Watershed Briefing Paper for the Kitsap Basin Watershed

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Executive Summary

Purpose

The Department of Ecology's Environmental Investigations and Laboratory Services Program (EILS) reviewed water quality information on the Kitsap Basin Watershed. The Kitsap Basin Water Quality Management Area (WRIA #15) consists of the Kitsap peninsula and adjacent marine waters

The purpose of the review is to describe what is known about this region and identify water quality issues that may require monitoring or intensive studies over the next two years. The review draws primarily on studies conducted by EILS during the past 10 years. This evaluation is part of an agency-wide scoping and data collection effort being done as part of the watershed approach to water quality management, a five-year process culminating in issuing water quality permits and implementing other pollution prevention and control actions.

Content

This report contains individual briefing papers with information on the following subjects about the Kitsap Basin Watershed:

Marine Ambient Monitoring

Known and potential problem areas for bacterial contamination, low DO, eutrophication, toxic organic compounds and metals, and harmful phytoplankton species are identified and their causes discussed.

River and Stream Ambient Monitoring

The lack of water quality data on the Kitsap Watershed is noted. The health of the benthic invertebrate community is evaluated for the Tahuya River and Seabeck Creek and inferences made about stream conditions.

Lake Ambient Monitoring

Descriptions are provided on the trophic status of eight Kitsap and Mason county lakes Lakes that have been surveyed for aquatic plants in Kitsap, Mason, and Pierce counties and those with noxious weeds are identified

Watershed Assessments

The history of fecal coliform contamination of the Minter/Burley Watersheds is described and other waterbodies with similar problems identified. A number of water quality issues are identified in Sinclair Inlet including eutrophication, low DO, and toxics, in addition to bacterial contamination.

Toxics in Surface Waters

Findings are summarized from studies on contaminants in storm drain discharges to Sinclair and Dyes Inlets; chemical residues in Sinclair/Dyes Inlets fish and clams; pesticide monitoring in Silverdale's Clear Creek; and copper applications to Sylvia Lake near Gig Harbor.

Ground Water

The only ground water data EILS has on the watershed, Olympic View Landfill, are described. Results of studies by other agencies are reviewed in the areas of seawater intrusion, residential effects on ground water, Submarine Base Bangor, and Day Road Industrial Park.

Compliance Monitoring

The status and findings of compliance inspections conducted at municipal and industrial treatment plants are reported.

Summary of Recommendations

Recommendations from individual briefing papers are compiled and summarized below:

1. Conduct a study to identify sources, and quantify and evaluate the impact of loading of BOD and nutrients to Hood Canal. A preventative BOD and nutrient TMDL should be pursued for Hood Canal.

2. Conduct studies to quantify and evaluate the impact of loading of BOD and nutrients to inner Sinclair Inlet and the sources and loading of toxic substances to the greater inlet. A preventative BOD and nutrient TMDL should be pursued for Sinclair and Dyes Inlets.

3. Follow the recommendations and actions listed in the Sinclair and Dyes Inlets Action Plans.

4. Agricultural BMPs and sewage system surveys should focus on Burley and Minter Creeks, with regular monitoring of fecal coliforms and total suspended solids, focusing on rain events.

5 Evaluate semi-enclosed bays and inlets with failing septic tanks, wastewater treatment plants, and other sources to establish priorities for monitoring Coordinate fecal coliform monitoring with the Department of Health and Metro

6 Assess the levels and bioavailability of selected toxics in the water columns of Sinclair Inlet, Eagle Harbor, and other poorly flushed embayments.

7 Evaluate heads of bays for DO since gradients of decreasing DO have been found with distance from present monitoring sites

8 Prepare Watershed Action Plans for Liberty Bay, Miller Bay, and Eagle Harbor, if not already completed.

9 Give high priority to establishing ambient water quality monitoring stations on the Tahuya River, Dewatto River, Clear Creek, and Chico Creek.

10 Concentrate biological monitoring on the Tahuya and Dewatto Rivers and identify other streams with more severe degradation than those already surveyed.

11 More lakes should be monitored for water quality trends and surveyed for aquatic plants to better detect serious degradation events and changes in plant communities. Monitor the noxious weeds in Long Lake every few years

12 Define the freshwater/seawater boundary along shorelines of intrusion-prone areas.

13. Evaluate residential impacts on ground water quality in high-density areas, using nitrate-N as an indicator

14. Characterize the surficial aquifer to define recharge areas in the watershed

15 Conduct EILS Class II inspections at facilities of concern to NWRO.

Acknowledgements

This report draws on data collected by many of EILS field staff. Most of the sample analyses were conducted by EILS and EPA chemists at the Manchester Environmental Laboratory.

Will Kendra and Larry Goldstein reviewed this report and made good suggestions for its improvement. Final formatting was done by Joan LeTourneau

Marine Ambient Monitoring

by

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Ambient Monitoring Section

Background

The Kitsap Water Quality Management Area (WRIA #15) represents a complex area with respect to the marine systems it includes State WRIA boundaries divide several major Puget Sound basins between two watersheds For example, Hood Canal is shared by both Kitsap and Eastern Olympic watersheds The watershed approach makes sense for freshwater systems or for semi-enclosed marine bays receiving river water from a single watershed (e g , Bellingham Bay); however, it is difficult to apply to the Puget Sound marine basins, which are commonly divided into: Puget Sound Main Basin, Hood Canal, South Puget Sound, Whidbey Basin, San Juan/Strait of Georgia, and Strait of Juan de Fuca Because contamination can come from either shoreline (or any watershed) of a subdivided waterbody (e g , Hood Canal), it is difficult to evaluate these waterbodies using the watershed approach In this report, all adjoining waterbodies to the Kitsap peninsula were considered part of the Kitsap Basin, not just those listed for WRIA #15 This means the addition of several areas with "WA-PS-xxxx" designations The waterbody segments considered for Kitsap and the Marine Waters Monitoring stations located within these segments are listed in Table 1

The Marine Waters Monitoring (MWM) program of the Ambient Monitoring Section is responsible for monitoring the marine waters of Puget Sound and the coastal estuaries Grays Harbor and Willapa Bay The data records for MWM stations located within WRIA #15 and its adjoining waterbody segments are shown in Table 2 Some of the monitoring stations represent open basins whereas others represent small, enclosed bays Stations are typically located in the central portion of the basin or bay, away from the nearshore or known point sources (Figure 1) Parameters monitored at MWM stations are listed in Table 3 Not all parameters are consistently available for all stations

Water Quality Concerns

Causes

Two primary factors causing poor water quality are: 1) the existence of anthropogenic inputs/alterations to the environment (e g , point and non-point contamination, nutrient

