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15. Supplementary Notes

The study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration, under the title Runoff Water Quality.

16. Abstract

This report summarizes findings detailed in Report Nos. 4 and 5 plus the work of Zawlocki on trace organics in highway runoff. Several hundred compounds tentatively, identified by GC-MS were grouped into nine categories, which were not mutually exclusive. Major components of these categories were petroleum products used by vehicles and incompletely combusted hydrocarbons. The concentrations of these trace organics groups were low compared to criteria proposed for protection of aquatic life.

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Introduction

This report is a departure from past annual reports which focused on the single major research development each year. Since three major research tasks were completed, each report was summarized in a separate report and this report is an executive summary of these reports. The major reports exclusive of dissertations prepared by this project are listed in Table 1.

Table 1

Highway Runoff Water Quality Reports

Report No. 1. Horner, R.R. and E.B. Welch, "Effects of Velocity and Nutrient Alterations on Stream Primary Producers and Associated Organisms," Nov., 1978.

Velocity and nutrient studies at twelve sites in Western Washington streams indicated that 50 cm/sec is the critical average current velocity where the productive base of the food web is impacted. Swift flowing streams rich in nutrients should not be slowed to this value and slow flowing streams should not be altered to have velocities greater than this value.

Report No. 2. Horner, R.R., S.J. Burges, J.F. Ferguson, B.W. Mar and E.B. Welch, "Highway Runoff Monitoring: The Initial Year," Jan., 1979.

The initial 15 months of effort to review the literature, select a prototype site, and compare the performance of several automatic sampling devices, and install a prototype sampling site on I-5 north of Seattle.

Report No. 3. Clark, D.L. and B.W. Mar, "Composite Sampling of Highway Runoff: Year 2," Jan.,1980.

A composite sampling device was developed that can be installed at less than ten percent of the cost of automatic sampling systems currently used in Federal highway runoff studies. This device was operated for one year, side-by-side the I-5 site, to demonstrate that the composite system provides identical results to the automated system.

Report No. 4. Vause, K.H., J.F. Ferguson and B.W. Mar, "Water Quality Impacts Associated with Leachates from Highway Woodwastes Embankments."

Laboratory and field studies of a woodchip fill on SR 302 demonstrated that the ultimate amounts of COD, TOC and BOD per ton of woodchips can be defined and that this material is leached exponentially by water. After a year the majority of the pollutant has been removed suggesting that pre-treating of the woodchips prior to use in the fill can reduce the pollutant release from a fill. This chips should be protected from rainfall and groundwater intrusion to avoid the release of leachate. Release of leachate onto tidal lands can cause beach discoloration and an underground deep outfall may be required.

Report No. 5. Aye, R.D., "Criteria and Requirements for Statewide Highway Runoff Monitoring Sites."

Criteria for selecting statewide monitoring sites for highway runoff are established to provide representative combinations of climate, traffic, highway, land use, geographic and topographic characteristics. Using these criteria, a minimum of six sites are recommended for use in this research.

Report No. 6. Asplund, R., J.F. Ferguson and B.W. Mar, "Characterization of Highway Runoff in Washington State," Dec., 1980.

A total of 241 storm events were sampled at ten sites during the first full year of statewide monitoring of highway runoff. Analyses of these data indicate that more than half of the observed solids in this runoff is traced to sanding operations. The total solids loading at each side was correlated with traffic during the storm. The ratio of other pollutants to solids was linear when there was sufficient traffic generated pollutants to saturate the available solids.

This report summarizes the efforts reported in Reports 4 and 6 and a yet-to-be-documented effort on trace organics present in highway runoff.

History

This project was initiated in May 1977 as a five-year field study to establish the impacts of highway operation and maintenance on receiving water quality and on aquatic ecosystems in the State of Washington. During the first year of effort (May 1977 - August 1978) a literature survey (Horner, et al., 1977) was made of existing knowledge and the need for field studies justified. The maritime climate of Western Washington with low intensity long-term rainfall creates a unique set of conditions. Most existing highway runoff data are for high intensity, short duration types of events, and such results are not applicable in the State of Washington. The major thrust of the first year's field activity was to reactivate the site on SR 520 employed by Sylvester and DeWalle (1972) in their cursory examination of this problem and to develop a prototype sampling station to test and improve sampling equipment (Horner et al., 1979). A study was made of the impact of nutrient additions and velocity changes in rivers of Western Washington (Horner and Welch, 1978) and critical thresholds defined for these parameters.

During the second year, criteria and requirements for selection of statewide highway runoff monitoring sites were developed (Aye, 1979), and a new inexpensive runoff sampling device was developed and tested. This device reduced the cost of sampling by a factor of ten and permitted the installation of 10 high performance sampling sites statewide at the cost of installing two conventional sites (Clark and Mar, 1980). Data collected from the

Sylvester site, and the prototype site were used to establish the sampling protocol for all sites.

