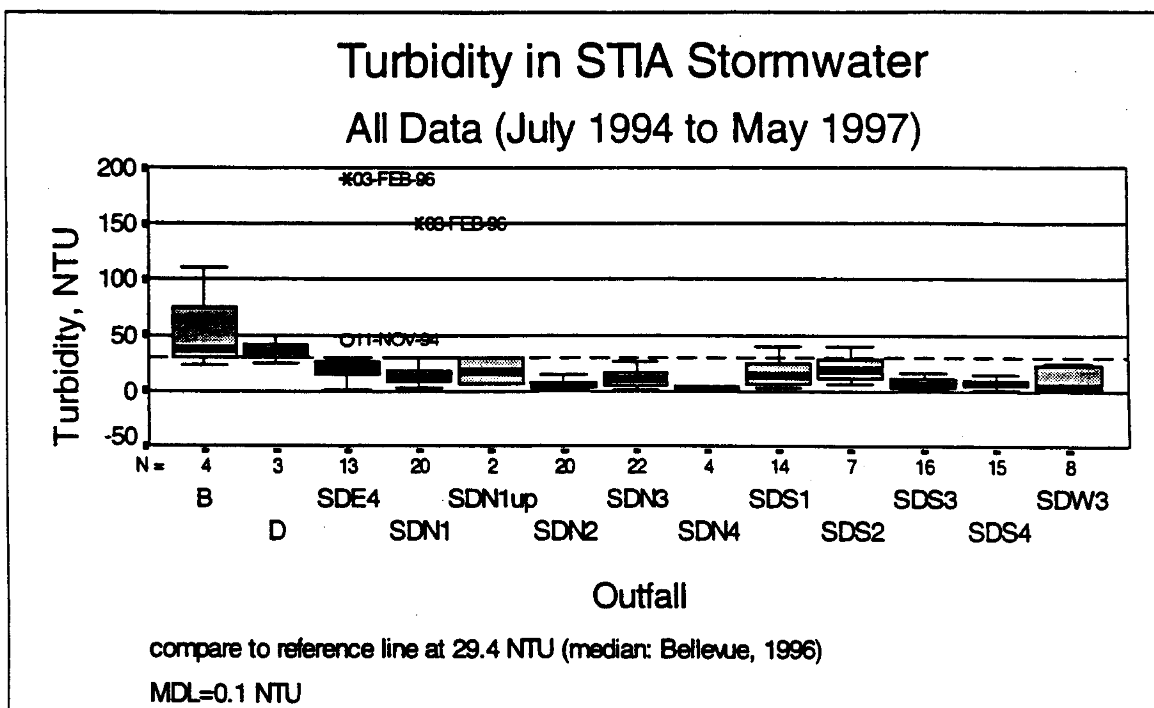

Figure 14 Turbidity compared in box plot for permit history

Ammonia

The ammonia reported is expressed as *total ammonia*, the sum of both ionized (NH_4^+) and unionized (NH_3) forms: not *ammonia-nitrogen*. The principal source of ammonia in past stormwater samples was the urea applied as a runway deicer. In 1996, urea use was limited to a small quantity used to prevent roadway deicing sand stockpiles from freezing. These stockpiles were stored away from storm drains inside maintenance buildings. Urea itself was not applied as a deicer in the 1996-97 winter. The Port completely discontinued the use of urea by the end of 1996 and successfully sold all remaining supplies to other industrial users.

STIA general results

This report compares STIA *total ammonia* values to *total ammonia* comparative values and the Ecology acute toxicity criterion; see Table 3. Acute total ammonia toxicity ranges from 6.8 to 32.6 mg/l over ranges of pH from 6.5 to 8.0 and temperature of 5° to 20°C. Ammonia toxicity depends upon both pH and temperature. It is important to note that the Ecology criterion applies to the receiving waters, not to the end-of pipe discharge. All ammonia concentrations at all STIA subbasins were well below any *acute* toxicity criterion. Therefore, there is no toxicity caused by ammonia in STIA stormwater.

With the exception of SDN1, virtually 100% of the ammonia data for STIA subbasins were below the most conservative comparative value of 0.17 mg/l (BURP, 1984). See Figure 15. Total ammonia was not detected in 28% of all samples in the current year and 17% for the three-year permit history.

Trends and outliers

Comparing Figure 15 with Figure 16 shows that in the current period there were no outlying ammonia values. Previous elevated ammonia was attributable to the urea used for runway deicing. As stated above, the Port's stormwater quality data show a substantial decline in ammonia in samples taken during or shortly after winter runway deicing events.

Though well below any toxicity concern, SDN1 has shown higher ammonia than other subbasins. An investigation in 1996-97 identified the cause was an inappropriate connection at a food service facility. Baseflow sampling and dye tests in April 1997 showed that the facility's loading dock drain connected to manhole SDN1-25. Soaps and disinfectants used to clean the food service trucks were the source of elevated BOD_5, and surfactants found in baseflow and storm samples. These cleaners were also probably the source of ammonia as well. The drain has been plugged and drainage rerouted to the sanitary sewer. The Port believes this source to be the cause of previous elevated ammonia values recorded at the original SDN1 subbasin monitoring point, manhole SDN1-27, which is downstream of the facility.

In summary, STIA runoff during typical storms produces ammonia concentrations that are a small fraction of the most conservative acute toxicity standard for receiving waters. Airfield outfalls produce ammonia concentrations less than comparable regional areas during typical storms.

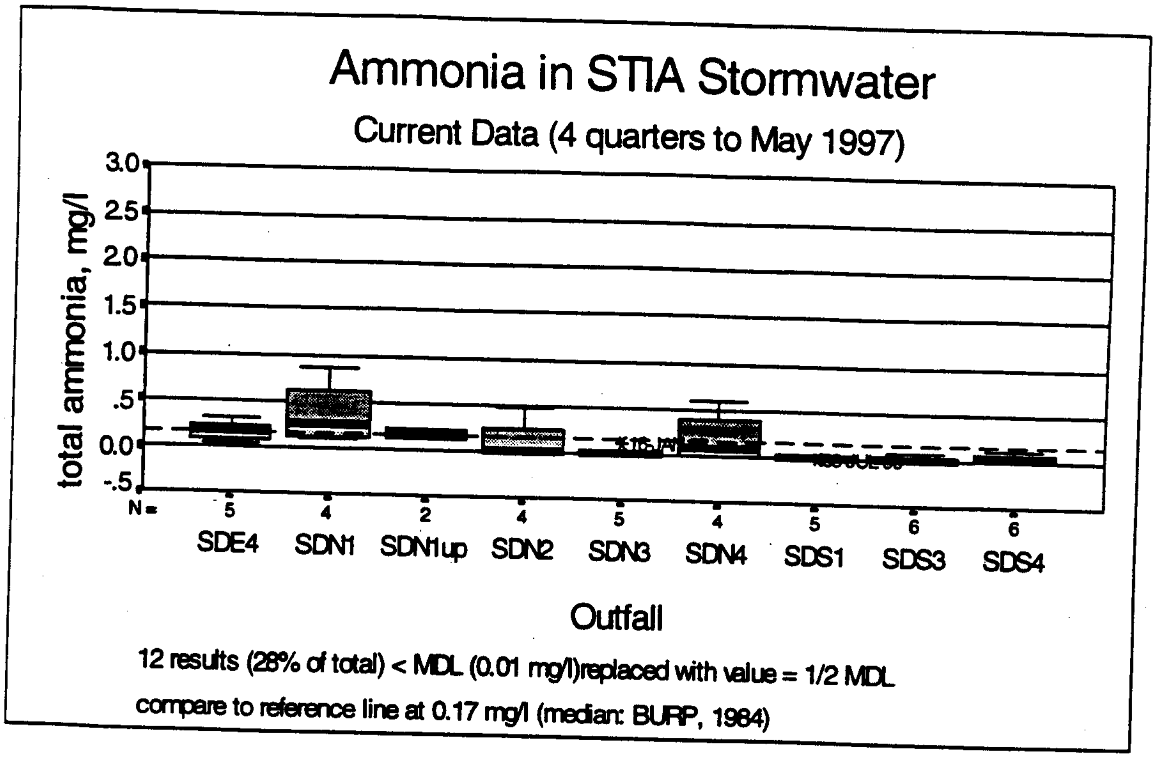

Figure 15 Ammonia compared in box plot for current period

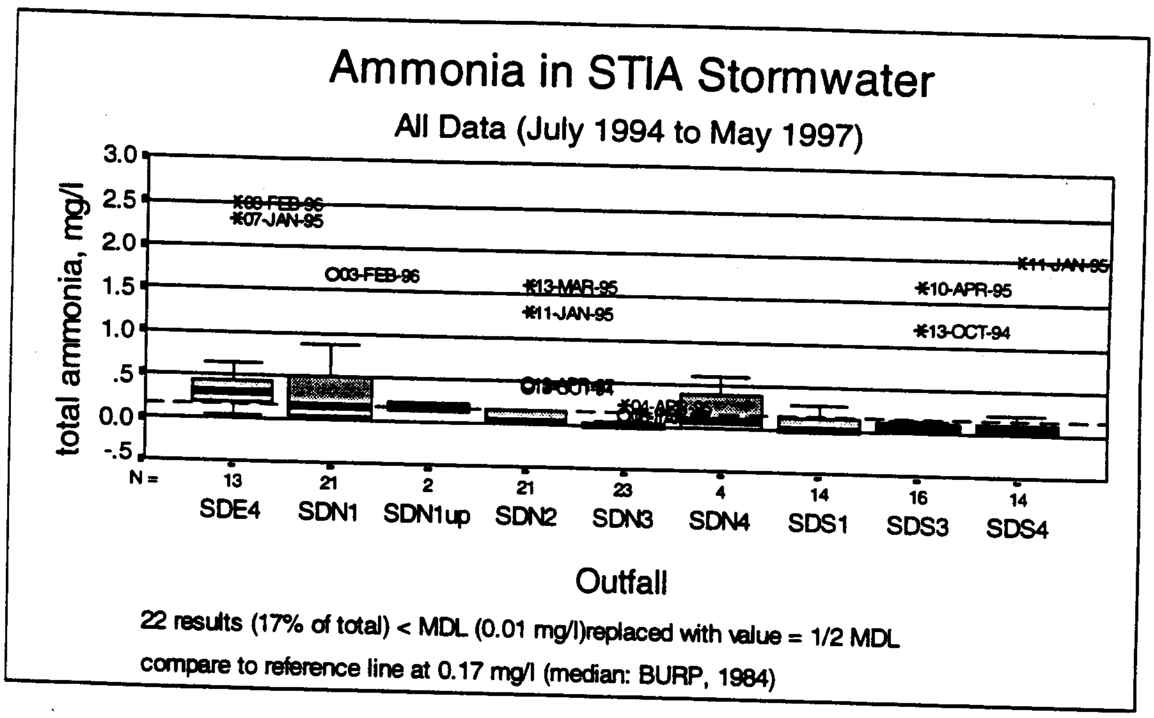

Figure 16 Ammonia compared in box plot for permit history

BOD_5

STIA General results

Figure 17 shows that airfield outfalls discharged less BOD_5 than terminal and "landside" outfalls. Overall, the airfield outfalls produced median BOD_5 values less than or approximately equal to the comparator value of 6.6 mg/l (BURP, 1984), which is just barely above the MDL of 4 mg/l. BOD_5 was not detected in 41% of the samples taken in the past year. Aircraft deicing glycols are the principal source of elevated BOD_5 in certain outfalls. The Port has recently completed three capital BMPs that will eliminate glycols from stormwater discharges in subbasins SDS1 and SDN2.

Excluding from the data set the 4 elevated BOD_5 values caused by glycols shows that 55% of the data are below the 6.6 mg/l comparator, and over 88% are less than 20 mg/l. Therefore, other than the known sources, there is no evidence to indicate that BOD_5 is a concern overall or at a particular outfall for causes other than those discussed herein.

Trends and outliers

SDS1 and SDN2 showed elevated BOD_5 values similar to several outliers shown in the previous report. Compare Figure 18 to Figure 19. One elevated value each at these outfalls in the current period was from a January 16, 1997 sample. Glycols were detected in both samples with values of 33 and 51 mg/l. The Port has recently completed three capital BMPs that eliminate these glycol source areas. In addition, the Port will construct three snow storage areas by November 1997. Monitoring during the next year will show that these BMPs effectively eliminate BOD_5 caused by aircraft deicing glycols.

As discussed under ammonia, the Port eliminated a source of BOD_5 in SDN1 caused by an inappropriate connection. The Port believes this was the source of the higher median shown in Figure 18 and the outlying value of 194 mg/l on 9/14/94 shown on Figure 19.

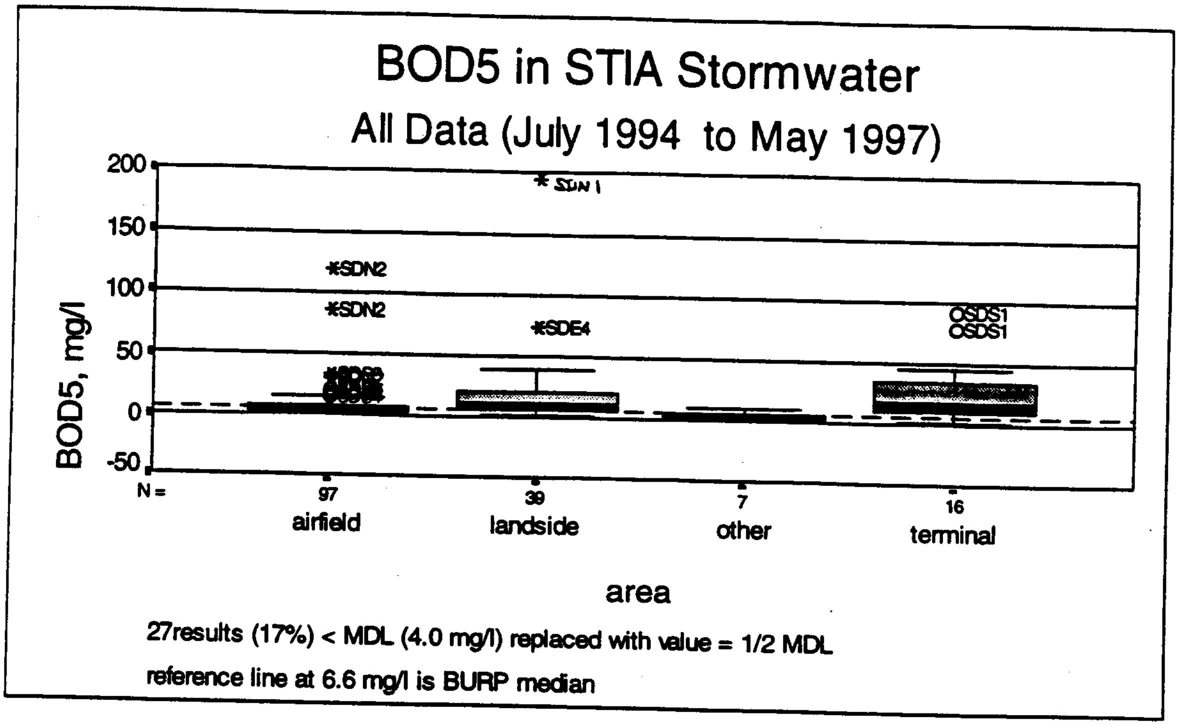

Figure 17 BOD$_5$ compared by subbasin activity

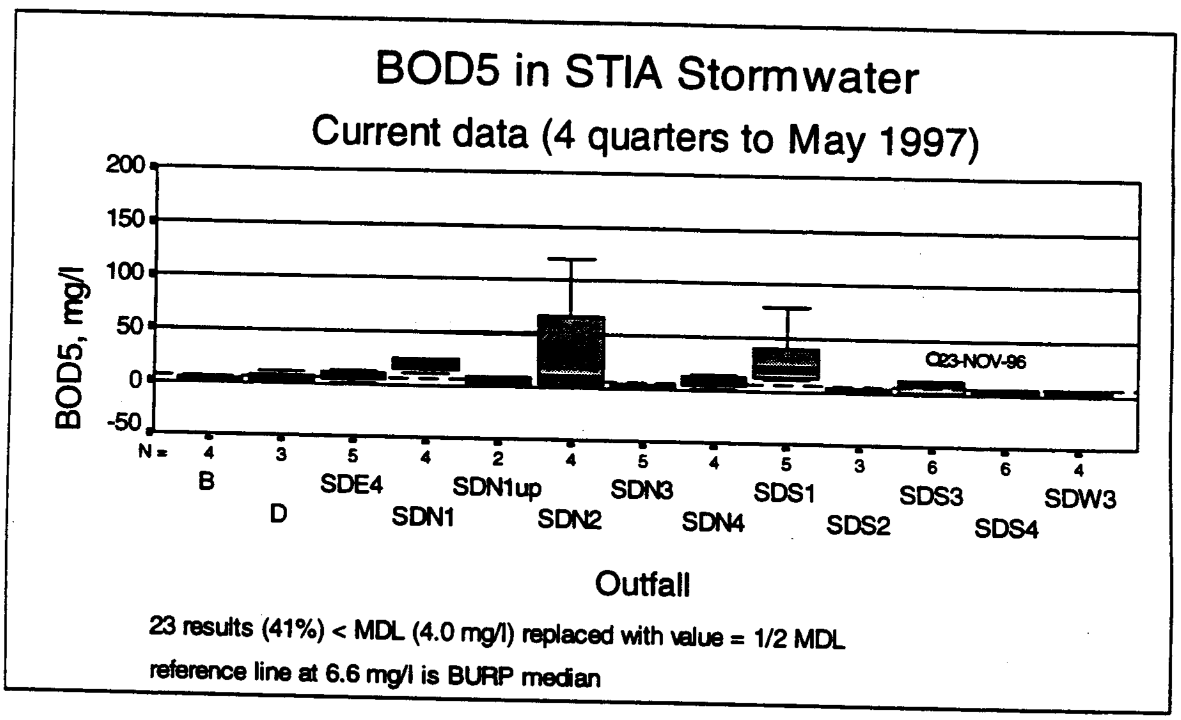

Figure 18 BOD$_5$ compared in box plot for current period

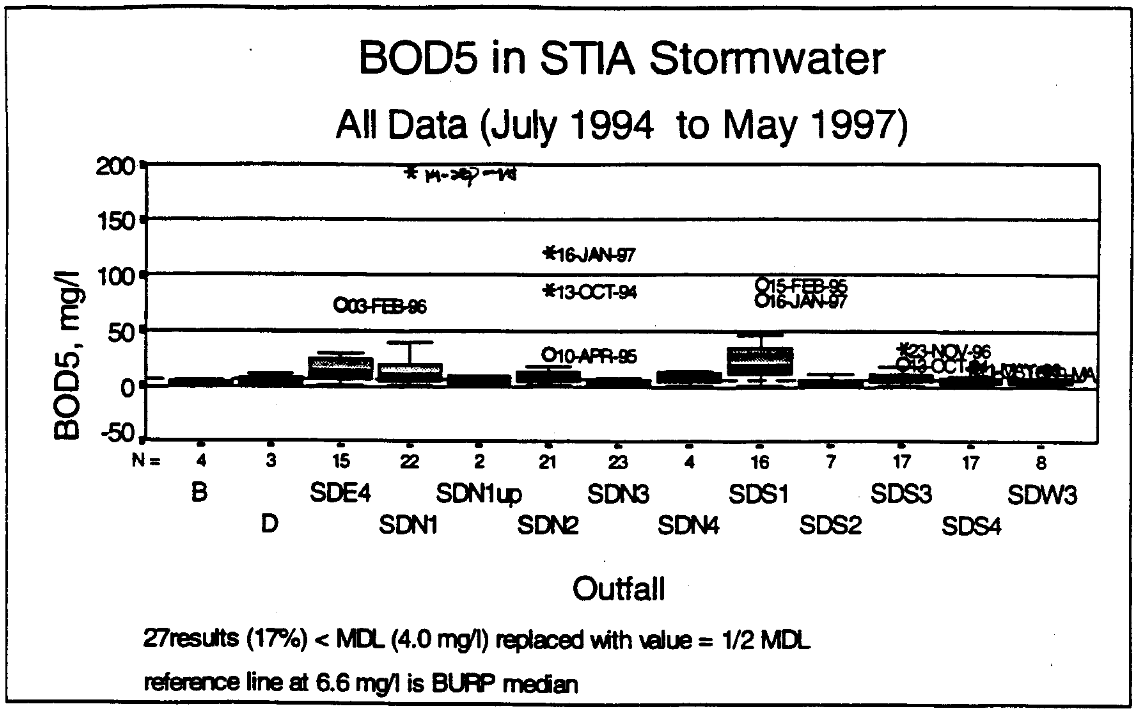

Figure 19 BOD_5 compared in box plot for permit history

Fecal coliforms in grab samples

Data for fecal coliforms represent instantaneous values, rather than SMCs or any other type of average. Fecal coliforms are analyzed only in grab samples. Automatic sampler bottles are neither autoclaved nor sealed during automatic sampling which is appropriate protocol in accordance with the Port's Procedures Manual (POS, 1997b). Ecology has reviewed and approved the Port's Procedures Manual.

STIA general results

Figure 20 shows that fecal coliforms are found principally in the terminal and landside subbasins. Because more than 75 % of the airfield subbasin samples showed fecal coliforms less than the comparative value of 201 per 100 ml, the Port considers that the airfield subbasins are not significant sources of fecal coliform. In the past, elevated fecal coliforms appeared in SDS2 (the "other" subbasin category). Because no Port sanitary sewers, septic systems or other possible sources are located in the SDS2 area, the historic elevated values are presumed to be from animal sources.

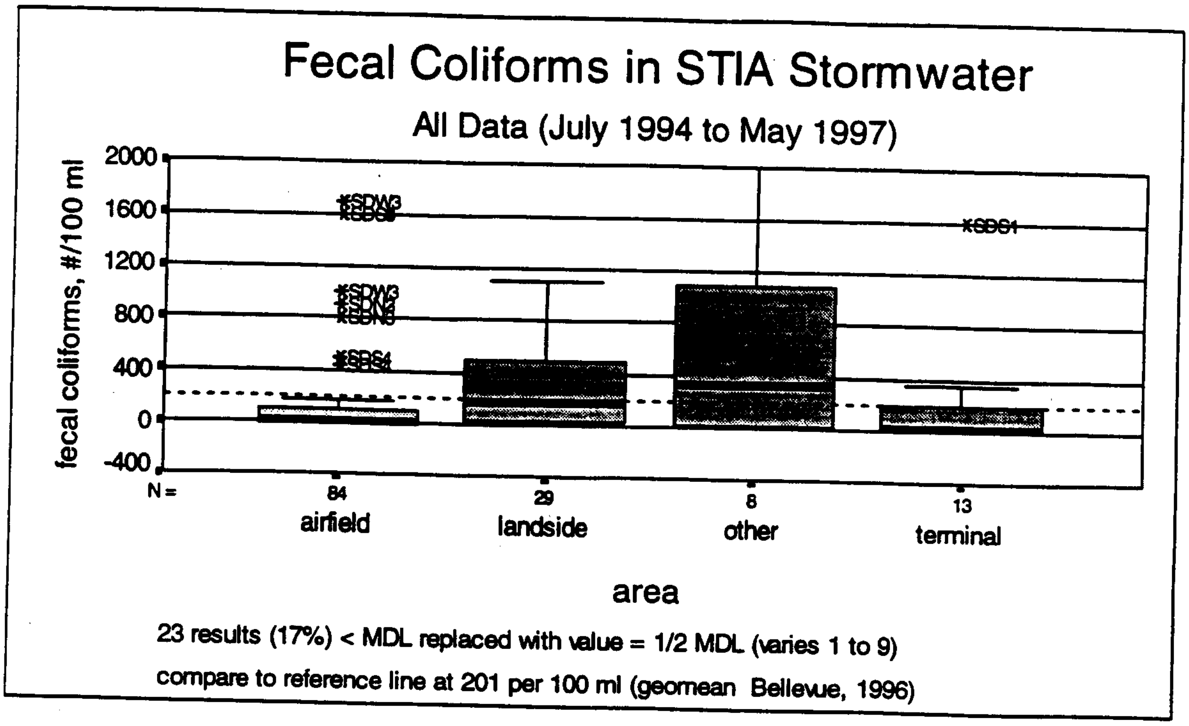

Figure 20 Fecal Coliforms compared by subbasin activity

Trends and outliers

Four samples taken in the current period indicated far less fecal coliforms than in past years at both SDS2 and SDW3. Two of these samples were taken for the Stipulated Agreement. Compare the dramatic decrease in the box plots shown in Figure 21 and Figure 22. In addition, a baseflow and an equipment blank QC sample taken at SDS2 in the current period[4] showed very low fecal coliforms (13 and 2 per 100 ml, respectively). These results suggest that either the previous source has vanished or errors were present in past samples at both SDS2 and SDW3. The sampling point for SDW3 was moved upstream prior to the current year's samples, because contaminants in non-Port runoff in the backwater that exists at the outfall could bias results,

Fecal coliform results for SDE4 remained elevated in the current year. This continuing trend shows that either the previously suspected source (autoclave

[4] The baseflow sample was taken manually on December 19, 1996 in an autoclaved bottle. An equipment blank was taken on January 16, 1997.

dumpster drains in the service tunnel) was not the sole cause. The Port will continue to investigate possible sources and implement an appropriate BMP as soon as practicable.

Three of the samples from SDS4 showed elevated fecal coliform levels above 500 per 100 ml in the current year. Last year, the source of elevated fecal coliforms was believed to be the drainage from the former "duck pond" on the Tyee golf course[5]. Because there are no sanitary sewer lines, septic tanks, or aircraft waste transfer activities in the SDS4 subbasin, the continuing presence of these higher levels of fecal coliforms suggests wild animal sources. In a recent urban stream study, 78% of fecal coliforms detected were traced to animals (King County, 1995) as opposed to human sources. The Port will continue to monitor fecal coliforms in the SDS4 subbasin.

In the current period, 2 of 5 samples from SDS1 had fecal coliform counts of 1600 or higher. Both of these samples predated the latest capital BMP that removed aircraft service areas. Consequently, two samples taken after completion of the BMP showed a dramatic drop in fecal coliform counts. The Port will continue to investigate possible sources of fecal coliforms in the SDS1 subbasin.

In summary, fecal coliforms are not present at levels of concern in samples from 9 of 12 outfalls. Elevated fecal coliforms are found occasionally in samples from the SDE4, SDS1, and SDS4 outfalls. Dramatic decreases in results for the SDS2 and SDW3 outfalls suggest the absence of previous sources or the presence of past sampling errors. The Port will continue to investigate potential sources and take appropriate BMP actions as required.

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[5] The "duck pond" was filled in the summer of 1996 during construction of the runway 34R safety area project.

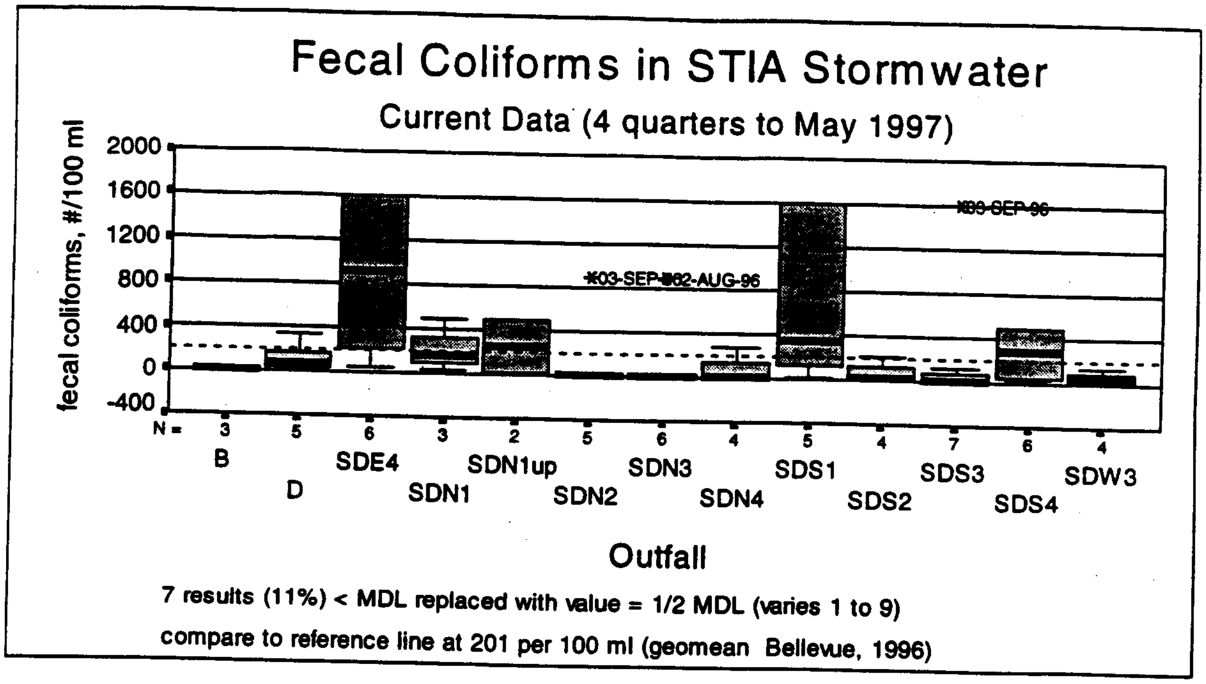

Figure 21 Fecal coliforms compared in box plot for current period

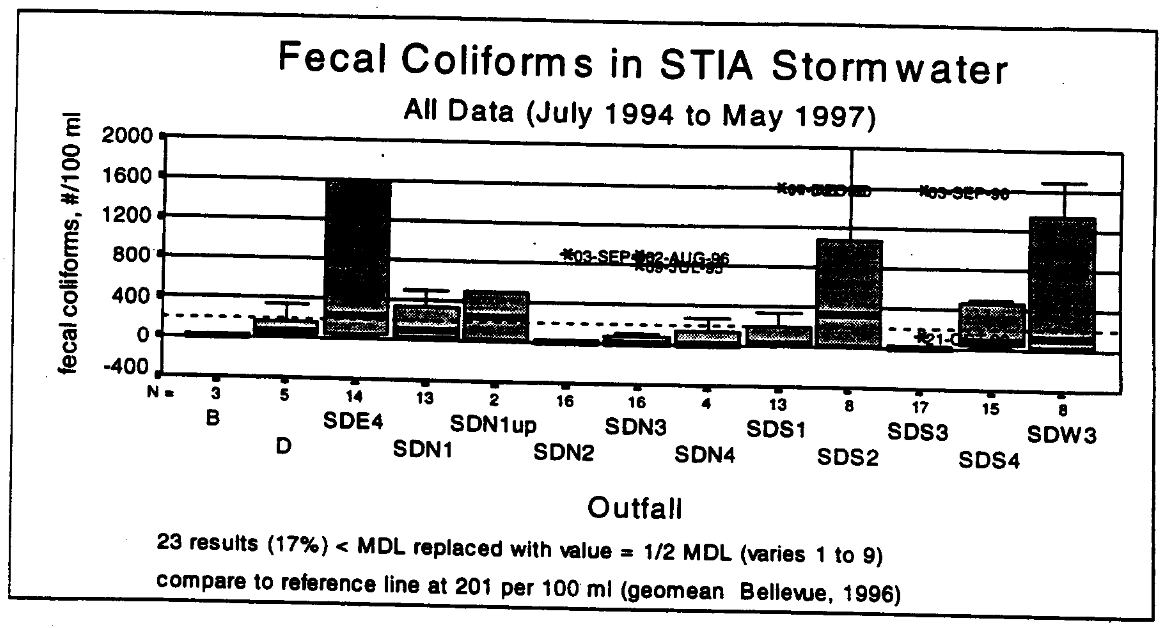

Figure 22 Fecal coliforms compared in box plot for permit history[6]

[6] SDW3 sample of 30,000 per 100 ml is not representative as it was collected in the backwater and abundant vegetation at the outfall structure. Sample bottles are neither autoclaved nor sealed during automatic sampling.

Surfactants

Surfactants tend to indicate the presence of detergents. There are no suitable surfactant comparator values readily available in the literature. Surfactants in raw domestic wastewater range from about 1 to 20 mg/l and are generally below 0.1 mg/l in natural waters (APHA, 1995). Values above approximately 4 times the detection limit, or about 0.4 mg/l would tend to indicate a positive presence of surfactants in STIA runoff. The test method is an aggregate of anionic surfactants that react with methylene blue, or methylene blue active substances (MBAS). Because MBAS includes far more substances than anthropogenic detergents, the method is subject to positive and negative interferences (APHA, 1995).

STIA general results

Comparing results to a value of 4 times the MDL, Figure 23 shows that surfactants did not appear at the airfield outfalls, where they were not even detected in 57% of the 64 samples. Surfactants appeared infrequently at the landside and terminal outfalls. Over 35% of all samples were below the detection limits. Therefore, surfactants generally do not appear to be a problem at STIA.

Trends and outliers

Figure 24 and Figure 25 show no increases in surfactants at any outfall over the past year. Several positive trends are apparent. Surfactants continue to be below levels of concern at the TY, attributable to the covered car wash constructed two years ago. The range at SDS1 has dropped, indicating that the recent capital BMPs are having positive effects already.