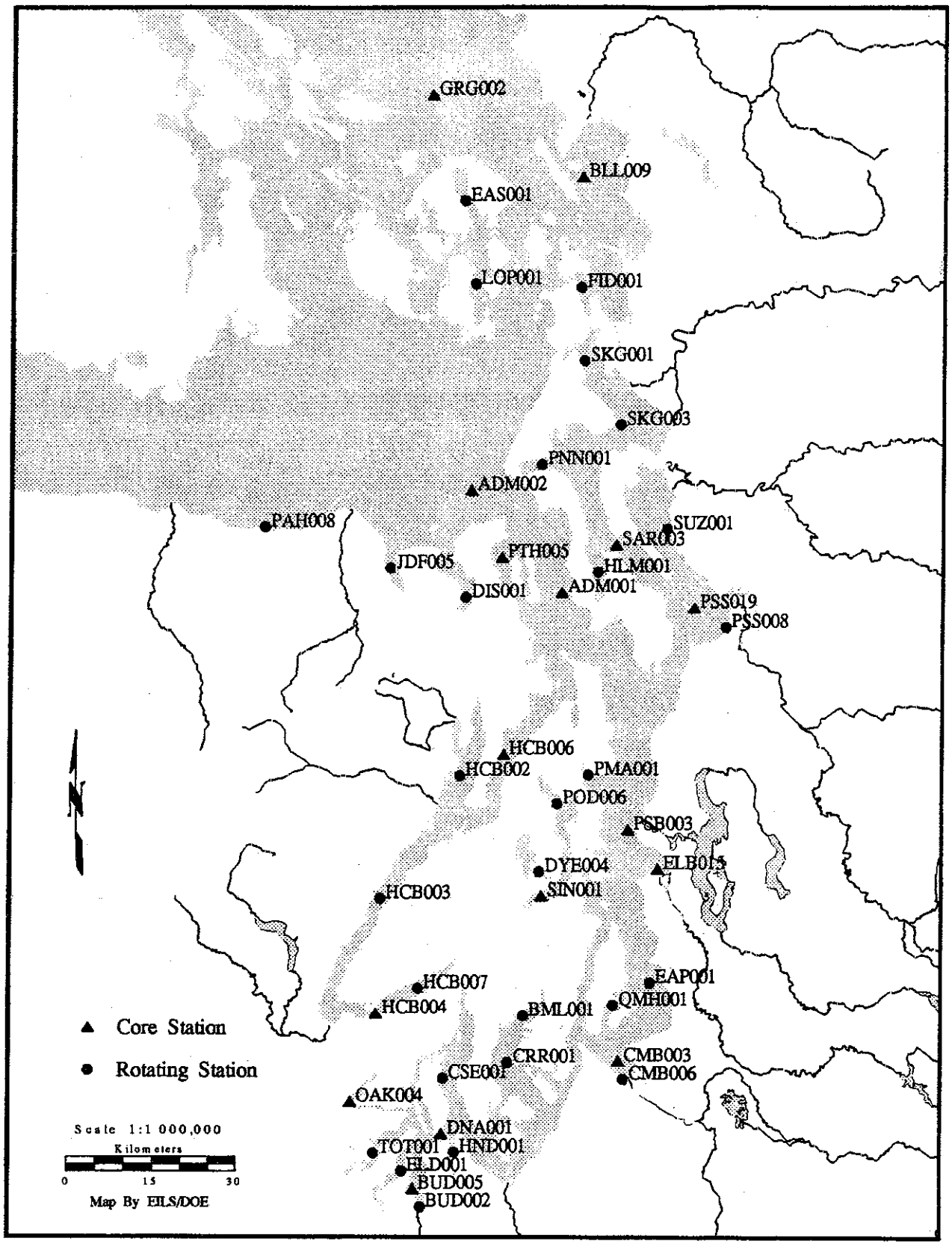

Figure 1 Locations of the long-term core and rotating stations for the Washington State Department of Ecology's Marine Water Monitoring in Puget Sound

Table 1. Waterbodies relevant to the Kitsap watershed. Also shown are the Marine Waters Monitoring stations located within the waterbody.

Segment #	Waterbody Name	Class	MWM Station (current)	MWM Station (historical)
WA-15-0010	Port Madison	AA	PMA001	
WA-15-0020	Eagle Harbor	AA	*none*	
WA-15-0030	Port Orchard/Agate Passage/Rich Passage	AA	*none*	POD005
WA-15-0040	Sinclair Inlet	A	SIN001	
WA-15-0050	Dyes Inlet/Port Washington Narrows	A	DYE004	DYE002, DYE003
WA-15-0060	Carr Inlet	AA	CRR001	
WA-15-0070	Henderson Bay	AA	BML001	
WA-15-0080	Port Gamble Bay	A	*none*	
WA-15-0100	Liberty Bay	AA	POD006	POD004
WA-15-0120	Quartermaster Harbor	AA	QMH001	
WA-15-0130	Hale Passage	AA	*none*	
WA-PS-0070	Tacoma Narrows	AA	*none*	NRR001
WA-PS-0090	Case Inlet	AA	CSE001	CSE002
WA-PS-0100	Hood Canal (North)	AA	HCB006	
WA-PS-0240	Puget Sound (Central)	AA	PSB003	
WA-PS-0250	Hood Canal (South)	AA	HCB003	
WA-PS-0260	Great Bend/Lynch Cove	AA	HCB004, HCB007	
WA-PS-0270	Puget Sound (S. Central) and East Passage	AA	EAP001	STL001
WA-PS-0290	Nisqually Reach/Drayton Passage	AA	*none*	NSQ001, NSQ002

Table 2. Marine Waters Monitoring data availability in WRIA #15, Kitsap. Station data available for current and historical stations. An "X" denotes monthly data in Ecology's Ambient Monitoring database and in US EPA Storet for the listed wateryear. Some wateryear records are incomplete due to missed surveys or isolated sampling events; sampling during winter months did not commence until WY1989. Station type: "C"=core; "R"=rotating (3 y rotation); blank = historical, not currently sampled.

Station Number	Station Name	Station Type	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Burley-Minter Lagoon																										
BML001	Burley-Minter Lagoon	R																X	X	X	X					x
Carr Inlet																										
CRR001	Off Green Point	R					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			x
Case Inlet																										
CSE001	S. Heron Island	R						X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			x
CSE002	Off Rocky Point																				X					
Dyes Inlet																										
DYE002	Windy Point					X																				
DYE003	Wash. Narrows		X	X		X		X	X	X	X	X	X	X	X	X	X	X								
DYE004	NE of Chico Bay	R																				X			X	
East Passage																										
EAP001	SW of Three Tree Point	R																X	X	X	X				X	
Hood Canal																										
HCB003	Eldon, Hamma Hamma R.	R					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	x
HCB004	Gt. Bend, Sisters Point	C				X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	x
HCB006	King Spit, Bangor	C				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	x
HCB007	Lynch Cove	R																			X	X	X	X	X	x
Nisqually Reach																										
NSQ001	Nisqually R. Delta						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
NSQ002	Devils Head														X											
Port Madison																										
PMA001	S. of Buoy 65	R																			X	X			X	
Port Orchard																										
POD004	Liberty Bay, Poulsbo					X																				
POD005	Brownsville					X		X	X	X	X	X	X	X	X	X	X	X								
POD006	Liberty Bay, Virg. Point	R						X	X	X	X	X	X	X	X	X	X	X				X			X	
Puget Sound Main Basin / Lk Wash. Ship Canal																										
PSB003	West Point	C					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	x
Quartermaster Harbor - Vashon Island																										
QMH001	Burton	R																				X			X	
Sinclair Inlet																										
SIN001	Naval Shipyards	C	X	X		X		X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	x
Steilacoom																										
STL001	Off Chambers Creek																				X	X				
Tacoma Narrows																										
NRR001	Point Defiance						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					

Table 3. Data parameters available for Marine Waters Monitoring stations. The database field name, US EPA STORET parameter code, units, and parameter name are listed below. Not all parameters are sampled at every station. Typically, parameter values are available at 0.5, 10, and 30 m (exceptions are fecal (0.1 m), pigments (0.5, 10 m), Secchi disk depth, and stations shallower than 30 m).

Dbase Field	P Code	Units	Parameter Name	
Physical parameters:				
TEMP	P10	°C	temperature* (also contains stn #, date, time, and depth)	
SALIN1	P480	ppt	salinity*†	(Oct 1986 - present)
SALIN2	P70305	mg/L	salinity†	(1973 - Sep 1986)
COND	P95	µmhos	specific conductivity	
light:				
SECCHI	P78	m	Secchi disk depth	
TRANSMIS	P74	%	percent light transmission	(via transmissometer)
Chemical parameters:				
OXYGEN	P300	mg/L	dissolved oxygen*	
PCTSAT	P301	%	percent oxygen saturation	
PH	P400	units	pH*	
nutrients‡:				
NH3_DIS	P608	mg/L	dissolved ammonium-N	(Oct 1990 - present)
NH3_N	P610	mg/L	total ammonium-N	(1973 - Sep 1990)
NO2_DIS	P613	mg/L	dissolved nitrite-N	(Oct 1990 - present)
NO2_N	P615	mg/L	total nitrite-N	(1973 - Sep 1990)
NO23_DIS	P631	mg/L	dissolved nitrate + nitrite-N	(Oct 1990 - present)
NO2_NO3	P630	mg/L	total nitrate + nitrite-N	(1973 - Sep 1990)
NO3_N	P620	mg/L	total nitrate-N	(1973 - Sep 1990)
OP_DIS	P671	mg/L	dissolved ortho-P	(Oct 1990 - present)
OP_TOT	P70507	mg/L	total ortho-P	(1973 - Sep 1990)
TP_P	P665	mg/L	total P	(1973 - Sep 1990)
pigments:				
CHL	P32211	µg/L	chlorophyll *a*	(extracted fluorescence)
PHEO	P32218	µg/L	phaeopigment	" "
Biological parameters:				
FC	P31616	#/100 mL	fecal coliform bacteria	(membrane filter method)

NOTES:

*Since Nov 1989, *in situ* CTD sensors have been used to obtain depth, temperature, salinity, light transmission, DO, and pH data. Prior to Nov 1989, these data were obtained using a variety of methods, except for light transmission which was not measured. Information on sensors and methods used is available upon request.