This report summarizes the results of the third year of research where, for the first time,all ten sites were in operation. A special study of leachate from a woodwaste fill section of highway was also conducted. The samples were routinely examined for solids, metals, COD and nutrients. Special studies were made to identify trace organics in the runoff samples.

Third Year Results

During the first year of full-time operation (1979-80) of ten highway runoff monitoring sites in the State of Washington, a total of 241 storm events were sampled. The locations of the sites are shown in Figure 1, and Table 2 describes each site. Details of the experimental procedures, data and results are reported by Asplund (1980) in his dissertation. A summary of these findings is published by Asplund, et al. (1980).

The characteristics of the storms observed at each site are summarized in Tables 3 and 4. Problems encountered in this collection of data are summarized in Table 5. The data collected at these sites are summarized in Tables 6 and 7 using methods summarized in Table 8. The experimental data included concentration of pollutants for a composite flow weighted runoff sample, rainfall volume and duration, runoff coefficient, and traffic between and during the storm. Details of these measurements are described by Clark (1980) and Asplund (1980). These data suggest that total suspended solids loadings (lbs/curb-mile) were a function of either rainfall duration or traffic during the storm, but not a function of traffic preceding storms, rainfall, or dry periods, as suggested by the literature. Asplund (1980)

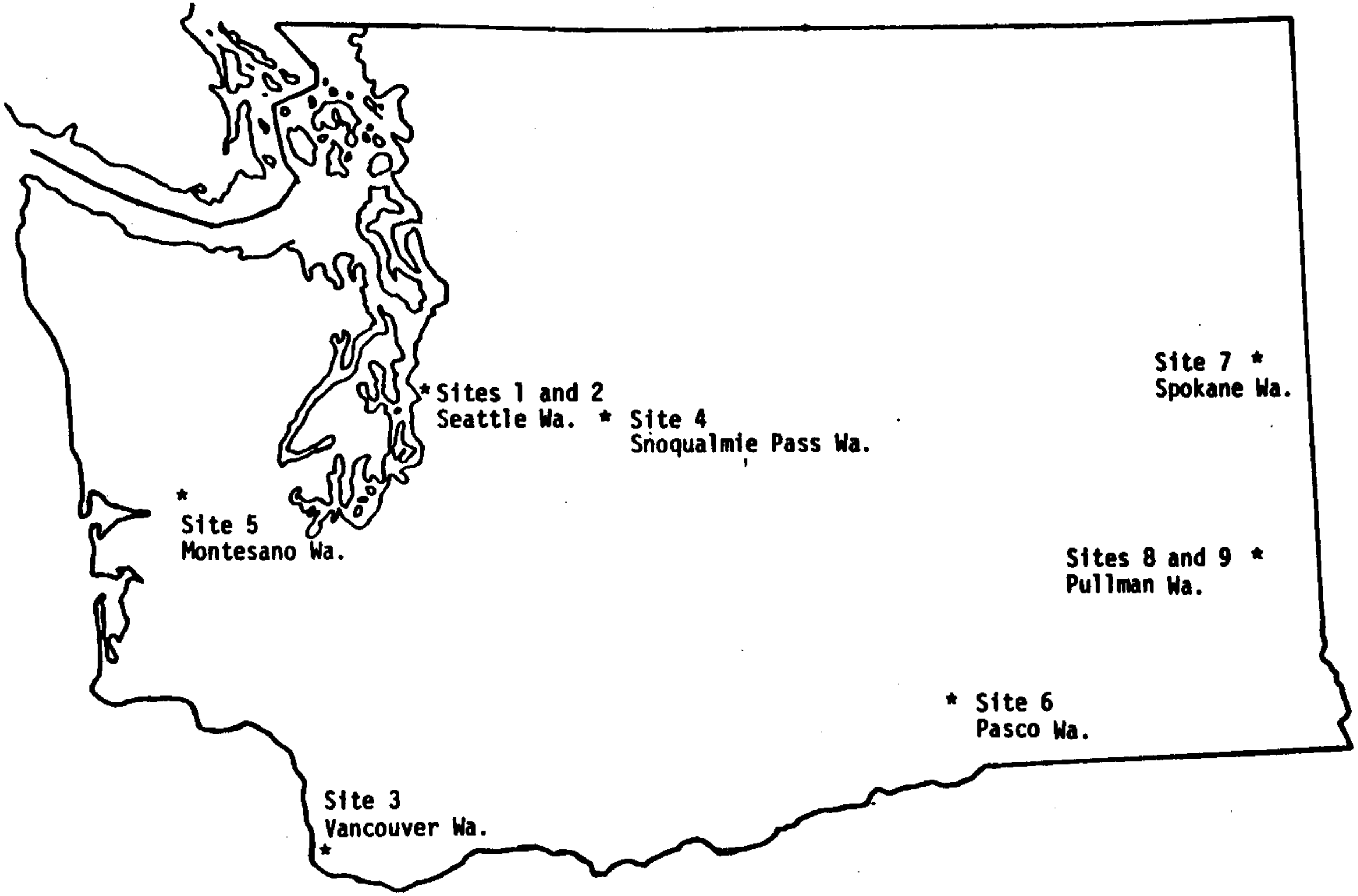

Figure 1. Sampling Site Locations in Washington State

Table 2. Physical Characteristics of the Highway Runoff Sampling Sites.