As mentioned earlier under FOG and TPH, in June 1997 the Port discovered a 10" overflow pipe from an IWS pump station that was connected to manhole SDE3-91, part of the SDE4 stormdrain. Occasional overflows were the source of both elevated FOG, TPH, and surfactants in baseflows and storm discharges. The overflow pipe was permanently plugged in mid June 1997. It is presumed that continuing monitoring will show a concomitant reduction in surfactants.

As discussed under ammonia and BOD_5, the Port eliminated a source of surfactants in SDN1 caused by an inappropriate connection. The Port believes this was the source of the outlying values shown on Figure 25.

In summary, surfactants were only rarely present at the terminal and landside outfalls. Several surfactant sources were identified and permanently eliminated in 1997. Data indicates that no surfactants are present in runoff from the five airfield subbasins.

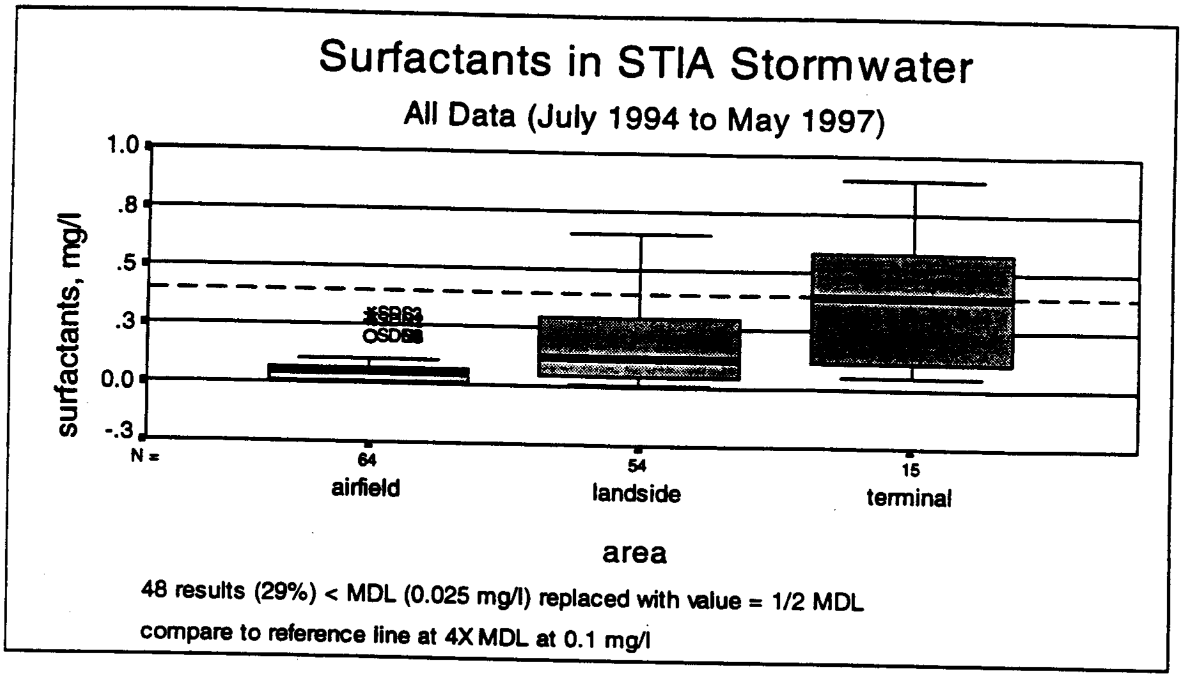

Figure 23 Surfactant compared by subbasin activity

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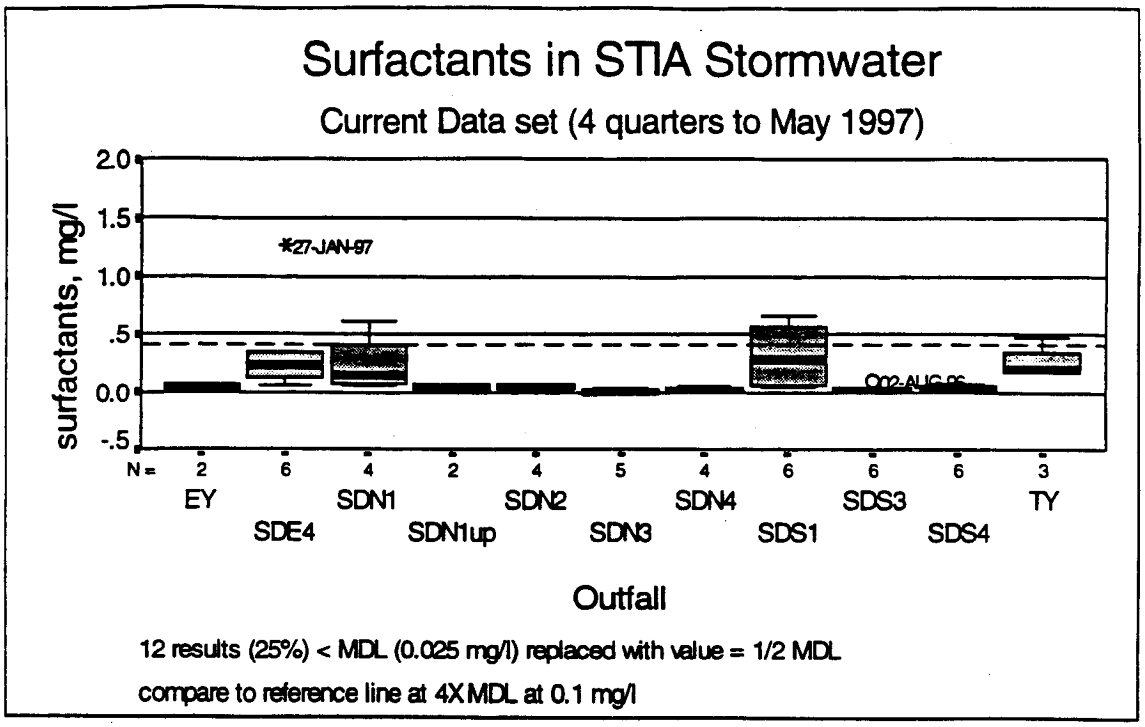

Figure 24 Surfactants compared in Box Plot for 1995-1996

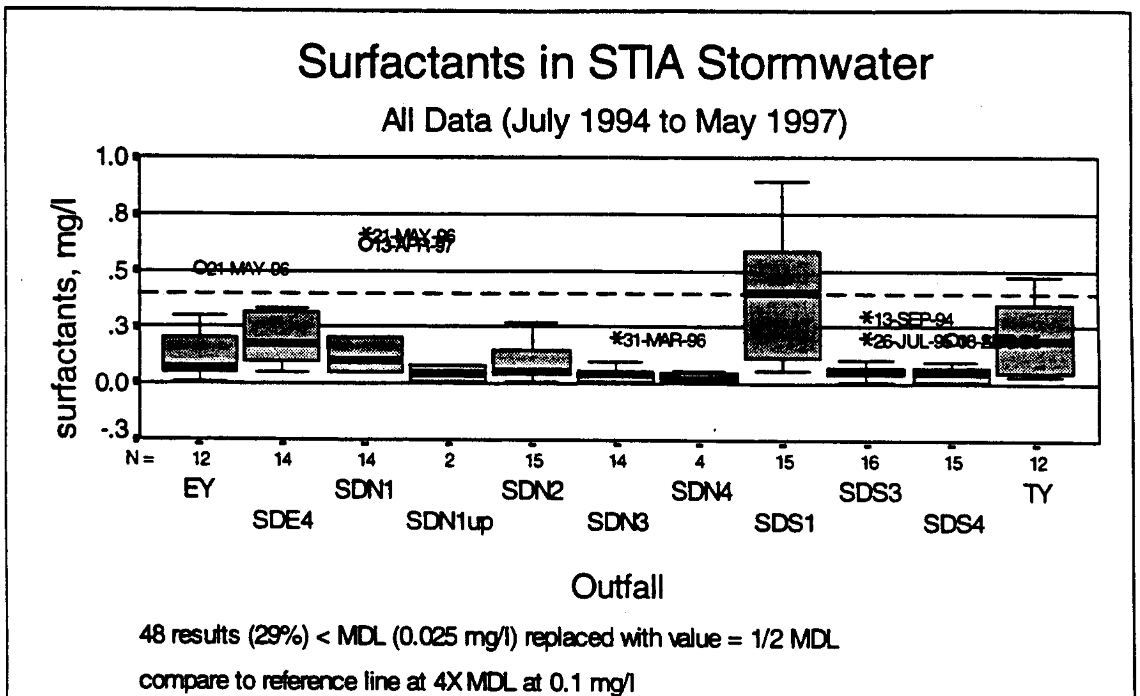

Figure 25 Surfactants compared in Box Plot for 1994-1996

Metals

All metals data are for total recoverable metals in outfall discharges. Ecology criteria apply to only the receiving waters after the discharge mixes with the receiving waters, not stormwater runoff at the outfall. The Port monitors total recoverable priority pollutant metals as required by the NPDES permit. The permit does not require dissolved metals analysis, though the Port has conducted limited analyses for dissolved copper, lead, and zinc (POS, 1995b).

Comparing metals results to criteria

Washington State water quality criteria (WAC 173-201) apply to the receiving waters, not to the discharges from a particular outfall itself. Often, stormwater discharge data are compared to these criteria even though values above the criteria are not an appropriate indicator of an "exceedance". Stormwater discharges are almost certainly diluted in any receiving water, and not allowing for such dilution may cause arbitrary conclusions.

The water quality standards for copper, lead and zinc are based on the dissolved form of the metal. The dissolved form of a metal approximates what aquatic life respond to, and therefore generally determines acute toxicity. As stormwater discharges mix with receiving waters, the overall chemistry of the mixture determines the dissolved and particulate metals fractions. The ratio of dissolved to total metals depends principally upon pH, temperature, and hardness (calcium carbonate concentration). The availability of "binding sites" (afforded by the electronegative attractions of suspended solids, dissolved and particulate organic carbon, sulfides, etc.) and the competition for these binding sites with other metals also determines the dissolved fraction of a particular metal. What is especially complex is that the dissolved metal itself takes on many forms, some of which may not actually cause acute toxicity.

For example, dissolved copper comprises the ionic form (Cu^{2+}) and many dissolved organic and inorganic complexes. The highly bioavailable ionic form is toxic to aquatic life at low concentrations while complexed copper is basically non-toxic (Hall, 1997.) Furthermore, the ionic form is highly reactive and readily forms non-toxic complexes. Therefore, it is inaccurate to assume that all dissolved copper is toxic. Ecology acknowledges this fact in the permit fact sheet.

Without analysis for the dissolved metal, which involves filtration of the sample immediately after collection, only estimates of the dissolved fraction are possible, even if site-specific "translator values" are available. Because 1) site-specific translators are not yet available for Miller and Des Moines Creeks, 2) applying criteria directly to the stormwater outfall does not allow for the inevitable dilution, and 3) dissolved metal chemistry and evaluation of associated toxicities is highly intricate, the criteria listed in Table 7 must be viewed only as a general guideline and not regulatory criteria. On the other hand, when data for a particular outfall are consistently less than these "criteria", it shows very conservatively that there should be little concern for potential toxicity, even in undiluted discharges.

STIA general results

General results are discussed below, while more detailed discussion follows under the headings of the three predominant metals: copper, lead, and zinc.

most metals not detected

Table 7 shows that of the 13 priority pollutant metals analyzed in more than 105 samples during the permit history airport-wide, only four were detected regularly: arsenic, copper, lead, and zinc. Eight metals were absent or below detection limits in 71% or more of the samples: antimony (Sb), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), silver (Ag), selenium (Se), and thallium (Tl). Nickel was undetected in more than 50% of 111 samples. The 95th percentile for each of these 9 metals was less than 10% of the acute criteria. Therefore, as demonstrated in the last annual report, continued monitoring for these 9 metals is not justified.

Consistent with the last annual report, arsenic data showed a maximum value of 5 ppb, and a median value of 2 ppb, both just above the MDL of 1 ppb. The acute toxicity criterion for total recoverable arsenic is 360 ppb (at 50 mg/l hardness), nearly 2 orders of magnitude (100X) greater than the maximum arsenic value detected. Therefore, as demonstrated in the last annual report, continued monitoring for arsenic is not justified. Accordingly, box-plot evaluations are limited to three metals, copper, lead, and zinc presented in Figure 26 through Figure 31.

airfield outfalls discharge less metals than landside and terminal

Overall, copper, lead and zinc were lowest in the airfield outfalls, while the terminal and landside outfalls exhibited higher concentrations. More than 95 percent of the airfield outfall samples for lead and zinc were below comparable regional data for commercial areas and all were far less than for highways. This is a clear and important distinction given that the commercial/industrial comparators used (Bellevue, 1996) are highly conservative because they reflect instream concentrations after outfall discharges were diluted in the receiving waters. Therefore, airfield outfalls discharge far less lead and zinc than typical urban sources.

Over 75% of the samples from the landside and terminal outfalls showed lead concentrations below the regional (commercial/industrial) comparator of 0.026 mg/l. However, the landside and terminal outfalls showed higher zinc levels than the regional comparator. This Bellevue, 1996 comparator represents instream concentrations after the stormwater was diluted in the receiving waters. Nonetheless, the majority of landside and terminal zinc was far less than the comparative value of 0.638 mg/l for highways.

STIA metals loadings are less than other urban land uses

Overall annual unit loading rates for copper, lead and zinc are each lower than from typical roadways and residential areas, and one to two orders of magnitude (10X to 100X) less than from commercial areas. Zinc unit loads are somewhat comparable to residential unit loads. See Table 4. However, the Port strongly believes that vehicle activity on public roads within the landside and terminal outfall areas skews the metals concentrations towards values characteristic of highways, which are not representative of the STIA portion of the runoff. Therefore, the overall median and 95th percentile summarized in Table 7 is skewed by this bias. These overall statistics are not representative of the airfield outfall group.

Because no trends are apparent, only box-plots showing results for the three-year sampling history appear in discussions of each metal below. These box plots show data for grouped and individual outfalls.

Copper

Copper in urban stormwater frequently exceeds acute criteria. In the Bellevue, 1996 study, more than 70% of the 154 copper results in storm samples (most were instream samples) exceeded the EPA acute criterion. Furthermore, 14% of the Bellevue baseflow samples, again most instream, exceeded the acute criterion. Therefore, it is not unusual for stormwater discharges and even receiving water baseflows to exceed the criterion for copper.

In urban stormwater, the major sources of copper are automobile brake linings, clutches, etc. (Bellevue, 1996; Woodward-Clyde Consultants, 1993). Unlike lead, there are no known programs to phase out the use of copper in automobiles. Without a cost-effective technology to remove dilute copper concentrations in stormwater, improvement of copper-impaired stormwater quality awaits either technological or cultural changes in transportation.

As has been shown with other pollutants, STIA stormwater copper results were lowest in the airfield subbasins. The landside and terminal subbasins are the principal sources of copper at STIA. These are the areas of greatest vehicle activity. The Port believes that vehicle activity on public roads high-biases copper data for the landside outfalls and terminal outfalls. Because a large area of aircraft service area was removed from SDS1 this year by two capital BMPs[7], copper data for the terminal outfall (SDS1) may decrease. On the other hand, non-Port runoff from S. 188th Street may become more dominant and sustain higher copper (plus other pollutants) results measured at this outfall.

Even though STIA copper results may appear to "exceed" the copper criterion, overall results are less than other urban land uses. The upper reference line in Figure 26 shows that the majority of STIA copper data were lower than in runoff from Interstate 5, a local highway. Overall STIA unit load estimates for copper

[7] Drainage from 34 acres of the SDS1 subbasin was re-routed to the IWS by 2 capital BMPs. See Table 14.

(values for both median and range) are less than from roadways and residential areas, and are 10 to 100 times less than from commercial areas. See the unit load estimates presented in Table 4.

Copper results from SDS3 are higher than from the other airfield outfalls. Because the majority of aircraft landings take place in the SDS3 subbasin, the Port believes aircraft brake wear to be a possible source of copper. A single elevated copper result of 0.139 mg/l in the first sample from the SDN4 outfall caused a larger box in Figure 27. Because of flow monitoring difficulties at the SDN4 physical outfall, the monitoring location was moved to an upstream manhole. Three subsequent samples from this manhole show copper results near the airfield median of 0.025 mg/l.

In summary, copper from STIA outfalls is less than other urban land uses including commercial areas, roadways and residential areas. Copper in urban stormwater runoff and urban streams commonly exceeds the receiving water criterion as demonstrated by several regional studies. STIA airfield outfalls generate less copper than landside and terminal outfalls, which the Port believes are negatively influenced by non-Port public road runoff.

Table 7 Overall Metals in STIA Stormwater[1]

results for total recoverable metals, values in mg/l

	SB	AS	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
detection limit	0.001	0.001	0.001	0.002	0.005	0.002	0.001	0.0001	0.005	0.001	0.003	0.001	0.004
# samples	105	105	105	112	105	120	120	105	111	105	112	105	120
median	0.002	0.002	0.001	0.001	0.005	0.030	0.005	0.0001	0.005	0.002	0.002	0.001	0.072
95th percentile	0.002	0.004	0.001	0.002	0.014	0.115	0.045	0.0002	0.018	0.002	0.005	0.001	0.417
#non-detected	77	47	90	80	76	0	12	78	59	77	98	83	1
%non-detected	73%	45%	86%	71%	72%	0%	10%	74%	53%	73%	88%	79%	1%
acute criteria (total recoverable)[2]	9.0[3]	0.360	0.130[3]	0.0009	0.612	0.005	0.016	0.002	0.483	0.020	0.0005	1.4[3]	0.040

1. This table summarizes metals sample data for all STIA outfalls grouped together. The results must be viewed as an overall summary and not characteristic of any one particular outfall. The airfield outfalls discharge far less metals (and other pollutants) than the landside or terminal outfalls. See Discussion.
2. Acute criteria listed are calculated at 28 mg/l total hardness, which is the 10th percentile for the receiving waters (see Stormwater Receiving Environment Monitoring Report, POS, 1997). All criteria are for total recoverable metals, computed by using a coefficient of unity in the formulae in the WDOE "CRITERIA.XLS" spreadsheet in "TSDCALC6.XLW", dated 6/96.
3. Criteria from WDOE "CRITERIA.XLS" spreadsheet in "TSDCALC6.XLW", dated 6/96. These are EPA criteria from the "Gold Book" and NTR-HH.

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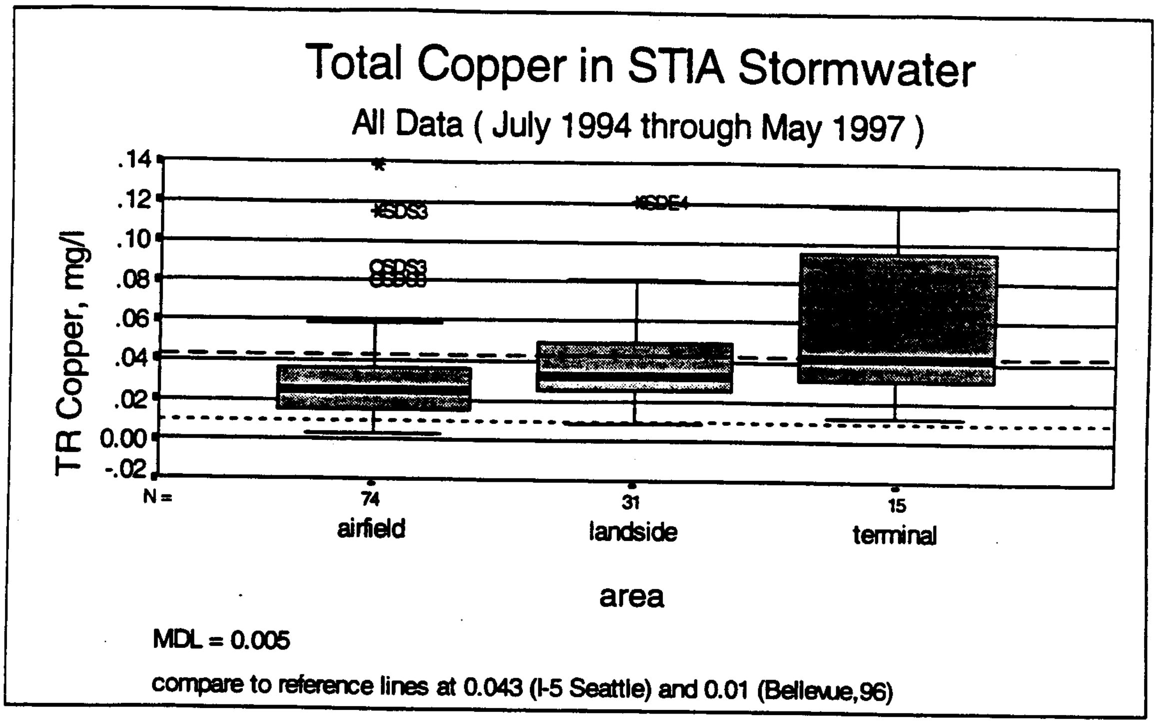

Figure 26 Total copper compared by subbasin activity

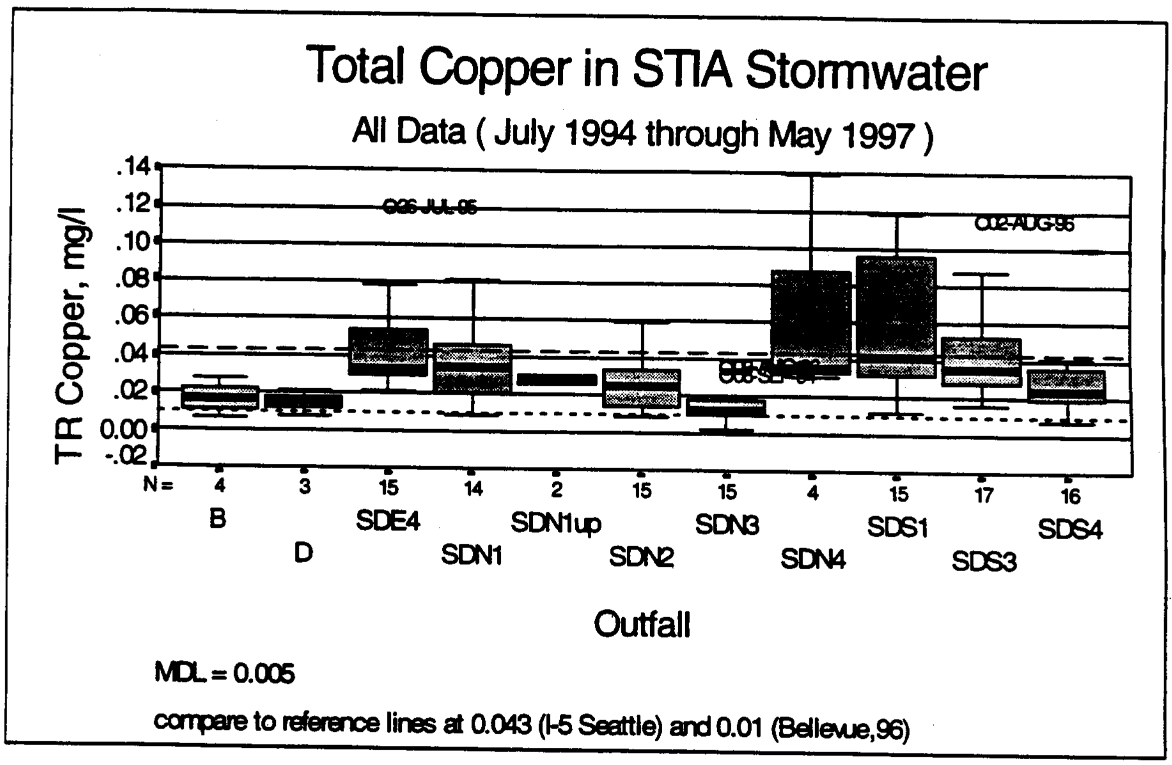

Figure 27 Copper compared in Box Plot for 1994-1996

Lead

As was the case with copper, STIA stormwater lead results were lowest in the airfield subbasins. The landside and terminal subbasins had slightly higher median lead values, though the difference is not as pronounced as with copper. The upper reference line in Figure 28 shows that overall, more than 75% of all STIA lead data were lower than the median of the City of Bellevue's 1996 study. Relative to the highway runoff comparator (0.466 mg/l in the 1982 study, see Table 3), the lower Bellevue median reflects the dramatic drop in lead concentrations attributable to the phase-out of leaded gasoline. Therefore, STIA runoff overall contains considerably less lead than local urban areas, and reflects the phase-out of leaded gasoline as well. In addition, because the airfield outfall group had more than 97% of all for the airfield outfalls were less than the Bellevue comparator (0.026 mg/l) which establishes that airfield outfalls are not significant sources of lead.

Furthermore, more than 75% of all STIA lead samples were below the acute toxicity criterion of 0.016 mg/l for total lead. This criterion is calculated at 28 mg/l total hardness, a highly conservative value which represents the 10th percentile recorded for the SRES (POS, 1997a.) More than 90% of all STIA data is less than the acute criterion of 0.026 mg/l (which matches the Bellevue comparator) calculated at a hardness of 44 mg/l, which is well within the range measured by the SRES. Therefore, lead from STIA outfalls is well below even the most conservative estimate of the toxic criterion for the receiving waters.

The only potential exceptions are landside subbasins SDE4 and SDN1, and the SDS1 terminal subbasin. See Figure 29. The Port believes that vehicle activity in these subbasins is a potential source of lead. Much of this non-industrial vehicle activity takes place on public roadways that drain to the Port's SDS and monitoring locations. Therefore, the public roadways may add a high-bias to the STIA results. Future monitoring may confirm the non-Port bias.

STIA unit load estimates for lead are one to two orders of magnitude (10 to 100X) less than from roads and commercial areas. The median and 90% confidence interval of lead unit load estimates is somewhat comparable to those from single-family residential areas. See the unit load estimates presented in Table 4.

In summary, the vast majority of lead in STIA stormwater is less than a regional instream comparative value of 0.026 mg/l, and less than the most conservative toxic criterion of 0.016 mg/l for lead in receiving waters. Airfield outfalls discharge far less lead than landside and terminal outfalls which the Port believes may be influenced by non-Port public road runoff. Nonetheless, STIA outfalls discharge far less lead than roads and commercial areas.

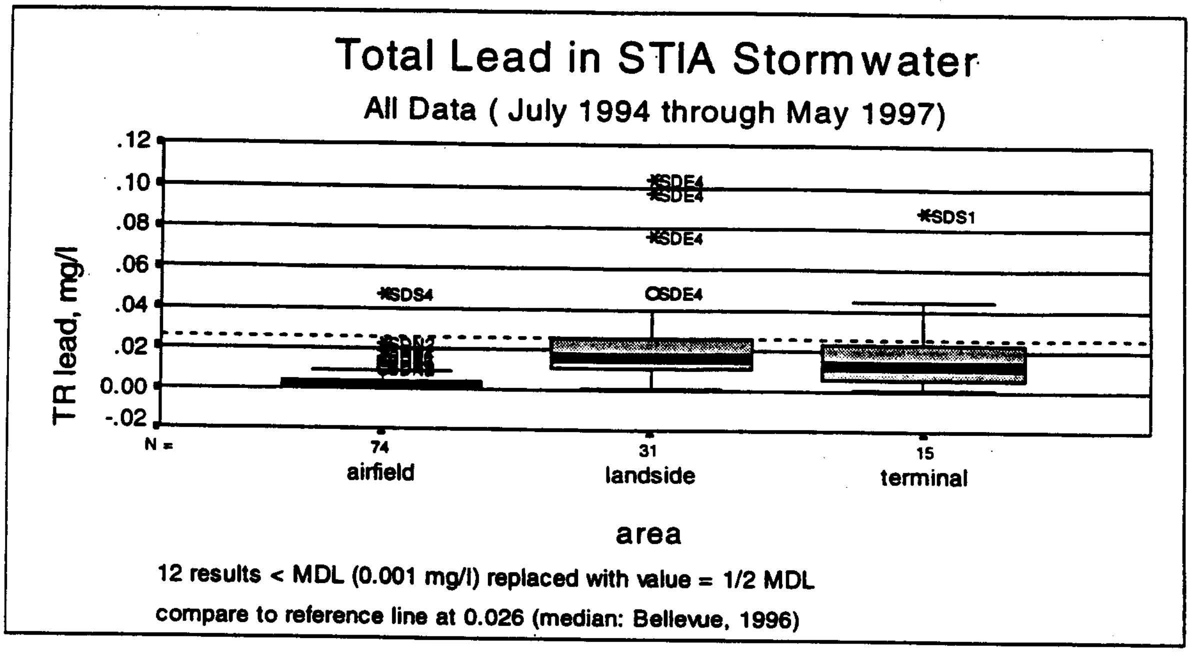

Figure 28 Total lead compared by subbasin activity

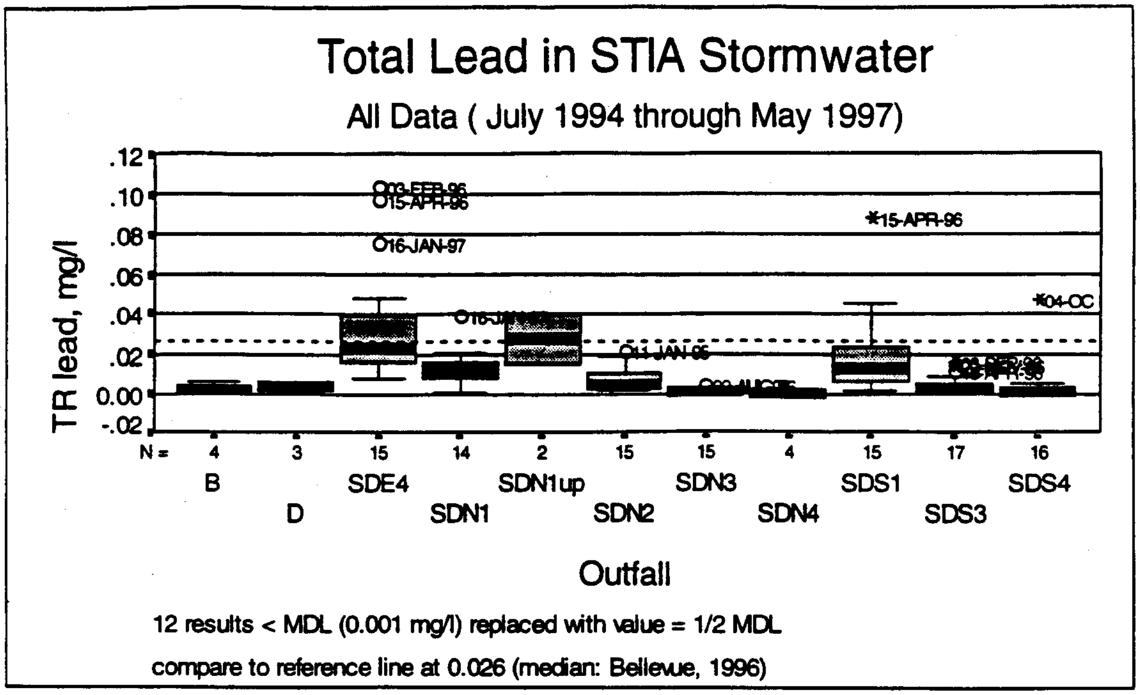

Figure 29 Lead compared in Box Plot for 1994-1996

Zinc

Once again, STIA stormwater sampling results were lowest in the airfield subbasins. The landside and terminal subbasins had higher median zinc values. See Figure 30. Landside outfalls displayed a median and range of total zinc nearly five times higher than those of the airfield outfalls. The terminal (SDS1) and landside subbasins, SDE4 and SDN1 experience considerable vehicle traffic where tire wear is an important source of zinc (EPA, 1993). Even though these landside and terminal outfalls are the principle sources of zinc, the Port believes that non-industrial, non-Port roadways high-bias the STIA results.

The upper reference line in Figure 30 shows that more than 97% of all airfield zinc data were lower than the median (0.161 mg/l) from the City of Bellevue's 1996 study. Again, this is the most conservative comparator and represents *instream* samples not undiluted outfall discharges. Because airfield zinc is even lower than this instream comparative value, the Port has clearly demonstrated that airfield runoff contains far less zinc than comparable regional areas. Nonetheless, the Port believes that samples from SDN3 show a potential high-bias because unlike other airfield outfalls, the SDN3 outfall is zinc-galvanized corrugated metal pipe (CMP). Nevertheless, nearly 100% of the results from SDN3 were lower than the regional comparator.

Even though the majority of landside outfall zinc exceeded the Bellevue comparator, 94% were less than the highway comparator of 0.638 mg/l. Unit loading estimates show that overall, STIA generates zinc somewhat comparable to roadways and far less than commercial areas. See Table 4. Again, the Port considers that non-industrial, non-Port public roadways skew the STIA landside outfall data toward typical roadway zinc loadings.