†Salinity was measured: via conductance using a CTD from Nov 1989 - present;
via refractometer from 1987 - Oct 1989;
and via titration from 1973 - 1987

‡Nutrients were sampled for dissolved rather than total concentrations beginning in Oct 1990. Samples for dissolved nutrient concentrations are filtered through 0.45 µm pore size cellulose filters. As of June 1992, dissolved nitrite-N has been determined in three urban embayments only (Bellingham Bay, Budd Inlet, Commencement Bay).

loading, alteration of habitat, freshwater diversion); and 2) a long residence time (poor flushing of water) Residence times are influenced by natural bathymetry, tidal forcing and circulation Simply stated, water quality problems become notable when input sources are significant or when removal mechanisms are slow However, in evaluating water quality, the natural water quality for that area must be considered Natural water quality does not always follow the WAC (1992) criteria; thus, knowledge of the environmental mechanisms affecting the various parameters is required Because information on pre-anthropogenic influence water quality can be limited to non-existent, this evaluation can be difficult

Problems and Data Gaps

Known water quality problems and concerns for the Kitsap MWM stations are listed in Table 4 Many of the Kitsap Section 303 (d) listings were for toxics and were based on data not collected by MWM Note that water-column toxics are not monitored by MWM

In addition, there are many areas in the Kitsap Basin where no monitoring stations exist and others where data records are scant Areas where the physical and hydrological set-up are conducive to water quality problems, yet where no or insufficient data exist are numerous Small constricted embayments, such as Miller Bay, Vaughn Bay, Burley Lagoon, Wollochet Bay, Van Geldern Cove, may develop water quality problems easily if anthropogenic inputs occur Other larger areas where water quality problems may be suspected are Nisqually, Port Gamble Bay, Eagle Harbor, and Henderson Bay MWM stations are located in the central portion of the bays; the heads of many of the monitored bays may be prone to poor flushing and often have been found to exhibit worse water quality than at the MWM station (e g , Eisner et al , 1994; Albertson et al , 1995)

Fecal Coliform Bacteria

As shown in Table 4, fecal coliform contamination has been recorded at Sinclair Inlet, Dyes Inlet/Washington Narrows, Carr Inlet, Henderson Bay, Liberty Bay, Case Inlet, central Puget Sound (off West Point), South Hood Canal, Lynch Cove, East Passage, and Nisqually Areas where fecal contamination could be a concern would be enclosed and poorly flushed inlets, bays, and harbors with anthropogenic input Natural sources (harbor seals, sea lions) can also contribute to the recorded fecal coliform concentrations however, from analysis of occupation patterns (temporally and spatially) these cannot solely account for the excursions observed

Of the areas listed above, those with chronically high fecal coliform excursions (>25% of observations) based on MWM data are Nisqually (NSQ001), starting sharply in 1989 through last data taken in 1991, and Washington Narrows (DYE003), starting sharply in 1980 through 1985 (last data taken 1988) Occasional (~10% of observations) high counts were recorded at Liberty Bay (POD005), Sinclair Inlet (SIN001), Henderson Inlet (BML001), and a Puget Sound Main Basin station (PSB003) The Sinclair station was incorrectly omitted from the 303 (d) listing due to an error in the criteria for water quality

Table 4. Summary of marine water quality issues in Kitsap watershed. Includes WRIA #15 and other PS segments.

Segment #	Area Name	Water Quality Issues	
		1996 Section 303 (d) listing	Other water quality concerns/observations
WA-15-0010	Port Madison	--	--
WA-15-0020	Eagle Harbor	Toxics (PAHs, Naphthalene, Fluoranthene, Acenaphthalene, Phenanthrene, Anthracene, Fluorene, PCB-1254, Benzo (a) pyrene, Benz (a) anthracene, Chrysene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Dibenzo (a,h) anthracene, Indeno (1,2,3-cd) pyrene)	No data on which to evaluate DO, fecals, nutrient loading, phytoplankton species.
WA-15-0030	Port Orchard/Agate Passage/Rich Passage	Toxics (PCBs) DO *@ POD005*	Only data is at Brownsville (POD005) and none since 1987.
WA-15-0040	Sinclair Inlet	Toxics (PCBs, Phenol, 2,4-Dimethyl phenol, Phenanthrene, Fuoroanthene, Indeno (1,2,3-c,d) pyrene, Benzo (g,h,i) perylene, Bis (2-ethyl hexyl) phthalate, Benzoic acid, Benz (z) anthracene, Chrysene, 1,4-Dichlorobenzene, Bytyl benzyl phthalate, 4-Methylphenol, Aldrin, Dieldrin) Metals (Mercury, Arsenic, Cadmium, Copper, Lead, Zinc)	Low DO occasionally in inner Sinclair Inlet during 1992 study noted by Albertson et al. (1995). Not noted in central inlet at SIN001 when sampled simultaneously. Frequent and numerous jellyfish medusa with reproductive mutations during 1992 study noted by Albertson et al. (1995). Very high fecals (100's org./100 mL) noted at SIN001.
WA-15-0050	Dyes Inlet/Port Washington Narrows	Toxics (PCBs, Bis(2-ethylhexyl Phthalate, Phenol, 3,3'-dichlorobenzidine, Benz (a) anthracene, Benzo (b) fluoranthene, Chrysene, Pentachlorophenol) Metals (Cadmium, Mercury, Silver, Antimony, Arsenic) Fecal Coliform	Very high fecals (100's org./100 mL) noted in early 1980's at Washington Narrows (DYE003, no longer monitored); low numbers seen NE of Chico Point (DYE004).
WA-15-0060	Carr Inlet	DO *@ CRR001* Fecal Coliform	Low DO also noted in 1954 (Collias et al., 1975), however, values not as low as current values at CRR001.
WA-15-0070	Henderson Bay	Fecal Coliform	Few data from Burley-Minter Lagoon (BML001); shows some fecal excursions. Presently monitoring in 1996.
WA-15-0080	Port Gamble Bay	Toxics (PCBs, Dieldrin)	No data on which to evaluate DO, fecals, nutrient loading.
WA-15-0100	Liberty Bay	Toxics (PCBs, Bis (2-ethylhexyl) phthalate, Benxoic acid, Phenol, 4-Methyl phenol) Fecal Coliform	Fecal excursions seen at Virginia Point (POD006). Only 1974 data from Poulsbo (POD004).
WA-15-0120	Quartermaster Harbor	Toxics (PCBs, Dieldrin)	Toxic phytoplankton often observed; PSP observed annually (Dr. R. Horner, UW, pers. comm.).
WA-15-0130	Hale Passage	--	No data, but likely well mixed.

Table 4 (continued.)

Segment #	Area Name	Water Quality Issues	
		1996 Section 303 (d) listing	Other water quality concerns/observations
WA-PS-0070	Tacoma Narrows	Toxics (PCBs, Dieldrin)	Naturally low DO (~6 mg/L) seen at NRR001 due to upwelling.
WA-PS-0090	Case Inlet	DO *@ CSE001* pH Fecal Coliform	Low DO also noted in 1959 (Collias et al., 1975), however, values not as low as current values at CSE001.
WA-PS-0100	Hood Canal (North)	Toxics (Acenaphthalene, Anthracene, Benz (a) anthracene, Benzo (a) pyrene, Total Benzo fluoranthenes, Benzo (g, h, I) perylene, Chrysene, Fluoranthene, Indeno (1,2,3-c,d) pyrene, Phenanthrene, Pyrene, 4-Methylphenol, Pentachlorophenol, Dibenzo (a, h) anthracene, Bis (2-ethylhexyl) phthalate) Metals (Copper, Lead, Mercury, Zinc)	Naturally low DO (4-5 mg/L) seen at HCB006 in late summer due to high productivity and upwelling.
WA-PS-0240	Puget Sound (Central)	Fecal Coliform *@ PSB003*	Naturally low DO (~6 mg/L) seen at PSB003 due to upwelling.
WA-PS-0250	Hood Canal (South)	Fecal Coliform	Naturally very low DO (2-3 mg/L) seen at HCB003 in late summer due to high productivity, upwelling, and reduced circulation.
WA-PS-0260	Great Bend/Lynch Cove	DO *@ HCB004, HCB007* pH *@ HCB004, HCB007* Fecal Coliform	Naturally low DO's, as above, but anthropogenic influence apparent. Similar conditions noted in 1954 (Collias et al., 1975) but seasonal extent longer now (includes Jan-Apr). DO's <2 mg/L observed July-Sep; <1 mg/L in July '96. Low pH cause not known but also observed by Mason County.
WA-PS-0270	Puget Sound (S. Central) and East Passage	Ammonia-N Fecal Coliform *@ EAP001*	Naturally low DO (~6 mg/L) seen at EAP001 due to upwelling.
WA-PS-0290	Nisqually Reach/Drayton Passage	Fecal Coliform *@ NSQ001*	Onset of high fecals (15-60 org./100 mL) during 1988-1991; not monitored since 1991.

limited waters (S Butkus, Ecology, pers comm) The fecal excursions in the Main Basin off West Point (PSB003) are intriguing Typically, the deep, well-mixed waters in large basins do not show fecal excursions (e g , ADM001, ADM002) The proximity of a METRO outfall, beaches, outflow from the Hiram Chittenden locks, and failing septics should be considered as possible sources for the excursions at PSB003 Less frequent excursions were in East Passage (EAP001), also representing a large basin water mass While MWM found only one excursion at this open water station, Metro lists multiple excursions at their more nearshore stations

Any semi-enclosed area with attributes such as freshwater input, failing septics, or wastewater treatment plants would be likely to have fecal contamination MWM monitoring data are lacking from many Kitsap areas such as Eagle Harbor, Port Gamble, and Port Orchard Also, the nearshore areas of many of the inlets may have fecal contamination when mid-bay monitoring stations do not, as was shown by the data from Carr and Case Inlets (Table 4) Because of the relatively short lifetime of fecal coliform bacteria in saline water (Lessard and Sieburth, 1983), mid-bay monitoring (e g , MWM stations) is not well-suited to detecting fecal contamination