Site Location	Climate	Average Yearly Rainfall	Site Description	Physical Characteristics Area	Physical Characteristics Length	Highway Description # Width, Pavement Type, Barrier	Traffic Volumes (ADT)	Surrounding Land Use	Sampler	Flowsplitter # Faction Split
1. I-5 I-5 & 158th NE Northbound lanes Seattle, WA	Puget Sound Lowlands-Marine	32-45	A wide radius curve with a 1.1% grade on a limited access highway, Sample intake: from drop-box	53,140 ft^2 1.2 Ac	780' 0.15 mi	4-12' concrete lanes 10'-DL-asphalt-curb 10'-ML-asphalt-NJ	53,000	Urban Residential	U of W Seattle	0.0125
2. SR-520 SR-520 at Montlake Westbound lanes NOAA Parking Lot Seattle, WA	Puget Sound Lowlands-Marine	32-45	Elevated bridge section with 2% grade site includes runoff from on ramps, Sample intake: from NW corner drain after on-ramp	4,310 ft^2 0.099 Ac	150' 0.029 mi	2-12' concrete lanes 2'-DL-concrete-NJ 1'-ML-concrete-NJ	42,000	Urban	U of W Seattle	0.210
3. Vancouver I-205 & St.Johns St. Southbound lanes Vancouver, WA	Cascade Foothills-Marine	40-50	A wide radius horizontal curve on a limited access highway Sample intake: off existing drop-box S. of St. Johns St.	11,970 ft^2 0.28 Ac	220' 0.042 mi	3-12' concrete lanes 10'-DL-asphalt-curb 8'-ML-asphalt	8,600	Low Density Residential	WSDOT/#1 Dist.Engr. Office Vancouver	0.044
4. Snoqualmie Pass I-90 at Mile post 41.5 Eastbound lanes North Bend, WA	West Slope Cascade Mountains	60-100	A wide radius curve with 1.2% grade on a limited access highway Sample intake: off curb	7,700 ft^2 0.18 Ac	140' 0.027 mi	3-12' concrete lanes 12'-DL-asphalt-curb 6'-ML-asphalt	7,700	Western Coastal Forest Undeveloped	WSDOT/#1 Field Engr. Office North Bend	0.093
5. Montesano SR-12 0.5 miles West of SR-12 and Montesano, WA	Western Olympics-Coastal	70-100+	Curved approach to bridge section and a portion of the on-ramp, Sample intake: off curb	12,210 ft^2 0.28 Ac	310' 0.059 mi	2-12' asphalt lanes 8'-DL-asphalt-curb 6'-ML-asphalt	7,300	Agricultural Pasture Land	WSDOT/#3 Field Main. Office Aberdeen	0.050, from 3-23-80 on 0.019
6. Pasco Interchange of SR-12 & SR-195 Eastbound lanes SR-12 Pasco, WA	Central Basin East Cascade Foothills	7-15	Wide radius horizonal curve in transition to a -0.9% horizontal grade, Sample intake: off existing culvert—site below grade	54,320 ft^2 1.25 Ac	1090' 0.21 mi	2-12' concrete lanes 10'-DL-asphalt-curb 4'-ML-asphalt 12'-asphalt gutter along DL	2,000	Semi-arid desert Undeveloped w/irrigation Agriculture	WSDOT/#3 Field Engr. Office Pasco	0.080
7. Spokane I-90 at Latah Cr. Bridge Eastbound lanes western pier section Spokane, WA	Northeastern	17-20	Horizontal bridge section on a limited access highway, Sample intake: from 5 bridge drains at base of middle pier.	9,590 ft^2 0.22 Ac	180' 0.035 mi	3-12' concrete lanes 3'-DL-concrete-NJ 2'-ML-concrete-NJ	17,300	Urban	WSDOT/#6 Dist. Main. Office Spokane	0.051
8. Pullman-8 SR-270 2.5 mi West of city, Eastbound lanes, Pullman, WA	Palouse - Blue Mountains	10-19	-1.0% horizontal grade on 30%-70% by weight sulfur-asphalt section of sulfur extended project, Sample intake: off curb	9,750 ft^2 0.22 Ac	500' 0.095 mi	1-12' asphalt lanes 7.5'-DL-asphalt-curb asphalt: 70% reg.mix 30% sulphur mix	2,500	Agriculture	WSU Pullman	0.071
9. Pullman-9 SR-270 2.5 mi West of city, Westbound lanes, Pullman, WA	Palouse - Blue Mountains	10-19	+1.0% horizontal grade on 30%-70% by weight sulfur-asphalt section of sulfur extended project, Sample intact: off curb	10,870 ft^2 0.25 Ac	500' 0.095 mi	1-12' asphalt lane 7.5'-DL-asphalt-curb asphalt: 70% reg. mix 30% sulphur mix	2,500	Agriculture	WSU Pullman	0.071
10. Pullman-Control SR-270 2.3 mi West of city, Eastbound lanes, Pullman WA	Palouse-Blue Mountains	10-19	-1.0% horizontal grade on asphalt control section of sulfur extended project, Sample intake: off curb	13,210 ft^2 0.30	500' 0.095 mi	1-12' asphalt lane 7.5'-DL-asphalt-curb asphalt: 100% reg. mix	2,500	Agriculture	WSU Pullman	0.071