In terms of potential toxicity, in the Bellevue, 1996 study, 61% of the 178 zinc samples exceeded EPA criterion. In fact, all comparative regional zinc values (in Table 3) would also exceed the criterion. However, STIA results indicate that 50% of airfield outfall results were *less than* the toxic criterion (calculated as 0.04 mg/l at a highly conservative hardness, see Table 7). When the criterion is calculated to be 0.057 mg/l at a more reasonable hardness of 44 mg/l, more than 70% of airfield zinc results are less than the toxic criterion.

In contrast, all landside outfall zinc results exceeded the criterion. Again, comparing STIA outfall results directly to any zinc criterion is not appropriate without allowing for dilution and the other considerations noted above. Nonetheless, the Port considers that roadway runoff is responsible for elevated zinc results in the landside outfalls. Because several BMPs dramatically reduced the service area for SDS1 (the "terminal" outfall), the unfavorable bias of zinc from public road runoff (S. 188th St.) may become more dominant in samples taken after May 1997.

SDN1 discharges displayed the highest zinc concentrations. See Figure 31. Two samples taken in manhole SDN1-22 ("SDN1up"), upstream of SR 518 and other public road runoff, showed less zinc than the overall SDN1 median. These samples suggest that the public road runoff elevates zinc in samples from SDN1-27, the historic monitoring location where 14 samples have been taken to date. Vehicle traffic is 9 times greater on SR 518 compared to the portion of Air Cargo Road within the SDN1 subbasin. However, three paired upstream/downstream samples in the two manholes showed similar zinc at both stations. See the section of this report entitled "Subbasin SDN1: testing public roadway bias and pollutant source tracing". The Port is continuing to investigate whether the source of zinc in SDN1 is public roads (Air Cargo Road), or from a potential STIA source. Other than Air Cargo Road, air cargo building rooftops comprise the balance of the SDN1 subbasin draining to manhole SDN1-22. In any case, rooftops are not industrial activity.

In summary, based upon both concentration data and load estimates, airfield outfalls produce less zinc than typical roads and commercial areas. The majority of zinc in airfield runoff is below even the most conservative toxic criterion even though this direct comparison is not appropriate. Overall, STIA outfall zinc is less than roadways, and comparable to single-family residential runoff. The Port believes that vehicle traffic (tire wear) accounts for higher zinc in the terminal and landside outfalls, especially at SDE4 and SDN1, which receive considerable offsite runoff from public roads.

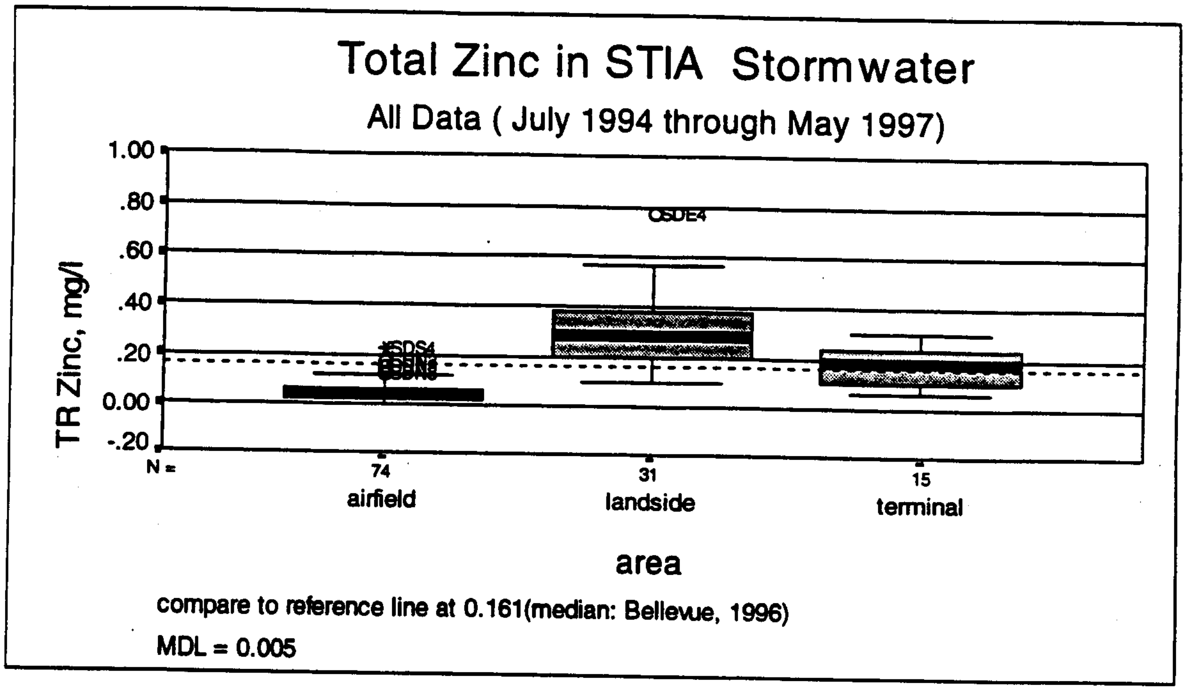

Figure 30 Total zinc compared by subbasin activity

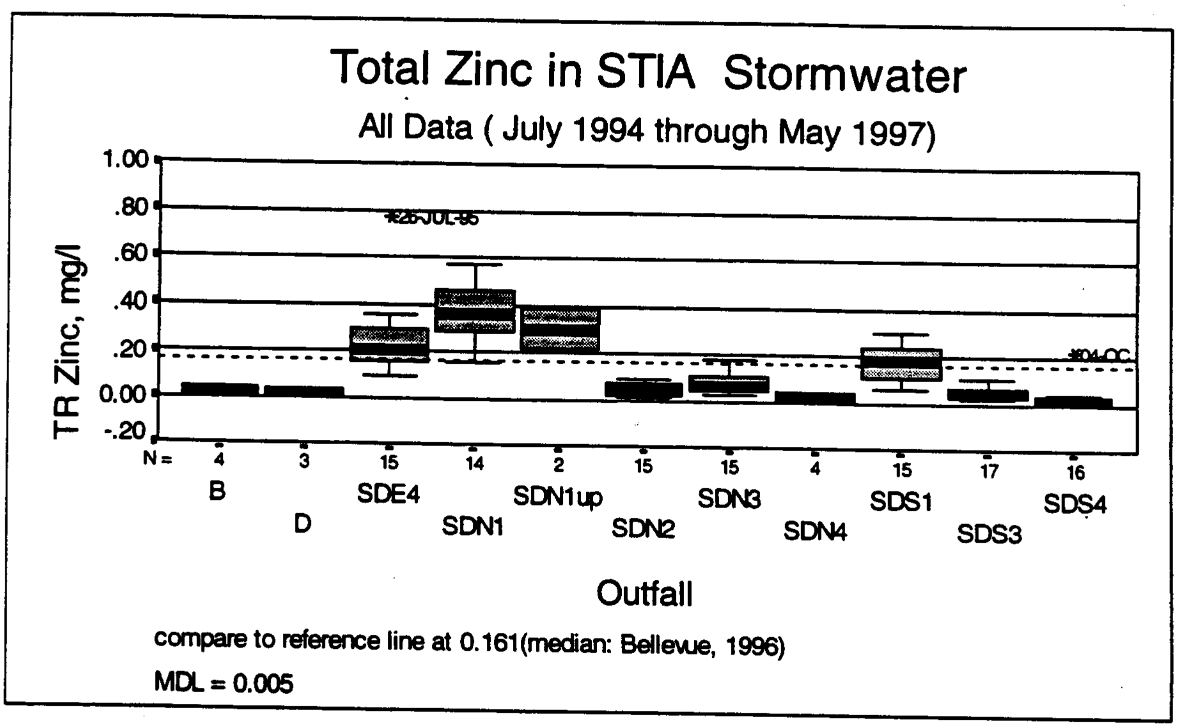

Figure 31 Zinc compared in Box Plot for 1994-1996

Glycols From Aircraft Deicing and Anti-icing

The Annual Glycol Report (POS, 1996b, 1997d) details the history of glycol application airport-wide. This report summarizes data reported by the airlines for the volumes of both ethylene and propylene glycol applied and number of aircraft treated each day. The FAA authorizes only ethylene and propylene glycols for aircraft deicing and anti-icing. All glycol application is performed by Port tenants (directly by airlines or their ground service providers). To ensure public safety, aircraft pilots make the ultimate decision on whether to apply glycols or not. The Port analyzes both types of glycol and sums the two results as "total glycols" which are also referred to as "glycols". The MDL is 5 mg/l for each glycol type, and therefore 10 mg/l for total glycols when neither constituent is detected.

Note that all ramp areas where aircraft are routinely deiced drain to the IWS. In the past year, the Port completed 4 capital BMPs where drainage from aircraft service areas was rerouted from the SDS to the IWS (see Table 14). The Port anticipates that data from the next year's monitoring cycle will confirm elimination of aircraft deicing glycols in stormwater discharges. Because the Port completed the capital BMP in SDS1 and SDN2 near the end of the current data gathering cycle, changes will become apparent through ongoing monitoring.

The glycol data discussed below encompass mostly composite samples taken during periods of aircraft deicing, representing average values during a storm event discharge, or in baseflow. The data set also includes storm and baseflow samples from the multi-day aircraft deicing sequences during the four severe winter-weather periods in the past two years. These data are summarized in Appendix B.

STIA General results

Overall, glycols were either below the detection limit or at relatively low values at most outfalls. Glycols were not detected in 73% of the 162 samples taken during the past three years. See Table 8 and Figure 32. These samples comprise all events including storms, baseflows, and intense aircraft deicing during severe winter weather. During the 4 months of June through September in the past two years, airlines applied less than 1% of the total glycol used annually. Overall, glycols were never detected at SDN4, and detected only once in the 26 and 27 samples from SDN3 and SDN1, respectively. On this single occasion at SDN3 and SDN1, glycol concentrations were barely 1 mg/l above the detection limit[8].

The Port's SRES showed no toxicity in samples from Miller and Des Moines Creeks during several severe winter weather periods[9] and the attendant aircraft and runway deicing (POS, 1997a). Only two outfall samples showed very limited moderate toxicity (an EC_{50}[10] was ≥72% of the sample), and toxicity was not consistent among each of the triplicate samples. Nonetheless, the Port has already completed capital BMPs that will eliminate or dramatically reduce glycols in subbasins SDN2 and SDS1. The Port will construct three snow storage areas that reroute drainage from the SDS to the IWS for snowmelt that may contain glycols. These BMPs not only address glycol, but also reduce this source of BOD_5.

trends and outliers

Routine aircraft deicing, such as frequently required for MD80 aircraft, may take place throughout the year during non-winter weather periods (no snow or ice). In addition to many samples taken in the past during these routine weather periods this year's results continue to show that glycols do not reach 5 outfalls (SDN1, SDN3, SDN4, SDS3 and SDS4). See Table 9. There are no aircraft service areas located in these 5 subbasins.

Samples in the past year showing that glycols reached SDS1 during routine and winter weather continued to indicate a direct association with aircraft deicing at the B-concourse gates. A sample from SDS1 on November 20, 1996 showed an elevated result[11] of 2859 mg/l, probably due to glycols directly entering drain inlet SDS1-98 or SDS1-99 near gate B12. As a result, the Port re-routed drainage from the SDS to the IWS for these associated aircraft service areas in May this past year.

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[8] Result of 6.1 mg/l for SDN1 sample taken 2/16/95. Result of 6.2 mg/l for SDN3 sample taken 3/5/97.
[9] December 10, 1995, January 20, 1996, November 24 1996, and December 30, 1996.
[10] EC_{50} is the effective concentration of the sample that caused a 50% reduction in light output in bioluminescent bacteria using the Microtox method.
[11] This result from a 6-hour time composite sample was reported on the November 1996 DMRs.

One of the 4 routine samples in the last year at SDN2 indicated the presence of glycols. Several time-series composite samples taken during the severe winter weather in November and December 1996 exhibited elevated glycol concentrations of 1,925 and 3,635 mg/l, respectively[12]. In these cases, the glycols could be attributable to either direct aircraft deicing in the North Cargo area, or due to glycols dripping from other aircraft during taxi and hold before takeoff. In June this year, the Port completed construction of a pump station that will divert the majority of discharges from SDN2 to the IWS during the wet season[13].

During the severe winter weather periods, glycols were present in stormwater from outfalls SDE4, SDS1, SDS3, SDS4, and SDN2. These rare occurrences reflect extensive aircraft deicing directly associated with multi-day periods of snowfall or sub-freezing temperatures. Glycol results were highest in SDS1 and SDN2 outfall discharges. The Port believes that glycols in subbasins SDE4, SDS3 and SDS4 are the result of glycol dripping from aircraft during taxi and hold and from shear during takeoff. Ecology has indicated that glycol shear is not regulated. Certain amounts of glycols from outfall SDN2 may also be attributable to these indirect sources. As discussed above, the Port has eliminated direct sources of glycols in SDE4, SDS1, and SDN2 due to glycol application at the gates.

As discussed under the snowmelt chapter below, by November this year, the Port will construct three snow-storage areas that drain to the IWS. These BMPs will divert runoff from the SDS to the IWS and will further reduce glycols draining from the SDE4 and SDN2 subbasins.

In summary, the Port has determined sources of glycols and completed a number of BMPs that reduce or eliminate glycols in stormwater discharges. Because the many routine-weather samples indicate an absence of glycols, and the winter-weather samples show glycols far below levels of concern, the Port believes that continued glycol monitoring for 5 outfalls is not justified (SDN1, SDN3, SDN4, SDS3, SDS4). Furthermore, glycols are not used directly in these drainage areas

[12] These results from 6-hour time composite samples were reported on the DMRs for these months. The December event was particularly severe and not representative of typical winter snowstorms

[13] The pump station is designed to divert flow rates up to the peak flow rate for the 6-month , 24-hour storm event for this subbasin.

because there are no aircraft service areas located in these 5 subbasins. Drainage from aircraft service areas previously connected to the SDS has been diverted to the IWS. The Port anticipates a dramatic reduction in glycols during winter weather samples at the remaining outfalls. Continued monitoring at these 3 outfalls will demonstrate the effectiveness of the BMPs completed in the past year.

Table 8 Overall Glycol Data Summary for Permit History

outfall	total # samples[1]	number detected	percent non-detected	median glycol (mg/l)	maximum glycol (mg/l)
SDE4	21	[illegible]	57%	[illegible]	92
SDN1	27	[illegible]	96%	[illegible]	6.1
SDN2	27	[illegible]	63%	[illegible]	684
SDN3	26	[illegible]	96%	[illegible]	6.2
SDN4	2	[illegible]	100%	[illegible]	5
SDS1	23	[illegible]	48%	[illegible]	6220[3]
SDS3	23	[illegible]	65%	[illegible]	115
SDS4	13	[illegible]	77%	[illegible]	31
overall	162	[illegible]	73%	[illegible]	

1. Includes SMCs, grab samples and average of time-composite samples from July 94 through May 1997.
2. Includes results where one-half the MDL was substituted when results reported as <MDL.
3. This result was from a baseflow grab sample, not a composite. The source was eliminated in May 1997. See discussion.

Table 9 Glycols during routine and winter -weather periods

outfall	# routine samples[1]	routine range	# winter samples[2]	winter range
SDE4	15	<MDL - 49	6	6 - 92
SDN1	24	<MDL	3	<MDL - 61
SDN2	22	<MDL - 51	5	23 - 684
SDN3	22	<MDL - 62	4	<MDL
SDN4	2	<MDL	0	ns
SDS1	15	<MDL - 39	8	<MDL - 6220
SDS3	19	<MDL	4	28 - 115
SDS4	7	<MDL	6	<MDL-31

1. Taken throughout the calendar year during non-winter weather periods (no snow or ice).
2. Taken only during severe winter weather (snow/ice) periods.
3. not detected (< method detection limit).
4. Not significant because result is within 20% of the MDL.
5. This result was from a baseflow grab sample, not a composite. The source was eliminated in May 1997. See discussion.

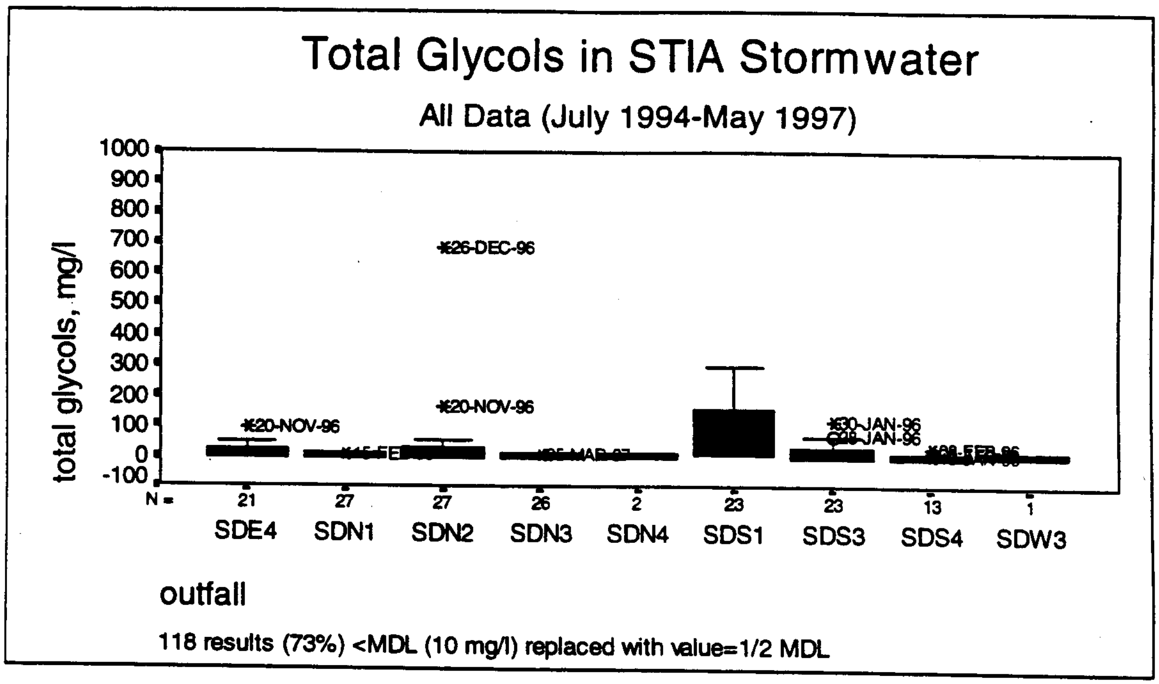

Figure 32 Total Glycol Box Plot for All Data

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Results From Other Monitoring Not Required by the NPDES Permit

This section presents and discusses the results of other stormwater monitoring conducted by the Port. These monitoring tasks were not explicitly required by the Port's NPDES permit. The Port carried out this additional monitoring generally to gain information about the design and effectiveness of stormwater BMPs or other SWPPP actions.

Airfield Deicing Operations: Stormwater Quality and BOD_5 Washoff

To ensure public safety and as mandated by the FAA, the Port applies chemicals to, and removes snow from airport ground surfaces. The Port has been studying the effects of these activities on stormwater quality over the past three winter seasons. The monitoring objective is to determine if there is a "first flush" of pollutants in subsequent runoff and what amount of rainfall "washes off" the majority of BOD_5. The Port has been undertaking this "washoff study" to determine if and to what degree stormwater BMPs are appropriate.

Background

Because a variety of airport deicing activity takes place when freezing conditions exist, specific monitoring results are segregated for discussion in this section. These events include deicing and anti-icing the ground surfaces of the runways and taxiways, ramps (aircraft terminal gate areas), airport vehicle drivelanes, and passenger vehicle roadways near the terminal. Deicing chemicals include potassium acetate (PA), calcium magnesium acetate (CMA), and urea.

In past years urea was applied only to areas drained by the IWS. The Port discontinued using urea in 1996 . Sand is typically applied to passenger vehicle routes including the access roads and terminal drive, and occasionally to airfield surfaces. Glycols are not used as ground-surface deicers or anti-icers.

In terms of stormwater quality, runway deicing activities manifest in pollutants such as BOD_5 (from PA, CMA, and aircraft glycols), total Kjeldahl nitrogen (TKN) and ammonia (from urea), and TSS and turbidity (from sand). TKN is the sum of organic nitrogen (such as urea), and the ammonia form of nitrogen. Ammonia forms during the decomposition of the organic nitrogen in urea.

BOD_5 in runway deicing washoff aggregates the oxygen-demanding effects of both aircraft deicing glycols and the acetate-based ground deicers. Glycols, PA, and mixtures of both have about the same ultimate BOD_5 of about 1 gram BOD_5/gram. By inference, the mass of glycol dripping/shearing off aircraft should be far less than the amount of PA and CMA applied to the runways/taxiways. Consequently, BOD_5 due to the aircraft glycols should be a fraction of the total BOD_5 observed. Because CMA is usually applied as a solid, the majority of BOD_5 associated with it should appear later than that attributable to the liquid-phase PA.

Glycols measured by this study are strictly the result of aircraft deicing that took place at the gates. Because glycols can also contribute BOD_5 during washoff monitoring, they were analyzed to discern their relative contribution to the BOD_5 measured. All glycol results are summarized and discussed in a previous chapter of this report.

Event summaries

In the past year, the STIA runways and taxiways and other surfaces were deiced extensively on two occasions. The first episode took place over two days on November 19-20, 1996, and the second continued for four days from December 26-29, 1996. The Airfield crew applied PA and CMA during both periods (POS, 1997d). Because the December event was extremely severe for the Puget Sound area (16 inches of snow), the Port applied nearly 9 times more PA in this second event than the first. Sand was also applied to the landside and airfield roadways during the second event. Urea was not applied directly, yet a limited amount was used in the sand to prevent stockpiles from freezing. The Port has since sold remaining urea and salt supplies to other interests.

Aircraft deicing was very intense during these two periods, with nearly 600 aircraft deiced during the 4-day December event. The number of aircraft deiced in each event was similar to the two 1995-96 winter events, but due to the severity of the weather, airlines used more than twice the glycols compared to last year. During the two events in January 1996 airlines applied 8% to 15% of the total annual glycol used. In contrast, airlines reported 13% to 31% of the total glycols used during the two events this year. Consequently, airlines applied nearly as much glycol during these two periods as they did during the entire past year. Glycols are discussed in a prior section of this report.

Rainfall began within a day or two of the snowfall. Monitoring proceeded at the SDN2 and SDS3 outfalls during the subsequent week during the first 2 and 4 inches of rainfall for the November and December events, respectively. Therefore results from this year are comparable to past data only to the extent that the duration and sampling were similar. Because of the extreme weather, pollutant concentrations were higher this year than in past samples, especially in the extreme December event. The December event is certainly not representative of typical winter weather. Nonetheless, the data are sufficient to achieve the objectives of the washoff study.

Methods

The Port undertook rigorous sampling and flow monitoring to provide adequate data to estimate incremental BOD_5 mass loads and attendant washoff functions.

Immediately following chemical application, the Port sampled baseflows, then took four 6-hour time-composite samples each day over the course of the ensuing snowmelt and rainfall. Automatic samplers took aliquots every 15 minutes and composited samples in washed one-gallon glass jars. Multiple samplers were programmed to sample at each outfall over several days. Doing so allowed staff to retrieve samples when driving conditions were safer.

Samples were analyzed for BOD_5, glycols, TKN, ammonia, and calcium, magnesium and potassium ions. Because BOD_5 aggregates the effect of glycols and acetates, the ions were analyzed to differentiate the relative BOD_5 from the glycols, PA, and CMA. The potassium ion (K^+) indicates the PA, and the calcium (Ca^{2+}) and magnesium (Mg^{2+}) indicate the CMA.

Pollutant loads were estimated as the product of pollutant concentration and discharge volume between samples. These incremental loads established an estimate of the rates of pollutant washoff over time and over subsequent rainfall. Discharge volumes at SDN2 were logged by an ISCO 4150 area-velocity flow meter installed in the round concrete discharge pipe. An ISCO 4230 flow meter logged discharges from the calibrated weir at the SDS3 outfall. These are the regular NPDES monitoring locations for each of these outfalls. Rainfall was logged by an ISCO tipping bucket rain gage set to record hundredths of an inch in five minute intervals.

General results

In general, concentrations peaked in the first two days, then dropped rapidly to very low levels with the onset of the first rainfall. See Figure 33 and Figure 34. Concentrations dropped to approximate background levels after the first 4 to 5 days and one to one and a half inches of rainfall after chemical application. Continuing low concentrations of the ions indicating PA and CMA showed that subsequent minor increases in BOD_5 were due to additional glycols in the runoff. See the note on Figure 33.

Similar to the results reported in the last annual report, this year's monitoring showed that a large fraction of the BOD_5 washed off in the first 1 inch of rainfall. A much smaller mass was washed off in the next 1.5 to 3.5 inches of rainfall. Because the effects of aircraft glycols are inextricably commingled in these BOD_5 washoff calculations, it is certain that the BOD_5 attributable only to the runway deicing chemicals (as opposed to the aircraft deicing glycols) washed-off with even less total rainfall.

Limited concentrations of TKN and ammonia were found in samples from both SDN2 and SDS3. These low level nitrogen analytes corroborate the limited amount of urea used to prevent sand stockpiles from freezing. Both TKN and ammonia concentrations were far less than in past years. Ammonia was generally not detected, and at most more than an order of magnitude (10X) below the receiving water criterion . TKN displayed similar washoff dynamics as last year, but because the Port no longer uses urea, it is no longer a focus of this study and is not discussed further.

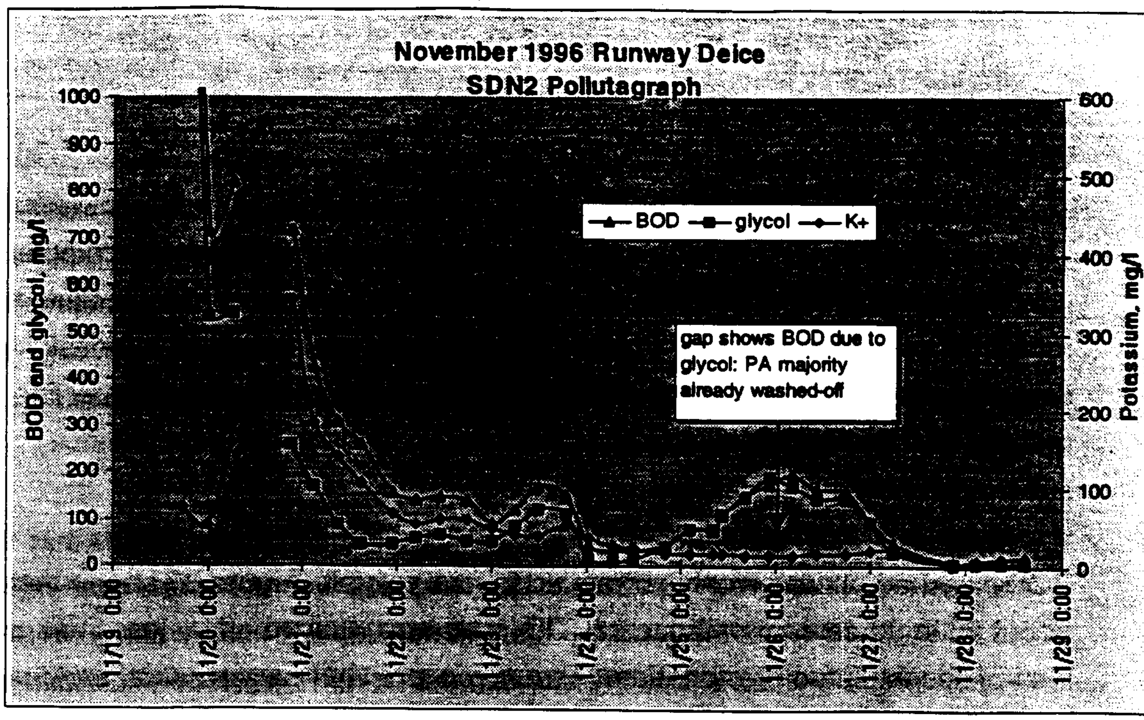
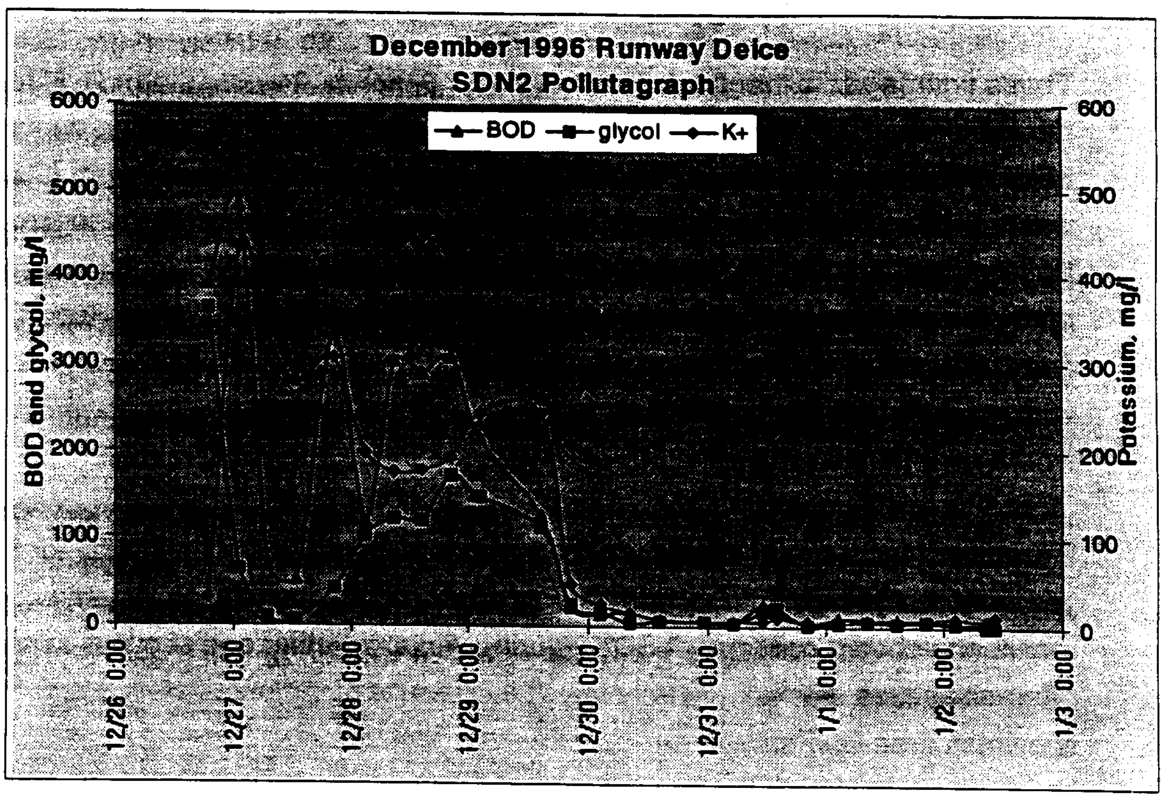


Figure 33 November 1996 Event Pollutagraph for SDN2



AR 033590

Figure 34 December 1996 Event Pollutagraph for SDN2

Washoff functions

These results apply directly only to the SDN2 subbasin because of incomplete flow monitoring data at SDS3. However, because the shapes of the pollutagraphs for SDS3 are similar to those from SDN2, and because these two subbasins were sampled over the same period, the washoff functions should be similar. These results identify a strong relationship between rainfall and pollutant washoff subsequent to runway deicing.

BOD_5 washed off was highly correlated to total rainfall. Figure 35 shows that about 80 to 90 percent of the total BOD_5 load was washed-off by less than one inch of accumulated precipitation. The relationship between washoff and rainfall was best described by logarithmic functions that had correlation coefficients (R^2) of 0.93 to 0.97. A correlation coefficient of 1.0 means that the regression equation is a perfect fit of the data.

These figures show that rainfall less than the 6-month, 24-hour storm (1.3" total rainfall for the STIA area) washed-off the majority of chemicals applied during the deicing/anti-icing periods. In fact, as little as the 1-month, 24-hour storm (0.65") washed-off close to 70% of the BOD_5 in both events. These curves also strongly illustrate the "first flush" principal where the majority of the BOD_5 load is washed off by the initial rainfall. Therefore, consistent with last year's Annual Report, the first 0.6 to 1.0 inch precipitation after a major runway deicing event washed off the vast majority of deicing chemicals applied. The corollary is also the Pareto effect, where ever diminishing amounts were washed off by additional rainfall.

Because of the general agreement between results of the washoff study for this year and last year, continued monitoring is not recommended. However, monitoring should continue at SDN2 during winter weather and snowfall to satisfy other objectives, namely to verify the effectiveness of the pump station and snowmelt area BMPs.

Summary

Overall, it appears that the 1-month, 24-hr storm (0.65" rainfall) washes off more than 75% of the total BOD_5 attributable to the PA and CMA deicing chemicals. Consistent with last years findings, the results from this year's washoff study conclude:

1. a marked first-flush effect is present for BOD_5 and indicators of PA and CMA,
2. concentration data and robust mass load estimates demonstrate the first-flush effect,
3. incremental loading estimates establish a coherent "washoff function",
4. the washoff function indicates that rainfall less than the 6-month, 24-hour rainfall event (1.3") subsequent to runway deicing washes off the majority of deicing chemicals,
5. no further monitoring is necessary at SDS3,
6. monitoring at SDN2 should continue so that effects of the new pump station BMP can be ascertained,
7. despite the severity of the December event, washoff functions exhibited similar dynamics to last year's,
8. the limited urea used in sand applied resulted in much lower TKN concentrations and far less total mass than last year, and
9. ammonia resulting from the limited urea was generally not detected.