Dissolved Oxygen

Although the DO standard for class AA and A waters is set at 7 0 and 6 0 mg/L, respectively, (WAC, 1992) the natural DO concentrations of many Puget Sound waters will be lower This is because the oceanic waters flowing into the region through the Strait of Juan de Fuca are upwelled Pacific Ocean waters that can have naturally low (i e , between 5 and 7 mg/L) DO concentrations, primarily in late summer Thus, DO excursions below 7 mg/L but above 5 mg/L are to be expected Natural phytoplankton production also results in low near-bottom DO concentrations, through the oxidation of sunken organic material Near-bottom DO concentrations are increased when mixed with oxygenated surface waters Strong density stratification (e g , in areas with freshwater input) inhibits mixing and results in maintaining low DO in near-bottom waters Thus, areas in Puget Sound with high production and strong density stratification can naturally have DO concentrations less than 5 mg/L in late summer because of these compounding effects

In order to assess eutrophication and its impact on low DO concentrations, it is important to consider historical data The areas on the 303 (d) listing, Hood Canal, Port Orchard, Carr Inlet and Case Inlet, all showed DO concentrations that were lower or low for longer periods of time than that showed in a historical database from the University of Washington, covering 1952-1966 (Collias et al , 1974) Of these, low DO is of strongest concern in Hood Canal The lowest DO recorded at a long-term MWM station was at HCB004 in southern Hood Canal, where concentrations were less than 1 mg/L Eutrophication processes and changes in circulation due to freshwater diversion are possible causes for the low DO (Newton et al , 1995) and were addressed in a focused monitoring project conducted in 1994-5 (Newton, 1995) Analysis is not complete for

that project, however production experiments clearly show phytoplankton growth to be stimulated by exogenous nutrients

In another focused project, monitoring data from Sinclair Inlet showed DO to be much lower at the head of the inlet than in the centrally located long-term monitoring station (SIN001; Alberston et al., 1995). This same pattern has been found in all other areas studied by MWM (Budd Inlet, Sequim Bay, Hood Canal). Hypoxia may be a significant problem in the headwaters of many of the Kitsap bays/inlets that would not be revealed by the MWM monitoring stations. Inner Sinclair/Dyes Inlets, Case Inlet, Carr Inlet, Liberty Bay, Eagle Harbor, Port Orchard, and Port Gamble are all possible candidates for this condition

Nutrients

As shown in Table 4, in S Central Puget Sound, ammonia-N concentrations were found by Kendra (1989) in exceedance off a freshwater creek at Fauntleroy Cove This occurrence did not originate in the Kitsap watershed and was likely localized

Eutrophication will have serious impacts in areas where flushing is low and where phytoplankton growth is nutrient limited. In well-mixed areas, phytoplankton are more typically light-limited since they are mixed below the euphotic zone Differentiating natural levels of primary production from those stimulated by exogenous nutrients is difficult It is important to assess suspected nutrient sources and to compare DO concentrations with historical levels The areas where eutrophication may be problematic are those discussed in the DO section, notably Hood Canal, Port Orchard, and Carr Inlet Other smaller areas may not show low DO concentrations because their shallower waters are mixed by wind yet still experience significant nutrient input, such as Henderson Bay, Eagle Harbor, and Dyes Inlet. The impact of complex organic forms of nutrients contained in anthropogenic inputs on phytoplankton species composition is recently gaining attention, thus eutrophication can lead to problems besides low DO

Toxics

As is highly evident in Table 4, many of the 303 (d) listings in Kitsap are from exceedances in toxic organic compounds and metals Because these analyses are expensive and because concentrations often are quite dilute in the water-column, instead sequestering to sediments, monitoring of toxics is not routinely conducted by MWM However, two notable areas in Kitsap, Sinclair Inlet and Eagle Harbor, are sites where significant chemical contamination occurs Very high levels of mercury and PCB's were recently found in rockfish from Sinclair (J. West/S O'Neill, WDFW, pers. comm.). Lacking is information on to what degree this contamination is historical (e.g., in sediments) or current (e.g., still mobile in water column and taken up by plankton) A student intern with MWM from The Evergreen State College under guidance of Dr. K.V. Ladd found significant levels of copper, zinc and nickel in net plankton from Sinclair Inlet

during spring 1996 (R. Upson, TESC, student paper). The medusae with reproductive mutations observed in 1992 (Albertson et al., 1995) also indicate on-going contamination, although this could be gained through their benthic phase.

Harmful Phytoplankton Species

The occurrence of harmful or toxic phytoplankton in these waters is not well-documented, though outbreaks have occurred. To some extent the lack of data on harmful phytoplankton occurrence indicates a lack of outbreaks, but it also indicates a lack of monitoring.

Quartermaster Harbor is a known site for Paralytic Shellfish Poisoning outbreaks due to blooms of the dinoflagellate species (*Alexandrium* spp.) that produce saxitoxin. Occurrence of PSP in Quartermaster Harbor seems to be happening reliably every year (Dr. R. Horner, UW, pers. comm.).

Other observations of harmful phytoplankton in the Kitsap areas include a diatom species (*Pseudonitzschia* spp.) that causes Amnesiatic Shellfish Poisoning in Hood Canal and a flagellate (*Heterosigma carterae*) that causes fish kills in Liberty Bay. The stimuli for blooms of harmful phytoplankton are not understood. Monitoring of phytoplankton species, to be effective, must be done frequently and accompanied by other environmental variables.

Recommendations

Any semi-enclosed area with attributes such as freshwater input, failing septic systems, or wastewater treatment plants would be likely to have fecal contamination. Evaluating the formerly mentioned attributes in the un-monitored areas is recommended in order to establish priorities for monitoring.

Within the Puget Sound Ambient Monitoring Program, better coordination between the Department of Health, Metro and Ecology and better coverage for fecal coliform monitoring in Puget Sound needs to occur.

Assessment of nutrient sources to Hood Canal (especially southern) is recommended.

Assessing water quality, especially DO, at the heads of inlets/bays is a critical need presently not addressed.

Comparing nutrient concentrations is not recommended, since phytoplankton uptake is rapid; however, analysis of nutrient ratios can be insightful since ammonium-N, in short supply naturally (0.03 mg/L in Admiralty Inlet), often is indicative of anthropogenic input.

To assess eutrophication, it is recommended to assess nutrient trends in freshwater inputs, where failing septics may occur, and where other exogenous nutrient sources are significant.

The degree of on-going versus historical chemical contamination and its availability in the water column and to plankton needs to be assessed. New technology (semi-permeable membrane devices) and/or mussel cages with tissue analysis would yield this information readily.

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River and Stream Ambient Monitoring

by

Brad Hopkins (water quality) and Rob Plotnikoff (biology)
Ambient Monitoring Section

Water Quality

The Ambient Freshwater Unit has collected no monthly water quality information over the last ten years from the Kitsap Water Quality Management Area (WQMA) Historical information on Chico Creek and the Dewatto River dating back to the late sixties to mid-seventies is available The only recent water quality information gathered by the Ambient Freshwater Unit was metals data on Clear Creek for May and September 1994 (Hopkins, 1995) Clear Creek was considered for listing in the 1994 303(d) List for potentially elevated metals The low metal concentrations found in the two samples collected in 1994 resulted in Clear Creek being removed from consideration for the 1994 303 (d) list

Biology

Two sites were surveyed for stream biology in the Kitsap WQMA Tahuya River biota reflected a high quality stream environment A distinct number of collected invertebrate species were characteristic of good stream quality conditions; well-oxygenated, cold water Environmental variables important for interpreting condition of the macroinvertebrate assemblages were: pH, dissolved oxygen, conductivity, and gradient

Seabeck Creek biologically reflected moderate stream quality Land development further upstream and riparian alteration influenced stream biota Introduction of nutrients and suspended particulates was indicated by the invertebrate assemblage and interpreted as moderate water quality degradation Stabilization of stream banks with riparian vegetation and limited activity in riparian areas would reduce introduction of suspended particulates and nutrient concentrations

Recommendations

Considering the glaring deficiency of recent water quality information within the Kitsap WQMA, the highest priority for monitoring should be given to basin stations that reflect ambient conditions The following rivers and streams should be considered for future monitoring:

1 Tahuya River
2 Dewatto River
3 Clear Creek
4 Chico Creek
5 Open

Future biological monitoring should concentrate on reference conditions at Tahuya River and Dewatto River. Other streams with more severe degradation than those already surveyed should be identified. A broader continuum of stream conditions should be surveyed to better represent the range of land use impacts on stream reaches. Biological response to stream alterations can then be used to develop aquatic life expectations for this WQMA.