Table 3. Monitored Storm Events at the Runoff Sites.

Site	no. of events	Monitoring Period
I-5	54	9-79 to 6-80
SR-520	43	9-79 to 6-80
Vancouver	61	8-79 to 6-80
Snoqualmie Pass	12	9-79 to 1-80, 4-80 to 6-80
Montesano	27	10-79 to 6-80
Pasco	17	9-79 to 3-80, 5/80 to 6-80
Spokane	6	9-79 to 6-80
Pullman - 8	9	9-79 to 6-80
Pullman - 9	6	9-79 to 3-80
Pullman - control	6	4-80 to 6-80

Table 4. Seasonal Rainfall, Runoff and Traffic Data.

Site	Fall - Spring Period				Winter Period			
	Rainfall (in)	Runoff (ft^3	Total Traffic	Traffic During	Rainfall (in)	Runoff (ft^3)	Total Traffic	Traffic During
I-5	9.60	33,600	6,000,000	444,000	26.3	74,400	8,460,000	1,960,000
I-5 w/grit	4.70	26,100	2,990,000	233,000	7.27	16,400	2,030,000	547,000
SR-520	9.66	2,530	4,420,000	374,000	24.2	7,210	4,570,000	872,000
Vancouver	16.0	5,310	1,370,000	106,000	29.2	5,980	1,210,000	107,000
Snoqualmie Pass	11.5	4,430	985,000	154,000	30.4	15,200	417,000	202,000
Montesano	17.4	18,600	881,000	168,000	49.7	35,900	970,000	447,000
Pasco	2.56	7,040	150,000	2,900	2.17	10,600	375,000	5,600
Spokane	3.02	1,250	2,080,000	144,000	5.86	4,500	2,790,000	331,000
Pullman-9	3.88	2,120	--	--	--	--	--	

Table 5. Summary of Site Problems and Sources of Errors (Solutions to Problems Encountered at the Runoff Sites).

Location	Specific Site Problems	Runoff Flow Problems: Measurement	Runoff Flow Problems: Storm Related	Traffic Measurement	Sample Collection	Laboratory
I-5	Loss of solids in H-flume (Collection and addition to composited sample) Recording rain gauge over estimated volumes	ISCO flow measurement over estimated flow (installation of flow tranquilizer) Only minor clogging (installation of netting)	Few	Excellent daily and VDS counts	No problems	No problems (Separate grit analysis for solids
SR-520	Leakage of site thru expansion joints (Site abandoned 6/80)	No problems Infrequent clogging	Few Tank overflowed 10 times	Excellent daily and VDS counts	No problems	Usual problems encountered with high solids levels (All samples measured with grad cyl or sludge pipets)
Vancouver	Possible flow barrier between concrete-asphalt lanes (installation of patch on lane)	No problems Infrequent clogging	Few	Excellent daily counts, Est. of storm duration for VDS counts (installation of recording rain gauge)	No problems Excellent collection and shipping ~2 days	No problems, Low values associated with site increased relative error
Snoqualmie Pass	No problems Winter freeze-up Jan-Mar 15, 1980	No problems Infrequent clogging	Foundation washed out (Replaced by next storm) Tank overflowed 12 times	Excellent daily counts VDS est. as for Van. (Possible install. of recording rain gauge)	Multiple compositing of storms due to infrequent sampling (New sampler will sample on demand	No problems
Montesano	Questionable drainage area-contribution of flow from bridge section (proposed dye tests)	No problems Infrequent clogging	Long duration storms caused frequent overflow 15 times (installation of flowsplitter)	Poor daily counts, counter 35 mi to E, VDS est. accord to Van. (installation of counter and recording rain gauges)	Infrequent sampling during winter period (Will now sample twice a week or more of necessary)	Problems due to high solids as above
Pasco	Site below grade, Sand in sampling equip., Possible inaccurate drainage area (Proposed flushing tests)	Frequent clogging (installation of netting on collection grate)	Tank floated twice, low winter runoff volumes due to snowfall (install. of drywell and concrete tank)	Poor daily counts, VDS est. as above (installation of counter and runoff duration recorder)	No problems Approximately shipping time - 2 days	Problems due to high solids as above
Spokane	Initial vandalism (installation of cage around site) Winter freeze-up	No problems Infrequent clogging	Multiple composite winter storms due to freeze-thawing of run-off	Poor daily counts, VDS est. as above (install. of counter in 5/80 and runoff duration recorder)	No problems, Site is sampled on demand, approximate shipping - 4 days	Problems due to high solids as above
Pullman-8	Repeated vandalism Animals reported in flowsplitter (site moved 5/80)	Frequent clogging (installation of netting)	Grab samples only due to winter freeze-up of site	No daily counts	No problems	Problems with total sulfur test replaced with SO_4 test
Pullman-9	Same as site 8 (Cage built around site)	Same as site 8	Same as site 8	No daily counts	No problems	Same for site 8