Wet Weather Inspections for Permitted Outfalls

Conducted on April 28, 1997
by: Scott Tobiason

Outfall Name	Outfall #	inspection point (1)	date (2)	depth of flow (3), in.	foam	floatables	suspended solids	oil sheen	discolorations	turbidity	odor	other	Remarks (4)
					Indicate "Y" if present:								
SDE4	002	manhole SDE4-47	28-Apr	?	N	N	N	N	N	N	N	N	Clear water discharge
SDS1	003	outfall	28-Apr	1	N	N	N	N	N	N	N	N	Clear water discharge
SDS2	004	outfall	28-Apr	3	N	N	N	N	N	N	N	N	Clear water discharge
SDS3	005	outfall	28-Apr	0.55'	Y	Y	N	N	Y	N	N	N	floating debris, styrofoam "peanuts", cups, cigarette butts, some minor foam/scum. brown/yellow color.
SDN1	006	drain inlet	28-Apr	5	N	N	N	N	N	N	N	N	Clear water discharge
SDN2	007	manhole	28-Apr	4	N	N	N	N	N	N	N	N	Clear water discharge
SDN3	008	outfall	28-Apr	2	Y	N	N	N	N	N	N	N	Foam below pool 20' from outfall, sample showed no surfactants using Hach field kit.
SDS4	009	outfall	28-Apr	8 (back-water)	Y	N	N	N	N	N	N	N	clear water discharge, minor light foam, typical of storm discharges
SDW3	010	outfall	28-Apr	2	N	N	N	N	N	N	N	N	Clear water discharge
SDN4	011	outfall	28-Apr	2	N	N	N	N	N	N	N	N	Clear water discharge
Eng Yard	012	drain inlet	28-Apr	0	N	N	N	N	N	N	N	N	no discharge
Taxi Yard	013	drain inlet	28-Apr	0	N	N	N	N	N	N	N	N	no discharge
Subbasin B	014	outfall	28-Apr	2	N	N	N	N	N	Y	N	N	turbidity due to recent tire ruts in road shoulder near fire pit
Subbasin D	015	outfall	28-Apr	2	N	N	N	N	N	Y	N	N	turbidity from Snow Equipment Storage Shed constructino project, ESC in place but needs fix

notes:
1. Inspected visually from surface through inlets, or by pumped sample for outfalls with monitoring points requiring confined-space entry (SDE4, SDN1, SDN2, EY, TY)
2. Quarterly sampling sites visited on numerous other dates during the period, noted in remarks
3. Depths of flow are approximate, unless registered by local monitoring equipment.

Other observations at non-permit locations:

Location	Outfall #	inspection point	date	depth of flow	foam	floatables	suspended solids	oil sheen	discolorations	turbidity	odor	other	Remarks
S 28th St outfall	n/a	outfall											not inspected
DM Creek *above* SDS1	n/a	creek			N	N	N	N	N	N	N	N	clear water in creek, no foam
DM Creek *Weir at Golf Course*	n/a	creek											not inspected
DM Creek at SDS4	n/a	creek			N	N	N	N	N	N	N	N	
L. Reba outlet	n/a	outlet											not inspected

Scott Tobiason

9/20/97

Stipulated Agreement Sampling

As a result of the Stipulated Settlement Agreement (Brasher et. al., 1995), the Port of Seattle agreed to sample 16 events over a minimum 4 month period at the Miller Creek outfalls (SDN1, SDN2, SDN3, and Lake Reba outlet). Pollutant analytes were limited to TSS, turbidity, BOD_5, glycols, and ammonia. In addition, the Agreement required two additional sampling events of all eleven (11) permitted outfalls (the full list of permit-required pollutant analytes). These requirements more than tripled the Port's sampling activity in the past two years.

The Port completed all required samples for the Miller Creek outfalls as of October 1996 (summarized in Appendix B). All additional samples from permitted outfall were completed by February 1997. Results from these additional samples were submitted to Ecology on monthly DMRs when applicable, and are included throughout this report. The Port provided all data to the Appellants as required, and submitted a final letter on March 31, 1997 documenting completion of all agreed sampling (POS, 1997e). The data showed nothing unusual in the results, which are consistent with findings previously published in the Port of Seattle's Annual Stormwater Monitoring Reports (POS, 1995a and 1996a). There Appellants did not present comments on any of the data.

The additional data provided by these samples allowed the Port to further substantiate it's position that Sea-Tac airport generates far less stormwater pollution than other urban land uses.

Special Investigations

Following are discussions of special monitoring and investigations that the Port conducted in the past year. These investigations and corrective actions, where necessary, constitute SWPPP activities intended to reduce and eliminate stormwater pollution.

Subbasin SDN1: testing public roadway bias and pollutant source tracing

This section discusses the details of the 1996-97 source tracing effort in subbasin SDN1. Results and conclusions have been summarized in the prior sections that discuss each pollutant. Previous stormwater data indicated a possible concern for certain elevated pollutants in SDN1 discharges. With concurrence from Ecology in August 1996, the Port began a study to determine if public roadway runoff biases Port samples taken in manhole SDN1-27. The results indicate that the roadways, as well as an inappropriate connection have biased results. These results justify moving the sampling station from manhole SDN1-27 to SDN1-22 which is above the discharge of the public road runoff.

Dye tests in April 1997 confirmed that more than 3 acres of public roads (SR 518, S. 154th St., and 24th Ave. S.) drain to manhole SDN1-25. Storm samples above and below this manhole showed elevated FOG and TPH attributable to the public road runoff. Therefore, all NPDES samples taken in manhole SDN1-27, the original permit-compliance sampling location, reflect a high-bias caused by the non-Port runoff, proving the hypothesis presented in the last annual report. Table summarizes these results. The Port is continuing to investigate possible sources of lower pH, and elevated zinc that continue in results at the SDN1-22 manhole.

Elevated ammonia, BOD_5 and fluoride found in SDN1-27 baseflows in July 1996, plus the presence of dry-weather discharges motivated a second aspect of the study. By sampling baseflows at three "key manholes", the Port discovered that a food service facility had an inappropriate connection to manhole SDN1-25. Baseflow samples in manhole SDN1-25 indicated elevated ammonia, surfactants and BOD_5 compared to samples from manhole SDN1-22 located above the facility.

However, investigations and dye tests in the 30-foot deep manhole SDN1-25 showed that the majority of the baseflow originated from a drainage swale inside the cloverleaf exit from SR 518 to S. 154th St. Nonetheless, minute baseflow from a pipe draining the food service facility contained the elevated concentrations of BOD_5, surfactants, and phosphates responsible for contaminating the larger and relatively cleaner baseflow coming from the drainage swale. Curiously, the non-Port baseflow from the drainage swale had much higher fecal coliforms, and about twice the ammonia. Table 11 summarizes the baseflow sampling results.

The Port also used the services of Midway Sewer District's remotely operated mobile television camera to inspect over 1000 feet of SDN1 piping in February

1997. However, the inspection did not reveal any suspect connections. Limitations posed by manhole configurations and vertical relief did not allow a complete inspection of manholes SDN1-22 and SDN1-25. Later, physical, confined-space entries into these 20 to 30 foot deep structures revealed the connections warranting the investigations above.

Facility drawings showed a possible connection to the SDN1 system from the food service loading dock trench drain. When the facility operator washed the inside of food service trucks, contaminated water drained to the trench drain. Dye tests in April 1997 confirmed that this connection existed. The Port took immediate action with the facility operator, requiring elimination of the connection. The Port will continue to monitor the facility to confirm that the connection is eliminated.

In summary, the Port's study concluded that manhole SDN1-22 is a more representative sampling location that eliminates earlier biases from public roadway runoff. SDN1 samples taken on October 4, 1996, and January 16, 1997 and reported on the respective DMRs reflect the unbiased SDN1-22 location. Due to equipment problems, samples were unsuccessful at SDN1-22 in April 1996, and as a result, results from manhole SDN1-27 were reported on the April 1996 DMRs. These results showed surfactants present at 0.6 mg/l but other results were normal. The Port eliminated the inappropriate connection from the food service facility (responsible for elevated BOD_5, ammonia and surfactants) in May 1997.

Subbasin SDE4: pollutant source tracing

In the spring of 1997, the Port discovered a repeating "signature" on hydrographs of continuous flow monitoring data for subbasin SDE4. Small discharges occurred periodically and were most evident during periods of dry-weather. An automatic sampler on standby for storm a sample serendipitously took a grab sample of one of these pulses on April 10, 1997.

Table 10 SDN1 up/down Storm Sample Results

storm	rain	pH up	pH dn	O&G up	O&G dn	TPH up	TPH dn	fecals up	fecals dn	TSS up	TSS dn	Turb up	Turb dn	NH3 up	NH3 dn	BOD up	BOD dn	Surf up	Surf dn	Cu up	Cu dn	Pb up	Pb dn	Zn up	Zn dn
10/4/96	0.59	7.2		<1.0	3.8	0.5	3.0	500		21		6.7	19	0.12	0.23	<4.0	6	<0.02		0.02		0.02		0.22	0.25
11/3/96	0.14[3]	4.6	6.0	<1.0	2.5	0.4	1.3	23	240	22	21	9	11	0.44	0.31	5.8	13	0.07	0.15	0.04	0.03	0.01	0.01	0.73	0.51
1/16/97	1.15	4.4	5.1	<1.0	na	2.1	3.6	23	161	62	66	29	30	0.23	0.39	9.9	24	0.08	0.06	0.03	0.04	0.04	0.04	0.39	0.34

1. all units mg/l, except pH, and fecals (#/100 ml)
2. locations: "up" is manhole SDN1-22, "down" is manhole SDN1-27
3. not an "NPDES storm", therefore results not reported on DMRs. Samples still suitable for dual upstream/downstream comparison.

Table 11 SDN1 up/down Baseflow Sample Results

date	rain	pH up	pH dn	fecals up	fecals dn	NH3 up	NH3 dn	BOD up	BOD dn	Surf up	Surf dn	[illegible] up	[illegible] dn	[illegible] up	[illegible] dn	TDP up	TDP dn	SRP up	SRP dn
7/16/96	0				900		6.6												
7/23/96	0		9.8		11		11.4		84		<0.05				0.73		0.73		0.60
9/12/96[3]	0		5.5		30		2.2		26		0.76		2.7		0.18		0.05		0.04
4/2/97	0	7.9	7.2			<0.01	<0.01	<4.0	22	0.05	2.4	0.14	0.08	0.15	0.19				
4/4/97[4]	0	7.6	5.8	>1600	300	0.07	0.03	<2	474	0.07	3.5	0.12	0.21			0.01	1.29	0.01	0.39

1. all units mg/l, except pH, and fecals (#/100 ml)
2. locations: "up" is manhole SDN1-22, "down" is manhole SDN1-27
3. dry-weather discharge pulse 03:40 to 05:00
4. locations within manhole SDN1-25: "up" is 24" CMP from SR 518, "down" is cast iron pipe from Food Service facility.

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The foam and fragrance in this SDE4 dry-weather flow grab sample suggested the presence of soapy vehicle washwater. Field kit analysis showed surfactants greater than 1.3 mg/l and enough fluoride to suggest the pulse had a domestic water source. Another foamy, fragrant discharge on June 2, 1997 was confirmed during a confined-space entry at the monitoring location (20 foot-deep manhole SDE4-47) while performing equipment maintenance.

On June 3, 1997 the Port traced the discharge upstream to its origin in manhole SDE3-91, a structure tributary to the SDE4 drainage network. A 6" PVC pipe connected from this manhole to the nearby IWS-283 pump station. An equipment malfunction in the pump station caused overflows to discharge to the SDE3-91 manhole. The Port immediately plugged the overflow pipe and took appropriate preventive maintenance actions The IWS-283 pump station handles washwater from the rental car wash after the water has gone through initial pretreatment in a sand filter.

The Port believes this problem caused the elevated results for FOG (9 mg/l), TPH (10 mg/l), and surfactants (1.28 mg/l) reported on the January 1997 DMRs. Previous sections discussed that these results were outlying values and not typical of the many samples collected at SDE4 to date.

Snowmelt: BOD_5 caused by glycols in snowpiles

In the 1996-97 Winter period, the Port monitored snowmelt during and after the two major snowstorms of November 19-20, 1996 and December 26-29, 1996. The December event was a rare, extreme occurrence of 16 to 18 inches of heavy snowfall followed by heavy rainfall of more than 5 inches in the next 5 days. The Port plowed and moved several thousand cubic yards of snow to four snow storage areas. Though this December event is not representative of nominal snowfall, it nonetheless provided an opportunity to investigate the dynamics of snowmelt contaminated with glycols and ground deicers. In both events, temperatures remained above freezing throughout the monitoring period, allowing a continuous snowmelt cycle.

Preliminary sampling with glycol analysis kits[14] during and after the November event showed that glycols of >300 mg/l emanated from the snowpile for the first 4 days. Glycol concentrations then began to drop below 100 mg/l within the first week of the melt cycle. The Port then deployed and setup automatic sampling equipment downstream of the snowpile to monitor the December event.

Sampling during and after the December event was concurrent with runway washoff monitoring at SDN2. Monitoring at SDN2 both above and below the north snowpile showed clear results. Samples and loading estimates indicated the duration and magnitude of BOD_5 in snowmelt attributable to glycols, the potassium acetate (PA) and calcium magnesium acetate (CMA) to a lesser extent. More limited sampling at SDE4 did not indicate as clear results.

Based upon comprehensive up/down time-series composites, and loading estimates, the sampling of the north snowpile during the melt cycle after the December event confirmed the following:

1. the north snowpile was a source of BOD_5 due to glycols (BOD_5 and glycols were both at higher concentrations downstream of the pile),
2. the north snowpile also was a source of nitrogen (predominantly TKN and very little ammonia) from small amounts of urea applied with deicing sand. The Port added the urea to the sand stockpiles to prevent them from freezing and hindering mechanical application. The amount of urea used was far less than in previous years. TKN from urea dropped dramatically after 4 days into the melt cycle,
3. 90% of glycols and corresponding BOD_5 emerged from the snowpile in the first 4 days of the melt cycle (based on concentrations and mass load estimates),
4. glycols and BOD_5 dropped dramatically after 4 days,
5. the north snowpile contained limited amounts of PA and CMA deicers, but far less compared to the BOD_5 due to the glycols (data showed that the snowpile runoff actually diluted PA and CMA coming from above it),

[14] HACH glycol kit results give concentration ranges only and not a specific glycol value. The kit detects either type of glycol.

6. glycols in the snowmelt dropped below 100 mg/l after 6 days of melt cycle, remained below 100 mg/l during the next 5 days of sampling, and dropped below detection in days 9-11 of the melt cycle,
7. BOD_5 displayed an initial drop below 100 mg/l after 7 days, but then began to rise again in day 8. The rise in BOD_5 was not caused by additional glycols because they remained below detection in days 9-11,
8. this rise in BOD_5 in days 8-11 was due to CMA solid melting, because both calcium and magnesium ions also rose in concentration while the potassium ion (indicating PA) decreased, and
9. turbidity increased below the snowpile as a result of equipment activity disturbing the gravel-surfaced snow storage area.

Therefore, monitoring showed a multiphase melt cycle: BOD_5 from glycols in the snowpile appeared rapidly in first few days followed by a drop for short period, then rose a second time due to the dissolving solid CMA deicer. The gravel-surfaced snow storage area contributed turbidity and solids.

In summary, plowed snow can contain glycols and other deicers that manifest as BOD_5. The BOD_5 due to liquid-phase deicers such as glycols and PA appears from snowpiles in the first few days of the melt and/or rain cycle . BOD_5 from solid-phase deicers such as CMA may show up later in the melt cycle. Because these conclusions are based upon sampling that took place during an extreme event, nominal snowmelt events should behave similarly, but display lower overall BOD_5 and glycol concentrations. The Port will complete capital construction of three snow storage areas by November 1997. Runoff from these three areas will be diverted to the IWS by local pump stations.

<u>Field QC samples</u>

Table 12 shows data for field quality control samples. These data demonstrate the adequacy and strong level of confidence of the Port's sampling protocols and results. Because the majority of data were near or below analyte detection limits in field blanks, the results confirm that little or no contamination occurred in the automatic sampling process. Furthermore, duplicate samples taken by the automatic samplers display little relative percent difference (RPD) between a particular sample and it's duplicate. The majority of duplicate analytes had an RPD of less than 10%. Only a limited number of cases exhibited more than the 20% RPD criterion commonly used to discern significant differences. Such differences would account for the variability of the composition of the discharge and the precision of the sampling technique.

Table 12 Field QC sample data

POS ID	stormdate	FOG	TPH	Fecal	TSS	Turb	BOD5	NH3	Glycols	Surf	Cu	Pb	Zn
Field (equipment) blanks[1]													
SDS3.123096.BLANK	26-Dec-96					0.32	<4.00	<0.010	<10.0				
EY.030697.BLANK1	05-Mar-97	<1.0			<0.50								
SDS2.011797.BLANK	16-Jan-97	1.4	<0.25	2	<0.5	0.13	<4.0		<10.0				
Duplicate composite samples[2]													
SDN3.011797.DUPE	16-Jan-97				12	12	5.4	0.134		<0.025	0.013	<0.001	0.042
SDN3.011797	16-Jan-97				13	13	4.9	0.132		<0.025	0.012	<0.001	0.043
RPD[3]													
SDW3.021197.DUPE	11-Feb-97				2.4	1.5							
SDW3.021197	11-Feb-97				2.2	1.9							
RPD[3]													
B.030697.DUPE	05-Mar-97				13	23	<4.0				0.0087	<0.001	0.019
B.030697	06-May-97				13	23	<4.0				0.0066	<0.001	0.017
RPD[3]													
SDN1.041397.DUPE	13-Apr-97				26	18	16.2	0.452		0.643	0.044	0.017	0.46
SDN1.041397	13-Apr-97				34	19	17	0.109		0.621	0.042	0.013	0.43
RPD[3]													

1. Field blanks taken by drawing deionized water through automatic sampler pump/tubing assembly at outfall indicated.
2. Automatic samplers programmed to take duplicate samples in adjacent sample bottles.
3. Relative percent difference.
4. Shaded data were below detection limits.

Summary of biases caused by non-Port runoff

As discussed under Background, several sampling locations include runoff from non-STIA sources. Data discussed previously in this report confirm that offsite runoff biases results, causing higher concentrations of several pollutants and biasing STIA results. The Port has already moved two sampling locations, and with Ecology's concurrence, may adjust others if conditions warrant.

outfall	source of bias	potential impacts	monitoring location status
SDN1	• public roads • food service facility	• Proven high bias for FOG and TPH. • BOD_5, surfactants from facility	• moved from manhole SDN1-27 to manhole SDN1-22 • Eliminated inappropriate connection
SDE4	• public roads • IWS pump station overflow • other?	• probable high bias for vehicle-source pollutants • proven surfactants from pump station overflow	• under study • eliminated inappropriate connection from overflow pipe
SDS1	• public roads (S. 188th St.)	• probably more dominant after May 1997	• under study
SDS3	• public roads (S. 188th St.)	• probable high-bias from vehicle-source pollutants in grab samples	• under study
SDS2	• public roads (16th Ave. S., S. 188th St.)	• probable high-bias from vehicle-source pollutants and TSS.	• subbasin to have no "industrial" activity by end of 1997. No further action.
SDW3	• public roads (S. 188th St.), animals	• proven high bias for FOG and bacteria (fecal coliforms)	• moved from outfall backwater to manhole SDW3-24

Stormwater Pollution Prevention Plan (SWPPP) Actions

Table 13 presents a summary of best management practice (BMP) activities described in the Stormwater Pollution prevention Plan (SWPPP, POS, 1995b). Summaries of wet and dry season inspections are included in Appendix C.

Table 13 SWPPP BMP SUMMARY

ACTIVITY	BMP	TYPE	STATUS	RESPONSIBLE ORGANIZATION
Aircraft servicing	• Restrict to IWS areas or drains blocked • Store glycol in IWS areas • Confine parking of lavatory waste trucks to IWS • Identify and connect problem SDS areas to IWS • Monitor SDS outfalls when and if aircraft are deiced in SDS subbasins (aircraft deicing is restricted to IWS areas only).	• Operational • Operational • Operational • Operational • Operational	• Ongoing • Ongoing • Ongoing • Ongoing • Ongoing	• AFLOB • AFLOB /HSES • AFLOB /HSES • AV/PMG • HSES
Airfield anti-icing/deicing	• Minimize chemical use • Sweep storage areas	• Operational • Source control	• Ongoing • Ongoing	• AFLOB • Maintenance
Spill control	• Implement Spill Plan	• Operational	• In effect	• AV/PMG
Construction sites education/training	• Require erosion and sediment control BMPs • Restrict equipment servicing • Encourage contractors to use secondary containment • Provide contractor/inspector training	• Source control • Source control • Source control • Operational	• Ongoing • Ongoing • Ongoing • Ongoing	• PMG • AFLOB • PMG • HSES
Erosion of bare ground surfaces in non-construction areas	• Implement soil erosion and control BMPs in contractor staging areas • Emphasize and enforce contractor responsibility for BMPs in contractor staging areas • Control erosion from temporary soil stockpiles	• Source control • Source control • Source control	• Ongoing • In effect • In effect	• PMG/Maintenance • PMG • PMG/Maintenance
Vehicle washing and maintenance	• Prohibit vehicle washing in SDS areas • Place signs in key locations • Clean sumps in Taxi Yard annually • Sweep Taxi Yard and control litter	• Source control • Operational • Source control • Source control	• Ongoing • In effect • Ongoing • Ongoing	• PMG/HSES • Maintenance • Maintenance • Maintenance

ACTIVITY	BMP	TYPE	STATUS	RESPONSIBLE ORGANIZATION
	• Maintain catch basin inserts	• Source control	• Ongoing	• Maintenance
Landscape management	• Strive to use environmentally benign chemicals	• Operational	• In effect	• Maintenance
	• Follow proper cleaning/disposal procedures	• Operational	• In effect	• Maintenance
	• Apply during dry periods	• Operational	• In effect	• Maintenance
	• Restrict use near waterways	• Operational	• In effect	• Maintenance
	• Incorporate BMPs in contractor specifications	• Operational	• Completed 12/95	• Maintenance
	• Implement IPM Plan	• Operational	• Completed 12/95	• Maintenance
	• Give priority to biological methods of pest management	• Operational	• Ongoing	• Maintenance
	• Apply fertilizer	• Operational	• Ongoing	• Maintenance
	• Conduct regular weeding and pruning	• Operational	• Ongoing	• Maintenance
	• Follow Ecology guidelines for herbicide application	• Operational	• Ongoing	• Maintenance
	• Apply herbicides/pesticides according to instructions	• Operational	• Ongoing	• Maintenance
	• Dethatch	• Operational	• Ongoing	• Maintenance
	• Trim ivy-covered areas	• Operational	• Ongoing	• Maintenance
	• Fertilize shrubs and trees by hand	• Operational	• Ongoing	• Maintenance
	• Do not use beauty bark in drainage ways	• Operational	• Ongoing	• Maintenance
	• Maintain stream corridors	• Operational	• Ongoing	• Maintenance
	• Prohibit Roundup use within 50 feet of a water body	• Operational	• Ongoing	• Maintenance
	• Do not apply pesticides or fertilizer on rainy days	• Operational	• Ongoing	• Maintenance
	• Avoid catch basin grates when applying fertilizer or pesticides	• Operational	• Ongoing	• Maintenance
Airfield maintenance	• Sweep pavement frequently	• Source control	• In effect	• Maintenance
	• Inspect catch basin sumps annually and clean as needed	• Source control	• Ongoing	• Maintenance
	• Store and dispose of sediments properly	• Operational	• In effect	• Maintenance
	• Construct secondary containment for used engine fluids	• Operational	• Ongoing	• Maintenance

ACTIVITY	BMP	TYPE	STATUS	RESPONSIBLE ORGANIZATION
Inappropriate connections and discharges	• Inspect outfalls for evidence of illicit connections	• Operational	• Ongoing	• HSES/ Maintenance/
Temporary storage of surplus and used materials	• Do not store liquids in westside yard	• Operational	• In effect	• Maintenance
	• Engineering Yard:			
	• Lock gate during off hours	• Operational	• Ongoing	• Maintenance
	• Place signs on surplus storage	• Operational	• Ongoing	• Maintenance
	• Control entry of surplus materials	• Operational	• Ongoing	• Maintenance
Tenant activities in SDS areas	• Monitor and educate tenants	• Operational	• Ongoing	• Tenant
	• Deice aircraft according to procedures	• Operational	• Ongoing	• Tenant
	• Encourage drip pans beneath fueling trucks if leakage is observed	• Operational	• Ongoing	• Tenant
	• Sweep around dumpsters	• Operational	• Ongoing	• Tenant
	• Store liquids in secondary containment	• Operational	• Ongoing	• Tenant
	• Do not store used fluids or hazardous waste in SDS areas	• Operational	• Ongoing	• Tenant
	• Do not maintain vehicles or equipment in SDS areas	• Operational	• Ongoing	• Tenant
	• Inspect catch basin grates	• Operational	• Ongoing	• Tenant
	• Require tenant water pollution control plans	• Operations	• Ongoing	• HSES
	• Ensure tenant compliance with Port SWPPP	• Operations	• Ongoing	• HSES
	• Require tenant spill control plans	• Source control	• In effect	• Tenant
Universal BMPs	• Designate a SWPPP implementation monitor	• Operational	• Ongoing	• HSES
	• Conduct regular inspections	• Operational	• Ongoing	• HSES
	• Assemble Pollution Prevention Team	• Operational	• Ongoing	• AV/PMG
	• Conduct SDS outfall monitoring	• Operational	• Ongoing	• HSES
	• Sign catch basins (dump no waste)	• Operational	• Ongoing	• Maintenance
	• Establish packing material source control	• Operational	• Ongoing	• AV/PMG

Table 14 Summary of completed BMPs

Completed SWPPP BMPs (mostly capital)	Objective	Subbasin	Date Completed	Cost
1. Terminate airfield glycol use for ground deicing	Eliminate a glycol source	airfield,term	12/95	na
2. Store Chemicals in IWS Area	remove industrial activity from SDS	airfield/term	12/95	na
3. Connect snow storage areas to IWS	Reduce BOD_5	SDN2, SDE4	By 11/1/97	TBD
4. Connect Loading Dock Dumpster slot drain to sanitary	remove industrial activity from SDS (eliminate source of fecal coliforms, BOD_5 in SDE4)	SDE4	10/95	$25K
5. Connect North Cargo Area (Area 114) to IWS via lift station	• eliminate glycol source • remove industrial activity from SDS	SDN2	6/97	$188K
6. Connect Cargo Area 4 (POS Maint, Area 100) to IWS	remove industrial activity from SDS	SDE4	8/96	$13K
7. Connect North Satellite (Area 106/107) to IWS	• eliminate glycol source • remove industrial activity from SDS	SDE4	10/95	$300K
8. Close SDS inlet near Gate C8	• eliminate glycol source • remove industrial activity from SDS	SDS3	12/95	$10K
9. Close SDS inlet near Gate B5	• eliminate glycol source • remove industrial activity from SDS	SDS3	12/95	$10K
10. Connect SDS area between the South Satellite and the B Concourse to the IWS (inlets SDS1-98, SDS1-99)	• eliminate glycol source • remove industrial activity from SDS	SDS1	5/97	$149K
11. Connect SDS area between the South Satellite and the NW Hangar to the IWS	• eliminate glycol source • remove industrial activity from SDS	SDS1	8/96	$88K
12. Connect Area 112/311 (D Concourse) to IWS	remove industrial activity from SDS	SDE4	11/95	TBD

Completed SWPPP BMPs (mostly capital)	Objective	Subbasin	Date Completed	Cost
13. Connect Area 314 (C Concourse) to IWS	remove industrial activity from SDS	SDS3	11/95	TBD
14. Relocate Hazardous Materials sheds to IWS area	remove industrial activity from SDS	SDW3	7/95	$4K
15. Cover and connect Taxi Yard Wash Pad to sanitary	remove industrial activity from SDS	TY	7/95	$30K
16. Evaluate alternative chemicals for anti-icing and deicing	source control	airfield/term	12/95	na
17. Store de/anti-icing chemicals in IWS areas	remove industrial activity from SDS	airfield/term	12/95	na
18. Connect airfield maintenance sediment storage yard to IWS	remove industrial activity from SDS	B	7/95	$5K
19. Connect Federal Express loading dock area to IWS	remove industrial activity from SDS	SDN1		TBD
Total				**>$822K**

Conclusions and Recommendations

Stormwater Quality

Overall, STIA stormwater quality is cleaner than regionally comparable data. Results continue to demonstrate that stormwater quality at the airfield outfalls under typical conditions is consistently cleaner than regional commercial and industrial areas. The dichotomy between airfield outfalls when results are compared to the terminal and landside outfalls indicates that landside and terminal outfalls are the principal pollutant sources. However, the data tend to indicate that runoff from non-Port public roadways unfavorably biases STIA stormwater, especially in the landside outfall samples. Nonetheless, overall STIA unit loads for TSS and metals are generally lower than roadways and commercial areas.

As a direct result of stormwater monitoring completed in the past year, the Port found and eliminated inappropriate connections to the SDE4 and SDN1 storm drains. Monitoring in the upcoming year should demonstrate that four major capital BMPs constructed in the past year dramatically reduce and even eliminate glycols in the SDS1, SDN2, and SDE4 subbasin stormwater.

Subsequent to runway deicing/anti-icing, the one-month, 24-hour storm (0.65") washes off from 70% to 80% of the of BOD_5 attributable to ground deicing chemicals. Less than the 6-month, 24-hour storm (1.3") washes off the vast majority of BOD_5 .

Recommendations

Based on the findings of this and past reports, the following key recommendations are offered to the Department of Ecology and the Port of Seattle Aviation Division:

1. Discontinue monitoring in SDN1 because this subbasin has no industrial activities. However, if monitoring requirements remain, continue to sample at manhole SDN1-22. This location removes the bias in the Port's samples caused by petroleum products in public road runoff from SR 518, S. 154th St.,

and 24th Ave. South. Verify that Air Cargo Road (another public roadway) is another possible bias for zinc and other metals.

2. Discontinue monitoring at SDS2 as soon as the soil remediation project is completed. Public road runoff commingles with Port runoff above the sampling location, and biases the Port's results.

3. Discontinue the FOG analysis by method from 413.1. Replace with method NWTPH-Dx which gives more representative results by reducing non-petroleum biases.

4. Reduce monitoring frequency from quarterly to once annually for the five airfield outfalls (SDS3, SDS4, SDN2, SDN3, and SDN4). This report continues to demonstrate that these subbasins discharge far less than other urban land uses. If this reduction is not feasible, continue quarterly monitoring at only one or two of these 5 subbasins. Given the similarity in activity in each subbasin, and the facts established by the Port's Annual Stormwater reports, these 5 subbasins are "substantially equivalent".

5. Investigate the bias that S. 188th St. May impose on SDS1 samples now that runoff from this public road is a larger component of that sampled at the outfall. In the past year, the Port completed two capital BMPs that reduced the Port's SDS1 subbasin drainage area from 40 to 6 acres.

6. Continue to investigate possible sources of fecal coliforms in SDE4 discharges.

7. Monitor stormwater at SDN2 to verify the effectiveness of two capital BMPs designed to reduce and eliminate glycols and BOD_5 during winter weather. This sampling should be in addition to regular monitoring.

8. Discontinue the "washoff study" monitoring during runway deicing events. Sufficient data exists from the past two seasons to provide relevant guidance.

9. Continue to monitor glycols in SDS1 discharges to verify the effectiveness of two capital BMPs designed to reduce and eliminate glycols and other pollutants by rerouting drainage to the IWS.

10. Discontinue monitoring for glycols in airfield subbasins SDS3, SDS4, SDN3, and SDN4, and in landside subbasin SDN1. All known direct sources of glycols have been eliminated. Ecology acknowledges that glycol shear from aircraft is not regulated. Amend the Port's Procedures Manual appropriately.

11. Discontinue formal glycol monitoring in the three remaining subbasins. Perform only limited glycol monitoring to verify BMP effectiveness. Glycols are not applied in subbasins SDS1, SDE4, and SDN2. The Port has completed several BMPs that eliminate aircraft service areas from these subbasins. Capital BMPs that divert snowmelt from snow storage areas in SDE4 and SDN1 will be completed by November 1997.

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References

1. APHA, 1995. Standard Methods for the Examination of Water and Wastewater. 19th Edition. American Public Health Association, WA DC, 1995.

2. Booth and Horner, 1995. Fundamentals of Urban Surface Water Management, Chapter IV. Course manual for class offered in cooperation with University of Washington Engineering Professional Programs, Seattle, WA. September 1995.