References

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Lake Ambient Monitoring

by

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Ambient Monitoring Section

Water Quality

Kitsap County is one of the fastest growing counties in the state. Consequently, many of its waterbodies have been impacted by the increased construction activities within the watersheds. According to the 1994 305(b) report, Tiger Lake was listed as the number one lake in the state in need of protection. In the same report, Wye Lake was listed as the number one lake in the state in need of management of eutrophication. Long and Mission Lakes also ranked high on the same list as Wye Lake. Table 5 lists the lakes monitored as part of Ecology's Lake Water Quality Assessment Program (LWQA) and the years they were monitored.

Table 5. Lakes monitored as part of Ecology's Lake Water Quality Assessment Program and the corresponding year they were monitored

Lake	WY89	WY90	WY91	WY92	WY93	WY94	WY95	WY96
Tiger	VE				V	V	V	V
Wooten	VE	V	V	V	V	V	V	V
Long	V	V	V	V	V	V	V	V
Kitsap	V	VE		V	V			
Haven								V
Mission		V	V	V	V		V	
Horseshoe							V	V
Wye					V	V	V	V
Buck					V			
Florence					E			
Wildcat						V	V	V

V = Monitored by volunteers
E = Monitored by Ecology
VE = Monitored by a volunteer and also independently by an Ecology employee.

Overall Lake Assessment

The following are excerpts from individual lake sections within the Lake Water Quality Assessment Program report for 1994 (Smith and Rector, In Prep).

Buck Lake -- Kitsap County

Buck Lake is located 1 5 miles southwest of Hansville It has no surface inlets, and seeps to Puget Sound Water clarity in Buck Lake was fair in 1994, but was not as good as in 1993 Despite high concentrations of total phosphorus, chlorophyll *a* concentrations and Secchi depths indicate that there was only a moderately high amount of algae in the water when the lake was sampled Dissolved oxygen concentrations were low below the thermocline, which is not unusual for a lake with moderate to high amounts of aquatic plants The high total phosphorus concentrations, moderately high amounts of plants and algae, and moderately low Secchi depths, indicate that Buck Lake was meso-eutrophic in 1994 Because most of Buck Lake's watershed is forested, and the only development near shore is a local park, Buck Lake is a good example of a naturally eutrophying lake Much of Buck Lake's shore is wetlands, and the volunteers reported that the area is used by a variety of wildlife Despite the trophic state assigned to the lake, "restoring" the lake to enhance recreational uses may not be warranted

Long Lake -- Kitsap County

Long Lake is located 3 5 miles southeast of Port Orchard It is two miles long The lake is fed principally by Salmonberry Creek, and drains via Curley Creek to Yukon Harbor Compared to previous years, water quality in Long Lake was good in 1994 From 1989 through 1994, the pattern of Secchi depths shows that water clarity is generally lowest during August However, there was no trend in water clarity from 1989 through 1994 This was tested using a seasonal Kendall test for trend, and results were not statistically significant at the 80% level ($p = 0\ 68$) Considering results from all three major trophic state parameters (total phosphorus, chlorophyll *a*, and Secchi depths), Long Lake was classified as eutrophic in 1994 However, concentrations of total phosphorus, total nitrogen, and chlorophyll *a* (which indicates the amount of algae in the water) were considerably lower in 1994 than in 1993 This suggests that the water quality was better in 1994 than in 1993, although it may take several years of data collection to determine if this is part of an improving trend in water quality

Tiger Lake -- Kitsap/Mason Counties

Tiger Lake is located 9 5 miles southwest of Bremerton Most of the lake (102 8 acres) is in Mason County, and the northern tip of the lake (6 3 acres) is in Kitsap County Tiger Lake has no surface inlets, and drains via Mission Creek to Hood Canal The water quality of Tiger Lake was good in 1994 Secchi depths were somewhat deeper in 1994 than in 1993 Despite a moderately high concentration of total phosphorus during the May survey, Secchi depths and chlorophyll concentrations indicate that there was a low amount of algae when the lake was

sampled. Total nitrogen concentrations were very low. Considering low nutrient concentrations, low algal growth, and good water clarity, Tiger Lake was classified as oligotrophic in 1994

Wildcat Lake -- Kitsap County

Wildcat Lake is located six miles northwest of Bremerton. It is fed by two inlets, and drains via Wildcat Creek to Dyes Inlet. Wildcat Lake had good water quality in 1994. Secchi depths were deep, indicating good water clarity. Concentrations of total phosphorus and total nitrogen were low when the lake was sampled in August. The concentration of chlorophyll *a*, which indicates the amount of algae in the water, was also low in the area that was sampled. Profile data show that concentrations of dissolved oxygen were very low below the thermocline. Low oxygen concentrations near the lake bottom are not unusual for most lakes; algae and aquatic plants decompose near the lake bottom, and the decomposition process removes oxygen from the water. However, the dissolved oxygen concentrations in Wildcat were very low throughout the entire lower layer of water. When the lake was last sampled in 1974, oxygen concentrations were also very low, so this probably has occurred for many years in Wildcat Lake. Considering good water clarity, low nutrient concentrations, a moderate amount of aquatic plants yet very low hypolimnetic oxygen concentrations, Wildcat Lake was classified as oligo-mesotrophic in 1994

Lake Wooten -- Mason County

Lake Wooten is located seven miles west of Belfair. The lake has no inlet and drains to Haven Lake and the Tahuya River. Secchi depths have been measured in Lake Wooten each year since 1989. During most years, the Secchi depths decreased gradually from May through October. Lake Wooten is the only lake in the program that consistently showed this pattern. Although Secchi depths decreased an average of 1.5% annually since 1989, this was not statistically significant at the 80% level using the seasonal Kendall test for trend ($p = 0.94$). Considering results from all three major trophic state parameters (total phosphorus, chlorophyll *a*, and Secchi depths), as well as a sparse community of aquatic plants, Lake Wooten was classified as oligotrophic in 1994.

Wye Lake -- Kitsap County

Wye Lake is located 3.5 miles southeast of Belfair. It is fed by about six intermittent inlets, and drains via an unnamed creek to Fern Lake, Rocky Creek, and ultimately to Case Inlet. Wye Lake had good water quality in 1994, despite its shallow depth and high concentrations of total phosphorus. Water clarity was very good, and the lake bottom could be seen throughout most of the monitoring season. Profile data did not change much from surface to bottom, because the lake is so shallow. Both volunteer-collected data and profile data collected during the field surveys show that water temperature in 1994 was very warm. Considering good water clarity, low algal concentrations and

moderately low populations of aquatic plants, Wye Lake was classified as mesotrophic in 1994.

Other Lakes

Additionally, Kitsap Lake and Mission Lake were sampled in 1993. Both were categorized as mesotrophic. Kitsap Lake is on the 303(d) list due to excessive phosphorus loading. Haven Lake was just recently added to the LWQA Program and no data are yet available.

Aquatic Plants

Kitsap County is trying to organize a lake program to include the 14 public access lakes. One of the main focuses of this group is aquatic plants. Planning is still in the conceptual phase. Table 7 lists the waterbodies surveyed for plants and the corresponding years they were surveyed. Table 8 lists the waterbodies with aquatic plants listed as weeds with the State Noxious Weed Control Board.

Table 6. Waterbodies that have been surveyed for aquatic plants

County	Waterbody Name	Date
Kitsap	Kitsap Lake	8/3/95
Kitsap	Long Lake	3/17/95
Kitsap	Long Lake	9/12/94
Kitsap	Panther Lake	8/2/95
Kitsap	Wildcat Lake	10/4/95
Mason	Devereaux Lk	8/16/94
Mason	Haven Lake	8/16/94
Mason	Wooten Lake	8/16/94
Pierce	Bay Lake	9/28/95

Table 7. Waterbodies with aquatic plants listed as weeds with the State Noxious Weed Control Board

Long Lake, Kitsap County	*Egeria densa* (Brazilian elodea)
	Myriophyllum spicatum (Eurasian milfoil)
	Lythrum salicaria (purple loosestrife)

Recommendations

It is recommended that many additional lakes in this WQMA be added to the LWQA Program in order to monitor trends through the coming years and to assist in detecting serious degradation events should they occur.

Additional lakes in the basin should be surveyed for aquatic plants. Though Long Lake is the only lake known to support noxious plants in the area, there are other populations in southern Mason County and nearby Jefferson County. It is important to monitor areas where these plants have not yet become established to catch populations in the early stages of invasion. Long Lake should also be monitored every few years to note any changes in the plant community over time.

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Watershed Assessments

by

Robert Cusimano
Watershed Assessments Section

Introduction

Since 1986 the Watershed Assessments Section (WAS) has only conducted one water quality study in the Kitsap WQMA, which examined the Burley and Minter Creek watersheds (Dickes and Patterson, 1994). However, Hood Canal and Sinclair and Dyes Inlets have been monitored by the Toxics Investigations and Ambient Monitoring Sections and are of interest with respect to possible watershed assessment issues (Newton *et al*., 1995; Albertson *et al*., 1995; Cubbage, 1995). The following are summaries of these studies and the water quality issues associated with each water body.