Table 6. Seasonal Summaries for Total Suspended Solids.

Site	Fall - Spring Period				Winter Period			
	Concentration (mg/l)		Pollutant Loading (lbs/acre)	Monitoring Period (days)	Concentration (mg/l)		Pollutant Loading (lbs/acre)	Monitoring Period (days)
	Average	Range			Average	Range		
I-5	115	32-452	198	120	220	47-848	839	150
I-5 w/grit	203	50-741	272	60	443	54-1370	372	30
SR-520	272	76-894	434	120	402	97-854	1830	135
Vancouver	48	13-140	58	150	119	16-168	162	150
Montesano	155	95-335	379	90	248	51-1260	2780	150
Pasco	199	38-587	85	75	168	19-512	56	135
Spokane	1278	67-2490	238	120	331	85-968	742	150
Pullman-9	64	14-522	28	90	-	-	-	-
Snoqualmie Pass	49	23-117	76	120	400	30-586	2120	60

Table 7. Comparison of the Seasonal Runoff Rates from Washington State and Envirex Runoff Sites.

		I-5	SR-520	Vancouver	Montesano	Snoqualmie Pass	Pasco	Spokane	Pullman-9	Sylvester & DeWalle	Metro Bellevue	Preston	Envirex[1] All Site	Envirex I-794	Range
Fall-Spring Runoff Rates															
TSS	lb/curb mi-day	36.8	12.4	2.56	20.0	4.13	11.5	12.6	0.80	10.8	34.7	13.3	13.2	27.5	0.8-36.8
	lb/curb mi-1000 vehicles	0.74	0.34	0.28	2.05	0.54	3.44	0.72	-	0.25	1.74	0.66	0.22	0.53	0.22-1.74
COD	lb/curb mi-day	9.22[2]	6.39	3.29	9.27	9.59	5.12	10.6	1.67	5.80	23.4	9.40	7.80	20.9	1.67-23.4
	lb/curb mi-1000 vehicles	0.18[2]	0.17	0.36	0.95	1.24	1.54	0.61	-	0.14	1.17	0.48	0.15	0.41	0.13-1.54
Pb	lb/curb mi-day	0.12	0.60	BDL	0.03	BDL	BDL	0.02	BDL	1.64	0.15	0.10	0.06	0.30	BDL-1.00
	lb/curb mi-1000 vehicles	0.002	0.002	BDL	0.003	BDL	BDL	0.001	-	0.04	0.0065	0.0049	0.0011	0.01	BDL-0.04
Winter Runoff Rates															
TSS	lb/curb mi-day	101.	46.3	7.1	80.0	234.	2.53	31.1[1]	-	N/A	N/A	N/A	N/A	100.	2.53-100.0
	lb/curb mi-1000 vehicles	1.50	1.37	0.87	13.6	33.7	0.91	1.67	-	N/A	N/A	N/A	N/A	1.83	0.87-33.7
COD	lb/curb mi-day	22.7[2]	25.9	4.02	28.1	53.5	2.71	20.2	-	N/A	N/A	N/A	N/A	89.3	2.71-89.2
	lb/curb mi-1000 vehicles	0.40[2]	0.77	0.50	4.34	7.70	0.90	1.07	-	N/A	N/A	N/A	N/A	1.32	0.40-7.70
Pb	lb/curb mi-day	0.43	0.17	BDL	0.12	0.11	0.005	0.06	-	N/A	N/A	N/A	N/A	0.02	BDL-0.02
	lb/curb mi-1000 vehicles	0.006	0.005	BDL	0.02	0.02	0.001	0.003	-	N/A	N/A	N/A	N/A	0.02	BDL-0.02

1 Yearly TSS Runoff Rate
2 Does Not Include Grit Fraction

Table 8. Methods Used in the Analysis of Highway Stormwater Runoff.