3. Brasher, et. al. 1995. Minnie Brasher, Normandy Park Community Club and the City of Des Moines v. State of Washington, Department of Ecology and Port of Seattle, March 24, 1995. Also known as the "Stipulated Agreement"

4. Chui, T.W., Mar, B.W., and Horner, R.R, 1982. Pollutant Loading Model for Highway Runoff. Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers, Vol 108, No. EE6, December, 1982.

5. EPA, 1993. Stormwater discharges potentially addressed by Phase II of the NPDES program. Draft report to Congress. October, 1993.

6. EPA, 1996. Letter describing changes in solvent used for FOG and TPH analysis: "Direct Replacement of Currently Approved Methods with Method 1664 for Determination of the Conventional Pollutant "Oil and Grease", dated July 9, 1996. US EPA, WA, DC

7. Hall, John C, et al., 1997. Water Quality Criteria for Copper. Water Environment Technology, June 1997 (Vol. 9, No. 6).

8. King County, 1995. Little Soos Creek Microbial Source Tracking: A Survey. Prepared by Dr. Mansour Samadpour and Naomi Checkowitz of the University of Washington for King County Department of Public Works, Surface Water Management Division. August, 1995

9. Marsalek, 1990. Evaluation of Pollutant Loads from Urban Nonpoint Sources. Water Science and Technology 22 (10/11): pages 23-30.

10. POS, 1996b. Port of Seattle letter to WDOE (Lisa Zinner), dated 9/4/96.

11. POS, 1995a. Annual Stormwater Monitoring Summary Report: Water Quality Data of the Discharges from the Storm Drainage System. Sea-Tac International Airport, Seattle WA. Prepared by Resource Planning Associates for the Port of Seattle, August 30, 1995

12. POS, 1995c. Stormwater Pollution Prevention Plan. Port of Seattle, November 1995. (in revision)

13. POS, 1996a. Annual Stormwater Monitoring Report for the period July 1, 1995 through June 30, 1996. Scott Tobiason, Port of Seattle, November 18, 1996.

14. POS, 1996b. Annual Glycol Report. Memorandum dated May 17, 1996 from Port of Seattle to WDOE (Lisa Zinner).

15. POS, 1997a. Stormwater Receiving Environment Monitoring Report for NPDES Permit No. WA-002465-1. Port of Seattle, June 1997.

16. POS, 1997b. Procedures Manual for Stormwater Monitoring, Sea-Tac International Airport, Seattle, WA. Scott Tobiason, Port of Seattle, March 7, 1997.

17. POS, 1997c. Port of Seattle letter to WDOE (Lisa Zinner), dated June 13, 1997.

18. POS, 1997d. Annual Glycol Report. Memorandum dated April 30, 1997 from Port of Seattle to WDOE (Lisa Zinner).

19. POS, 1997e. Port of Seattle letter to Shawn McEvoy (Appellant), "Re: Completion of Sampling Required by the Stipulated Settlement Agreement." Dated March 31, 1997.

20. POS, 1997f. Port of Seattle Letter to WDOE (Lisa Zinner), dated August 8, 1997.

21. Redmond, 1990. Redmond Way Oil/Water Separator Engineering Report. City of Redmond, 1990

22. SPSS, 1993. SPSS for Windows, Base System User's Guide. Release 6.0 SPSS Inc., Chicago IL, © 1993

23. WDOE, 1996. Letter from WDOE (Lisa Zinner) to Port of Seattle (Michael Feldman), authorizing silver to be dropped from Stormwater Receiving Environment Study, dated August 14, 1996.

24. WDOE 1994 National Pollutant Discharge Elimination System permit No. WA-002465-1, issued June 30, 1994 by Washington Department of Ecology, Olympia, WA

25. WDOE, 1991 . Supplement S-6 to Statistical Guidance for Ecology Site Managers.

26. Woodward-Clyde Consultants, 1993. Santa Clara Valley Nonpoint Source Pollution Control Program. Woodward-Clyde Consultants, Oakland, CA 1993

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Appendices

Appendix A

Hydraulic and Hydrologic Estimations

This appendix presents hydraulic information required by the STIA NPDES permit. Paragraph 2 of section C of NPDES permit special condition S3 states "The Permittee shall submit the following data for the storm event used: date, duration, the number of dry hours preceding the storm event, total rainfall during the storm event (inches), maximum flow rate (gallons per minute), and the total flow from the rain event (gallons)." This appendix contains these required data items. Daily maximum runoff volumes are reported monthly on DMRs.

Table 15 outlines the storms monitored, the outfalls sampled, and the storm date, total rainfall, duration, and 48-hour antecedent precipitation.

Runoff Volumes

In 1995, the Port developed a WATERWORKS software-based model for hydraulic evaluation of the stormwater subbasins at STIA. Port Engineering, amongst others, uses the model to evaluate the stormwater piping for various design storms. Runoff volumes generated by this model were used to develop linear equations for estimating runoff volumes for each subbasin. These equations are nested in the spreadsheet that estimates the maximum daily discharge values submitted in the monthly DMRs. The Port has used this procedure since the fourth quarter of 1995. Table 16 presents total runoff volumes estimated for each storm event monitored.

The reader is referred to the Procedures Manual (POS, 1997b) and last year's annual report (POS, 1996a, 1995a) for a discussion of the method used to estimate runoff volumes. Table 18 shows the areas estimated for each subbasin. The areas of some subbasins will change as portions of SDS areas are connected to the IWS as specified in the SWPPP.

Peak Discharges

Peak discharges presented in Table 17 are estimated by the "rational method" for each storm event sampled in the preceding year. The peak rate of each storm depends upon the time-of-concentration, or T_c, for the particular subbasin and the rainfall distribution of the particular storm. The WATERWORKS model developed the T_c values presented in Table 18. The peak discharge, Q_p, is then estimated by the rational method using the following equation.

$$Q_p\ (\text{gpm}) = \frac{C \times I \times A \times 43560\ \text{ft}^3/\text{ac} \times 7.48\ \text{gal/ft}^3}{12\ \text{in/ft} \times 60\ \text{min/hr}}$$

where:

C = runoff coefficient = (0.90(A_i) + 0.25(A_p))/A

where :

A_i = the impervious area in acres, and

A_p = the pervious area in acres

I = peak intensity in inches/hour

A = subbasin area in acres

The Port's ISCO rain gage records rainfall at 5-minute intervals, thus resolving rainfall rates, or "intensities" for periods as short as 5-minutes. The rainfall record for the storm of interest is examined to determine the peak intensity for the time span that matches the time-of-concentration. The ISCO rain gage allows the user to aggregate rainfall for multiples of the 5-minute recording interval that best approaches the times of concentration desired. This basin-specific intensity is then translated to an hourly peak intensity using the following equation:

$$I = i \times 60/T_c$$

where:

i = maximum rainfall depth (inches) of a time equal to the time of concentration

T_c = the time of concentration, displayed in Table A3.

For example, the T_c for SDE-4 is 21 minutes; therefore, the rainfall record for the storm of interest is examined to find the one period of 20 minutes that has the greatest rainfall depth

Table 15 Monitored Storm Events

Storm Event Sampling History for July, 1996 through May 1997																				
				Rainfall		Outfalls Sampled														
	Storm		Duration	Depth	48-hour	002	003	004	005	006	007	008	009	010	011	012	013	014	015	
Date	quarter	Type	(hr)	(in.)	Ant (in)	SDE4	SDS1	SDS2	SDS3	SDN1	SDN2	SDN3	SDS4	SDW3	SDN4	EY	TY	B	D	MC3
5/30/97	97 Q2		35	1.65	0.04	1						1								
4/19/97	97 Q2		26	1.16	0.00						1		1					1		
4/13/97	97 Q2		17	0.26	0.04		1			1										
3/5/97	97 Q2		19	0.39	0.24	1			1			1			1	1	1	1	1	
2/26/97	97 Q1		25	0.24	0.00									grab						
2/11/97	97 Q1		18	0.48	0.00			1						1		1	1		1	
1/27/97	97 Q1		26	0.41	0.00	1							1	1				1	1	
1/16/97	97 Q1		23	1.21	0.00	1	1	1	1	2	1	1	1	1	1			1	grab	
12/19/96	96 Q4		48	0.36	na	1						1								
12/4/96	96 Q4		7	0.82	0.16		1	1				1	1	1	1			1	1	
11/23/96	96 Q4		34	0.63	0.00		1	grab	1			grab		grab					1	
10/21/96	96 Q4		17	0.68	0.00				1		1					1				
10/4/96	96 Q4		8	0.59	0.08					1			1				1			
9/3/96	96 Q3		1	0.29	0.00	1			1		1				1					
8/2/96	96 Q3		27	1.01	0.00		1		1			1					1			
7/17/96	96 Q3		57	0.59	0.00	grab	grab		grab	1	grab		grab				1			
7/3/96	96 Q3		11	0.23	0.00		1			1			1			1	1			

"1" means NPDES grab and composite sample obtained
na means no data available; rain gage failed to record data, or gap exists in rainfall data records.
"wo" means a runway deicing washoff sample obtained
"grab" means only a grab sample taken
"DB" means aircraft deicing event, baseflow sample, "DS" means aircraft deicing event, storm sample
"stip" means only sampled for parameters of the Stipulated Agreement for Miller Creek outfalls.

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Table 16 Estimated Runoff Volumes for Storm Events Monitored

Estimated Runoff Volumes for Storm Events Monitored July, 1996 through May, 1997													
Monitored Event Date	Rainfall (inches)	Runoff Volumes for Sea-Tac Airport Sub-Basins (gallons) 002 SDE-4	003 SDS-1	004 SDS-2	005 SDS-3	006 SDN-1	007 SDN-[illegible]	008 SDN-3	009 SDS-[illegible]	010 SDW-[illegible]	011 SDN-[illegible]	014 [illegible]	015 [illegible]
5/30/97	1.65	3,714,000	331,000	86,000	10,690,000	614,000	1,215,000	1,280,000	1,410,000	594,000	466,000	449,000	473,000
4/19/97	1.16	2,443,000	209,000	46,000	6,632,000	406,000	779,000	678,000	833,000	351,000	328,000	315,000	333,000
4/13/97	0.26	190,000	16,000	3,000	503,000	32,000	61,000	41,000	51,000	22,000	74,000	71,000	75,000
3/5/97	0.39	516,000	43,000	7,000	1,368,000	86,000	166,000	111,000	140,000	59,000	111,000	106,000	112,000
2/26/97	0.24	154,000	13,000	3,000	407,000	26,000	50,000	33,000	41,000	17,000	68,000	66,000	69,000
2/11/97	0.48	833,000	69,000	12,000	2,205,000	139,000	268,000	179,000	228,000	96,000	136,000	131,000	138,000
1/27/97	0.41	580,000	48,000	8,000	1,537,000	97,000	187,000	125,000	158,000	67,000	116,000	112,000	118,000
1/16/97	1.21	2,567,000	221,000	49,000	7,012,000	426,000	821,000	731,000	886,000	373,000	342,000	329,000	347,000
12/19/96	0.36	427,000	35,000	6,000	1,132,000	72,000	138,000	92,000	116,000	49,000	102,000	98,000	104,000
12/4/96	0.82	1,645,000	136,000	25,000	4,255,000	274,000	514,000	370,000	511,000	216,000	232,000	223,000	235,000
11/23/96	0.63	1,229,000	100,000	16,000	3,083,000	205,000	379,000	238,000	360,000	152,000	178,000	172,000	181,000
10/21/96	0.68	1,336,000	109,000	18,000	3,381,000	223,000	414,000	270,000	398,000	168,000	193,000	185,000	195,000
10/4/96	0.59	1,144,000	93,000	15,000	2,851,000	191,000	352,000	214,000	330,000	139,000	167,000	161,000	170,000
9/3/96	0.29	252,000	21,000	4,000	667,000	42,000	81,000	54,000	67,000	29,000	82,000	79,000	84,000
8/2/96	1.01	2,083,000	176,000	36,000	5,539,000	347,000	658,000	531,000	683,000	288,000	286,000	275,000	290,000
7/17/96	0.59	1,144,000	93,000	15,000	2,851,000	191,000	352,000	214,000	330,000	139,000	167,000	161,000	170,000
7/3/96	0.23	137,000	12,000	2,000	362,000	23,000	44,000	30,000	36,000	15,000	65,000	63,000	66,000
Rainfall data from Port of Seattle and/or National Weather Service rain gage at Sea-Tac Airport													
Runoff volumes based upon basin-specific engineering models													
ND means No Data available; rain gage failed to record data, or gap exists in rainfall data records.													

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Table 17 Estimated Peak Runoff Rates for Storm Events Monitored

Estimated Peak Runoff Rates for Storm Events Monitored July 1996 through May 1997

Monitored Event Date	Peak Rainfall Intensity (in/hr) for Storm Time of Concentration (min) of:								Peak Runoff Rates for Sea-Tac Airport Sub-Basins (gpm)												[illegible]	
	5	10	20	40	50	55	60	80	002 SDE-4	003 SDS-1	004 SDS-2	005 SDS-3	006 SDN-1	007 SDN-2	008 SDN-3	009 SDS-4	010 SDW-1	011 SDN-4	012 [illegible]	013 [illegible]	[illegible]	[illegible]
5/30/97			0.20			0.28			23480						3600							
4/19/97					0.14			0.17						2117		2318					4614	
4/13/97	na	na	na	na	na	na	na	na		na			na									
3/5/97	0.02		0.03		0.08	0.08		0.10	3522			8052			1029			452	147	195	2714	1432
2/26/97				0.09	0.12												763					
2/11/97	0.02			0.07			0.10				57						594		147	195		
1/27/97			0.03	0.06	0.08			0.11	3522							1325	509				2986	1575
1/16/97		0.03	0.04	0.07	0.09	0.09	0.10	0.10	4696	941	57	8052	2052	1361	1157	1490	594	508			2714	1432
12/19/96	na	na	na	na	na	na	na	na	na						na							
12/4/96				0.12	0.14	0.14	0.15	0.21		1612	85				1800	2318	1018	790			5700	3007
11/23/96				0.13	0.13	0.13	0.17	0.18		1747	96	14493			1671		1103					2577
10/21/96	0.03				0.15			0.20				16103		2268					220			
10/4/96	0.03	0.06			0.15								2052			2484				293		
9/3/96			0.10		0.17			0.29	11740			23350		2570				960				
8/2/96	0.04			0.18	0.18	0.18		0.25		2419		20129			2314					391		
7/17/96	0.04	0.04	0.06	0.08	0.10			0.16	7044	1075		12883	1368	1512		1656				391		
7/3/96	0.02	0.04		0.06	0.06					806			1368			993			147	195		

Absent values indicate location not sampled for that storm
Rainfall data from Port of Seattle and/or National Weather Service rain gage at Sea-Tac Airport
Peak runoff rates based upon "rational method": Q=CIA. See Appendix A
na means no data available; rain gage failed to record data, or gap exists in rainfall data records.

Table 18 Summary of Subbasin Hydrologic Characteristics

Subbasin	Outfall Number	A_p (acres)	A_i (acres)	Total Area (ac)	C	T_C (min)
SDE-[illegible]	002	22	90	112	0.77	21
SDS	003	0	6	6	.90	TBD
SDS-2	004	5	0	5	.25	60
SDS-3	005	222	202	424	0.56	78
SDN-1	006	0	14	14	.90	10
SDN-2	007	7	29	36	.77	50
SDN-3	008	43	17	60	.43	55
SDS-4	009	32	25	57	0.54	50
SDW-3	010	14	10	24	.52	38
SDN-[illegible]	011	20	6	26	0.40	TBD
Eng Yard	012	0	1.5	1.5	.90	5
Taxi Yard	013	0	2	2	.90	5
Subbasin B	.014	40	0	40	0.25	TBD
Subbasin D	015	35	2	37	0.29	TBD

Appendix B

Summarized Analytical Data for all Storm Events Monitored

[illegible]	[illegible]	[illegible]	purpose	[illegible]	pH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	glycols	Surf
SDE4	SDE4 111394	11-Nov-94	NPDES	NO		2.8	1.1	1100	56	46	7	0.39	5	0.2
SDE4	SDE4 111994	19-Nov-94	NPDES	NO							8		5	
SDE4	SDE4 010795	07-Jan-95	NPDES	NO	7.0	3.6	2.8	45	16	27	26	2.3		0.05
SDE4	SDE4 041095	10-Apr-95	NPDES	NO	6.6	0.22	1.1	260	16	19	8	0.42	5	0.2
SDE4	SDE4 072695	26-Jul-95	NPDES	NO	6.9	5.7	3.8	4000	41	30	29	0.44		1.5
SDE4	SDE4 081795	16-Aug-95	NPDES	NO									7.9	
SDE4	SDE4 102695	25-Oct-95	NPDES	NO	7.1	5.9	0.5	300	14	27	27	0.18		0.1
SDE4	SDE4 020496 GRAB	03-Feb-96	NPDES	YES	7.9	17	8.8	22						
SDE4	SDE4 020396	03-Feb-96	NPDES	YES	7.6				210	190	74	2.5	26	0.1
SDE4	SDE4 032296	22-Mar-96	STIP AG	NO					44	19	12	0.64	5	0.3
SDE4	SDE4 032296 GRAB	22-Mar-96	STIP AG	NO	7.1	2.8	3.9	20						
SDE4	SDE4 041696 GRAB	15-Apr-96	NPDES	NO	6.4	2.8	3.35	17						
SDE4	SDE4 041696	15-Apr-96	NPDES	NO					53	11	6.54	0.128	5	0.123
SDE4	SDE4 051796	17-May-96	SES	NO										
SDE4	SDE4 052296	21-May-96	SES	NO	7.3		2.5		8.8		22			
SDE4	SDE4 071796 GRAB	17-Jul-96	NPDES	NO				220						0.335
SDE4	SDE4 090396	03-Sep-96	NPDES	NO					40	15	7.06	0.182	5	0.15
SDE4	SDE4 090396 GRAB	03-Sep-96	NPDES	NO	7.3	3.1	2.64	1600						
SDE4	SDE4 121996 GRAB	19-Dec-96	NPDES	NO	6.5	3.3	1.97	220						
SDE4	SDE4 122196	19-Dec-96	NPDES	NO					42	24	11.7	0.304	5	0.067
SDE4	SDE4 011697	16-Jan-97	NPDES	NO					140	1.5	12.8	0.053	5	0.135
SDE4	SDE4 011697 GRAB	16-Jan-97	NPDES	NO	7.1	9	10	1600						
SDE4	SDE4 012797	27-Jan-97	STIP AG	NO					49	20	2	0.221	49.4	1.28
SDE4	SDE4 012797 GRAB	27-Jan-97	STIP AG	NO	6.2	0.5	5	50						
SDE4	SDE4 030697	05-Mar-97	NPDES	NO					30	14	4.36	0.082	5	0.318
SDE4	SDE4 030597 GRAB	05-Mar-97	NPDES	NO	6.3	~~103*~~	3.06	1600						
SDE4	SDE4 053097	30-May-97	NPDES	NO		1.1	1.2							
SDS1	SDS1 101994	19-Oct-94	NPDES	NO	5.8	1.1	0.5	10	2.5	11	12	0.13		0.5
SDS1	SDS1 111994	19-Nov-94	NPDES	NO							46		14	
SDS1	SDS1 021695	15-Feb-95	NPDES	YES	6.6	3.4	5.3	4.5	6.7	40	92	0.06	275	0.4
SDS1	SDS1 051195	11-May-95	NPDES	NO	7.4	10	0.5		34	25	2			0.6
SDS1	SDS1 060495	04-Jun-95	NPDES	NO	6.4	5.6	5.4	60	14	36	15	0.29		0.8
SDS1	SDS1 080795	06-Aug-95	NPDES	NO	7.2	3.3	0.5	4	28	8.9	13	0.14		0.9
SDS1	SDS1 101695	15-Oct-95	NPDES	NO	7.1	1.2	0.5	200	8.6	3.6	5	0.17		0.1
SDS1	SDS1 011396 GRAB	13-Jan-96	NPDES	NO	7.1	0.5	1.8	0.5						
SDS1	SDS1 011496	13-Jan-96	NPDES	NO					3.2	4	18	0.012	5	0.3
SDS1	SDS1 041696	15-Apr-96	NPDES	NO					74	16	23.9	0.219	5	0.081
SDS1	SDS1 041696 GRAB	15-Apr-96	NPDES	NO	6.7	2.5	0.32	4						
SDS1	SDS1 042296	22-Apr-96	STIP AG	NO					17	6.3	9.28	0.023	5	0.134
SDS1	SDS1 042296 GRAB	22-Apr-96	STIP AG	NO	7.5	1.9	0.58	23						
SDS1	SDS1 052296	21-May-96	SES	NO	7.3		2.5		7.8		29			
SDS1	SDS1 070396 GRAB	03-Jul-96	NPDES	NO	5.9	0.5	0.35	2*						
SDS1	SDS1 070496	03-Jul-96	NPDES	NO					17	6	11.2	0.014	5	0.427
SDS1	SDS1 071796 GRAB	17-Jul-96	NPDES	NO				1600						~~0.465*~~
SDS1	SDS1 080296	02-Aug-96	STIP AG	NO					15	7.2	12.5	0.005		0.663
SDS1	SDS1 080296 GRAB	02-Aug-96	STIP AG	NO	5.4	0.5	0.42	130						
SDS1	SDS1 120496 GRAB	04-Dec-96	NPDES	NO	6.8	2.4	0.35	1600						
SDS1	SDS1 120496	04-Dec-96	NPDES	NO					22	21	40.5	0.005	29	0.055
SDS1	SDS1 011697	16-Jan-97	NPDES	NO					37	17	79	0.005	33.4	0.06
SDS1	SDS1 011697 GRAB	16-Jan-97	NPDES	NO	6.6	0.5	2.9	350						
SDS1	SDS1 041397 GRAB	13-Apr-97	NPDES	NO	7.1	0.5	2.6	23						
SDS1	SDS1 041397	13-Apr-97	NPDES	NO					49	27	21.2	0.005	5	0.574
SDS2	SDS2 051095	09-May-95	NPDES	NO	7.2	3.4	0.5	440	15	15	11			
SDS2	SDS2 051195	11-May-95	NPDES	NO	7.4	1.4	0.5	780	7.8	6.1	4			
SDS2	SDS2 061095	10-Jun-95	NPDES	NO	7.1	1.8	0.5	1400	18	8.2	8			
SDS2	SDS2 090595	05-Sep-95	NPDES	NO	6.7	2.2	0.5	2600	52	28	5	0.012		
SDS2	SDS2 112396 GRAB	23-Nov-96	NPDES	YES	6.7	0.5	0.125	23						
SDS2	SDS2 120496	04-Dec-96	NPDES	NO					37	29	2			
SDS2	SDS2 120496 GRAB	04-Dec-96	NPDES	NO	6.7	0.5	0.125	8						
SDS2	SDS2 011697 GRAB	16-Jan-97	STIP AG	NO	6.8	0.5	0.125	220						
SDS2	SDS2 011797	16-Jan-97	STIP AG	NO					16	19	2			
SDS2	SDS2 021197 GRAB	11-Feb-97	STIP AG	NO	6.8	4	0.125	11						
SDS2	SDS2 021197	11-Feb-97	STIP AG	NO					32	39	3			
SDS3	SDS3 091494	13-Sep-94	NPDES	NO	7.1	8.3	0.5	20	4.5	5.8	8	0.061		0.3
SDS3	SDS3 101394	13-Oct-94	NPDES	NO		1.4	0.5	1	6.7	12	22	1.2		0.1
SDS3	SDS3 111994	19-Nov-94	NPDES	NO					2.3	4.9	18	0.12	5	0.05
SDS3	SDS3 111994 grab	19-Nov-94	NPDES	NO		0.5	0.5	2						
SDS3	SDS3 010795	07-Jan-95	NPDES	NO	7.2	0.65	0.5	1	2	3.7	5	0.14		0.05
SDS3	SDS3 041295	10-Apr-95	NPDES	NO	7.3	0.55	0.5	1	1	1.9	4	1.7	5	0.05
SDS3	SDS3 072695	26-Jul-95	NPDES	NO	7.7	0.65	0.5	1.5	20	15	8	0.085		0.2
SDS3	SDS3 101695	15-Oct-95	NPDES	NO	7.4	1.4	0.5	1	2.2	3	5	0.12		0.05
SDS3	SDS3 011396 GRAB	13-Jan-96	NPDES	NO	7.4	0.5	0.5	0.5						
SDS3	SDS3 011496	13-Jan-96	NPDES	NO					1.6	2.1	8	0.025	5	0.05
SDS3	SDS3 032296	22-Mar-96	STIP AG	NO					4.1	2.9	8	0.021	5	0.05
SDS3	SDS3 032296 grab	22-Mar-96	STIP AG	NO	7.5	0.5	0.5	13						
SDS3	SDS3 041696	15-Apr-96	NPDES	NO					20	6.6	6.36	0.036	5	0.033
SDS3	SDS3 041696 GRAB	15-Apr-96	NPDES	NO	7.4	1.2	0.31	1						
SDS3	SDS3 052296	21-May-96	SES	NO	8.9		0.5		2.6		14			
SDS3	SDS3 071796 GRAB	17-Jul-96	NPDES	NO				1						
SDS3	SDS3 080296	02-Aug-96	NPDES	NO					19	13	9.8	0.045		0.107
SDS3	SDS3 080296 GRAB	02-Aug-96	NPDES	NO	7.4	0.5	0.3	8						

SDS3	SDS3 090396 GRAB	03-Sep-96	NPDES	NO	7.0	0.5	0.125	1600						
SDS3	SDS3 090396	03-Sep-96	NPDES	NO					33	16	11.4	0.077		0.046
SDS3	SDS3 102196 GRAB	21-Oct-96	NPDES	NO	7.0	0.5	0.125	130						
SDS3	SDS3 102196	21-Oct-96	NPDES	NO					4.8	4.2	2	0.005	5	0.01
SDS3	SDS3 112396 GRAB	23-Nov-96	STIP AG	YES	7.3	0.5	0.125	1						
SDS3	SDS3 112396	23-Nov-96	STIP AG	YES					16	9.2	34.2	0.005	28	0.01
SDS3	SDS3 011697	16-Jan-97	NPDES	NO					5.6	0.7	9.78	0.025	5	0.01
SDS3	SDS3 011697 GRAB	16-Jan-97	NPDES	NO	6.9	3	0.54	30						
SDS3	SDS3 030597 GRAB	05-Mar-97	NPDES	NO	7.2	0.5	0.125	1						
SDS3	SDS3 030597	05-Mar-97	NPDES	NO					3.4	2.5	2	0.015	5	0.04
SDN1	SDN1 091494	13-Sep-94	NPDES	NO	6.6	3.3	0.5	4000	21.5	6.4	194	0.025		1.3
SDN1	SDN1 101994	19-Oct-94	NPDES	NO	6.8	1.8	0.6	180	13	10	8	0.5		0.2
SDN1	SDN1 111994	19-Nov-94	NPDES	NO							6		5	
SDN1	SDN1 011295	11-Jan-95	NPDES	NO	7.4	2.6	5.1	1000	22	30	4	0.37		0.05
SDN1	SDN1 030595	04-Mar-95	STIP AG	NO					1	3.5	4	0.005	5	
SDN1	SDN1 030995	08-Mar-95	STIP AG	NO					14	17	6	0.35	5	
SDN1	SDN1 031595	13-Mar-95	STIP AG	NO					9.6	17	4	0.05	5	
SDN1	SDN1 040595	04-Apr-95	STIP AG	NO					6	7.6	5	0.078	5	
SDN1	SDN1 040795	06-Apr-95	NPDES	NO	7.6	0.6	0.5	58	18	6.2	40	0.005	5	0.05
SDN1	SDN1 080795	06-Aug-95	NPDES	NO	7.8	21	5.6	42	56	16	27	0.011		0.05
SDN1	SDN1 110795	06-Nov-95	NPDES	NO	6.7	16	3.4	25	15	14	8	0.52		0.05
SDN1	SDN1 020496	03-Feb-96	NPDES	YES	7.5				130	150	15	1.7	5	0.1
SDN1	SDN1 020496 GRAB	03-Feb-96	NPDES	YES	7.4	7.3	7.5	100						
SDN1	SDN1 033196 GRAB	31-Mar-96	STIP AG	NO	6.9	8	4.1	340						
SDN1	SDN1 041696	15-Apr-96	STIP AG	NO					47	7.1	2	0.103	5	
SDN1	SDN1 042296 GRAB	22-Apr-96	NPDES	NO	7.3	1	0.25	6						
SDN1	SDN1 042296	22-Apr-96	NPDES	NO					31	9.5	8.8	0.184	5	0.048
SDN1	SDN1 051396	13-May-96	STIP AG	NO					14	15	4.22	0.0267	5	
SDN1	SDN1 052296	21-May-96	STIP AG	NO					11	7.3	10.2	0.164	5	0.657
SDN1	SDN1 062396 A	23-Jun-96	SES	NO	6.3		3		22		16	0.63		
SDN1	SDN1 062396	23-Jun-96	STIP AG	NO					36	8.3	20	0.684	5	0.124
SDN1	SDN1 062396 GRAB	23-Jun-96	STIP AG	NO	5.5	2	0.92	23						
SDN1	SDN1 070396 GRAB	03-Jul-96	NPDES	NO	6.2	2.8	1.8	~~999*~~						
SDN1	SDN1 070496	03-Jul-96	NPDES	NO					51	18	10.7	0.142	5	0.098
SDN1	SDN1 071796	16-Jul-96	STIP AG	NO					19	2.1	25.1	0.859	5	0.2
SDN1	SDN1 071796 grab	17-Jul-96	NPDES	NO				500						~~0.438*~~
SDN1	SDN1up 100496 GRAB	04-Oct-96	NPDES	NO	7.2	0.5	0.5	500						
SDN1	SDN1up 100496	04-Oct-96	NPDES	NO					21	6.7	2	0.122		0.01
SDN1	SDN1up 011697 GRAB	16-Jan-97	NPDES	NO	4.4	0.5	2.1	23						
SDN1	SDN1up 011697	16-Jan-97	NPDES	NO					62	29	9.94	0.227		0.08
SDN1	SDN1 011697 GRAB	16-Jan-97	NPDES	NO	5.2	SAMPL	3.6	161						
SDN1	SDN1 011697	16-Jan-97	NPDES	NO					66	30	23.6	0.387		0.058
SDN1	SDN1 041397 grab	13-Apr-97	NPDES	NO	4.6	0.5	1.08	33						
SDN1	SDN1 041397	13-Apr-97	NPDES	NO					34	19	17	0.109		0.621
SDN2	SDN2 090894	08-Sep-94	NPDES	NO	6.8	1.8	0.6	3	3.2	4.1	11	0.005		0.2
SDN2	SDN2 101394	13-Oct-94	NPDES	NO		1.1	0.5	2	6.5	8.1	86	0.44		0.2
SDN2	SDN2 111394	11-Nov-94	NPDES	NO		0.5	0.5	30	2	5.4	7	0.041		0.05
SDN2	SDN2 111994	19-Nov-94	NPDES	NO							10		5	
SDN2	SDN2 011295	11-Jan-95	NPDES	NO	8.0	2.3	0.5	4	7.5	14	4	1.3		0.05
SDN2	SDN2 030595	04-Mar-95	STIP AG	NO					2.4	2.1	12	0.021	36	
SDN2	SDN2 031595	13-Mar-95	STIP AG	NO					1	2.2	5	1.6	5	
SDN2	SDN2 040795	06-Apr-95	STIP AG	NO					7.2	4.8	15	0.005	5	
SDN2	SDN2 041295	10-Apr-95	NPDES	NO	7.6	4	5.2	1	5.6	4.9	30	5	19	0.05
SDN2	SDN2 080795	06-Aug-95	NPDES	NO	7.0	2.6	0.6	15	8.9	5.1	6	0.091		0.2
SDN2	SDN2 101695	15-Oct-95	NPDES	NO	7.3	1.9	0.6	1	1.25	1.8	5	0.021		0.1
SDN2	SDN2 021796 GRAB	17-Feb-96	NPDES	NO	7.6	0.5	0.5	10						
SDN2	SDN2 021796	17-Feb-96	NPDES	NO					1	2	6	0.005	17.3	0.05
SDN2	SDN2 033196 GRAB	31-Mar-96	STIP AG	NO	6.7	0.5	0.6	16						
SDN2	SDN2 041696	16-Apr-96	STIP AG	NO					15	11	2	0.044	5	
SDN2	SDN2 042296 GRAB	22-Apr-96	NPDES	NO	7.2	0.5	0.125	50						
SDN2	SDN2 042296	22-Apr-96	NPDES	NO					5.3	2.5	6.64	0.005	5	0.01
SDN2	SDN2 051396	13-May-96	STIP AG	NO					5.6	5.3	4.86	0.045	5	
SDN2	SDN2 052296	21-May-96	STIP AG	NO					10	2	5.08	0.043	5	0.266
SDN2	SDN2 062396	23-Jun-96	STIP AG	NO					33	7.5	18.3	0.166	5	0.026
SDN2	SDN2 062396 GRAB	23-Jun-96	STIP AG	NO	6.8	1	0.46	2						
SDN2	SDN2 071796 grab	17-Jul-96	NPDES	NO				4						~~0.147*~~
SDN2	SDN2 090396 GRAB	03-Sep-96	NPDES	NO	7.2	1.6	0.29	900						
SDN2	SDN2 090396	03-Sep-96	NPDES	NO					10	10	12.3	0.034		0.068
SDN2	SDN2 102196 GRAB	21-Oct-96	NPDES	NO	6.5	0.5	0.32	2						
SDN2	SDN2 102196	21-Oct-96	NPDES	NO					4.2	2.9	4.5	0.005	5	0.01
SDN2	SDN2 011697 GRAB	16-Jan-97	NPDES	NO	7.5	4.3	0.39	11						
SDN2	SDN2 011697	16-Jan-97	NPDES	NO					8.8	1.5	120	0.005	50.9	0.038
SDN2	SDN2 041997	19-Apr-97	NPDES	NO					17	8.5	2	0.478	5	0.063
SDN2	SDN2 041997 GRAB	19-Apr-97	NPDES	NO	6.9	0.5	0.87	4						
SDN3	SDN3 090894	08-Sep-94	NPDES	NO	6.4	1.1	0.5	2200	2.1	5.1	5	0.061		0.05
SDN3	SDN3 102694	25-Oct-94	NPDES	NO		2.9	0.5	2	9.2	8	4	0.038		0.05
SDN3	SDN3 111994	19-Nov-94	NPDES	NO							4		5	
SDN3	SDN3 010795	07-Jan-95	NPDES	NO	7.8	0.5	0.5	1	0.62	1.6	2	0.011		0.05
SDN3	SDN3 030595	04-Mar-95	STIP AG	NO					1	2.3	3	0.005	5	
SDN3	SDN3 030995	08-Mar-95	STIP AG	NO					5	12	3	0.016	5	
SDN3	SDN3 031595	13-Mar-95	STIP AG	NO					4	5.9	5	0.018	5	