Waterbody Summaries

Burley and Minter Creek Watersheds

In 1981, the commercial oyster beds in Burley Lagoon were reclassified from Approved to Restricted. In 1982, Minter Bay was reclassified from Approved to Prohibited. Data collected by the Department of Health and United States Food and Drug Administration documented levels of fecal coliform bacteria (FC) which exceeded the National Shellfish Sanitation Program standards for Approved commercial shellfish areas. Nonpoint pollution has been suspected to be the major cause of increased FC concentrations and the resulting shellfish harvest restrictions.

Water quality studies completed in the early and mid-1980s showed freshwater tributaries to be the primary source of FC to the estuarine shellfish growing areas. The sources in the drainages were identified as failing on-site sewage systems, livestock sources from small farms, and, in general, stormwater runoff. After five years of watershed management and restoration efforts, the Bremerton-Kitsap County Health Department conducted a water quality study in both Burley and Minter Creek watersheds and found that water quality in the area had not improved significantly since 1983, except for Bear Creek. Improvements in Bear Creek were likely the result of intensive implementation of livestock best management practices (BMPs) and on-site septic system repairs.

Violations of the FC Class AA standard were found throughout the Burley Creek watershed by WAS in 1992-93 sampling surveys. The lower reach of Burley Creek just upstream from the lagoon was found to be of particular poor quality (i.e., both parts of the FC standard were violated). The water quality standard for FC was exceeded on the mainstem of Bear Creek. Rain events were found to elevate FC and TSS concentrations throughout the watershed.

Violations of the FC Class AA standard were also identified throughout the Minter Creek watershed. Again, concentrations were particularly high during rain events.
When compared to earlier studies, the 1992-93 survey data showed that the mean FC levels in Burley Creek had increased at some sites or had not changed at others, except in upper Purdy Creek where no reasons for the decrease in FC levels could be identified.
The mean FC levels in Minter Creek were found to be significantly higher at some sites or showed no improvement at other sites from earlier studies.

Although there has been concentrated effort to implement agricultural BMPs in the Burley and Minter Creek watersheds over the last ten-year period, Dickes and Patterson did not find significant improvements in water quality. They suggested that remedial efforts in the watershed may only be slowing the water quality degradation rate caused by growth and development.

Hood Canal

The Ambient Monitoring Section is currently evaluating the extent of low dissolved oxygen and the potential adverse effects of nutrient enrichment in Hood Canal. Based on preliminary results, a possible change in the historical water quality of the canal is indicated. Although this work is summarized in the ambient section briefing paper, it is relevant to watershed assessment issues and projects designed to quantify the impacts of loading of BOD and nutrients from point and nonpoint sources to Hood Canal.

Sinclair and Dyes Inlets

The Ambient Monitoring Section has also examined the general water quality characteristics of Sinclair and Dyes Inlets and defined some of the physical characteristics associated with the area. In addition, the Toxics Investigations Section has documented chemicals in storm drains and outfalls discharging to these inlets (see page 34). As with Hood Canal, these studies are relevant to watershed assessments because they have identified issues which may need to be examined with respect to projects designed to quantify the loading, transport, and fate of pollutants from the watershed.

The ambient monitoring data suggest that inner Sinclair Inlet has high phytoplankton abundance and sometimes low dissolved oxygen, which suggest it may be sensitive to eutrophication. The toxics data show that sediments associated with some storm drain

discharges to Sinclair Inlet have elevated concentrations of a number of toxic substances (e g., PCBs, PAHs, toluene, etc.).

In addition to Ecology studies in this area, the Sinclair Inlet Watershed Action Plan (SIWAC, 1993) prepared for the Sinclair Inlet Watershed Management Committee, contains a water quality assessment for the area. They identify high FC concentrations as of concern in both the marine and some freshwaters in the Sinclair Inlet watershed. The high FC concentrations are attributed to nonpoint pollution in the watershed. Freshwater streams of major concern are Beaver Creek, Blackjack Creek, and Gorst Creek. In addition, they cited studies which show high levels of some toxic substances such as PCBs, mercury, chromium, and tributyl tin found in some marine sediments.

The Dyes Inlet Watershed Action Plan (DICCWAC, 1992) prepared by the Dyes Inlet/Clear Creek Watershed Management Committee, contains a water quality assessment for the area. They identify high FC concentrations as of concern in both the marine and some freshwaters in the Dyes Inlet watershed. The high FC concentrations are attributed to nonpoint pollution in the watershed. Freshwater streams of major concern are Clear Creek, Chico Creek, and Barker Creek. Commercial shellfish harvesting has been prohibited within Dyes Inlet since the late 1960s.

Other Studies

Water quality data has been collected and watershed characterizations done for other parts of the WQMA. For example, the Puget Sound Cooperative River Basin Team (1994) prepared a watershed report for Liberty and Miller Bays which summarizes water quality of the fresh and marine waters. The Bremerton-Kitsap County Health Department (1988) reported on water quality and contaminant sources in Liberty Bay, Sinclair Inlet, and Eagle Harbor. These reports identify high FC concentrations due to nonpoint pollution as the major problem in these areas. Contamination of shellfish was cited as the major impact from elevated FC concentrations in Liberty Bay and Eagle Harbor. Dogfish Creek (tributary to Liberty Bay) and Grover Creek (tributary to Miller Bay) have FC concentrations that exceed water quality standards. Of the three water bodies, inner Liberty Bay appears to be the most polluted.

Issues

- High fecal coliform and TSS concentrations in freshwaters (WA-15-1400, -1450, -1300,-1355, -1015,-1060) discharging to Burley Lagoon and Minter Bay.
- Low dissolved oxygen and possible nutrient enrichment of Hood Canal.

- High fecal coliform concentrations in freshwaters discharging to Sinclair and Dyes Inlets (WA-15-4000, -4100, -4200, -4400, -4900, -5000, -5100) and possible nutrient enrichment of the inlet waters.

- Toxics in Sinclair Inlet.

- High fecal coliform concentrations in freshwaters discharging to Liberty (WA-15-0100) and Miller Bays. High fecal coliform concentrations in the marine waters of Liberty Bay and Eagle Harbor (WA-15-0020)

Recommendations

Burley and Minter Watersheds

The 1992-93 water quality investigation of Burley and Minter Creek watersheds was not designed to identify the effectiveness of specific BMPs. In order to evaluate the effectiveness of site specific BMPs, regular monitoring of FC and TSS concentrations upstream/downstream and before/after BMP implementation should be a priority.

Future monitoring of nonpoint pollution in Burley and Minter Creeks should target rain events.

Agricultural BMPs and sewage system surveys should be focused in Burley Creek and Minter Creek as recommended by Dickes and Patterson (1994).

Hood Canal

A joint study by WAS and the Ambient Monitoring Section should be conducted to identify sources, and quantify and evaluate the impact of loading of BOD and nutrients to Hood Canal. The study should include an evaluation of the chemical, physical, and biological processes that determine the transport and fate of these pollutants. A hydrodynamic and water quality model of the canal should be developed and used to determine the transport and fate of BOD and nutrients, and estimate possible future impacts of increased loading to the system. A preventative BOD and nutrient TMDL should be pursued for Hood Canal.

Sinclair Inlet and Dyes Inlet

Follow the recommendations and actions listed in the Sinclair and Dyes Inlet Action Plans.

A joint study by WAS, the Toxics Investigations Section, and the Ambient Monitoring Section should be conducted to quantify and evaluate the impact of loading of BOD and

nutrients to inner Sinclair and Dyes Inlets and the loading of toxic substances to the greater area. The study should include an evaluation of the chemical, physical, and biological processes that determine the transport and fate of these pollutants. A hydrodynamic and water quality model of Sinclair and Dyes Inlets should be developed and used to determine the transport and fate of BOD and nutrients, and estimate possible future impacts of increased loading to the system. A preventative BOD and nutrient TMDL should be pursued for Sinclair and Dyes Inlets.

Others

If they have not been completed, prepare Watershed Action Plans for Liberty and Miller Bays, and Eagle Harbor, and follow the recommendations of each plan.

References

Albertson, S., J. Newton, L. Eisner, C. Janzen, and S. Bell. 1995. 1992 Sinclair and Dyes Inlet Seasonal Monitoring Report., Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Publication #95-345, Olympia, WA.

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Toxics in Surface Waters

by

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Toxics Investigations Section

Introduction

Within the past ten years, Toxics Investigations has collected only limited data on the occurrence of toxic chemicals in the marine and freshwaters of Kitsap peninsula. Most of the work has been in the urbanized areas of Sinclair and Dyes Inlets. Copper applications to control algae in Sylvia Lake near Gig Harbor were also recently monitored. These studies are summarized below. In the late 1980's, priority pollutant screening surveys were conducted of the intertidal or nearshore areas of McNeil Island, Quartermaster Harbor, and Port Gamble Bay (Norton, 1988; Yake, 1986; Yake and Norton, 1987). These surveys found no significant chemical contamination so are not discussed further.