Pollutant Test	Procedure: Standard Methods	Procedure: EPA Math-Chem. Analysis	Procedure: Atomic Absorption Method	Procedure: IR Carbon Analysis	Analysis: Initial within 48 hours	Analysis: Later Frozen or Preserved	Averaged Estimated Laboratory Error %
TSS	X				X		15
VSS	X				X		15
COD	X				X		10-15
TOC	X			X		X	12-38
Grease & Oil		Freon-extraction & distillation, then run as TOC		X		X	18-53
Lead			X			X	12
Zinc			X			X	9
Copper			X			X	7
NO_3-NO_2-N		X				X	16
TKN		Micro X				X	18-100
Total Phos.	X					X	14
Chloride	Specific Electrode X					X	8
Specific Conductance	X				X		Serious Solids Inhibition Problems w/test.

presents detailed examination of data for each site. Based on literature values, a mass balance is developed for sources of solids observed in highway runoff. These data suggest adjacent land use in Western Washington contributes less than 10% of these solids and the major sources appear to be vehicle related and, in winter, related to sanding application in icy conditions. Ash from the eruption of Mt. St. Helens was detected immediately after the major eruptions, but traffic-generated winds removed these solids from the Western Washington sites prior to the storms that were monitored.

Two major conclusions were drawn from these results: The first conclusion was that solids present in highway runoff are strongly correlated with traffic during the storm and not traffic during the period preceding a storm as reported in the literature. This may be unique to Western Washington where the pavement remains wet for many hours and vehicles act as scrubbing agents to remove solids. During short, intensive storms the impact of the precipitation may be the major source of solids removal, but during the low intensity, long duration storms in Western Washington the vehicles can be the major removal mechanism. The data also indicated that sand added during icy periods contributed more than fifty percent of the annual solids loading observed in highway runoff. The second major conclusion from the third year of study was that, excluding the sand applications for de-icing, the highway runoff solids loadings (lb/curb-mile/1000 vehicles during storm) are higher than natural values and appear to be constant among Western Washington sites when corrected for variability in runoff coefficients (Figure 2). These two conclusions permit the formulation of a simple model to predict solids loading from highway runoff of the form:

$$TSS\ (lbs/curb\text{-}mile) = K*VDS*RC$$

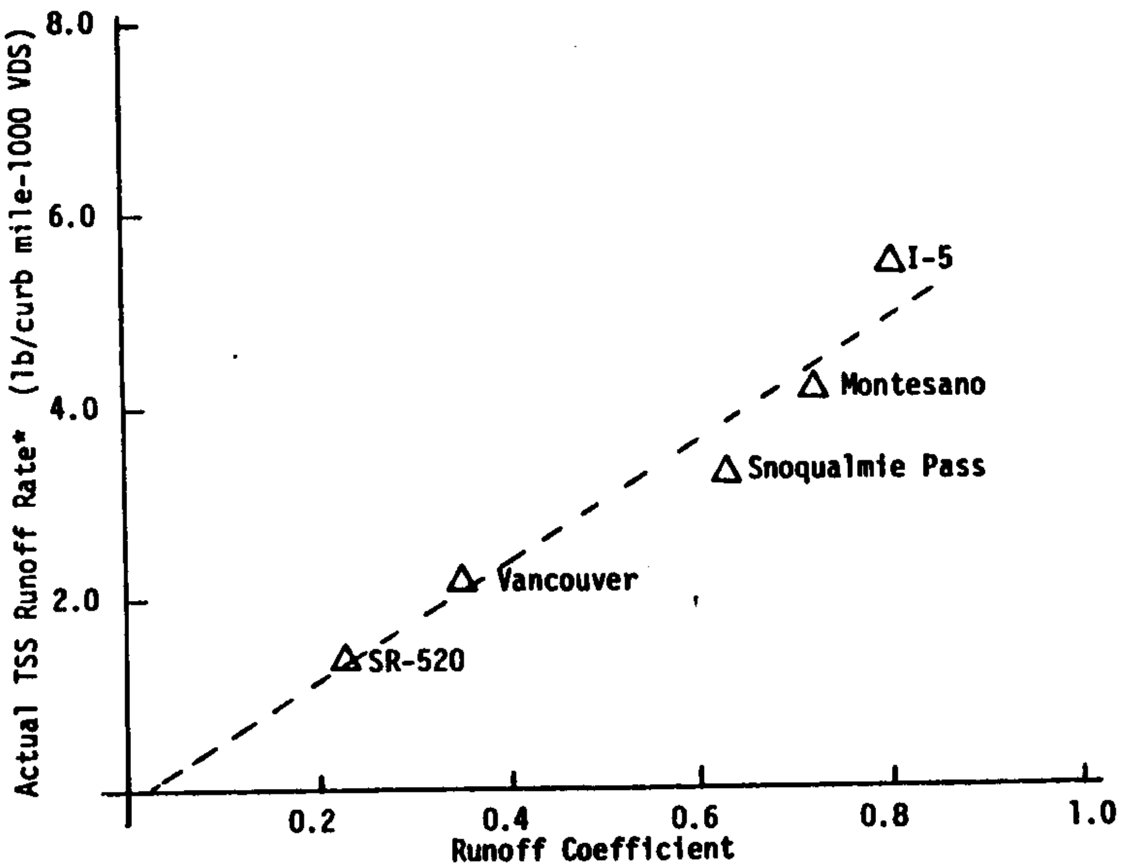

Figure 2. Total Suspended Solids Runoff Rate Versus Runoff Coefficient for the Fall-Spring Period at the Western Sites.*

* Derived from the cumulative TSS to cumulative VDS plots and based on actual runoff loads at the SR-520 site.

TABLE 9. Rainfall, runoff and traffic data for storms sampled for trace organics.

Storm Event	Date	Rainfall (in)	Duration (Hr)	Average Intensity (In/Hr)	Vehicles During Storm	Vehicles Preceding Storm	Runoff Volume (ft^3)	Runoff Coefficient	Dry Days
I5-78[1]	10-14-79	0.25	7	.036	5,980	2,022,980	903	0.82	36
I5-79[1]	10-20-79	0.74	18	.041	38,540	142,690	1287	0.39	6
I5-93[1]	12-18-79	1.34	22	.061	46,300	46,300	4301	0.93	1
520-11[1]	12-02-79	1.39	17	.082	26,610	224,200	350[3]	0.75[4]	5
520-16[1]	12-19-80	0.7	19	.037	35,800	62,650	176[3]	.75[4]	1
520-43[2]	05-28-80	0.80	18	.044	23,400	187,200	201[3]	.75[4]	6
I5-131[2]	05-28-80	0.86	20	.043	46,980	298,120	3059	0.80	6
I5-87[1,2]	12-2-79	1.20	18	.067	58,830	294,570	2862	0.71	5

1. Extraction for aliphatic and aromatic fractions.

2. Extraction for GC/MS analysis.

3. Measured values are low due to leakage through expansion joints.

4. Estimated (Aplund, 1980).

where: K is obtained from the slope of the curve in Figure 2;

VDS is the number of vehicles crossing the highway section of interest during the storm;

RC is the runoff coefficient of a particular storm, and may vary depending on storm characteristics and traffic.

There are insufficient data from Eastern Washington sites to develop a statistically sound conclusion on pollutant loading causality at this time, and year four studies are designed to increase this data base.

A weaker conclusion from the third year's data is that the ratio of any pollutant loading to the total suspended solids loading is a constant. This observation is being explored during year four of the project to develop definitive values for these ratios applicable to highways in the State of Washington.

During year three an intensive effort was made to establish the presence of trace organics in highway runoff. The analyses required many weeks of sample preparation to separate the trace organics from runoff water and into fractions containing different types of organic compounds. Analytical costs of several thousand dollars per sample were necessary to conduct this study, and these costs limited the scope of effort. A total of six samples obtained from the Interstate-5 and State Route 520 sites plus controls were processed (filtration, extraction, clean up and concentration) to measure the weights of trace organics in the particulate and soluble extract fractions of highway runoff. Three samples were analyzed by gas chromatography (GC) coupled to mass spectroscopy (MS) using computer data systems (CDS). Characteristics of the storms sampled are shown in Table 9. Table 10 presents the summary of the data for gross parameters used in

TABLE 10. Concentration of suspended solids, composite organic parameters and extract weights in storm samples.

Storm	TSS mg/l	VSS mg/l	COD mg/l	TOC mg/l	Oil/Grease mg/l	Particulate Extract mg/l	Soluble Extract mg/l
I5-78	97	26	61	21.8	38.7[1]	15.6	7.8
I5-79	32	12	61	18.4	28.7[1]	7.3	5.1
I5-93	118	26	52	28.3	30.7	9.5	3.0
520-11	335	115	271	36.8	30.7	30.8	0.62
520-16	144	53	130	25.8	48.0	19.1	2.7
520-43	408	74	280	356	480	17.6	4.6
I5-131	57	19	166	97.5	93.5	13.4	9.3
I5-87	72	10	59	12.5	14.6	13.5	1.1

1. Samples from storms I5-78 and I5-79 were obtained for Oil/Grease analysis.

TABLE 11. Identified organic compounds grouped into nine categories.

Class of Compounds	STORM I5-87			STORM I5-131			STORM 520-43		
	Particulate (µg/l)	Soluble (µg/l)	Total (µg/l)	Particulate (µg/l)	Soluble (µg/l)	Total (µg/l)	Particulate (µg/l)	Soluble (µg/l)	Total (µg/l)
Aliphatic Alcohols	T	160	160	478	155	633	327	126	453
Aliphatic Hydrocarbons	3710	3220	6930[1]	1850	6364	2490	913	20	933
Aromatic Compounds including Heterocyclics	2050	148	2200	297	96	393	596	128	724
Halogenated Organics	T	T	T	173	9	82	114	T	114
Ketones and Aldehydes	1130	T	1130	87	39	126	385	128	513
Organosulfur Compounds	1200	62	1260	T	5,3	5.3	4.9	T	4,9
Oxygenates excluding Alcohols, phenolics, ketones/aldehydes	3170	410	3580	3510	228	3740	2440	126	2570
Nitrogen Containing Compounds	1420	62	1480	87	28	115	325	135	460
Phenolics	2830	80	2910	T	2.9	2.9	T	T	T
Total Chromatographed	13800	9520	23300	7220	2410	9630	5080	1488	6570

T - trace

characterizing organic pollutants. Details of the experimental procedures and data analysis are found in Zawlocki (1981). Table 11 presents the results of the GC/MS/CDS analysis. To simplify the interpretations the several hundred compounds tentatively identified by this analysis were grouped into nine categories, which are not mutually exclusive. Comparing sums of the detected trace organics with the amount introduced indicates that not all trace organics were identified. These data suggest that the major categories present are aliphatics that can be traced to petroleum products such as fuels, oils, rubber or plastics, aromatics which may be added to fuels for octane improvement, and oxygenated compounds that suggest incomplete combustion of hydrocarbons. Halogenated compounds were observed in two of the three samples and probably originate from bromine compounds found in leaded gasolines. The compounds detected by GC/MS/CDS were not consistent in each sample and additional sample analyses are necessary to resolve these differences. Since the concentrations observed in these samples are quite low compared to criteria proposed for the protection of aquatic life, the extent of the analyses do not seem to justify further analysis at this time. On the other hand, the criteria for potential carcinogenic compounds are very stringent; and if highway runoff can enter drinking water supplies, additional study of these trace organics may be necessary.

This project has elected to focus on bioassay studies to determine if highway runoff waters can be demonstrated to be harmful to aquatic life. If no problem can be demonstrated, the need for the analysis of trace organics will be eliminated.

An extensive literature review, laboratory column studies and field observations on SR 302 woodwaste fill project near Victor, Washington, were completed to establish the water quality impacts of woodwaste fills. Vause (1980) reports the details of these efforts and Vause, Ferguson and Mar (1980) have summarized these findings for the Washington State Department of Transportation. Six columns (6" dia. x 5' high) were filled with woodchips from the SR 302 project and subjected to a range of flow rates anticipated in the actual site. The columns and the site were monitored for almost one year to determine the concentration and loadings of COD, BOD and TOC. The data indicated that the pollutants were caused by physical leaching of wood extracts and that microbial fermentation was of secondary importance. Passage of low pH leachate through soils can increase concentrations of metals, but these were not high enough to cause toxicity problems. Based on laboratory and field studies the ultimate release of pollutants appears to be:

80 ± 20 lb COD/ton solids

20 ± 5 lb TOC/ton solids

30 ± 8 lb BOD/ton solids

The pollutants are released at an exponentially decreasing rate, and concentrations low after one year of soaking. The environmental impacts of these pollutants depends on the dilution and assimilation provided prior to discharge. Since pre-soaking of woodwaste prior to placement would remove much of these pollutants, the use of old weathered chips rather than fresh waste would reduce the pollution problem. Proper placement and installation may prevent water from entering the fill and subsequent leaching. Finally, proper drainage and discharge of the leachates to high volumes of dilution waters would reduce environmental impact.

Future Work

The fourth year of this project will obtain one more year of field data for all sites except the SR 520 site. The SR 520 site was discontinued because of low runoff coefficients caused by leaking between bridge sections. These field data will be used to validate the solids loading model and to establish the ratio of pollutants to solids at each site. Two years of field data from Eastern Washington will hopefully be adequate to describe the pollutant loading for these arid sites.

Three special studies will be intensified this year. Metal analysis will focus on the transport and assimilation of trace metals between the highway and receiving waters. Bioassays will attempt to establish if highway runoff are toxic to aquatic life and what are the natures of the toxicants. Material balances for pollutants generated on the highway will be conducted to identify the fraction of pollutants released during dry periods that enter the receiving waters. These three results will be used to estimate the effectiveness of practices to mitigate highway runoff impacts.

A prototype environmental impact statement will be prepared to provide a framework and procedures for future EIS describing the impact of highway runoff.

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