SDN3	SDN3 040595	04-Apr-95	STIP AG	NO					1	1.8	3	0.25	6	
SDN3	SDN3 060495	04-Jun-95	NPDES	NO	7.0	2.5	0.5	40	15	25	8	0.005		0.05
SDN3	SDN3 071095	09-Jul-95	NPDES	NO	7.0	3.3	0.5	800	21	24	7	0.005		0.1
SDN3	SDN3 110795	06-Nov-95	NPDES	NO	7.2	2.1	0.5	4	15	16	3	0.005		
SDN3	SDN3 011496 GRAB	13-Jan-96	NPDES	NO	7.2	0.5	0.5	1						
SDN3	SDN3 011496	13-Jan-96	NPDES	NO					3.8	4.7	5	0.011	5	0.05
SDN3	SDN3 020496	03-Feb-96	STIP AG	YES						9.7		0.14	5	
SDN3	SDN3 040196	31-Mar-96	STIP AG	NO					11	16	5	0.013	5	0.2
SDN3	SDN3 033196 GRAB	31-Mar-96	STIP AG	NO	6.8	1.4	0.5	1						
SDN3	SDN3 041696 GRAB	15-Apr-96	NPDES	NO	7.6	2	0.125	50						
SDN3	SDN3 041696	15-Apr-96	NPDES	NO					27	22	2	0.04	5	0.01
SDN3	SDN3 042296 GRAB	22-Apr-96	STIP AG	NO	7.1	0.5	0.125	110						
SDN3	SDN3 042296	22-Apr-96	STIP AG	NO					15	9.5	6.56	0.034	5	0.01
SDN3	SDN3 051396	13-May-96	STIP AG	NO					16	18	2	0.075	5	
SDN3	SDN3 052296	22-May-96	STIP AG	NO					16	5.2	2	0.005	5	
SDN3	SDN3 062396 A	23-Jun-96	SES	NO	7.3		0.5		7.3		5	0.014		
SDN3	SDN3 080396	02-Aug-96	NPDES	NO					26	26	2	0.005		0.041
SDN3	SDN3 080396 GRAB	02-Aug-96	NPDES	NO	7.4	0.5	0.3	900						
SDN3	SDN3 112396 GRAB	23-Nov-96	NPDES	YES	7.3	0.5	0.125	14						
SDN3	SDN3 120496	04-Dec-96	NPDES	NO					16	14	2	0.01	5	0.01
SDN3	SDN3 120496 GRAB	04-Dec-96	NPDES	NO	6.5	0.5	0.125	14						
SDN3	SDN3 122196	19-Dec-96	NPDES	NO					2.6	4.5	4	0.021	5	0.01
SDN3	SDN3 122096 GRAB	19-Dec-96	NPDES	NO	6.3	0.5	0.125	7						
SDN3	SDN3 011797	16-Jan-97	NPDES	NO					13	13	4.92	0.132		0.01
SDN3	SDN3 011697 GRAB	16-Jan-97	NPDES	NO	6.7	1.4	0.125	4						
SDN3	SDN3 030597 GRAB	05-Mar-97	NPDES	NO	7.2	~~36*~~	0.125	1						
SDN3	SDN3 030597	05-Mar-97	NPDES	NO					10	10	2	0.005	6.2	0.036
SDN3	SDN3 053097	30-May-97	NPDES	NO		0.5	0.125							
SDS4	SDS4 091494	13-Sep-94	NPDES	NO	7.1	3	0.5	132	2.8	1.3	8	0.233		0.2
SDS4	SDS4 101394	13-Oct-94	NPDES	NO	7.0	1.2	0.5	70	5.7	5.6	16	0.029		0.1
SDS4	SDS4 111994	19-Nov-94	NPDES	NO							5		5	
SDS4	SDS4 011295	11-Jan-95	NPDES	NO	7.8	0.5	0.5	92	3.5	8.4	3	2		0.05
SDS4	SDS4 051295	11-May-95	NPDES	NO	7.5	1.8	0.5	16	7.7	5.3	4			0.05
SDS4	SDS4 080795	06-Aug-95	NPDES	NO	7.6	2.7	0.5	16	4.2	3.7	9	0.018		0.2
SDS4	SDS4 101695	15-Oct-95	NPDES	NO	7.7	1.7	0.5	27.5	6.6	4.2	5	0.049		0.05
SDS4	SDS4 011496 GRAB	13-Jan-96	NPDES	NO	7.4	0.5	0.5	440						
SDS4	SDS4 011496	13-Jan-96	NPDES	NO					20	6	6	0.02	5	0.05
SDS4	SDS4 041696 GRAB	15-Apr-96	NPDES	NO	7.6	2.7	0.125	350						
SDS4	SDS4 041696	15-Apr-96	NPDES	NO					26	14	4.64	0.128	5	0.01
SDS4	SDS4 042296	22-Apr-96	STIP AG	NO					19	8.9	6.44	0.047	5	0.01
SDS4	SDS4 042296 GRAB	22-Apr-96	STIP AG	NO	7.2	0.5	0.125	1600						
SDS4	SDS4 052296	21-May-96	SES	NO	7.9		0.5		4.8		18			
SDS4	SDS4 070496	03-Jul-96	NPDES	NO					20	11	6	0.084	5	0.029
SDS4	SDS4 070396 GRAB	03-Jul-96	NPDES	NO	6.9	0.5	0.76	~~388*~~						
SDS4	SDS4 071796 GRAB	17-Jul-96	NPDES	NO				500						~~0.01*~~
SDS4	SDS4 100396 GRAB	04-Oct-96	NPDES	NO	6.7	0.5	0.125	500		9.5				
SDS4	SDS4 100496	04-Oct-96	NPDES	NO					~~4310*~~	~~2650*~~	6.04	0.027		0.069
SDS4	SDS4 120496 GRAB	04-Dec-96	NPDES	NO	6.8	0.5	0.125	80						
SDS4	SDS4 120496	04-Dec-96	NPDES	NO					11	6.5	2	0.014	5	0.01
SDS4	SDS4 011697 GRAB	16-Jan-97	NPDES	NO	7.4	4	0.26	1600						
SDS4	SDS4 011797	16-Jan-97	NPDES	NO					17	2.2	3.92	0.12		0.01
SDS4	SDS4 012797 GRAB	27-Jan-97	STIP AG	NO	7.5	3	0.125	30						
SDS4	SDS4 012797	27-Jan-97	STIP AG	NO					12	9.1	4.3	0.017		0.01
SDS4	SDS4 041997	19-Apr-97	NPDES	NO					42	12	4.44	0.067	5	0.079
SDS4	SDS4 041997 GRAB	19-Apr-97	NPDES	NO	7.4	0.5	0.5	50						
SDW3	SDW3 051095	09-May-95	NPDES	NO	7.3	0.5	0.5	1700	88	310	15			
SDW3	SDW3 051195	11-May-95	NPDES	NO	7.4	1.1	0.5	73	20	25	4			
SDW3	SDW3 061095	10-Jun-95	NPDES	NO	7.0	0.5	0.5	1000	5.7	2.3	5			
SDW3	SDW3 081795	16-Aug-95	NPDES	NO	7.2	2.9	6.6	30000	56	20	6			
SDW3	SDW3 112396 GRAB	23-Nov-96	NPDES	YES	7.4	0.5	0.26	50						
SDW3	SDW3 120496	04-Dec-96	NPDES	NO					7.2	2.6	2			
SDW3	SDW3 011697 GRAB	16-Jan-97	STIP AG	NO	6.7	0.5		148						
SDW3	SDW3 011697	16-Jan-97	STIP AG	NO					7.1	1	4.18			
SDW3	SDW3 012797	27-Jan-97	STIP AG	NO					3.2	3.2	6.7			
SDW3	SDW3 021197 GRAB	11-Feb-97	STIP AG	NO	6.8	0.5	0.125	17						
SDW3	SDW3 021197	11-Feb-97	STIP AG	NO					2.2	1.9	2			
SDW3	SDW3 022697 GRAB	26-Feb-97	STIP AG	NO	6.1	9.7	0.125	1						
SDN4	SDN4 090396	03-Sep-96	NPDES	NO					8	3	14.1	0.6		0.036
SDN4	SDN4 090396 GRAB	03-Sep-96	NPDES	NO	6.6	1.2	0.125	280						
SDN4	SDN4 120496 GRAB	04-Dec-96	NPDES	NO	6.6	0.5	0.125	1						
SDN4	SDN4 120496	04-Dec-96	NPDES	NO					7	4.5	8.46	0.005	5	0.01
SDN4	SDN4 011697	16-Jan-97	NPDES	NO					11	1.7	12.1	0.192		0.01
SDN4	SDN4 011697 GRAB	16-Jan-97	NPDES	NO	7.3	1.6	0.125	4						
SDN4	SDN4 030597 GRAB	05-Mar-97	NPDES	NO	8.1	0.5	0.125	1						
SDN4	SDN4 030597	05-Mar-97	NPDES	NO					3.8	2.5	2	0.014	5	0.056
EY	EY 091494	13-Sep-94	NPDES	NO	6.9	2.2			24.9					0.3
EY	EY 101394	13-Oct-94	NPDES	NO	7.0	2.1			25					0.2
EY	EY 030995	08-Mar-95	NPDES	NO	6.6	0.5			3.2					0.05
EY	EY 060495	04-Jun-95	NPDES	NO	5.5	6.5			25					0.2
EY	EY 072695	26-Jul-95	NPDES	NO	5.8	4.1			56					0.2
EY	EY 101695	15-Oct-95	NPDES	NO	6.5	0.5			12					0.05

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	pH	[illegible]	[illegible]	Fecals	[illegible]	[illegible]	[illegible]	[illegible]	Glycols	Surf
EY	EY 021796	17-Feb-96	NPDES	NO					24					0.05
EY	EY 021796 GRAB	17-Feb-96	NPDES	NO	7.7	0.5								
EY	EY 042296	22-Apr-96	NPDES	NO					39					0.054
EY	EY 042296 GRAB	22-Apr-96	NPDES	NO	7.2	0.5								
EY	EY 052296	21-May-96	STIP AG	NO					28					0.511
EY	EY 052296 GRAB	21-May-96	STIP AG	NO	6.1	1								
EY	EY 062396	23-Jun-96	STIP AG	NO					262					0.058
EY	EY 062396 GRAB	23-Jun-96	STIP AG	NO	6.2	0.5								
EY	EY 070496	03-Jul-96	NPDES	NO					16					0.079
EY	EY 070396 GRAB	03-Jul-96	NPDES	NO	6.3	0.5								
EY	EY 102196	21-Oct-96	NPDES	NO					12	4.3				0.01
EY	EY 102196 GRAB	21-Oct-96	NPDES	NO	5.8	0.5								
EY	EY 021297	11-Feb-97	NPDES	NO					8.6					
EY	EY 021197 GRAB	11-Feb-97	NPDES	NO	5.6	1.9								
EY	EY 030597	05-Mar-97	NPDES	NO					17					
EY	EY 030597 GRAB	05-Mar-97	NPDES	NO	5.1	0.5								
TY	TY 090894	08-Sep-94	NPDES	NO	7.9	3.9			4					0.3
TY	TY 101994	19-Oct-94	NPDES	NO	6.5	1.3			10					0.4
TY	TY 030495	04-Mar-95	NPDES	NO	6.9	5.7			18				5	0.05
TY	TY 060495	04-Jun-95	NPDES	NO	5.5	7.6			22					0.4
TY	TY 081795	16-Aug-95	NPDES	NO	6.8	2.3			20					0.1
TY	TY 090595	05-Sep-95	NPDES	NO		1.6								
TY	TY 101695-1	15-Oct-95	NPDES	NO	6.7	19			480					0.05
TY	TY 032296 GRAB	22-Mar-96	STIP AG	NO	6.9	3.9								
TY	TY 032296	22-Mar-96	NPDES	NO						12				0.3
TY	TY 041696 GRAB	15-Apr-96	NPDES	NO	6.1	3.7								
TY	TY 041696	15-Apr-96	NPDES	NO					30					0.032
TY	TY 042296	22-Apr-96	NPDES	NO					23					0.041
TY	TY 042296 GRAB	22-Apr-96	NPDES	NO	7.3	2								
TY	TY 070396 GRAB	03-Jul-96	NPDES	NO	6.2	1.4								
TY	TY 070496	03-Jul-96	NPDES	NO					28					0.183
TY	TY 071796 grab	17-Jul-96	STIP AG	NO	5.9	1.9								
TY	TY 071896	17-Jul-96	STIP AG	NO					13					0.475
TY	TY 080296	02-Aug-96	STIP AG	NO					33					0.204
TY	TY 080296 GRAB	02-Aug-96	STIP AG	NO	6.4	1.6								
TY	TY 100496 GRAB	04-Oct-96	NPDES	NO	7.2	1.4	1.34							
TY	TY 100496	04-Oct-96	NPDES	NO					17	4				
TY	TY 021197 GRAB	11-Feb-97	NPDES	NO	5.7	5.1								
TY	TY 021297	11-Feb-97	NPDES	NO					29					
TY	TY 030597 GRAB	05-Mar-97	NPDES	NO	6.0	~~18*~~								
TY	TY 030697	05-Mar-97	NPDES	NO					188					
B	B 041997 GRAB	19-Apr-97	NPDES	NO	6.9	0.5	0.5	30						
B	B 120496	04-Dec-96	NPDES	NO					91	110	2			
B	B 120496 GRAB	04-Dec-96	NPDES	NO	6.5	0.5	0.125	2						
B	B 011797	16-Jan-97	NPDES	NO					37	40	5.66			
B	B 012797 GRAB	27-Jan-97	NPDES	NO	7.1	0.5	0.125	4						
B	B 012897	27-Jan-97	NPDES	NO					23	35	3.28			
B	B 030697	05-Mar-97	NPDES	NO					13	23	2			
D	D 120496 GRAB	04-Dec-96	NPDES	NO	6.8	1.2	0.125	70						
D	D 011797 GRAB	16-Jan-97	NPDES	NO	7.0	3.9	0.47	350						
D	D 012797 GRAB	27-Jan-97	NPDES	NO	7.1	13	0.125	170						
D	D 012897	27-Jan-97	NPDES	NO					38	35	11.3			
D	D 021297	11-Feb-97	NPDES	NO					38	49	3			
D	D 021197 GRAB	11-Feb-97	NPDES	NO	6.5	7.1	0.25	38						
D	D 030597	05-Mar-97	NPDES	NO					34	25	2			
D	D 030597 GRAB	05-Mar-97	NPDES	NO	7.0	0.5	0.125	2						

highlighted <MDL, value = 1/2 MDL
lined-out data not representative

Overall	count	163	160	140	134	180	151	159	127	83	132
	median*	6.9	1.4	0.5	36	15.0	8.9	6.4	0.05	5.0	0.06
	95th	7.8	8	5.2	1600	66	40	40	1.51	33	0.637
	75th	7.3	2.9	0.8	275	28	18	12	0.19	5	0.20
	25th	6.6	0.5	0.3	4.0	6.6	4.3	4.0	0.0	5.0	0.05
	#non-detected	0	57	86	23	6	0	27	22	60	42
	%non-detected	0%	36%	61%	17%	3%	0%	17%	17%	72%	32%
*Geomean for pH and Fecals											
By Subbasin											
SDE4	count	14	13	15	14	14	13	15	13	12	14
	median*	6.9	3.1	2.8	230	41.5	20.0	11.7	0.30	5.0	0.18
	95th	7.7	12.2	9.2	2440	165	104	42.5	2.4	36.5	1.4
	75th	7.3	5.7	3.9	1475	52.0	27.0	24.0	0.44	5.7	0.31
	25th	6.5	2.8	1.6	46.3	19.5	15.0	7.0	0.18	5.0	0.11
	#non-detected	0	2	2	0	0	0	1	0	9	1
	%non-detected	0%	15%	13%	0%	0%	0%	7%	0%	75%	7%

Outfall	[illegible] ID	stormdate	purpose	detect	pH	[illegible]	TPH	Fecals	[illegible]	Turb	BOD5	[illegible]	total glycols	surf
			SDS1	count	15	14	15	13	15	14	16	13	9	14
				median*	6.7	1.6	0.5	37	17.0	13.5	16.5	0.02	5.0	0.41
				95th	7.4	7.1	5.3	1600	56.5	37.4	82.3	0.25	178.4	0.84
				75th	7.2	3.1	2.6	200	31.0	24.0	31.9	0.14	29.0	0.59
				25th	6.5	0.5	0.5	5	8.2	6.5	11.8	0.01	5.0	0.11
				#non-detected	0	5	5	2	0	0	0	4	5	0
				%non-detected	0%	36%	33%	15%	0%	0%	0%	31%	56%	0%
			SDS2	count	8	8	8	8	7	7	7	1		
				median*	6.9	1.6	0.3	165	18	19	4.0			
				95th	7.3	3.8	0.5	2180	48	36	10.1			
				75th	7.1	2.5	0.5	935	35	29	6.5			
				25th	6.7	0.5	0.1	20	16	12	2.5			
				#non-detected	0	3	8	0	0	0	3			
				%non-detected	0%	38%	100%	0%	0%	0%	43%			
			SDS3	count	15	16	17	17	17	16	17	16	9	16
				median*	7.4	0.5	0.5	4	4.5	4.6	8.0	0.05	5.0	0.05
				95th	8.1	4.3	0.5	424	22.6	15.3	24.4	1.33	18.8	0.23
				75th	7.4	1.3	0.5	13	16.0	9.9	11.4	0.12	5.0	0.06
				25th	7.2	0.5	0.3	1	2.3	2.8	5.0	0.02	5.0	0.04
				#non-detected	0	11	14	10	0	0	2	2	8	9
				%non-detected	0%	69%	82%	59%	0%	0%	12%	13%	89%	56%
			SDS4	count	16	15	16	15	15	15	17	14	7	15
				median*	7.3	1.2	0.5	133	11	6.5	5.0	0.05	5.0	0.05
				95th	7.8	3.3	0.6	1600	31	13	16.4	0.85	5.0	0.20
				75th	7.6	2.7	0.5	470	20	9.3	6.4	0.11	5.0	0.07
				25th	7.1	0.5	0.1	40	5.3	4.8	4.3	0.02	5.0	0.01
				#non-detected	0	7	14	1	0	0	1	0	7	10
				%non-detected	0%	47%	88%	7%	0%	0%	6%	0%	100%	67%
			SDW3	count	8	8	7	8	8	8	8			
				median*	7.0	0.6	0.5	162	7.2	2.9	4.6			
				95th	7.4	7.3	4.8	20095	76.8	210	12.1			
				75th	7.3	1.6	0.5	1175	29.0	21.3	6.2			
				25th	6.7	0.5	0.2	41.8	5.1	2.2	3.5			
				#non-detected	0	5	5	1	0	0	2			
				%non-detected	0%	63%	71%	13%	0%	0%	25%			
			B	count	3	3	3	3	4	4	4	0	0	0
				median*	6.8	0.5	0.1	6	30.0	37.5	2.6			
				95th	7.1	0.5	0.5	27	82.9	99.5	5.3			
				75th	7.0	0.5	0.3	17	50.5	57.5	3.9			
				25th	6.7	0.5	0.1	3	20.5	32.0	2.0			
				#non-detected	0	3	3	0	0	0	3			
				%non-detected	0%	[redacted]	100%	0%	0%	0%	75%			
			D	count	5	5	5	5	3	3	3	0	0	0
				median*	6.9	3.9	0.1	50	38.0	35.0	3.0			
				95th	7.1	11.8	0.4	314	38.0	47.6	10.5			
				75th	7.0	7.1	0.3	170	38.0	42.0	7.2			
				25th	6.8	1.2	0.1	38	36.0	30.0	2.5			
				#non-detected	0	2	4	0	0	0	4			
				%non-detected	0%	40%	80%	0%	0%	0%	133%			
			SDN1**	count	17	14	16	15	23	22	24	23	14	16
				median*	6.5	2.3	2.0	113	21.5	12.0	9.4	0.16	5.0	0.09
				95th	7.6	17.8	6.1	1900	65.6	30.0	38.1	0.84	5.0	0.82
				75th	7.4	6.3	3.7	420	41.5	17.8	17.8	0.44	5.0	0.20
				25th	6.2	0.7	0.5	29	14.0	7.2	4.8	0.06	5.0	0.05
				#non-detected	0	4	3		1	0	2	2	14	5
				%non-detected	0%	29%	19%	0%	4%	0%	8%	9%	100%	31%
			**includes SDN1 up samples											

[illegible]	[illegible]	[illegible]	purpose	ground deicer?	pH	TOG	[illegible]	fecals	[illegible]	[illegible]	BOD	NH3	total glycols	surf
			SDN2	count	13	15	15	16	20	20	21	20	14	15
				median*	7.1	1.1	0.5	7.2	6.1	4.9	6.6	0.04	5.0	0.05
				95th	7.8	4.1	2.2	262.5	17.8	11.2	86.0	1.77	41.2	0.22
				75th	7.5	2.1	0.5	15.3	9.2	7.7	12.3	0.23	14.2	0.15
				25th	6.8	0.5	0.4	2.0	3.0	2.2	5.0	0.01	5.0	0.04
				#non-detected	0	6	9	2	2	0	2	6	10	6
				%non-detected	0%	40%	60%	13%	10%	0%	10%	30%	71%	40%
			SDN3	count	16	16	18	16	22	22	23	23	15	14
				median*	7.0	0.8	0.4	15.8	10.5	9.9	4.0	0.01	5.0	0.05
				95th	7.7	3.0	0.5	1225	25.8	25.0	7.0	0.14	5.4	0.1
				75th	7.3	2.0	0.5	65	15.8	16.0	5.0	0.04	5.0	0.1
				25th	6.8	0.5	0.1	1.8	3.9	5.1	2.0	0.01	5.0	0.0
				#non-detected	0	9	17	5	3	0	7	7	14	10
				%non-detected	0%	56%	94%	31%	14%	0%	30%	30%	93%	71%
			SDN4	count	4	4	4	4	4	4	4	4	2	4
				median*	7.1	0.9	0.1	5.8	7.5	2.8	10.3	0.10	5.0	0.02
				95th	8.0	1.5	0.1	238.6	10.6	4.3	13.8	0.54	5.0	0.05
				75th	7.5	1.3	0.1	73.0	8.8	3.4	12.6	0.29	5.0	0.04
				25th	6.6	0.5	0.1	1.0	6.2	2.3	6.8	0.01	5.0	0.01
				#non-detected	0	2	4	2	0	0	1	1	2	2
				%non-detected	0%	50%	100%	50%	0%	0%	25%	25%	100%	50%

Outfall	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tl	Zn
SDE4	SDE4 111394	11-Nov-94	NPDES	NO	0.001	0.001	0.0005	0.001	0.0025	0.021	0.008	0.00005	0.005	0.0005	0.0015	0.0005	0.195
SDE4	SDE4 111994	19-Nov-94	NPDES	NO													
SDE4	SDE4 010795	07-Jan-95	NPDES	NO	0.001	0.003	0.0005	0.001	0.005	0.031	0.014	0.00005	0.005	0.0005	0.0015	0.0005	0.337
SDE4	SDE4 041095	10-Apr-95	NPDES	NO	0.001	0.001	0.0005	0.002	0.0025	0.029	0.011	0.00005	0.005	0.0005	0.0015	0.0005	0.263
SDE4	SDE4 072695	26-Jul-95	NPDES	NO	0.008	0.004	0.0005	0.001	0.006	0.121	0.023	0.00005	0.005	0.0005	0.0015	0.0005	0.779
SDE4	SDE4 081795	16-Aug-95	NPDES	NO													
SDE4	SDE4 102695	25-Oct-95	NPDES	NO	0.001	0.002	0.0005	0.001	0.0025	0.033	0.021	0.00005	0.005	0.001	0.0015	0.001	0.204
SDE4	SDE4 020496 GRAB	03-Feb-96	NPDES	YES													
SDE4	SDE4 020396	03-Feb-96	NPDES	YES	0.001	0.003	0.0005	0.001	0.03	0.054	0.104	0.00005	0.02	0.0005	0.0015	0.0005	0.279
SDE4	SDE4 032296	22-Mar-96	STIP AG	NO	0.002	0.003	0.0005	0.001	0.007	0.057	0.026	0.00005	0.005	0.0005	0.0015	0.0005	0.361
SDE4	SDE4 032296 GRAB	22-Mar-96	STIP AG	NO													
SDE4	SDE4 041696 GRAB	15-Apr-96	NPDES	NO													
SDE4	SDE4 041696	15-Apr-96	NPDES	NO	0.0015	0.0015	0.001	0.002	0.015	0.078	0.0977	0.00005	0.014	0.0015	0.005	0.0005	0.32
SDE4	SDE4 051796	17-May-96	SES	NO				0.0005		0.027	0.011		0.002		0.00015		0.11
SDE4	SDE4 052296	21-May-96	SES	NO				0.0007		0.045	0.018		0.004		0.00015		0.243
SDE4	SDE4 071796 GRAB	17-Jul-96	NPDES	NO													
SDE4	SDE4 090396	03-Sep-96	NPDES	NO	0.0015	0.0031	0.001	0.001	0.005	0.053	0.0252	0.00011	0.0025	0.0015	0.005	0.0005	0.138
SDE4	SDE4 090396 GRAB	03-Sep-96	NPDES	NO													
SDE4	SDE4 121996 GRAB	19-Dec-96	NPDES	NO													
SDE4	SDE4 122196	19-Dec-96	NPDES	NO	0.0015	0.0015	0.001	0.00127	0.005	0.0304	0.0289	0.00005	0.01	0.0015	0.0005	0.0005	0.171
SDE4	SDE4 011697	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00072	0.005	0.0424	0.0756	0.00005	0.013	0.0015	0.0005	0.0005	0.19
SDE4	SDE4 011697 GRAB	16-Jan-97	NPDES	NO													
SDE4	SDE4 012797	27-Jan-97	STIP AG	NO	0.0015	0.0015	0.001	0.00025	0.012	0.0307	0.0486	0.00005	0.011	0.0015	0.0005	0.0005	0.148
SDE4	SDE4 012797 GRAB	27-Jan-97	STIP AG	NO													
SDE4	SDE4 030697	05-Mar-97	NPDES	NO	0.0015	0.0015	0.001	0.00057	0.005	0.0232	0.0232	0.00005	0.018	0.0015	0.0005	0.0005	0.098
SDE4	SDE4 030597 GRAB	05-Mar-97	NPDES	NO													
SDE4	SDE4 053097	30-May-97	NPDES	NO													
SDS1	SDS1 101994	19-Oct-94	NPDES	NO	0.003	0.001	0.0005	0.001	0.007	0.084	0.006	0.00005	0.005	0.002	0.0015	0.0005	0.234
SDS1	SDS1 111994	19-Nov-94	NPDES	NO													
SDS1	SDS1 021695	15-Feb-95	NPDES	YES	0.0005	0.0005	0.0005	0.001	0.0025	0.016	0.006	0.00005	0.005	0.0005	0.0015	0.0005	0.125
SDS1	SDS1 051195	11-May-95	NPDES	NO	0.002	0.004	0.0005	0.013	0.017	0.119	0.045	0.00005	0.005	0.0005	0.0015	0.0005	0.304
SDS1	SDS1 060495	04-Jun-95	NPDES	NO	0.002	0.002	0.002	0.011	0.014	0.115	0.017	0.00005	0.01	0.0005	0.024	0.0005	0.29
SDS1	SDS1 080795	06-Aug-95	NPDES	NO	0.002	0.003	0.0005	0.002	0.007	0.089	0.019	0.00005	0.005	0.0005	0.0015	0.0005	0.211
SDS1	SDS1 101695	15-Oct-95	NPDES	NO	0.001	0.001	0.0005	0.001	0.0025	0.042	0.005	0.00005	0.005	0.0005	0.0015	0.0005	0.116
SDS1	SDS1 011396 GRAB	13-Jan-96	NPDES	NO													
SDS1	SDS1 011496	13-Jan-96	NPDES	NO	0.0005	0.001	0.0005	0.001	0.0025	0.019	0.006	0.00005	0.005	0.0005	0.0015	0.0005	0.104
SDS1	SDS1 041696	15-Apr-96	NPDES	NO	0.0015	0.0015	0.001	0.004	0.016	0.117	0.0883	0.00005	0.014	0.0015	0.005	0.0005	0.255
SDS1	SDS1 041696 GRAB	15-Apr-96	NPDES	NO													
SDS1	SDS1 042296	22-Apr-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.012	0.0077	0.00005	0.0025	0.0015	0.005	0.0005	0.062
SDS1	SDS1 042296 GRAB	22-Apr-96	STIP AG	NO													
SDS1	SDS1 052296	21-May-96	SES	NO				0.0011		0.035	0.0103		0.0032		0.00015		0.106
SDS1	SDS1 070396 GRAB	03-Jul-96	NPDES	NO													
SDS1	SDS1 070496	03-Jul-96	NPDES	NO	0.0015	0.0048	0.001	0.001	0.005	0.038	0.0127	0.00005	0.0025	0.0015	0.005	0.0005	0.188
SDS1	SDS1 071796 GRAB	17-Jul-96	NPDES	NO													
SDS1	SDS1 080296	02-Aug-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.102	0.015	0.00005	0.0025	0.0015	0.005	0.0005	0.209
SDS1	SDS1 080296 GRAB	02-Aug-96	STIP AG	NO													
SDS1	SDS1 120496 GRAB	04-Dec-96	NPDES	NO													
SDS1	SDS1 120496	04-Dec-96	NPDES	NO	0.0015	0.0015	0.001	0.00074	0.005	0.0276	0.0013	0.00014	0.008	0.0015	0.0005	0.0005	0.096
SDS1	SDS1 011697	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00089	0.005	0.0414	0.0273	0.00005	0.0025	0.0015	0.0005	0.0005	0.112
SDS1	SDS1 011697 GRAB	16-Jan-97	NPDES	NO													
SDS1	SDS1 041397 GRAB	13-Apr-97	NPDES	NO													
SDS1	SDS1 041397	13-Apr-97	NPDES	NO	0.0015	0.0038	0.001	0.00214	0.005	0.0706	0.0408	0.00012	0.025*	0.0015	0.0005	0.0005	0.253
SDS2	SDS2 051095	09-May-95	NPDES	NO													
SDS2	SDS2 051195	11-May-95	NPDES	NO													
SDS2	SDS2 061095	10-Jun-95	NPDES	NO													
SDS2	SDS2 090595	05-Sep-95	NPDES	NO													
SDS2	SDS2 112396 GRAB	23-Nov-96	NPDES	YES													
SDS2	SDS2 120496	04-Dec-96	NPDES	NO													
SDS2	SDS2 120496 GRAB	04-Dec-96	NPDES	NO													
SDS2	SDS2 011697 GRAB	16-Jan-97	STIP AG	NO													
SDS2	SDS2 011797	16-Jan-97	STIP AG	NO													
SDS2	SDS2 021197 GRAB	11-Feb-97	STIP AG	NO													
SDS2	SDS2 021197	11-Feb-97	STIP AG	NO													
SDS3	SDS3 091494	13-Sep-94	NPDES	NO	0.002	0.004	0.0005	0.001	0.0025	0.041	0.004	0.00005	0.005	0.002	0.0015	0.0005	0.031
SDS3	SDS3 101394	13-Oct-94	NPDES	NO	0.0005	0.003	0.0005	0.001	0.006	0.053	0.003	0.00005	0.005	0.001	0.0015	0.0005	0.076
SDS3	SDS3 111994	19-Nov-94	NPDES	NO	0.0005	0.001	0.0005	0.001	0.0025	0.027	0.004	0.00005	0.005	0.0005	0.0015	0.002	0.108
SDS3	SDS3 111994 grab	19-Nov-94	NPDES	NO													
SDS3	SDS3 010795	07-Jan-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.005	0.016	0.002	0.00005	0.005	0.0005	0.0015	0.0005	0.058
SDS3	SDS3 041295	10-Apr-95	NPDES	NO	0.001	0.001	0.0005	0.001	0.0025	0.041	0.002	0.00005	0.005	0.0005	0.0015	0.0005	0.044
SDS3	SDS3 072695	26-Jul-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.087	0.005	0.00005	0.005	0.0005	0.0015	0.001	0.069
SDS3	SDS3 101695	15-Oct-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.032	0.002	0.00005	0.005	0.0005	0.0015	0.0005	0.037
SDS3	SDS3 011396 GRAB	13-Jan-96	NPDES	NO													
SDS3	SDS3 011496	13-Jan-96	NPDES	NO	0.0005	0.001	0.0005	0.001	0.0025	0.029	0.002	0.00005	0.005	0.0005	0.0015	0.001	0.054
SDS3	SDS3 032296	22-Mar-96	STIP AG	NO	0.001	0.002	0.0005	0.001	0.0025	0.028	0.002	0.00005	0.005	0.0005	0.0015	0.0005	0.054
SDS3	SDS3 032296 grab	22-Mar-96	STIP AG	NO													
SDS3	SDS3 041696	15-Apr-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.046	0.0116	0.00005	0.014	0.0015	0.005	0.0005	0.074
SDS3	SDS3 041696 GRAB	15-Apr-96	NPDES	NO													
SDS3	SDS3 052296	21-May-96	SES	NO				0.0003		0.035	0.0011		0.002		0.00015		0.036
SDS3	SDS3 071796 GRAB	17-Jul-96	NPDES	NO													
SDS3	SDS3 080296	02-Aug-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.115	0.0091	0.00005	0.007	0.0015	0.005	0.0005	0.097
SDS3	SDS3 080296 GRAB	02-Aug-96	NPDES	NO													

[illegible]	[illegible]	[illegible]	purpose	[illegible]	pH	TOC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NH3	[illegible]	[illegible]

Outfall	[illegible]	[illegible]	purpose	[illegible]	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
SDS3	SDS3 090396 GRAB	03-Sep-96	NPDES	NO													
SDS3	SDS3 090396	03-Sep-96	NPDES	NO	0.0015	0.0032	0.006	0.008	0.011	0.08	0.0158	0.00016	0.0025	0.0015	0.005	0.0005	0.062
SDS3	SDS3 102196 GRAB	21-Oct-96	NPDES	NO													
SDS3	SDS3 102196	21-Oct-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.025	0.0033	0.00005	0.005	0.0015	0.005	0.0005	0.022
SDS3	SDS3 112396 GRAB	23-Nov-96	STIP AG	YES													
SDS3	SDS3 112396	23-Nov-96	STIP AG	YES	0.0015	0.0015	0.001	0.00025	0.005	0.388	0.0141	0.00042	0.025	0.0015	0.0005	0.0005	0.061
SDS3	SDS3 011697	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00084	0.005	0.0291	0.0018	0.00005	0.005	0.0015	0.0005	0.0005	0.042
SDS3	SDS3 011697 GRAB	16-Jan-97	NPDES	NO													
SDS3	SDS3 030597 GRAB	05-Mar-97	NPDES	NO													
SDS3	SDS3 030597	05-Mar-97	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.018	0.0018	0.00005	0.0025	0.0015	0.0005	0.0005	0.037
SDN1	SDN1 091494	13-Sep-94	NPDES	NO	0.002	0.001	0.0005	0.001	0.008	0.064	0.008	0.00005	0.01	0.001	0.0015	0.0005	1.03
SDN1	SDN1 101994	19-Oct-94	NPDES	NO	0.001	0.0005	0.0005	0.001	0.0025	0.034	0.008	0.00005	0.005	0.002	0.0015	0.0005	0.416
SDN1	SDN1 111994	19-Nov-94	NPDES	NO													
SDN1	SDN1 011295	11-Jan-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.006	0.02	0.016	0.00005	0.005	0.005	0.0015	0.001	0.285
SDN1	SDN1 030595	04-Mar-95	STIP AG	NO													
SDN1	SDN1 030995	08-Mar-95	STIP AG	NO													
SDN1	SDN1 031595	13-Mar-95	STIP AG	NO													
SDN1	SDN1 040595	04-Apr-95	STIP AG	NO													
SDN1	SDN1 040795	06-Apr-95	NPDES	NO	0.0005	0.0005	0.0005	0.001	0.0025	0.009	0.001	0.00005	0.005	0.001	0.0015	0.0005	0.286
SDN1	SDN1 080795	06-Aug-95	NPDES	NO	0.002	0.002	0.0005	0.001	0.0025	0.035	0.009	0.0002	0.005	0.001	0.0015	0.0005	0.464
SDN1	SDN1 110795	06-Nov-95	NPDES	NO	0.0005	0.0005	0.0005	0.0007	0.0025	0.023	0.013	0.00005	0.005	0.0005	0.0001	0.0005	0.375
SDN1	SDN1 020496	03-Feb-96	NPDES	YES	0.0005	0.001	0.0005	0.001	0.005	0.019	0.021	0.00005	0.005	0.001	0.0015	0.0005	0.288
SDN1	SDN1 020496 GRAB	03-Feb-96	NPDES	YES													
SDN1	SDN1 033196 GRAB	31-Mar-96	STIP AG	NO													
SDN1	SDN1 041696	15-Apr-96	STIP AG	NO													
SDN1	SDN1 042296 GRAB	22-Apr-96	NPDES	NO													
SDN1	SDN1 042296	22-Apr-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.016	0.0111	0.00005	0.006	0.0015	0.005	0.0011	0.16
SDN1	SDN1 051396	13-May-96	STIP AG	NO													
SDN1	SDN1 052296	21-May-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.027	0.0074	0.00005	0.0025	0.0015	0.005	0.0005	0.299
SDN1	SDN1 062396 A	23-Jun-96	SES	NO				0.0001		0.081	0.0104		0.006		0.00015		0.506
SDN1	SDN1 062396	23-Jun-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.08	0.013	0.00005	0.0025	0.0015	0.005	0.0005	0.569
SDN1	SDN1 062396 GRAB	23-Jun-96	STIP AG	NO													
SDN1	SDN1 070396 GRAB	03-Jul-96	NPDES	NO													
SDN1	SDN1 070496	03-Jul-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.046	0.0193	0.00005	0.009	0.0015	0.005	0.0005	0.355
SDN1	SDN1 071796	16-Jul-96	STIP AG	NO													
SDN1	SDN1 071796 grab	17-Jul-96	NPDES	NO													
SDN1	SDN1up 100496 GRAB	04-Oct-96	NPDES	NO													
SDN1	SDN1up 100496	04-Oct-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.025	0.0156	0.00013	0.013	0.0015	0.005	0.0005	0.219
SDN1	SDN1up 011697 GRAB	16-Jan-97	NPDES	NO													
SDN1	SDN1up 011697	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00062	0.011	0.0302	0.0396	0.00005	0.0025	0.0015	0.0005	0.0005	0.391
SDN1	SDN1 011697 GRAB	16-Jan-97	NPDES	NO													
SDN1	SDN1 011697	16-Jan-97	NPDES	NO						0.0391	0.0387						0.343
SDN1	SDN1 041397 grab	13-Apr-97	NPDES	NO													
SDN1	SDN1 041397	13-Apr-97	NPDES	NO	0.0015	0.0015	0.001	0.00066	0.005	0.0415	0.0128	0.00025	0.01	0.0015	0.0005	0.0005	0.433
SDN2	SDN2 090894	08-Sep-94	NPDES	NO	0.0005	0.003	0.0005	0.001	0.0025	0.028	0.007	0.00005	0.005	0.001	0.0015	0.0005	0.022
SDN2	SDN2 101394	13-Oct-94	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.059	0.005	0.00005	0.005	0.002	0.0015	0.0005	0.067
SDN2	SDN2 111394	11-Nov-94	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.013	0.004	0.00005	0.005	0.0005	0.0015	0.0005	0.03
SDN2	SDN2 111994	19-Nov-94	NPDES	NO													
SDN2	SDN2 011295	11-Jan-95	NPDES	NO	0.0005	0.003	0.0005	0.001	0.007	0.035	0.022	0.00005	0.005	0.0005	0.0015	0.0005	0.076
SDN2	SDN2 030595	04-Mar-95	STIP AG	NO													
SDN2	SDN2 031595	13-Mar-95	STIP AG	NO													
SDN2	SDN2 040795	06-Apr-95	STIP AG	NO													
SDN2	SDN2 041295	10-Apr-95	NPDES	NO	0.002	0.002	0.0005	0.001	0.0025	0.025	0.003	0.00005	0.005	0.0005	0.0015	0.0005	0.098
SDN2	SDN2 080795	06-Aug-95	NPDES	NO	0.001	0.004	0.0005	0.001	0.0025	0.028	0.01	0.0021	0.005	0.001	0.0015	0.0005	0.049
SDN2	SDN2 101695	15-Oct-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.016	0.002	0.00005	0.005	0.0005	0.0015	0.0005	0.024
SDN2	SDN2 021796 GRAB	17-Feb-96	NPDES	NO													
SDN2	SDN2 021796	17-Feb-96	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.009	0.005	0.00005	0.005	0.0005	0.0015	0.0005	0.027
SDN2	SDN2 033196 GRAB	31-Mar-96	STIP AG	NO													
SDN2	SDN2 041696	16-Apr-96	STIP AG	NO													
SDN2	SDN2 042296 GRAB	22-Apr-96	NPDES	NO													
SDN2	SDN2 042296	22-Apr-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.013	0.0028	0.00005	0.0025	0.0015	0.005	0.0005	0.017
SDN2	SDN2 051396	13-May-96	STIP AG	NO													
SDN2	SDN2 052296	21-May-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.014	0.0016	0.00005	0.0025	0.0015	0.005	0.0005	0.076
SDN2	SDN2 062396	23-Jun-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.055	0.0117	0.00005	0.0025	0.0015	0.005	0.0005	0.076
SDN2	SDN2 062396 GRAB	23-Jun-96	STIP AG	NO													
SDN2	SDN2 071796 grab	17-Jul-96	NPDES	NO													
SDN2	SDN2 090396 GRAB	03-Sep-96	NPDES	NO													
SDN2	SDN2 090396	03-Sep-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.033	0.0062	0.00005	0.0025	0.0015	0.005	0.0005	0.042
SDN2	SDN2 102196 GRAB	21-Oct-96	NPDES	NO													
SDN2	SDN2 102196	21-Oct-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.01	0.0024	0.00005	0.0025	0.0015	0.005	0.0005	0.02
SDN2	SDN2 011697 GRAB	16-Jan-97	NPDES	NO													
SDN2	SDN2 011697	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.0007	0.005	0.0182	0.011	0.00005	0.0025	0.0015	0.0005	0.0005	0.048
SDN2	SDN2 041997	19-Apr-97	NPDES	NO	0.0015	0.0015	0.001	0.00087	0.005	0.0424	0.0191	0.0001	0.02	0.0015	0.0005	0.0005	0.083
SDN2	SDN2 041997 GRAB	19-Apr-97	NPDES	NO													
SDN3	SDN3 090894	08-Sep-94	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.032	0.002	0.00005	0.005	0.002	0.0015	0.0005	0.063
SDN3	SDN3 102694	25-Oct-94	NPDES	NO													
SDN3	SDN3 111994	19-Nov-94	NPDES	NO													
SDN3	SDN3 010795	07-Jan-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.005	0.003	0.001	0.00005	0.005	0.0005	0.0015	0.0005	0.052
SDN3	SDN3 030595	04-Mar-95	STIP AG	NO													
SDN3	SDN3 030995	08-Mar-95	STIP AG	NO													
SDN3	SDN3 031595	13-Mar-95	STIP AG	NO													

Outfall	[illegible]	Stormdate	Purpose	[illegible]	[illegible]	As	Be	Cd	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Ag	[illegible]	Zn
SDN3	SDN3 040595	04-Apr-95	STIP AG	NO													
SDN3	SDN3 060495	04-Jun-95	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.011	0.001	0.00005	0.005	0.0005	0.0015	0.0005	0.126
SDN3	SDN3 071095	09-Jul-95	NPDES	NO	0.0005	0.005	0.0005	0.001	0.0025	0.036	0.004	0.00005	0.01	0.0005	0.0015	0.0005	0.18
SDN3	SDN3 110795	06-Nov-95	NPDES	NO	0.0005	0.002	0.0005	0.0001	0.0025	0.01	0.001	0.00005	0.005	0.0005	0.0001	0.0005	0.068
SDN3	SDN3 011496 GRAB	13-Jan-96	NPDES	NO													
SDN3	SDN3 011496	13-Jan-96	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.01	0.002	0.00005	0.005	0.0005	0.0015	0.002	0.047
SDN3	SDN3 020496	03-Feb-96	STIP AG	YES													
SDN3	SDN3 040196	31-Mar-96	STIP AG	NO	0.0005	0.002	0.0005	0.001	0.0025	0.015	0.002	0.00005	0.005	0.0005	0.0015	0.0005	0.101
SDN3	SDN3 033196 GRAB	31-Mar-96	STIP AG	NO													
SDN3	SDN3 041696 GRAB	15-Apr-96	NPDES	NO													
SDN3	SDN3 041696	15-Apr-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.018	0.0034	0.00005	0.006	0.0015	0.005	0.0005	0.121
SDN3	SDN3 042296 GRAB	22-Apr-96	STIP AG	NO													
SDN3	SDN3 042296	22-Apr-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.016	0.0013	0.00005	0.006	0.0015	0.005	0.0012	0.063
SDN3	SDN3 051396	13-May-96	STIP AG	NO													
SDN3	SDN3 052296	22-May-96	STIP AG	NO													
SDN3	SDN3 062396 A	23-Jun-96	SES	NO				0.0001		0.0042	0.00025		0.003		0.00015		0.051
SDN3	SDN3 080396	02-Aug-96	NPDES	NO	0.0015	0.0034	0.001	0.001	0.005	0.037	0.0043	0.00005	0.0025	0.0015	0.005	0.0005	0.156
SDN3	SDN3 080396 GRAB	02-Aug-96	NPDES	NO													
SDN3	SDN3 112396 GRAB	23-Nov-96	NPDES	YES													
SDN3	SDN3 120496	04-Dec-96	NPDES	NO	0.0015	0.0031	0.001	0.00025	0.005	0.0179	0.0021	0.00017	0.01	0.0015	0.0005	0.0005	0.033
SDN3	SDN3 120496 GRAB	04-Dec-96	NPDES	NO													
SDN3	SDN3 122196	19-Dec-96	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0111	0.0005	0.00005	0.015	0.0015	0.0005	0.0005	0.045
SDN3	SDN3 122096 GRAB	19-Dec-96	NPDES	NO													
SDN3	SDN3 011797	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0119	0.0005	0.00005	0.006	0.0015	0.0005	0.0005	0.043
SDN3	SDN3 011697 GRAB	16-Jan-97	NPDES	NO													
SDN3	SDN3 030597 GRAB	05-Mar-97	NPDES	NO													
SDN3	SDN3 030597	05-Mar-97	NPDES	NO	0.003	0.0015	0.001	0.00025	0.005	0.0105	0.0005	0.00005	0.019	0.0015	0.0005	0.0005	0.032
SDN3	SDN3 053097	30-May-97	NPDES	NO													
SDS4	SDS4 091494	13-Sep-94	NPDES	NO	0.002	0.002	0.0005	0.001	0.005	0.02	0.004	0.00005	0.005	0.002	0.0015	0.0005	0.009
SDS4	SDS4 101394	13-Oct-94	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.036	0.001	0.00005	0.005	0.002	0.0015	0.0005	0.047
SDS4	SDS4 111994	19-Nov-94	NPDES	NO													
SDS4	SDS4 011295	11-Jan-95	NPDES	NO	0.0005	0.003	0.0005	0.001	0.0025	0.017	0.003	0.00005	0.005	0.0005	0.0015	0.001	0.019
SDS4	SDS4 051295	11-May-95	NPDES	NO	0.0005	0.001	0.0005	0.001	0.0025	0.008	0.0005	0.00005	0.005	0.0005	0.0015	0.0005	0.01
SDS4	SDS4 080795	06-Aug-95	NPDES	NO	0.001	0.002	0.0005	0.001	0.0025	0.02	0.002	0.00005	0.005	0.001	0.0015	0.0005	0.016
SDS4	SDS4 101695	15-Oct-95	NPDES	NO	0.0005	0.001	0.0005	0.001	0.0025	0.023	0.001	0.00005	0.005	0.0005	0.0015	0.0005	0.022
SDS4	SDS4 011496 GRAB	13-Jan-96	NPDES	NO													
SDS4	SDS4 011496	13-Jan-96	NPDES	NO	0.0005	0.002	0.0005	0.001	0.0025	0.018	0.0005	0.00005	0.005	0.0005	0.0015	0.001	0.019
SDS4	SDS4 041696 GRAB	15-Apr-96	NPDES	NO													
SDS4	SDS4 041696	15-Apr-96	NPDES	NO	0.0111	0.0015	0.001	0.001	0.005	0.041	0.0054	0.00005	0.009	0.0015	0.005	0.0005	0.031
SDS4	SDS4 042296	22-Apr-96	STIP AG	NO	0.0015	0.0015	0.001	0.001	0.005	0.033	0.0005	0.00005	0.005	0.0015	0.005	0.0013	0.017
SDS4	SDS4 042296 GRAB	22-Apr-96	STIP AG	NO													
SDS4	SDS4 052296	21-May-96	SES	NO				0.0001		0.036	0.0008		0.006		0.00015		0.018
SDS4	SDS4 070496	03-Jul-96	NPDES	NO	0.0015	0.0015	0.001	0.001	0.005	0.024	0.001	0.00005	0.009	0.0015	0.005	0.0005	0.02
SDS4	SDS4 070396 GRAB	03-Jul-96	NPDES	NO													
SDS4	SDS4 071796 GRAB	17-Jul-96	NPDES	NO													
SDS4	SDS4 100396 GRAB	04-Oct-96	NPDES	NO													
SDS4	SDS4 100496	04-Oct-96	NPDES	NO	0.0015	0.0043	0.007	0.002	0.076	0.18	0.0469	0.00072	0.133	0.0015	0.005	0.0005	0.228
SDS4	SDS4 120496 GRAB	04-Dec-96	NPDES	NO													
SDS4	SDS4 120496	04-Dec-96	NPDES	NO	0.0015	0.0015	0.001	0.00267	0.005	0.0227	0.0018	0.00023	0.012	0.0015	0.0005	0.0005	0.032
SDS4	SDS4 011697 GRAB	16-Jan-97	NPDES	NO													
SDS4	SDS4 011797	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0314	0.0016	0.00005	0.0026	0.0015	0.0005	0.0005	0.024
SDS4	SDS4 012797 GRAB	27-Jan-97	STIP AG	NO													
SDS4	SDS4 012797	27-Jan-97	STIP AG	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0174	0.0011	0.00005	0.009	0.0015	0.0005	0.0005	0.02
SDS4	SDS4 041997	19-Apr-97	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0389	0.0029	0.00012	0.017	0.0015	0.0005	0.0005	0.038
SDS4	SDS4 041997 GRAB	19-Apr-97	NPDES	NO													
SDW3	SDW3 051095	09-May-95	NPDES	NO													
SDW3	SDW3 051195	11-May-95	NPDES	NO													
SDW3	SDW3 061095	10-Jun-95	NPDES	NO													
SDW3	SDW3 081795	16-Aug-95	NPDES	NO													
SDW3	SDW3 112396 GRAB	23-Nov-96	NPDES	YES													
SDW3	SDW3 120496	04-Dec-96	NPDES	NO													
SDW3	SDW3 011697 GRAB	16-Jan-97	STIP AG	NO													
SDW3	SDW3 011697	16-Jan-97	STIP AG	NO													
SDW3	SDW3 012797	27-Jan-97	STIP AG	NO													
SDW3	SDW3 021197 GRAB	11-Feb-97	STIP AG	NO													
SDW3	SDW3 021197	11-Feb-97	STIP AG	NO													
SDW3	SDW3 022697 GRAB	26-Feb-97	STIP AG	NO													
SDN4	SDN4 090396	03-Sep-96	NPDES	NO	0.0015	0.0015	0.003	0.001	0.009	0.139	0.0005	0.00005	0.01	0.0015	0.005	0.0005	0.047
SDN4	SDN4 090396 GRAB	03-Sep-96	NPDES	NO													
SDN4	SDN4 120496 GRAB	04-Dec-96	NPDES	NO													
SDN4	SDN4 120496	04-Dec-96	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0342	0.0015	0.00037	0.01	0.0015	0.0005	0.0005	0.023
SDN4	SDN4 011697	16-Jan-97	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.0359	0.0005	0.00005	0.007	0.0015	0.0005	0.0005	0.025
SDN4	SDN4 011697 GRAB	16-Jan-97	NPDES	NO													
SDN4	SDN4 030597 GRAB	05-Mar-97	NPDES	NO													
SDN4	SDN4 030597	05-Mar-97	NPDES	NO	0.0015	0.0015	0.001	0.00025	0.005	0.031	0.0005	0.00005	0.017	0.0015	0.0005	0.0005	0.019
EY	EY 091494	13-Sep-94	NPDES	NO													
EY	EY 101394	13-Oct-94	NPDES	NO													
EY	EY 030995	08-Mar-95	NPDES	NO													
EY	EY 060495	04-Jun-95	NPDES	NO													
EY	EY 072695	26-Jul-95	NPDES	NO													
EY	EY 101695	15-Oct-95	NPDES	NO													

Outfall	[illegible] ID	[illegible]	purpose	[illegible]	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
EY	EY 021796	17-Feb-96	NPDES	NO													
EY	EY 021796 GRAB	17-Feb-96	NPDES	NO													
EY	EY 042296	22-Apr-96	NPDES	NO													
EY	EY 042296 GRAB	22-Apr-96	NPDES	NO													
EY	EY 052296	21-May-96	STIP AG	NO													
EY	EY 052296 GRAB	21-May-96	STIP AG	NO													
EY	EY 062396	23-Jun-96	STIP AG	NO													
EY	EY 062396 GRAB	23-Jun-96	STIP AG	NO													
EY	EY 070496	03-Jul-96	NPDES	NO													
EY	EY 070396 GRAB	03-Jul-96	NPDES	NO													
EY	EY 102196	21-Oct-96	NPDES	NO													
EY	EY 102196 GRAB	21-Oct-96	NPDES	NO													
EY	EY 021297	11-Feb-97	NPDES	NO													
EY	EY 021197 GRAB	11-Feb-97	NPDES	NO													
EY	EY 030597	05-Mar-97	NPDES	NO													
EY	EY 030597 GRAB	05-Mar-97	NPDES	NO													
TY	TY 090894	08-Sep-94	NPDES	NO													
TY	TY 101994	19-Oct-94	NPDES	NO													
TY	TY 030495	04-Mar-95	NPDES	NO													
TY	TY 060495	04-Jun-95	NPDES	NO													
TY	TY 081795	16-Aug-95	NPDES	NO													
TY	TY 090595	05-Sep-95	NPDES	NO													
TY	TY 101695-1	15-Oct-95	NPDES	NO													
TY	TY 032296 GRAB	22-Mar-96	STIP AG	NO													
TY	TY 032296	22-Mar-96	NPDES	NO													
TY	TY 041696 GRAB	15-Apr-96	NPDES	NO													
TY	TY 041696	15-Apr-96	NPDES	NO													
TY	TY 042296	22-Apr-96	NPDES	NO													
TY	TY 042296 GRAB	22-Apr-96	NPDES	NO													
TY	TY 070396 GRAB	03-Jul-96	NPDES	NO													
TY	TY 070496	03-Jul-96	NPDES	NO													
TY	TY 071796 grab	17-Jul-96	STIP AG	NO													
TY	TY 071896	17-Jul-96	STIP AG	NO													
TY	TY 080296	02-Aug-96	STIP AG	NO													
TY	TY 080296 GRAB	02-Aug-96	STIP AG	NO													
TY	TY 100496 GRAB	04-Oct-96	NPDES	NO													
TY	TY 100496	04-Oct-96	NPDES	NO													
TY	TY 021197 GRAB	11-Feb-97	NPDES	NO													
TY	TY 021297	11-Feb-97	NPDES	NO													
TY	TY 030597 GRAB	05-Mar-97	NPDES	NO													
TY	TY 030697	05-Mar-97	NPDES	NO													
B	B 041997 GRAB	19-Apr-97	NPDES	NO													
B	B 120496	04-Dec-96	NPDES	NO						0.0276	0.0063						0.041
B	B 120496 GRAB	04-Dec-96	NPDES	NO													
B	B 011797	16-Jan-97	NPDES	NO						0.0178	0.0015						0.034
B	B 012797 GRAB	27-Jan-97	NPDES	NO													
B	B 012897	27-Jan-97	NPDES	NO						0.0149	0.0019						0.028
B	B 030697	05-Mar-97	NPDES	NO						0.0066	0.0005						0.017
D	D 120496 GRAB	04-Dec-96	NPDES	NO													
D	D 011797 GRAB	16-Jan-97	NPDES	NO													
D	D 012797 GRAB	27-Jan-97	NPDES	NO													
D	D 012897	27-Jan-97	NPDES	NO						0.0157	0.0038						0.023
D	D 021297	11-Feb-97	NPDES	NO						0.0082	0.0005						0.0025
D	D 021197 GRAB	11-Feb-97	NPDES	NO													
D	D 030597	05-Mar-97	NPDES	NO						0.0211	0.0061						0.022
D	D 030597 GRAB	05-Mar-97	NPDES	NO													
			Overall	count	105	105	105	112	105	120	120	105	111	105	112	105	120
highlighted <MDL value = 1/2 MDL				median*	0.002	0.002	0.001	0.001	0.005	0.030	0.005	0.0001	0.005	0.002	0.002	0.001	0.072
lined-out data not representative				95th	0.002	0.004	0.001	0.002	0.014	0.115	0.045	0.0002	0.018	0.002	0.005	0.001	0.417
				75th	0.002	0.002	0.001	0.001	0.005	0.042	0.013	0.0001	0.009	0.002	0.005	0.001	0.205
				25th	0.001	0.002	0.001	0.001	0.003	0.018	0.002	0.0001	0.005	0.001	0.001	0.001	0.033
			#non-detected		77	47	90	80	76	0	12	78	59	77	98	83	1
			%non-detected		73%	45%	86%	71%	72%	0%	10%	74%	53%	73%	88%	79%	1%
			*Geomean for p														
		By Subbasin															
			SDE4	count	13	13	13	15	13	15	15	13	15	13	15	13	15
				median*	0.002	0.002	0.001	0.001	0.005	0.033	0.023	0.0001	0.005	0.001	0.002	0.001	0.204
				95th	0.004	0.003	0.001	0.002	0.021	0.091	0.100	0.0001	0.019	0.002	0.005	0.001	0.486
				75th	0.002	0.003	0.001	0.001	0.007	0.054	0.039	0.0001	0.012	0.002	0.002	0.001	0.300
				25th	0.001	0.002	0.001	0.001	0.005	0.030	0.016	0.0001	0.005	0.001	0.001	0.001	0.160
			#non-detected		6	5	13	8	7	0	0	12	7	12	15	12	0
			%non-detected		46%	38%	100%	53%	54%	0%	0%	92%	47%	92%	100%	92%	0%

Outfall	[illegible]	[illegible]	purpose	[illegible]	[illegible]	As	Be	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Ag	[illegible]	Zn
			SDS1	count	14	14	14	15	14	15	15	14	14	14	15	14	1[illegible]
				median*	0.002	0.002	0.001	0.001	0.005	0.042	0.013	0.0001	0.005	0.002	0.002	0.001	0.1[illegible]
				95th	0.002	0.004	0.001	0.012	0.016	0.118	0.058	0.0001	0.011	0.002	0.011	0.001	0.294
				75th	0.002	0.003	0.001	0.002	0.007	0.096	0.023	0.0001	0.005	0.002	0.005	0.001	0.244
				25th	0.002	0.001	0.001	0.001	0.005	0.031	0.006	0.0001	0.003	0.001	0.001	0.001	0.109
				#non-detected	10	7	14	7	10	0	0	12	10	14	15	15	0
				%non-detected	71%	50%	100%	47%	71%	0%	0%	86%	71%	100%	100%	107%	0%
			SDS2	count													
				median*													
				95th													
				75th													
				25th													
				#non-detected													
				%non-detected													
			SDS3	count	16	16	16	17	16	17	17	16	17	16	17	16	17
				median*	0.001	0.002	0.001	0.001	0.005	0.035	0.003	0.0001	0.005	0.001	0.002	0.001	0.054
				95th	0.002	0.003	0.002	0.002	0.007	0.170	0.014	0.0002	0.016	0.002	0.005	0.001	0.099
				75th	0.002	0.002	0.001	0.001	0.005	0.053	0.005	0.0001	0.005	0.002	0.002	0.001	0.069
				25th	0.001	0.002	0.001	0.001	0.003	0.028	0.002	0.0001	0.005	0.001	0.002	0.001	0.037
				#non-detected	13	6	16	14	13	0	0	14	11	14	17	13	0
				%non-detected	81%	38%	100%	82%	81%	0%	0%	88%	65%	88%	100%	81%	0%
			SDS4	count	15	15	15	16	15	16	16	15	16	15	16	15	16
				median*	0.002	0.002	0.001	0.001	0.005	0.024	0.001	0.0001	0.005	0.002	0.002	0.001	0.020
				95th	0.005	0.003	0.003	0.002	0.026	0.076	0.016	0.0004	0.046	0.002	0.005	0.001	0.092
				75th	0.002	0.002	0.001	0.001	0.005	0.036	0.003	0.0001	0.009	0.002	0.002	0.001	0.031
				25th	0.001	0.002	0.001	0.001	0.003	0.020	0.001	0.0001	0.005	0.001	0.001	0.001	0.018
				#non-detected	12	7	14	14	13	0	3	12	8	12	16	12	0
				%non-detected	80%	47%	93%	88%	87%	0%	19%	80%	50%	80%	100%	80%	0%
			SDW3	count													
				median*													
				95th													
				75th													
				25th													
				#non-detected													
				%non-detected													
			B	count	0	0	0	0	0	4	4	0	0	0	0	0	4
				median*						0.016	0.002						0.031
				95th						0.026	0.006						0.040
				75th						0.020	0.003						0.036
				25th						0.013	0.001						0.025
				#non-detected						0	1						0
				%non-detected						0%	25%						0%
			D	count	0	0	0	0	0	3	3	0	0	0	0	0	3
				median*						0.016	0.002						0.031
				95th						0.026	0.006						0.040
				75th						0.020	0.003						0.036
				25th						0.013	0.001						0.025
				#non-detected						0	1						1
				%non-detected						0%	33%						33%
			SDN1**	count	14	14	14	15	14	16	16	14	15	14	15	14	16
				median*	0.002	0.002	0.001	0.001	0.005	0.032	0.013	0.0001	0.005	0.002	0.002	0.001	0.365
				95th	0.002	0.002	0.001	0.001	0.009	0.080	0.039	0.0002	0.011	0.003	0.005	0.001	0.684
				75th	0.002	0.002	0.001	0.001	0.005	0.043	0.017	0.0001	0.008	0.002	0.005	0.001	0.441
				25th	0.001	0.001	0.001	0.001	0.003	0.022	0.009	0.0001	0.005	0.001	0.001	0.001	0.288
				#non-detected	12	11	14	12	10	0	0	11	9	8	15	12	0
				%non-detected	86%	79%	100%	80%	71%	0%	0%	79%	60%	57%	100%	86%	0%
			**Includes SDN1														

Outfall	[illegible]	[illegible]	purpose	[illegible]	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
			SDN2	count	15	15	15	15	15	15	15	15	15	15	15	15	15
				median*	0.002	0.002	0.001	0.001	0.005	0.025	0.005	0.0001	0.005	0.002	0.002	0.001	0.048
				95th	0.002	0.003	0.001	0.001	0.006	0.056	0.020	0.0007	0.009	0.002	0.005	0.001	0.088
				75th	0.002	0.002	0.001	0.001	0.005	0.034	0.011	0.0001	0.005	0.002	0.005	0.001	0.076
				25th	0.001	0.002	0.001	0.001	0.003	0.014	0.003	0.0001	0.003	0.001	0.002	0.001	0.026
				#non-detected	13	7	15	14	14	0	0	13	14	12	16	15	0
				%non-detected	87%	47%	100%	93%	93%	0%	0%	87%	93%	80%	107%	100%	0%
			SDN3	count	14	14	14	15	14	15	15	14	15	14	15	14	15
				median*	0.001	0.002	0.001	0.001	0.005	0.012	0.001	0.0001	0.005	0.002	0.002	0.001	0.063
				95th	0.002	0.004	0.001	0.001	0.005	0.036	0.004	0.0001	0.016	0.002	0.005	0.001	0.163
				75th	0.002	0.002	0.001	0.001	0.005	0.018	0.002	0.0001	0.008	0.002	0.002	0.001	0.111
				25th	0.001	0.002	0.001	0.000	0.003	0.010	0.001	0.0001	0.005	0.001	0.001	0.001	0.046
				#non-detected	13	5	14	15	13	0	4	13	7	13	15	12	0
				%non-detected	93%	36%	100%	100%	93%	0%	27%	93%	47%	93%	100%	86%	0%
			SDN4	count	4	4	4	4	4	4	4	4	4	4	4	4	4
				median*	0.002	0.002	0.001	0.000	0.005	0.035	0.001	0.0001	0.010	0.002	0.001	0.001	0.024
				95th	0.002	0.002	0.003	0.001	0.008	0.124	0.001	0.0003	0.016	0.002	0.004	0.001	0.044
				75th	0.002	0.002	0.002	0.000	0.006	0.062	0.001	0.0001	0.012	0.002	0.002	0.001	0.031
				25th	0.002	0.002	0.001	0.000	0.005	0.033	0.001	0.0001	0.009	0.002	0.001	0.001	0.022
				#non-detected	4	4	3	4	3	0	3	3	0	4	4	4	0
				%non-detected	100%	100%	75%	100%	75%	0%	75%	75%	0%	100%	100%	100%	0%

Outfall	[illegible]	[illegible]	purpose	ground [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Zn

AR 033640

All Glycol Data

stormdate	[illegible]	[illegible]	[illegible]	[illegible]	ground deice	[illegible] glycol	[illegible] glycol	[illegible] glycol	BOD
11-Nov-94	SDE4 111394	SDE4		NPDES	no				7
18-Nov-94	SDE4 111894	SDE4		baseflow	no				26
19-Nov-94	SDE4 111994	SDE4		NPDES	no				8
10-Apr-95	SDE4 041095	SDE4		NPDES	no				8
28-Apr-95	SDE4 042895	SDE4		baseflow	no				
02-May-95	SDE4 050295	SDE4		rain	no	9.6	9.6		
16-Aug-95	SDE4 081795	SDE4		NPDES	no	8		8	
19-Jan-96	SDE4 012096 AVG	SDE4	avg	snow	yes	24	13	11	72
03-Feb-96	SDE4 020396	SDE4	flow-wt	NPDES	yes	26	14	12	74
03-Feb-96	SDE4 020496 AVG	SDE4	avg	snow	yes	30	18	12	95
22-Mar-96	SDE4 032296	SDE4	flow-wt	NPDES	no				12
15-Apr-96	SDE4 041696	SDE4	flow-wt	NPDES	no				6.5
03-Sep-96	SDE4 090396	SDE4	flow-wt	NPDES	no				7.06
20-Nov-96	SDE4 112196 A99	SDE4	avg	snow	yes	92	21	71	
15-Dec-96	SDE4 121596	SDE4	flow-wt	rain	no				9
19-Dec-96	SDE4 122196	SDE4	flow-wt	NPDES	no				11.7
26-Dec-96	SDE4 010797 AVG	SDE4	avg	snow	yes	23	8	15	13
26-Dec-96	SDE4 123196 AVG	SDE4	avg	snow	yes	6	3	4	33
27-Jan-97	SDE4 012797	SDE4	flow-wt	NPDES	no	49		49	
05-Mar-97	SDE4 030697	SDE4	flow-wt	NPDES	no				4.4
16-Jan-97	SDE4 011697	SDE4	flow-wt	NPDES	no				12.8
19-Nov-94	SDN1 111994	SDN1		NPDES	no				6
05-Jan-95	SDN1 010595	SDN1		baseflow	no				11
08-Feb-95	SDN1 020895	SDN1		baseflow	no				
13-Feb-95	SDN1 021395	SDN1		baseflow	yes				5
15-Feb-95	SDN1 021695	SDN1		rain	yes	6	6		31
04-Mar-95	SDN1 030595	SDN1		NPDES	no				4
08-Mar-95	SDN1 030995	SDN1		NPDES	no				6
13-Mar-95	SDN1 031595	SDN1		NPDES	no				4
04-Apr-95	SDN1 040595	SDN1		NPDES	no				5
06-Apr-95	SDN1 040795	SDN1		NPDES	no				40
03-Feb-96	SDN1 020496	SDN1	flow-wt	NPDES	yes				15
05-Apr-96	SDN1 040596 GRAB	SDN1	grab	baseflow	no				44
11-Apr-96	SDN1 041296	SDN1	flow-wt	rain	no				15
15-Apr-96	SDN1 041696	SDN1	flow-wt	NPDES	no				
22-Apr-96	SDN1 042296	SDN1	flow-wt	NPDES	no				8.8
25-Apr-96	SDN1 042596	SDN1	flow-wt	rain	no				2.4
13-May-96	SDN1 051396	SDN1	flow-wt	NPDES	no				4.2
21-May-96	SDN1 052296	SDN1	flow-wt	NPDES	no				10.2
22-May-96	SDN1 052296 GRAB	SDN1	random	NPDES	no				12.4
23-Jun-96	SDN1 062396	SDN1	flow-wt	NPDES	no				20
03-Jul-96	SDN1 070496	SDN1	flow-wt	NPDES	no				10.7
16-Jul-96	SDN1 071796	SDN1	flow-wt	NPDES	no				25.1
02-Aug-96	SDN1 080296	SDN1	flow-wt		no				14.2
03-Sep-96	SDN1 090396	SDN1	flow-wt		no				10
13-Sep-96	SDN1 091496	SDN1	flow-wt	rain	no				10.3
18-Sep-96	SDN1 091996	SDN1	flow-wt		no				
04-Oct-96	SDN1 100496	SDN1	unk	rain	no				6
19-Nov-94	SDN2 111994	SDN2		NPDES	no				10
04-Mar-95	SDN2 030595	SDN2		NPDES	no	36	36		
13-Mar-95	SDN2 031595	SDN2		NPDES	no				5
06-Apr-95	SDN2 040795	SDN2		NPDES	no				15
10-Apr-95	SDN2 041295	SDN2		NPDES	no	19		19	30
09-Dec-95	SDN2 121095	SDN2	flow-wt	rain	no				
19-Jan-96	SDN2 012296 AVG	SDN2	avg	rain	yes	44	22	24	21
03-Feb-96	SDN2 020696 AVG	SDN2	avg	rain	yes	23	9	14	108
03-Feb-96	SDN2 020496 GRAB	SDN2	grab	NPDES	yes	44	18	26	180
17-Feb-96	SDN2 021796	SDN2	flow-wt	NPDES	no	17.3	6.3	11	6

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Stormdate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29-Mar-96	SDN2 032996 GRAB	SDN2	grab	rain	no	[redacted]	[redacted]	[redacted]	10
05-Apr-96	SDN2 040596 GRAB	SDN2	grab	baseflow	no	[redacted]	[redacted]	[redacted]	[redacted]
16-Apr-96	SDN2 041696	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
19-Apr-96	SDN2 041996	SDN2		rain	no	[redacted]	[redacted]	[redacted]	[redacted]
22-Apr-96	SDN2 042296	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	6.6
25-Apr-96	SDN2 042596	SDN2	flow-wt	rain	no	[redacted]	[redacted]	[redacted]	2.14
13-May-96	SDN2 051396	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	4.9
21-May-96	SDN2 052296	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	5.08
22-May-96	SDN2 052296 GRAB	SDN2	random	NPDES	no	[redacted]	[redacted]	[redacted]	5.7
23-Jun-96	SDN2 062396	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	18.3
16-Jul-96	SDN2 071796	SDN2	time-	NPDES	no	[redacted]	[redacted]	[redacted]	18.3
21-Oct-96	SDN2 102196	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	4.5
20-Nov-96	SDN2 112896 AVG	SDN2	avg	snow	yes	165	31	134	249
26-Dec-96	SDN2 010297 AVG	SDN2	avg	snow	yes	37	11	27	54
26-Dec-96	SDN2 123196 AVG	SDN2	avg	snow	yes	684	315	370	1180
16-Jan-97	SDN2 011697	SDN2	flow-wt	NPDES	no	51	[redacted]	51	120
19-Apr-97	SDN2 041997	SDN2	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
19-Nov-94	SDN3 111994	SDN3		NPDES	no	[redacted]	[redacted]	[redacted]	4
08-Feb-95	SDN3 020895	SDN3		baseflow	no	[redacted]	[redacted]	[redacted]	
13-Feb-95	SDN3 021395	SDN3		baseflow	yes	[redacted]	[redacted]	[redacted]	3
15-Feb-95	SDN3 021695	SDN3		rain	yes	[redacted]	[redacted]	[redacted]	[redacted]
04-Mar-95	SDN3 030595	SDN3		NPDES	no	[redacted]	[redacted]	[redacted]	3
08-Mar-95	SDN3 030995	SDN3		NPDES	no	[redacted]	[redacted]	[redacted]	3
13-Mar-95	SDN3 031595	SDN3		NPDES	no	[redacted]	[redacted]	[redacted]	5
04-Apr-95	SDN3 040595	SDN3		NPDES	no	[redacted]	[redacted]	[redacted]	3
13-Jan-96	SDN3 011496	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	5
19-Jan-96	SDN3 012096 AVG	SDN3	avg	rain	yes	5	3	2.5	30
03-Feb-96	SDN3 020496	SDN3	flow-wt	NPDES	yes	[redacted]	[redacted]	[redacted]	
29-Mar-96	SDN3 033096 GRAB	SDN3	grab	rain	no	[redacted]	[redacted]	[redacted]	5
31-Mar-96	SDN3 040196	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	5
05-Apr-96	SDN3 040596 GRAB	SDN3	grab	baseflow	no	[redacted]	[redacted]	[redacted]	5
11-Apr-96	SDN3 041296 GRAB	SDN3	grab	rain	no	[redacted]	[redacted]	[redacted]	4
15-Apr-96	SDN3 041696	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
19-Apr-96	SDN3 041996	SDN3		rain	no	[redacted]	[redacted]	[redacted]	[redacted]
22-Apr-96	SDN3 042296	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	6.6
25-Apr-96	SDN3 042596	SDN3	flow-wt	rain	no	[redacted]	[redacted]	[redacted]	[redacted]
07-May-96	SDN3 050796 GRAB	SDN3	random	baseflow	no	[redacted]	[redacted]	[redacted]	[redacted]
10-May-96	SDN3 051096 GRAB	SDN3	random	baseflow	no	[redacted]	[redacted]	[redacted]	[redacted]
13-May-96	SDN3 051396	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
22-May-96	SDN3 052296	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
04-Dec-96	SDN3 120496	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
19-Dec-96	SDN3 122196	SDN3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
05-Mar-97	SDN3 030597	SDN3	flow-wt	NPDES	no	6.2	6.2	[redacted]	[redacted]
04-Dec-96	SDN4 120496	SDN4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	8
05-Mar-97	SDN4 030597	SDN4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
18-Nov-94	SDS1 111894	SDS1		baseflow	no	32	32	[redacted]	[redacted]
19-Nov-94	SDS1 111994	SDS1		NPDES	no	14	14	[redacted]	46
08-Feb-95	SDS1 020895	SDS1		baseflow	no	[redacted]	[redacted]	[redacted]	
13-Feb-95	SDS1 021395	SDS1		baseflow	yes	[redacted]	[redacted]	[redacted]	5
15-Feb-95	SDS1 021695	SDS1		NPDES	yes	275	260	15	[redacted]
28-Apr-95	SDS1 042895	SDS1		baseflow	no	[redacted]	[redacted]	[redacted]	
02-May-95	SDS1 050295	SDS1		rain	no	[redacted]	[redacted]	[redacted]	
29-Sep-95	SDS1 092995	SDS1		baseflow	no	[redacted]	[redacted]	[redacted]	
13-Jan-96	SDS1 011496	SDS1	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	18
19-Jan-96	SDS1 012096 AVG	SDS1	avg	snow	yes	298	105	193	130
28-Jan-96	SDS1 012896	SDS1		baseflow	yes	6220	320	5900	
30-Jan-96	SDS1 013096	SDS1		baseflow	yes	291	71	220	690
01-Feb-96	SDS1 020196	SDS1		baseflow	yes	36	13	23	170

stormdate	POS ID	outfall	type	event	ground deice?	total glycols	[illegible] glycol	[illegible] glycol	BOD5
03-Feb-96	SDS1 020496 AVG	SDS1	avg	NPDES	yes	118	23	96	131
15-Apr-96	SDS1 041696	SDS1	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	23.9
22-Apr-96	SDS1 042296	SDS1	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	9
03-Jul-96	SDS1 070496	SDS1	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	11.2
03-Nov-96	SDS1 110496	SDS1	flow-wt	rain	no	[redacted]	[redacted]	[redacted]	6.4
20-Nov-96	SDS1 112096 A1	SDS1	time-	snow	yes	2859	59	2800	428
23-Nov-96	SDS1 112396	SDS1	flow-wt	NPDES	yes	198	8.4	190	258
04-Dec-96	SDS1 120496	SDS1	flow-wt	NPDES	no	29	[redacted]	24	41
16-Jan-97	SDS1 011697	SDS1	flow-wt	NPDES	no	33	[redacted]	33	79
13-Apr-97	SDS1 041397	SDS1	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	21.2
08-Sep-94	SDS3 090894	SDS3		rain	no	[redacted]	[redacted]	[redacted]	
18-Nov-94	SDS3 111894	SDS3		baseflow	no	[redacted]	[redacted]	[redacted]	2
19-Nov-94	SDS3 111994	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	18
08-Feb-95	SDS3 020895	SDS3		baseflow	no	[redacted]	[redacted]	[redacted]	
10-Apr-95	SDS3 041295	SDS3		NPDES	no	[redacted]	[redacted]	[redacted]	4
28-Apr-95	SDS3 042895	SDS3		baseflow	no	[redacted]	[redacted]	[redacted]	
02-May-95	SDS3 050295	SDS3		baseflow	no	[redacted]	[redacted]	[redacted]	
29-Sep-95	SDS3 093095	SDS3	unk	baseflow	no	[redacted]	[redacted]	[redacted]	
29-Sep-95	SDS3 093095 GRAB	SDS3	random	baseflow	no	[redacted]	[redacted]	[redacted]	
13-Jan-96	SDS3 011496	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	8
19-Jan-96	SDS3 012296 AVG	SDS3	avg	rain	yes	40	25	14	118
28-Jan-96	SDS3 012896	SDS3		baseflow	yes	73	28	45	
30-Jan-96	SDS3 013096	SDS3		baseflow	yes	115	96	19	210
01-Feb-96	SDS3 020196	SDS3		baseflow	yes	31	18	13	130
03-Feb-96	SDS3 020696 AVG	SDS3	avg	rain	yes	29	16	13	162
22-Mar-96	SDS3 032296	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	8
15-Apr-96	SDS3 041696	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	6.4
21-Oct-96	SDS3 102196	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
20-Nov-96	SDS3 112896 AVG	SDS3	avg	snow	yes	28	14	15	75
23-Nov-96	SDS3 112396	SDS3	flow-wt	NPDES	yes	28	18	10	34
26-Dec-96	SDS3 010297 AVG	SDS3	avg	snow	yes	62	19	44	252
16-Jan-97	SDS3 011697	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	10
05-Mar-97	SDS3 030597	SDS3	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
19-Nov-94	SDS4 111994	SDS4		NPDES	no	[redacted]	[redacted]	[redacted]	5
13-Feb-95	SDS4 021395	SDS4		baseflow	yes	[redacted]	[redacted]	[redacted]	5
15-Feb-95	SDS4 021695	SDS4		rain	yes	[redacted]	[redacted]	[redacted]	[redacted]
13-Jan-96	SDS4 011496	SDS4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	6
19-Jan-96	SDS4 012096 AVG	SDS4	avg	snow	yes	6	3	4	138
01-Feb-96	SDS4 020196	SDS4		baseflow	yes	[redacted]	[redacted]	[redacted]	4
03-Feb-96	SDS4 020596	SDS4		rain	no	21	14	7	13
03-Feb-96	SDS4 020496 AVG	SDS4	avg	NPDES	yes	31	13	18	242
15-Apr-96	SDS4 041696	SDS4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	4.6
22-Apr-96	SDS4 042296	SDS4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	6.4
03-Jul-96	SDS4 070496	SDS4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	6
04-Dec-96	SDS4 120496	SDS4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	[redacted]
19-Apr-97	SDS4 041997	SDS4	flow-wt	NPDES	no	[redacted]	[redacted]	[redacted]	4.4
03-Feb-96	SDW3 020496 AVG	SDW3	avg	NPDES	yes	12	6	6	76

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Miller Creek Outfall Sample Results for Stipulated Agreement

POS Sample ID	TSS, mg/l	Turb, NTU	BOD5, mg/l	NH3, mg/l	Ethylene glycol, mg/l	Propylene glycol, mg/l	total glycols, mg/l	comments
MC3 030595	65	52	10	0.21	2.5	2.5	5	
MC3 030995	38	28	5.0	0.26	2.5	2.5	5	
MC3 031595	6.0	6.2	3.0	0.06	2.5	2.5	5	These are Lake Reba outlet samples
MC3 040595	6.0	3.2	3.0	0.005	2.5	2.5	5	
MC3 040795	10	6.0	7.0	0.005	2.5	2.5	5	
MC3 012096			45	0.20	12	8	20	S. McEvoy requested. First storm after runway deice. Avg of six time composites over 24 hours
MC3 020496	13	11	27	0.39	5.7	4.7	10	First storm after runway deice. Average of seven time composites over 18 hours
MC3 032996	7.5	5.4	7.0	0.11	2.5	2.5	5	0.13" storm
MC3 040596	15	5.6	5	0.005	2.5	2.5	5	Baseflow sample, no stormflow
MC3 041296	2	6.2	8	0.005	2.5	2.5	5	0.20" storm
MC3 041696	12	6.1	2	0.088	2.5	2.5	5	0.49" storm
MC3 042296	10	4.1	6.64	0.059	2.5	2.5	5	0.50"+ storm
MC3 050796	8	3.1	2	0.005	2.5	2.5	5	0.09" storm
MC3 051096	7.2	4.5	2	0.005	2.5	2.5	5	Baseflow sample, no stormflow
MC3 071796	4.4	4.1	5.78	0.005	2.5	2.5	5	0.27" storm
MC3 091996	10	2.7	4.22	0.024	2.5	2.5	5	0.05" storm
SDN1 030595	1	3.5	4.0	0.005	2.5	2.5	5	
SDN1 030995	14	17	6.0	0.35	2.5	2.5	5	
SDN1 031595	9.6	17	4.0	0.05	2.5	2.5	5	These are SDN1 outfall samples
SDN1 040595	6.0	7.6	5.0	0.08	2.5	2.5	5	
SDN1 040596	48	9.3	44	0.88	2.5	2.5	5	Baseflow sample, no stormflow
SDN1 041296	5.0	16	15	0.23	2.5	2.5	5	0.20" storm
SDN1 041696	47	7.1	2.0	0.10	2.5	2.5	5	0.49" storm
SDN1 042596	12	12	2.4	0.07	2.5	2.5	5	0.31" storm
SDN1 051396	14	15	4.22	0.0267	2.5	2.5	5	0.21" storm
SDN1 052296	11	5	12.4	0.52	2.5	2.5	5	0.31" storm
SDN1 071796	19	2.1	25.1	0.859	2.5	2.5	5	0.27" storm
SDN1 080296	35	20	14.2	0.46	2.5	2.5	5	1.01" storm
SDN1 090396	49.3	15	9.88	0.528	2.5	2.5	5	0.29" storm
SDN1 091496	50	22	10.3	0.298	2.5	2.5	5	0.52" storm
SDN1 091996	3.6	7	2	0.253	2.5	2.5	5	0.05" storm
SDN1 100496		19	6	0.23	2.5	2.5	5	0.59" storm

values shaded were reported as below detection limits: values in table = 1/2 detection limit

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Miller Creek Outfall Sample Results for Stipulated Agreement

POS Sample ID	TSS, mg/l	Turb, NTU	BOD5, mg/l	NH3, mg/l	Ethylene glycol, mg/l	Propylene glycol, mg/l	total glycols, mg/l	comments
SDN2 030595	2.4	2.1	12	0.02	36	2.5	36	
SDN2 031595	1	2.2	5.0	1.6	2.5	2.5	5	Elevated ammonia, suspect sample contamination. No urea used since Feb 17, 1995
SDN2 040795	7.2	4.8	15	0.005	2.5	2.5	5	
SDN2 011996	26	41	28	0.66	43	44	88	S. McEvoy requested. Runway deice: avg of seven time composites during snowmelt runoff period over 18 hours
SDN2 012096	3.1	4.3	19	0.21	11	12	23	S. McEvoy requested. First storm after runway deice. Avg of two time composites over 12 hours
SDN2 020496	15	13	203	0.23	16	23	39	First storm after runway deice. Average of grab plus two time composites over 18 hours
SDN2 032996	34	3.3	10	0.32	2.5	2.5	5	0.13" storm
SDN2 040596	0.6	0.5	0.50	0.15	2.5	2.5	5	Baseflow sample, no stormflow
SDN2 041696	15	11	2	0.044	2.5	2.5	5	0.49" storm
SDN2 041996	0.67	1.5	2	0.056	2.5	2.5	5	0.02" storm
SDN2 042596	4.4	3.6	2.14	0.005	2.5	2.5	5	0.31" storm
SDN2 051396	5.6	5.3	4.86	0.045	2.5	2.5	5	0.21" storm
SDN2 052296	2.8	2.5	5.7	0.005	2.5	2.5	5	0.31" storm
SDN2 070396	34	22	21.4	0.011	2.5	2.5	5	0.23" storm
SDN2 071796	3.33	4.1	18.3	0.034	2.5	2.5	5	0.27" storm
SDN2 102196	4.2	2.9	4.5	0.005	2.5	2.5	5	0.75" storm
SDN3 030595	1	2.3	3.0	0.005	2.5	2.5	5	
SDN3 030995	5	12	3.0	0.02	2.5	2.5	5	
SDN3 031595	4.0	5.9	5.0	0.02	2.5	2.5	5	
SDN3 040595	1	1.8	3.0	0.25	2.5	2.5	5	
SDN3 011996	4.8	4.2	42	0.18	2.5	2.5	5	S. McEvoy requested. Runway deice: sample during snowmelt runoff period
SDN3 012096	5.5	9.7	18	0.08	2.5	2.5	5	S. McEvoy requested. First storm after runway deice.
SDN3 020496		9.7		0.14	2.5	2.5	5	First storm after runway deice, insuff stormflow for full sample, S. McEvoy requested it anyway.
SDN3 033196	26	2.8	5.0	0.04	2.5	2.5	5	0.13" storm, but no stormflow to enable sampler at this site, S. McEvoy requested it anyway.
SDN3 040596	79	100	5	0.01	2.5	2.5	5	Baseflow sample, no stormflow
SDN3 041296	9.1	15	4	0.005	2.5	2.5	5	0.20" storm
SDN3 041996	9.6	11	2	0.018	2.5	2.5	5	0.02" storm
SDN3 042596	5	6.4	1	0.005	2.5	2.5	5	0.31" storm
SDN3 050796	1.2	2.2	2	0.005	2.5	2.5	5	0.09" storm
SDN3 051096	0.25	2.2	2	0.071	2.5	2.5	5	Baseflow sample, no stormflow
SDN3 051396	16	18	2	0.075	2.5	2.5	5	0.21" storm
SDN3 052296	16	5.2	2	0.005	2.5	2.5	5	0.31" storm

These are SDN2 outfall samples

These are SDN3 outfall samples

values shaded were reported as below detection limits: values in table = 1/2 detection limit

AR 033646

Appendix C

Loading Estimates

Loading estimates provide another useful degree of sophistication in assessing water quality beyond concentration data alone. Loading estimates are by no means exact and should be viewed only as general order-of magnitude estimates.

The loading estimates presented in this report are based upon the method of Marsalek (1990). This method uses statistics for a log-normal data distribution to estimate a mean and range for a given confidence interval. The data set comprises 14 to 23 quarterly samples per outfall taken throughout the calendar year in the three-year period June 1994 to May 1997. The data set is limited to 4-8 samples at outfalls SDW3 and SDS2 (only annual samples), and SDN4, B, and D because sampling requirements were added in late 1996.

An annual load estimate for a particular outfall is the product of the log-mean concentration and total annual runoff volume. The total annual runoff is estimated by simple the runoff-coefficient averaging method and assumes an annual rainfall of 38.6" (30-year average per National Weather Service). This method estimates that 90% of the total rainfall results in runoff. Annual loads are then converted to "unit loads" by dividing by subbasin area. Because annual load estimates are site-specific, only unit loads can be compared amongst sites, regions, land-uses, etc. Loading estimates can also be compared over time to show the effect of BMPs.

Two major capital BMPs reduced the SDS1 subbasin drainage area from 40 to 6 acres. Such a change in surface area, and consequent annual runoff will dramatically influence load estimates. Because the majority of data for SDS1 comprise results from samples taken prior to these two BMPs, loading estimates presented in this report reflect historical information. Any future estimates should use sample data taken after the BMPs (May 1997), and should also be adjusted for the reduced drainage area.

Appendix D

Outfall Inspection Results

Dry Weather Inspections for Permitted Outfalls

Conducted on Multiple Visits May 1-Sept 30, 1996 during dry days by Scott Tobiason, Eli Weissman

Outfall Name	Outfall #	Inspection point (1)	date (2)	depth of flow (3), in.	foam	floatables	suspended solids	oil sheen	discolorations	turbidity	odor	other	Remarks (4)
					Indicate "Y" if present:								
SDE4	002	*	7/26, 9/24	1/2"	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Confined space entries to manhole bottom. Observed from surface 5/3, 6/28
SDS1	003	outfall	6/17, 7/16	1/2"	Y	Ø	Ø	Ø	Y	Ø	Ø	Ø	Iron bacteria on 6/17,source in seep of SDS1-123 manhole wall. Strong fuel odor and brown scum in baseflow<1gpm on 6/25, 7/2, 7/24, 8/28 (TPH=0.54, FOG<1):no source in upstream manholes. No odor 5/3, 6/28, 7/4, 7/9, 7/12, 7/16, 7/31, 8/1, 8/6.
SDS2	004	outfall	7/31	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	no discharge
SDS3	005	outfall	6/17, 7/16	0.10' (weir)	Ø	Y	Ø	Ø	Y	Y	Ø	Y	Saw algae & orange/brown turbidity in sump on 6/17, dead rats and packing peanuts other occasions. Also visited 5/3, 6/27, 7/2, 7/9, 7/12, 7/16, 7/30.
SDN1	006	drain inlet	5/7, 5/10	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	no discharges (Taylor Assoc.)
SDN1	006	drain inlet	7/16, 7/23, 7/26	1/2"	Y	Ø	Ø	Ø	Ø	Ø	Y	Ø	septic odor, samples taken from baseflow, <1 gpm. Foam traced to vehicle wash at Caterair on 7/23. To be video-inspected
SDN2	007	manhole	multi: see remarks	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	no discharges on: 5/3, 5/7, 5/10, 6/12, 6/17, 6/20, 6/25, 7/16, 7/23, 7/26, 7/30, 8/26, 8/30
SDN3	008	outfall	5/3, 5/7, 5/10	1/2" typical	Ø	Y	Ø	Ø	Ø	Ø	Ø	Y	orange/brown scum seen 5/7, sampled 5/10: no surfactants, TPH, or FOG. Also visited 6/12, 6/17, 6/25, 7/9, 7/17, 7/23, 7/24
SDS4	009	outfall	6/26, 7/16	0.4' typical	Ø	Ø	Ø	Ø	Y	Y	Y	Y	bad odor and dry-wx discharge traced to duck-pond dewatering on 6/26, ceased immediately. Turbid discharges 7/16, 7/24 and 7/30 traced to roadway washing at POS construction site, curtailed future operations. Also visited 5/3, 6/17, 8/31, 9/13.
SDW3	010	outfall	7/31	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	
SDN4	011	outfall	multi: see remarks	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	no discharges on 6/12, 7/16, 7/23, 8/30, 9/24
Eng Yard	012	drain inlet		Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	no discharges on 7/2, 7/4
Taxi Yard	013	drain inlet	7/1, 7/16	Ø	Ø	Ø	Ø	Y	Ø	Ø	Ø	Ø	oil drips/puddles from vehicles reported and cleaned up on 7/12.

notes:

* SDE4 inspected in manhole SDE4-47 during confined space entries on dates listed.

1. Inspection points at first visible point downstream from outfalls with monitoring points requiring confined-space entry (SDE4, SDN1, SDN2, EY, TY)
2. Quarterly sampling sites visited on numerous other dates during this dry season, noted in remarks
3. Depths of flow are approximate, unless registered by local monitoring equipment.
4. Other observations included to account for numerous other site visits during this dry season.

Other observations at non-permit locations:

Location	Outfall #	Inspection point	date	depth of flow	foam	floatables	suspended solids	oil sheen	discolorations	turbidity	odor	other	Remarks
S 28th St outfall	n/a	outfall	6/17/96	Ø	Ø	Ø	Ø	Y	Y	Y	Ø	Ø	Dark black and turbid discharge from outfall, also in pool below.
DM Creek *above* SDS1	n/a	creek	7/17 storm	Ø	Ø	Ø	Ø	Ø	Y	Y	Ø	Ø	creek is turbid and black color, SDS1 is clear, low turbidity
DM Creek *above* SDS1	n/a	creek	7/24, 8/30	Y	Y	Ø	Ø	Ø	Ø	Ø	Ø	Y	foam in creek above outfall, green viscid, fetid gel on rocks in creek, found large floating fetid mass of green gel in creek 150' above SDS1 outfall on 7/24. Traced green gel to Bow Lake on 8/30, found on vegetation at outlet.
DM Creek at SDS4	n/a	creek	7/17 storm	Y	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	foam in E. Branch of creek (surf =0.75), no foam at SDS4, S28th nor SDS1, foam in creek above SDS1.
L. Reba outlet	n/a	outlet	7/17 storm	Y	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	much foam, about 1 cubic yard, surf <0.025 ppm in Reba composite, some surfactants in SDN1(0.45 ppm) and SDN2 (0.15 ppm). Took photo. No foam on 7/18

Scott Tobiason

9/30/97

Wet Weather Inspections for Permitted Outfalls

Conducted on April 28, 1997
by Scott Tobiason

Outfall Name	Outfall #	inspection point (1)	date (2)	depth of flow (3), in.	foam	floatables	suspended solids	oil sheen	discolorations	turbidity	odor	other	Remarks (4)
					Indicate "Y" if present:								
SDE4	002	manhole SDE4-47	28-Apr	?	N	N	N	N	N	N	N	N	Clear water discharge
SDS1	003	outfall	28-Apr	1	N	N	N	N	N	N	N	N	Clear water discharge
SDS2	004	outfall	28-Apr	3	N	N	N	N	N	N	N	N	Clear water discharge
SDS3	005	outfall	28-Apr	0.55'	Y	Y	N	N	Y	N	N	N	floating debris, styrofoam "peanuts", cups, cigarette butts, some minor foam/scum. brown/yellow color.
SDN1	006	drain inlet	28-Apr	5	N	N	N	N	N	N	N	N	Clear water discharge
SDN2	007	manhole	28-Apr	4	N	N	N	N	N	N	N	N	Clear water discharge
SDN3	008	outfall	28-Apr	2	Y	N	N	N	N	N	N	N	Foam below pool 20' from outfall, sample showed no surfactants using Hach field kit.
SDS4	009	outfall	28-Apr	8 (back-water)	Y	N	N	N	N	N	N	N	clear water discharge, minor light foam, typical of storm discharges
SDW3	010	outfall	28-Apr	2	N	N	N	N	N	N	N	N	Clear water discharge
SDN4	011	outfall	28-Apr	2	N	N	N	N	N	N	N	N	Clear water discharge
Eng Yard	012	drain inlet	28-Apr	0	N	N	N	N	N	N	N	N	no discharge
Taxi Yard	013	drain inlet	28-Apr	0	N	N	N	N	N	N	N	N	no discharge
Subbasin B	014	outfall	28-Apr	2	N	N	N	N	N	Y	N	N	turbidity due to recent tire ruts in road shoulder near fire pit
Subbasin D	015	outfall	28-Apr	2	N	N	N	N	N	Y	N	N	turbidity from Snow Equipment Storage Shed constructino project, ESC in place but needs fix

notes:
1. Inspected visually from surface through inlets, or by pumped sample for outfalls with monitoring points requiring confined-space entry (SDE4, SDN1, SDN2, EY, TY)
2. Quarterly sampling sites visited on numerous other dates during the period, noted in remarks
3. Depths of flow are approximate, unless registered by local monitoring equipment.

Other observations at non-permit locations:

S 28th St outfall	n/a	outfall											not inspected
DM Creek *above* SDS1	n/a	creek			N	N	N	N	N	N	N	N	clear water in creek, no foam
DM Creek *Weir at Golf Course*	n/a	creek											not inspected
DM Creek at SDS4	n/a	creek			N	N	N	N	N	N	N	N	
L. Reba outlet	n/a	outlet											not inspected

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