Concerns about toxics in Sinclair Inlet and other Kitsap embayments were also previously discussed in the ambient monitoring and watershed assessments briefing papers, and recommendations made for follow-up studies.

Summary of Studies

Storm Drain Monitoring

Sediments from eight west Bremerton storm drains were analyzed in 1992 to determine the types of contaminants being discharged and rank the drains for source tracing (Cubbage, 1992a). Four sites exceeded Puget Sound marine sediment standards for one or more of the following: chlorinated pesticides, PAHs, butylbenzylphthalate, PCBs, VOAs, mercury, zinc, and pentachlorophenol. Storm drains in Puget Sound Naval Shipyard were not sampled.

Follow-up sampling was done at selected storm drains in 1993 and included two outfalls in Port Orchard and three in Silverdale (Cubbage, 1995). Three Bremerton drains were singled out as concerns (see Figure 2): H1 - PCBs, PAHs, and toluene; G2 - PCBs; and Y1 - pentachlorophenol, toluene, and chlorinated pesticides. The investigator recommended that sources of these chemicals be investigated. As far as is known, no further work was done.

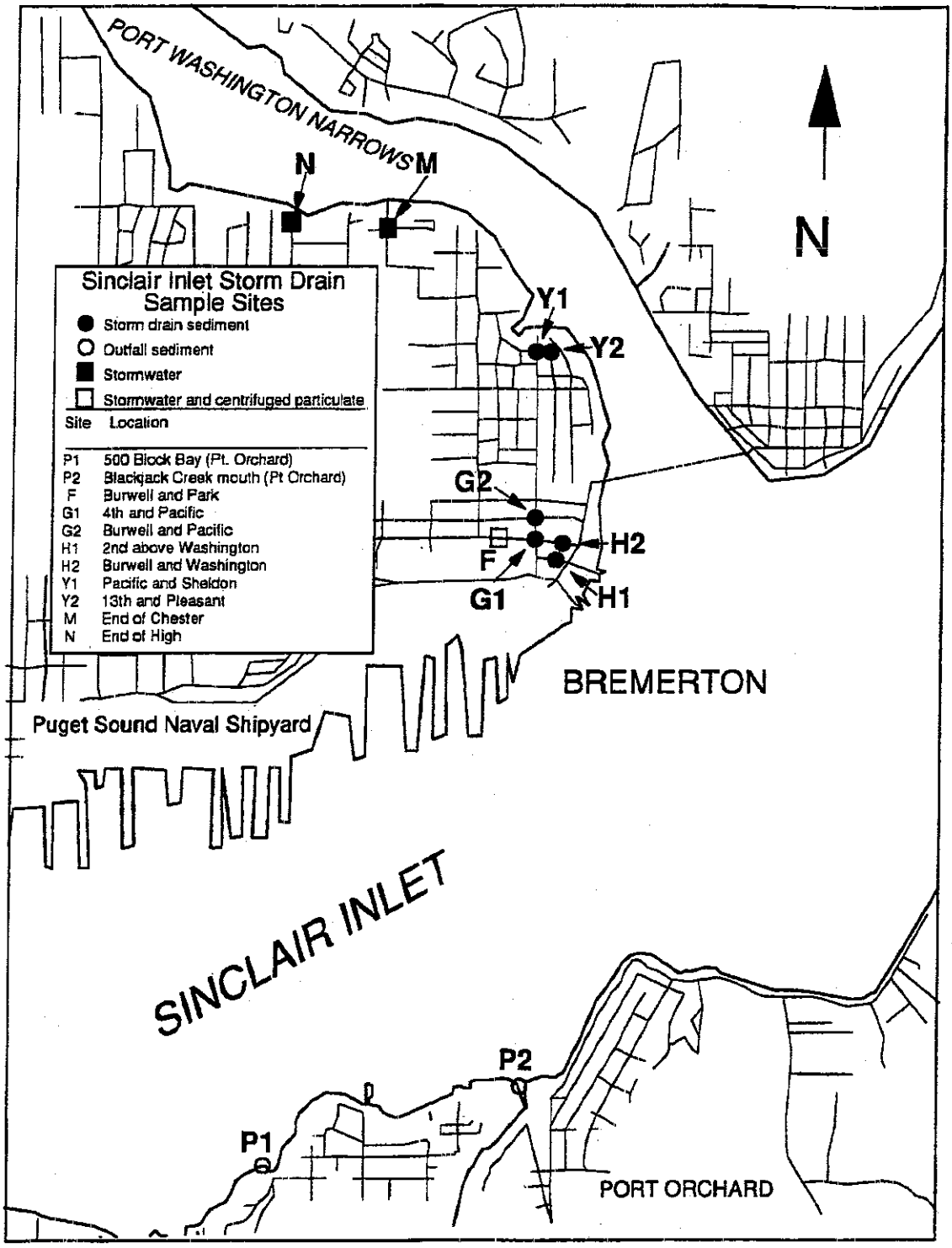

Figure 2. Sample sites in Bremerton and Port Orchard.

Contaminants in Fish and Clams

Several species of flatfish (fillets) and clams collected from Sinclair and Dyes Inlets in 1990 and 1991 were analyzed for metals, butyltin, PAHs, chlorinated pesticides, and PCBs (Cubbage, 1992b). The only organic compound detected in fish tissue was 2 parts per billion (ppb) of DDE in one sample. Trace amounts of PAH compounds (50 ppb total PAH) were found in the clam samples; neither pesticides nor PCBs were detectable. Concentrations of metals were moderate to low in both fish and clams

These findings are in contrast to results from the WDFW fish monitoring program, earlier described by the ambient monitoring section, most likely due to different species being analyzed.

Pesticide/PCB Monitoring in Clear Creek

Water and fish samples from Silverdale's Clear Creek were analyzed for up to 160 pesticides or degradation products as part of Toxics Investigation's Washington State Pesticide Monitoring Program (Dale Davis, unpublished 1995 data). Fish were also analyzed for PCBs.

Results showed no evidence of significant pesticide contamination. Water samples had low concentrations ($\leq$ 1 ppb) of six herbicides commonly used on lawns, gardens, and roadsides. The insecticide malathion was also detected once in water but at non-toxic concentrations (0.05 ppb). DDE and several other first generation pesticides were present in cutthroat trout fillets at 0.7 - 13 ppb; PCBs were also detected at 46 ppb. These concentration are typical of background residues in western Washington fish. However, as in many other state water bodies, the PCB concentration in the fish sample exceeds the EPA 1.4 ppb human health criteria (10^{-6} cancer risk) qualifying Clear Creek for listing as water quality limited (303d).

Copper Treatment of Sylvia Lake

Sylvia Lake, three miles west of Gig Harbor, has been treated repeatedly with copper compounds to control algae. A 1994 Toxics Investigations study showed that copper levels in the lake and outlet stream exceeded water quality criteria for a least 18 days following a summer application of copper sulfate (Serdar, 1995). Water and sediment samples analyzed from tributaries to the lake showed these were not significant sources of copper (Serdar, 1996). Continued use of copper could adversely effect the hatching and rearing of coho and chum salmon in the 1/2 mile long outlet stream that flows into Carr Inlet. Further copper treatments have not been allowed in Sylvia Lake.

Recommendations

Investigate sources of chemical contaminants in Bremerton storm drains.

References

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Ground Water

by

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Toxics Investigations Section

EILS Studies

Only one ground water study has been conducted by EILS in the Kitsap Basin during the past ten years. A study of leachate effects from the Olympic View Landfill was conducted in September 1989 (W. Yake, unpublished Ecology data). The survey included samples from ground water and soil pore-water beneath the land application area as well as input and output from the treatment system and a nearby intermittent creek. Elevated nitrate concentrations were found in the soil pore-water. However, alder trees in the area were considered a potential source in addition to applied effluent.

Background

Eighty percent of water used in the basin is from ground water (Economic and Engineering Services (E&E) et al., 1991). Twenty-five percent of Kitsap County residents are served by domestic wells, mostly screened in the shallow aquifer system. Over 10,000 wells exist in Kitsap County (Kitsap PUD, 1996).

Population in the area is increasing rapidly. E&E, et al. (1991) predict a doubling of the population in the area between 1989 and 2040, from 183,000 to 366,000.

Several layers of glacial and interglacial deposits compose the main aquifer system (E&E et al., 1991). About five coarse-grained glacial deposits are sandwiched between silt and clay units. The coarse-grained deposits are the main aquifer units for the area. The uppermost layer covering most of the Kitsap Peninsula is a veneer of undifferentiated till (cemented conglomerate of sand, gravel, silt, and clay) which has low permeability and varies in thickness up to 200 feet.

The only source of recharge to the deeper aquifers is from precipitation. The extensive till layer over much of the area leads to significant surface or subsurface runoff. However, the high variability in Kitsap County till characteristics (E & E et al., 1991) may provide the area's most significant ground water recharge area, especially where the permeability is greatest. Recharge potential is highest in the western and southern parts of the Kitsap Basin due to higher precipitation and medium to high soil permeability.

Overdrafting and declining ground water elevations are a major concern for the Kitsap Basin (E&E, 1991) Because ground and surface water are hydraulically continuous, declining ground water levels results in less recharge to streams

Sea Water Intrusion

Kitsap County has over 200 miles of shoreline A potential for sea water intrusion exists along developed shorelines, especially if numerous, large, sea level and deeper public supply wells are added as planned (J Liszak, Ecology, pers comm) Indications of sea water intrusion have been observed on Vashon and Maury Islands

Dion, et al (1988) did not find evidence of sea water intrusion on Bainbridge Island based on chloride samples from 210 wells All wells were sampled in April and September 1985 A subset of 24 wells was also sampled monthly

However, Dion, et al (1988) noted a high potential for sea water intrusion on the island, especially if high capacity production wells are developed in areas where the ground water heads are low relative to sea level

Residential Effects on Ground Water Quality, i.e., Nitrate from On-Site Sewage Systems, Fertilizers, and Animals; Pesticides

Data presented in E &E (1991) from Class 3 and 4 public water supply wells, though limited, show consistently low nitrate concentrations (< 0 5 mg/L) in the less developed, southwest parts of the basin, while many higher concentrations (up to 4 mg/L) are reported in the Poulsbo/Bremerton, Bainbridge Island, and Indianola-Hansville areas In areas where nitrate concentrations were elevated, both "shallow" and "deep" wells appeared to be affected

Ground Water Effects on Surface Water Quality

The widespread, shallow till layer in the Kitsap Basin often precludes effective on-site sewage treatment Bacteria and viruses from failing on-site systems have affected many shellfish growing areas in the basin Increased shoreline development may lead to more widespread bacterial contamination of marine water (see also ambient monitoring and watershed assessments papers)

Submarine Base Bangor (SUBASE) Contaminated Sites

The USGS is conducting a study of the ground water flow system and chemistry for SUBASE (M van Heeswijk, USGS, pers comm) Approximately ten percent of the base contains sites with shallow ground water and soil contamination Several of these sites are being remediated and others will be remediated in the near future Contaminants include

ordnance chemicals, trace metals, chlorinated hydrocarbons, petroleum hydrocarbons, pesticides, and PCB's.

The objectives of the study are to: a) assess the flow of contaminated water from shallow to deep aquifers, and b) assess effects of increased ground water use on contaminant pathways and saltwater intrusion.

Water level measurements have been made on 400 wells on two dates. In spring of 1995, 136 water supply wells were sampled for common ions, nutrients, VOCs, trace elements, and ordnance compounds. Synthetic organic compounds were found in only two of 50 wells which was attributed to off-base sources (Greene, 1996). Trichloroethylene (TCE) exceeded the drinking water standard in one well that was probably contaminated by a local off-base dump

Reports on the hydrogeologic framework and ground water quality are scheduled for publication in 1997. A report on shallow aquifer recharge as well as a ground water modeling report are scheduled for publication in Fall 1998

Kitsap County PUD has also contracted out the development of a ground water flow model for the vicinity of SUBASE. The study will include predictions of effects of future ground water use on the system, including contaminant migration and salt water intrusion

Day Road Industrial Park, Bainbridge Island

Kitsap Newspaper Group is currently discharging to an on-site sewage system in violation of state and local regulations (McNickle and Swanson, 1995). VOCs, although not sampled nor confirmed in the discharge, are present in many of the materials used in the printing process

Ecology and the Bremerton Kitsap County Health Department have conducted several rounds of well sampling near the Day Road Industrial Park (McNickle and Swanson, 1995). TCE was found twice in the business park's well in 1989 at a concentration seven-times the Drinking Water Standard. Cyanide, arsenic, cadmium, and chromium were also found in domestic wells in concentrations below the drinking water standards. TCE was not found in 1992, 1994, or 1995 sampling

Chloroform was detected in 1994 and 1995 in private wells at levels four times the Ground Water Standards. However, no Drinking Water Standard exists for chloroform alone. Instead the health standard is for total trihalomethanes. The chloroform concentrations found in these wells were far below the trihalomethane health standard

Other Studies

Vashon-Maury Island Ground Water Management Plan (March 1995);
Seabeck Hydrogeologic Characterization and Aquifer Protection Plan (April 1996);
Kitsap County Initial Basin Assessment (October 1995);
Ecology Bainbridge Island seawater intrusion monitoring 1985-87;
Kitsap County Ground Water Management Plan (April 1996);
Day Road Industrial Site Ground Water sampling by Bremerton Kitsap County Health Department

Recommendations

Characterize the surficial aquifer to define recharge areas in the watershed.

Evaluate residential impacts on ground water quality in high-density areas such as Silverdale and Keyport, using nitrate-N as an indicator

Define the freshwater/seawater boundary along shorelines of intrusion-prone areas (i.e., Silverdale, Keyport)

References

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Economic and Engineering Services, Inc., Pacific Groundwater Group, and Robinson and Noble, Inc. 1991. Kitsap County Ground Water Management Plan, Grant No. 1, Background data collection and management issues: Olympia, WA, 2 v.

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Keyport PUD. 1996. Kitsap County Ground Water Management Plan, Volume III.

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Compliance Monitoring

by

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Toxics Investigation Section

EILS Class II Inspections

There are currently 32 dischargers in the Kitsap WQMA that have permits under the National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge Permit Program (WAC 173-216). These include:

- NPDES Major Permits - 1 Industrial, 2 Municipal
- NPDES Minor Permits - 1 Industrial, 13 Municipal
- State Discharge to Publicly Owned Treatment Works (POTW) Permits - 8 Industrial
- State Discharge to Ground Permits - 1 Industrial

The following summarizes information from the three dischargers that have had EILS Class II inspections during the last ten years. It is important to note that Class II inspections more than five years old may not be representative of the facility today

City of Port Orchard Sewage Treatment Plant

The Port Orchard plant was inspected in 1989 and in 1994. In 1994 (Hoyle-Dodson, 1995) reduction of BOD_5 and TSS across the plant was excellent, with BOD and TSS meeting NPDES permit limits. Tentative dilution zone modeling suggested that dilution at the edge of the chronic mixing zone was insufficient to meet the ammonia standard. A mixing zone study was recommended. One effluent fecal coliform count exceeded the monthly average permit limit. An evaluation of contact time in the chlorine contact chamber was recommended. Split comparisons between samples were divergent and a review of sampling techniques was recommended. Wastewater bioassays showed significant acute and chronic toxicity. It was recommended that the need for a pretreatment program to reduce influent metals be evaluated. The plant discharges to Sinclair Inlet, WA-15-0040. The water body is 303(d) listed for parameters including six metals.

Central Kitsap Wastewater Treatment Plant

Heffner (1990) inspected the Central Kitsap plant in 1988. The plant was upset at the time of the inspection resulting in effluent exceeding NPDES permit BOD, TSS, and

chlorine residual concentrations. Numerous priority pollutants were detected in one or more of the samples collected. Most were found in low concentrations. Bioassays showed some toxicity to rainbow trout (acute) and Microtox. Ammonia was considered a possible cause. The plant discharges into Port Orchard Bay, WA-15-0030. The water body is 303(d) listed for parameters including dissolved oxygen.

Bremerton Wastewater Treatment Plant

The Bremerton facility was inspected in 1988 (Reif, 1988). The plant had very good effluent quality and did not violate any NPDES permit limits. Several bioassays indicated a slight amount of effluent toxicity.

NWRO Inspections

Ten dischargers in the Kitsap WQMA have received regional compliance inspections with sampling in the last two years. The same list comprises regional inspections with sampling during the last five years:

Municipal
Bremerton (major)
Kitsap-Central (major)
City of Bainbridge Island (minor)
Kitsap-Kingston (minor)
Kitsap-Manchester (minor)
Messenger House Care Center (minor)
Pope & Talbot (minor)
Port Orchard STP (minor)
Vashon STP (minor)

Industrial
Stone Consolidated (major)

Recommendations

Neither of the two municipal major dischargers have received EILS Class II inspections during the last five years. With the exception of Port Orchard Sewage Treatment Plant, none of the 13 municipal minor dischargers have received EILS Class II inspections during the last ten years. No industrial dischargers have been inspected by EILS during the last ten years.

EILS Class II inspections are recommended for facilities of concern to NWRO

References

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Hoyle-Dodson, G. 1995. City of Port Orchard Sewage Treatment Plant Class II Inspection. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

Reif, D. 1988. Bremerton Wastewater Treatment Plant Class II Inspection. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.

Zinner, L. 1990. Port Orchard Wastewater Treatment Plant Class II Inspection, January 1989. Memorandum to Jacques Faigenblum, Wash. St. Dept. Health. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA.