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Water Quality Studies of Wildcat Creek near McCleary, Washington

Summer 1977

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FIGURES AND TABLES

INTRODUCTION

Wildcat Creek is a small stream (average maximum flow 336 cfs)[1], draining 19.8 square miles within the Chehalis River Basin. The stream is comprised of three forks, the East, Middle and West with the East Fork originating several miles northeast of McCleary, Washington and entering Cloquallum Creek nine miles to the southwest. Wildcat Creek is considered Class A waters with multiple usage having particular significance to salmon fisheries with chum and coho utilizing the stream for spawning and rearing.

The McCleary sewage treatment plant discharges into Wildcat Creek from Sam's Canal, a spring-fed tributary that enters Wildcat Creek downstream from the Olympic Highway bridge west of McCleary. Simpson Timber Company also discharges cooling water from its sawmill to Wildcat Creek via storm sewers that enter Sam's Canal.

In 1970 two significant fish kills occurred in Wildcat Creek from toxic pollutants, with one kill totaling over 11,000 fish. According to a fisheries publication "abatement of pollution problems in the vicinity of McCleary on Wildcat Creek is needed to assure continued production from this fine salmon stream."[2]

Previous studies of Wildcat Creek and Sam's Canal were conducted in 1973.[3] Water quality data was obtained from Sam's Canal and Wildcat Creek near the confluence of the canal. A study of benthic macro-invertebrate populations and fish and mussel in-situ bioassays were also conducted. These studies showed some enrichment occurring in the canal above the

STP outfall and a decrease in water quality with toxic effects to fish, mussels and some benthic invertebrates below the outfall in both Sam's Canal and Wildcat Creek. No lower limits of the area affected in Wildcat Creek were determined.

The McCleary STP is being required by federal and state law to go to advanced waste treatment as it does not meet secondary effluent standards with the existing facilities (trickling filter). McCleary will rehabilitate its present facilities and add tertiary filtration and dechlorination facilities to meet requirements.

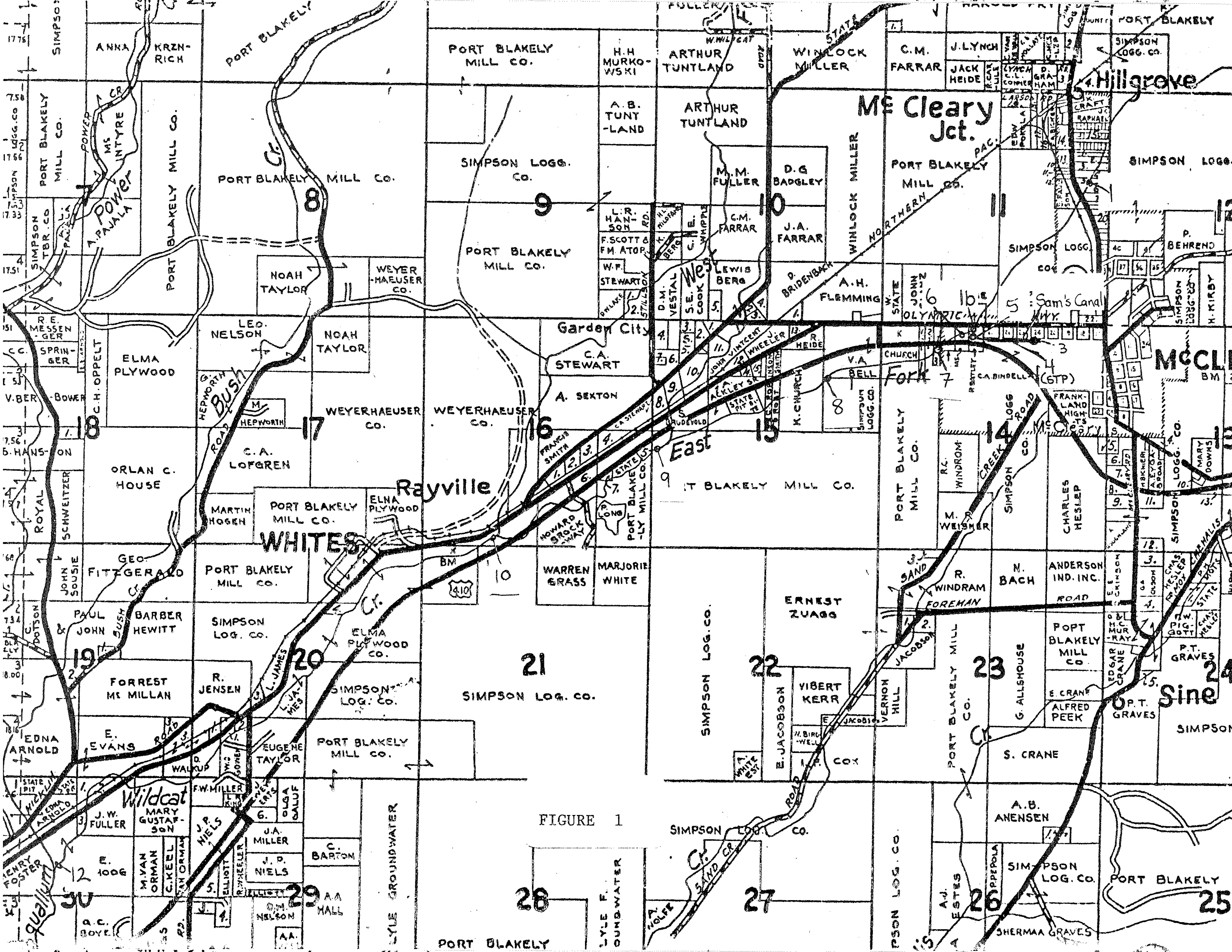
The intent of this study is to evaluate the advisability of nutrient removal at the McCleary STP and determine the lower limit for deleterious effects from the STP effluent in Wildcat Creek.

Station Location and Description

See Figure 1 for a map of the study area and station location. Descriptions of each station are as follows:

Station 1: Approximately 70 yards upstream from Summit Road bridge. Heavily shaded with deciduous and coniferous trees and shrubs. Bottom substrate, predominantly cobbles with some pebbles. Sampling area in a deep pool below riffle. Average velocity .6 ft/sec.

Station 3: Sam's Canal 5 yards upstream from STP outfall. Exposed with some shading from grasses, briers and shrubs along banks. Bottom substrate gravel and clay. Sample area approximately 1 foot wide and 3 inches deep.


McCleary Jct.
Hillgrove
McCLEARY
Garden City
Rayville
WHITES
Sine
Wildcat
West
East
Fork
Bush
Power
Cr.
Sam's Canal
OLYMPIC HWY.
NORTHERN PAC.
FOREMAN ROAD
SAND CR.
CREEK ROAD
410
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28
29
PORT BLAKELY MILL CO.
SIMPSON LOGG. CO.
SIMPSON LOG. CO.
WEYERHAEUSER CO.
ELMA PLYWOOD
ARTHUR TUNTLAND
WINLOCK MILLER
C.M. FARRAR
ERNEST ZUAGG
CHARLES HESLEP
LYLE GROUNDWATER
FIGURE 1

Station 4: McCleary sewage treatment plant chlorine contact chamber. Average low flow retention time, 15 minutes.

Station 5: Mouth of Sam's Canal. Moderately shaded with deciduous trees and shrubs. Bottom substrate boulders and cobbles. Samples taken from riffle. Average velocity .5 ft/sec.

Station 6: 10 yards below confluence of Sam's Canal and Wildcat Creek. Heavily shaded with deciduous trees. Sampling site in a pool below a riffle. Bottom substrate primarily gravel with some cobbles and boulders. Average velocity .4 ft/sec.

Station 7: 10 yards downstream from Hwy. 8 bridge; approximately 200 yards below station 6. Exposed with partial shading from deciduous and coniferous trees. Bottom substrate gravel covered with layer of sediment. Sampling site in a pool after spillway over bridge structure. Average velocity .2 ft/sec.

Station 8: .5 miles downstream from station 7. Heavily shaded with deciduous and coniferous trees. Bottom substrate pebbles and cobbles. Samples taken from pool below riffle. Average velocity .8 ft/sec.

Station 9: .75 miles below station 8; 75 yards below confluence of Middle and East Fork of Wildcat Creek. Moderately shaded with deciduous and coniferous trees. Bottom substrate generally cobbles with some pebbles and gravel. Sample site in pool below riffle. Average velocity .9 ft/sec.

Station 10: Approximately .8 miles below station 9; 15 yards below confluence of West and East Fork of Wildcat Creek. Moderately shaded with deciduous trees. Bottom substrate cobbles and gravel. Average velocity .9 ft/sec.

Station 12: Approximately 2 miles below station 10 at mouth of Wildcat Creek. Heavily shaded with deciduous trees. Bottom substrate gravel with some cobbles. Samples taken in pool below riffle. Average velocity .9 ft/sec.

METHODS AND MATERIALS

The survey was conducted during the summer, 1977, under low flow conditions. Chemical, biological and physical evaluations were made to determine changes in water quality, stream productivity, diversity and population distribution of macro-invertebrates, salmonid fish densities and habitats. Acute toxic effects of the STP effluent were also determined.

Chemical and Physical Parameters

All chemical analyses, excluding dissolved oxygen (DO), conductivity, pH and chlorine residual, were conducted by the Department of Ecology Analytical Laboratory in Olympia, according to methods described in Standard Methods for the Examination of Water and Wastewater[4] and the Manual of Methods for Chemical Analyses of Water and Wastes.[5] Parameters measured were nitrates, nitrites, ammonia nitrogen, unionized ammonia, kjeldahl nitrogen, total and orthophosphates, total suspended solids,

biomass, turbidity, total and fecal coliform, five-day biological oxygen demand (BOD_5), chlorophyll *a* and pheophytin *a*.

All other parameters were measured in the field. Dissolved oxygen was measured with an IBC Dissolved Oxygen Field Monitor. Conductivity was determined using a Chemtrix Type 70 conductivity meter. pH was measured with a Leeds and Northrup 7417 pH/specific ion/mv meter. Chlorine residual was analyzed using a Hach Model CN-66 DPD Free and Total Chlorine Test Kit. Temperature was also taken in the field with a centigrade thermometer. Stream flow was gaged with a Marsh-MacBirney Model 201 Portable Current Meter.

Two consecutive 24 hour diel surveys were conducted on August 9-11. Field parameters were measured at four hour intervals at each station. Water samples for complete analysis were taken every 24 hours for a total of three times at all stations. All samples were placed on ice and transported to the DOE laboratory the same day they were taken. Nutrient samples were acidified with sulfuric acid in addition to holding on ice.

Flows were gaged at stations 5, 6, 9, 10, and 12 at the beginning and end of the diels surveys. The flow from the STP was determined by multiplying pump capacity by hours of pump operation.

Biological Parameters

Several short term biological studies were conducted during the summer. Diversity (Shannon-Weaver Index) and population distribution of

benthic macro-invertebrates was determined using Hester-Dendy multi-plate samplers[6]. Salmonid fish densities were determined using electroshock technique according to the Zippin removal method[7]. An Autotrophic Index was developed from periphyton biomass and chlorophyll a content. Algal assays were done to determine algal bloom potential and productivity. Acute toxic effects of the STP effluent to fish were determined in two 96-hour in-situ bioassays using fingerling coho salmon (Oncorhynchus kisutch).

Invertebrate identification and counts and algal assays were conducted by the Environmental Protection Agency Region X Surveillance and Analysis Division. Coho salmon were provided by the Department of Fisheries Matlock hatchery.

Initial water quality data was gathered from 15 sites in Wildcat Creek and Sam's Canal at the end of June. Ten final stations were chosen from this preliminary data. Triplicate multi-plate samplers and a periphyton slide board were suspended in the stream at stations, 1, 5, 6, 7, 8, 9, 10 and 12 at this time. Depth of each sampler and stream velocity was measured. The samplers remained in the stream for six weeks. Periphyton slides were gathered at two week intervals for biomass, chlorophyll a and pheophytin a determinations. Slides were placed in the dark on ice until they reached the DOE laboratory where they were frozen at -6°C until analyzed. The multi-plate samplers were retrieved at the end of six weeks and placed directly into a specimen jar. Samplers were covered with a 60-70% ethanol solution and transported to the EPA laboratory for identification and counting.

The fish bioassays were conducted from August 6-14. Fingerling coho salmon were transported in a 50-gallon container with a portable aerator from the Matlock hatchery, placed in fish live boxes at Station 1 and allowed to acclimate for 24 hours before each bioassay. Following acclimation, live boxes containing 10-20 fish each were placed at stations 1, 5, 6, 7, 8, 9, 10, and 12 and mortalities were counted every 24 hours. During the initial bioassay, the STP operated without chlorinating its effluent. Chlorination was resumed at the beginning of the second bioassay.

Water samples for algal assays and additional nutrient analysis were collected on August 12 from Stations 1, 5, 6, 9, and 10 and transported to the EPA laboratory.

The salmonid density survey was made on September 7 at Stations 1 b, 6, 7, and 8. Species were identified, counted, and lengths measured in the field. Sample area was approximately 150-175 linear feet.

RESULTS

Chemical and Physical Parameters

The results for all water quality parameters are presented in Tables 1-5. All values except DO, chlorine residual, and fecal coliform, represent the mean value for a 48 hour period from August 9-11.

TABLE 1

Mean Nutrient Values for a 48-hour Period
from August 9 to 11

STATION	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	O-PO_4-P (mg/l)	T-PO_4-P (mg/l)
1	.28	.02	.03	.19	.04	.03
3	.19	.02	.05	.26	.06	.08
4	.82	.06	10.5	14.2	3.8	6.1
5	.32	.09	4.1	6.5	1.9	2.7
6	.37	.05	1.9	3.3	1.0	1.3
7	.67	.10	2.3	2.6	1.0	1.3
8	1.5	.05	.08	.33	.54	.70
9	1.3	.02	.04	.27	.38	.45
10	.79	.02	.03	.14	.17	.20
12	.55	.02	.03	.08	.07	.07

TABLE 2

Mean Values for a 48-hour Period
from August 9 to 11

STATION	TEMP. (°C)	pH	COND. (umhos/cm)	TURB. (NTU)	T.S.S. (mg/l)	B.O.D. (mg/l)
1	14.5	7.1	85	2	1	2
3	22.7	6.9	124	3	5	2
4	19.4	7.1	444	16	22	26
5	21.0	7.1	238	6	9	10
6	18.9	7.0	182	4	8	6
7	18.8	6.8	170	3	4	6
8	17.4	6.9	150	3	5	3
9	16.4	6.8	138	3	5	2
10	15.8	6.9	116	2	1	2
12	16.2	6.9	116	1	3	2

TABLE 3
Dissolved oxygen mg/l

STATION	1	3	4	5	6	7	8	9	10	12
8/9										
1000 hrs.	10.4	—	3.2	6.6	—	—	8.3	9.2	9.5	9.2
1400	9.0	6.6	5.9	4.9	7.3	7.1	8.0	8.2	8.1	8.6
1800	8.3	4.1	4.4	5.8	6.6	7.0	7.3	9.0	8.8	8.2
2200	7.5	4.9	5.6	4.7	5.8	5.1	5.5	6.5	6.9	6.8
8/10										
0200	9.4	3.8	2.0	6.5	7.0	6.3	6.2	8.3	9.0	8.7
0600	9.4	3.7	1.9	4.0	6.8	6.6	6.2	8.2	8.9	8.8
1000	10.0	5.2	3.4	5.0	6.7	6.2	6.3	8.8	9.8	9.5
1800	9.0	5.0	3.3	5.8	6.8	7.0	—	8.2	8.1	8.3
2200	8.9	5.5	6.0	5.2	6.0	6.6	5.4	7.4	7.6	7.3
8/11										
0200	8.9	5.2	3.9	6.1	6.6	7.2	6.1	8.1	10.0	8.6
0600	9.4	5.6	4.3	5.5	6.7	7.0	6.8	8.1	8.1	8.2
1000	9.2	6.5	6.7	5.6	6.0	7.4	7.1	7.2	8.5	8.0

TABLE 4
Chlorine residual mg/l

STATION	1	3	4	5	6	7	8
8/10							
1800 hrs.	0	0	.8	0	0	0	0
2200	0	-	.8	.2	0	-	-
8/11							
0200	-	-	1.4	.2	.2	.1	-
0600	-	-	1.7	.1	.1	.1	-
1000	-	-	.9	-	.1	.1	0

TABLE 5

Fecal Coliform

Colonies/100 ml

Station	8/9	8/10	8/11
1	est. 35	40	est. 140
3	450	est. 1,300	est. 500
4	est. 110,000	96,000	est. 11,000
5	est. 18,000	11,000	est. 1,400
6	est. 9,700	10,000	470
7	est. 9,600	4,400	2,500
8	est. 740	est. 830	est. 170
9	370	300	220
10	88	110	74
12	est. 28	est. 17	32

Ammonia nitrogen (NH_3-N) and nitrate nigrogen (NO_3-N) levels were a mean of 10.5 mg/l and .82 mg/l respectively at station 4 (STP). NH_3-N levels in Wildcat Creek decreased steadily downstream from the STP and reached levels equivalent to above the STP by Station 9. NO_3-N levels initially decreased but then increased to 1.5 mg/l at station 8 probably due to nitrification of ammonia. These levels decreased downstream from station 8 to reach a final mean value of .55 mg/l at station 12, approximately twice the levels found at station 1. Unionized ammonia was found in concentrations above the recommended .02 mg/l[8] in Sam's Canal only. Concentrations ranged from .02 to .2 mg/l at the STP and .02 to .04 at station 5. Both ortho- and total phosphates are highest at station 4 with 3.8 mg/l and 6.1 mg/l respectively. There is a gradual decline in these levels as the effluent reaches Wildcat Creek and continues downstream. Final levels are .07 mg/l for both parameters; approximately twice the levels found at station 1.

Water temperatures ranged from 13.0 to 25.4°C. The warmest temperatures were found in Sam's Canal. Wildcat Creek below the confluence with the canal is 3-7°C higher than the waters above the confluence. The average temperature of the stream cooled with each successive downstream station.

The pH in both Wildcat Creek and Sam's Canal ranged 6.4 to 7.5 with averages of 6.8-7.1. Total suspended solids averaged 1 mg/l at station 1, 22 mg/l at station 4 and returned to background levels by station 10.

Background BOD levels in Wildcat Creek were <2 mg/l. The STP effluent contained an average BOD of 26 mg/l. This dropped to 6 mg/l above the confluence of the canal and the creek and reach background levels at station 8.

Dissolved oxygen levels were above 5.0 mg/l at all stations in Wildcat Creek. Dissolved oxygen in Sam's Canal was generally below 6.0 mg/l at all stations and the STP effluent was between 1.9 mg/l and 6.7 mg/l. During the night DO levels generally dropped below 6.0 mg/l at stations 6, 7 and 8. The lowest levels were usually noted at 2200 hours.

The STP operated with a total chlorine residual of .8-1.7 mg/l. The chlorine dissipated slowly and was detectable as far downstream as stations 6 and 7 with values of .2 and <.2 mg/l respectively. The chlorine residual values found at stations 6 and 7 are not consistent with dilution ratios determined for these stations (See below). The chlorine residual data from these stations should be viewed more as an indicator of presence or absence rather than actual values.

The coliform data from August 9 and 10 represents unchlorinated effluent from the STP. The fecal coliform levels were 110,000 and 96,000 colonies/100 ml at station 4. Chlorination was resumed after the sampling period on August 10. The fecal levels are still relatively high with 11,000 colonies/100 ml. Coliform levels generally declined downstream, reaching levels of <100 colonies/100 ml by station 10. During the third sampling period, station 7 showed an increase in fecal coliform, possibly due to regrowth.

The dilution ratios for the STP effluent are as follows;

	MGD	Dilution Ratio
Station 1	1.3	
3	.3	
4	.3	
5	.6	1:1
6	1.9	6:1
7	1.9	
8	1.9	
9	2.3	8:1
10	3.3	11:1
12	4.4	15:1

Biological Parameters

Benthic macro-invertebrate diversities are reported in Table 6. The Shannon-Weaver diversity index assigns values between 0-4. Generally, in clean waters the index is between 3 and 4, in moderately polluted waters, 1-3 and heavily polluted water <1. A high diversity index occurs when the population is evenly distributed over a number of species indicating a healthy environment. A low diversity occurs when the population distribution is disproportionate or only a few species exist, indicating an environment under stress. According to the diversity index little or no pollution exists in Wildcat Creek above the STP. Below the STP, the stream is moderately polluted but slowly recovers and reaches an index value indicating no pollution by station 10.

TABLE 6
Macro-invertebrate Diversity

STATION	DIVERSITY INDEX
1	3.33
5	1.60
6	2.45
7	2.31
8	2.52
9	2.16
10	3.61
12	3.53

3-4 = no pollution

1-3 = moderate pollution

0-1 = heavy pollution

Population distribution by Order of macro-invertebrates collected at each station is summarized in Table 7. Populations were small and varied at station 1. Stations 5 and 6 showed a large increase in numbers of invertebrates with Diptera (true flies) being the predominant Order found. Many members of this Order are pollution tolerant. Mayflies (Emphemeroptera) began to increase in abundance at station 7 while numbers of Diptera dropped. The pollution sensitive Plecoptera (stone flies) began to appear in significant numbers at station 8. A greater variety of invertebrates with a more balanced distribution was found at stations 10 and 12.

Densities of salmonid fish in Wildcat Creek are reported as fish per linear foot with the following results:

Station	Density/linear ft.	Total fish/station
1 b	.17	28
6	.06	9
7	.31	50
8	.55	83

The two species found were Salmo gairdneri (Rainbow trout) and Oncorhynchus kisutch (coho salmon) with coho being the most predominant. Ninety-six percent of all fish captured were under four inches.

The mortalities that occurred in the fish bioassays are summarized in Table 8. Station 1 was used as a control. The bioassay conducted

TABLE 7

MACROINVERTEBRATE POPULATION DISTRIBUTION

Station	Diptera	Trichoptera	Plecoptera	Ephemeroptera	Coleoptera	Crustacea	Gastropoda	Other
1	64	3	8	43	1	--	--	1
5	3545	--	--	--	--	--	--	40
6	2140	7	6	39	1	2	1	4
7	233	--	--	241	--	1	1	1
8	31	4	34	205	--	--	--	--
9	51	10	47	368	--	--	--	--
10	79	25	48	60	--	--	2	2
12	51	16	18	50	25	--	1	--

TABLE 8
Fish Bioassay Mortalities

STATION	1	5	6	7	8	9	10	12
20 fish/live box								
No chlorination								
8/7	0	1	0	0	0	0	0	0
8/8	1	0	0	0	0	0	0	0
8/9	0	0	0	0	0	0	0	0
8/10	0	9	0	0	0	0	1	0
Totals	1	10	0	0	0	0	1	0
10 fish/live box								
Chlorinated effluent								
8/11	0	10	0	1	0	2	2	0
8/12	0	--	0	0	0	2	0	0
8/13	0	--	0	0	0	0	0	0
8/14	0	--	0	0	0	1	0	0
Totals	0	10	0	1	0	5	2	0

during no chlorination at the STP showed few mortalities although station 5 had 50% mortality after 96 hours. This may have been due more to low DO levels rather than toxic pollutants from the STP. When the STP resumed chlorination 100% mortality occurred at station 5 within 24 hours. Mortalities occurring at other stations were more erratic with 10% at station 7, 50% at station 9, and 20% at station 10 over 96 hours. Stations 1, 6, and 12 had no mortalities.

Some habitat changes were observed in Sam's Canal and Wildcat Creek below the STP. Wildcat Creek generally has a gravel/cobble bottom with some boulders with approximately a 50:50 pool-riffle ratio. The stream is well shaded with dense underbrush, deciduous and mature coniferous trees. Sam's Canal is greatly exposed with some brush and grass covering near the banks. The bottom substrate is generally gravel. Below the sewage treatment plant in Sam's Canal there was heavy slime growth with a thick spongy layer of sediment and slime covering the bottom in depths up to 1 foot. The slime growth was noticeable on bottom substrates at stations 6 and 7 in Wildcat Creek. Very little periphyton growth was observed at station 6. The slime is less noticeable at station 7 and periphyton growth increases dramatically in areas receiving sunlight. Station 7 is the only station where aquatic plant growth is observed on bottom substrates. A sewage odor is noticeable as far as station 7.

Periphyton biomass and chlorophyll a results and chlorophyll/pheophyton ratios are presented in Table 9. No Autotrophic Index was developed as the biomass and chlorophyll values are questionable

TABLE 9

Chlorophyll a, Biomass and Chlorophyll/Periphyton Ratios

Station	Chlorophyll a mg/m^2	Biomass mg/m^2	Chlorophyll/Pheophytin
7/15			
1	2.8	1.4	1.57
5	8.2	173.1	1.19
6	1.4	52.4	1.20
7	58.1	38.7	1.64
9	32.9	8.0	1.63
10	4.0	1.3	1.37
12	59.0	9.7	1.65
7/29			
1	2.3	.8	- -
5	24.3	67.2	1.18
6	1.6	11.3	1.03
7	198.1	13.1	1.50
8	56.7	5.5	1.62
9	59.9	8.4	1.69
10	13.4	1.7	1.60
8/12			
1	1.8	4.2	1.38
5	3.9	32.7	1.22
6	3.0	14.3	1.30
7	295.7	22.3	1.62
9	85.2	18.9	1.68
10	9.6	5.5	1.66
12	11.0	13.9	1.60

due to problems in analyses. The data is presented, rather, to indicate general occurrences in the stream. An increase in biomass was seen at station 5 during all three sampling periods. Biomass values generally decreased downstream from station 5. Chlorophyll values were more erratic. Generally the highest values were noted at station 7 and lower values at stations 5 and 6. The trends in biomass and chlorophyll values are generally consistent with macro-invertebrate abundance and observable periphyton growth.

The chlorophyll/pheophytin ratios can be used to indicate general health of the periphyton communities. Ratios result in values ranging from 1.0 - 1.7. A value of 1.7 occurrs in a sample consisting of pure chlorophyll and indicates the periphyton population contains mostly intact, non-decaying organisms. A value of 1.0 results from a pure pheophyton sample with no chlorophyll present. Pheophyton is a natural degradation product of chlorophyll and will occur to a greater or lesser degree in all periphyton communities depending on whether the populations are dying off or growing.

Results from stations 5 and 6 showed periphyton populations consisted mostly of pheophyton. All other stations had higher values, indicating more viable periphyton populations.

Results from algal assays showed growth is limited primarily by phosphorous with a secondary nitrogen limitation at station 1. All stations below the STP are limited by nitrogen. Potential algal productivity in Wildcat Creek is reflected in the actual yields of

the test algae, Selanastrum capricornutum, used in the assays (Table 10). Results show nitrogen is available in the control to support increased growth but under natural conditions excessive growth was not observed, indicating other limiting factors exist in the stream, such as light availability and water retention time.

Conclusions

According to both chemical and biological parameters, the STP impacts the water quality and biology of Wildcat Creek. The heaviest impact occurs from the confluence of Sam's Canal and Wildcat Creek to station 7. Toxic levels of >.02 mg/l chlorine occur along with increased water temperatures and low DO. Benthic macroinvertebrates reflect the presence of organic pollution with a low diversity index and a population comprised of pollution tolerant organisms. Salmonid fish densities are low and do not increase until below station 7.

Water quality data generally shows a return to conditions found in Wildcat Creek above the STP at station 10. Invertebrate diversity and distribution also recover by station 10.

Nutrient removal from the STP effluent as a means to improve the quality of Wildcat Creek would have little impact as toxic levels of nutrients did not occur in Wildcat Creek and excessive algal growth is being limited by natural conditions. The problems of chlorine toxicity and degraded water quality will improve with the upgrade of the sewage treatment plant and addition of tertiary filtration and dechlorination facilities.

TABLE 10

Standing Crop of *Selanastrum capricornutum* after 14 Days

Station	Yield (mg/l)
1 C	5.00
1 N	7.09
1 P	12.60
1 N + P	38.00
5 C	131.00
5 N	175.00
5 P	125.00
5 N + P	169.00
6 C	71.9
6 N	108.0
6 P	74.0
6 N + P	114.0
9 C	60.8
9 N	98.7
9 P	62.8
9 N + P	96.1
10 C	21.6
10 N	57.7
10 P	21.7
10 N + P	59.6

C = Control (No additional nutrients)

N = Addition of 1000 ug of nitrogen

P = Addition of 50 ug of phosphorous

N + P = Addition of 1000 ug of nitrogen and 50 ug of phosphorous

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February 15, 1973

Memo to: Mike Price
From: Ron Devitt
Subject: Wildcat Creek, Drainage Ditch, STP effluent

State of Washington
Department of Ecology

On 1-11-73, I sampled Wildcat Creek, the city storm ditch, and McCleary STP effluent.

The following locations were sampled as indicated by the attached schematic diagram.

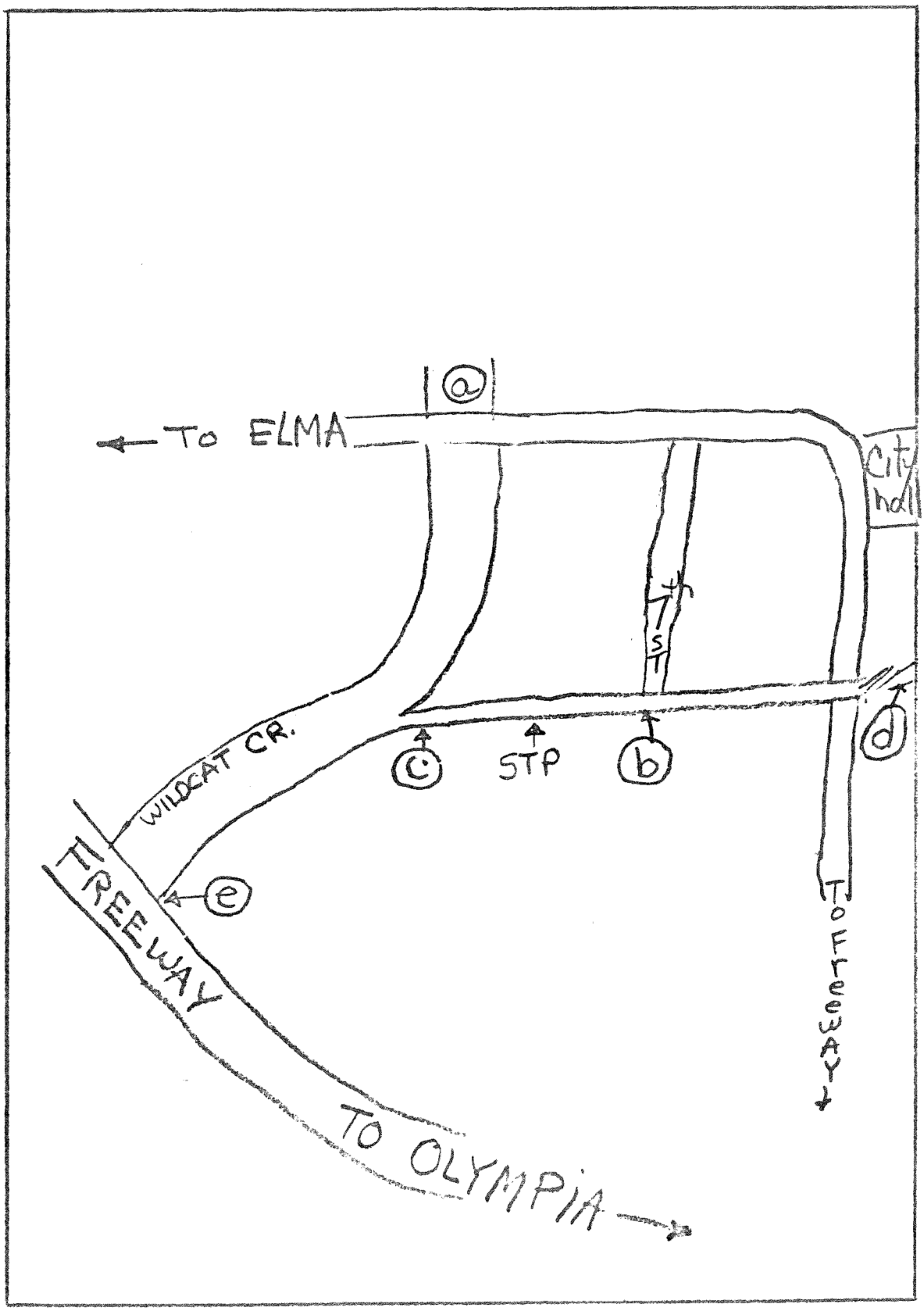
Station #1	Location
a.	Wildcat Creek @ Simpson Avenue Bridge , upstream side.
b.	Drainage @ end of culvert at 7th street.
c.	Drainage 30 yds below STP.
d.	Drainage 10 yds above trash rack.
e.	Wildcat Creek @ Aberdeen-Olympia Freeway Bridge, upstream side.
f.	Lateral drainages inside culvert 5 yds downstream of trash rack.
g.	Wildcat Creek @ McKnight Rd. Bridge, downstream side.

The following pairs of data are presented to indicate differences in water characteristics due to the listed effects:

1. Changes from d to b caused by storm runoff from city.
2. Changes from b to c caused by the influence of the sewage treatment plant.
3. Changes from a to e caused by influence of the combined drainages from the ditch.

d to b- Influence of Storm Runoff

	(d) Upstream	(b) Downstream
ph	6.7	6.8
Turbidity (JTU)	3	10
Conductivity (µmhos/cm@25°C)	57	91
COD (ppm)	4	15
Total Coliform Colonies/100ml	1600	3100
Fecal Coliform Colonies/100ml	<20	60
NO_3-Filtered (ppm)	.28	.39
NO_2-Filtered (ppm)	.01	.01
NH_3-Unfiltered (ppm)	ND	ND
T. Kjeldahl Unfiltered (ppm)	.08	.02
T. phos. Unfiltered (ppm)	.02	.14
Time Hrs.	1045	1005
Temperature °C	4.3	5.2
Dissolved Oxygen (ppm)	11.8	12.0


@
To ELMA
City hall
1st
WILDCAT CR.
c
STP
b
d
e
FREEWAY
TO OLYMPIA
To Freeway

The drainage ditch is completely underground from the trash rack (d) to 7th street (b). I walked the length of this culvert because the drainage upstream was clear and turbid downstream. The weather had been snow and light rain. Consequently there was considerable flow in all the storm sewers entering the culvert. It was found that changes in water quality were due to the effects of lateral drainages. Samples were taken of two typical drainages immediately below the trash rack. The following data were reported.

	Left Pipe	Right Pipe
pH	6.6	6.5
Turbidity	70	70
Conductivity	170	270

These values explain the increase in turbidity and conductivity due to the storm drains. Evidently the dilutional effects of the main drainage counteracts the effect of the slightly acidic pH. Also numbers of storm drains may have slightly different characteristics.

Increase in total and fecal coliform may be due to sewerage fractures or bypass. The lift station above the trash rack is said to bypass intermittently during high water flow. Evidence of this event was observed later in the month. I took pictures and filled out a DOE complaint form.

Comparing b to c Influence of STP

	(b) Upstream	(c) Downstream	STP
pH	6.8	6.9	7.0
Turbidity	10	10	12
Conductivity	91	118	235
COD	15	23	54
Total Coliform	3100	1600	20,000
Fecal Coliform	60	<20	270
NO_3-N-Filtered	.39	.45	.66
NO_2-N-Filtered	<.01	.02	.05
NH_3-N-Unfiltered	ND	.09	.54
T. Kjeldahl-N-Unfiltered	.02	.10	.84
T. Phosphate Unfiltered	.14	.59	2.62
Time	1005	1020	
Temperature	5.2	6.0	
D.O.	12.0	10.8	

A general decrease in water quality was noted, excepting turbidity which exhibited no increase, and coliform which decreased.

The reasons for the decrease in coliform are not known but the following theories are offered.

1. Natural die off due to cold temperatures.
2. Residual chlorine continuing to disinfect in receiving water.
3. Coincidental difference of grab samples due to different sampling times and varying disinfection of STP effluent due to varying flow and chlorine residual. It is thought that flow is cyclic depending on lift stations. A combination of the above factors may offer an explanation why the coliform seemed to decrease at the downstream station.
4. The rate of flow from the treatment plant compared to the flow in the ditch was much smaller.

Comparing a to e-The effect of the ditch on Wildcat Creek

	(a) Upstream	(e) Downstream	(c) Ditch
pH	7.0	6.9	6.9
Turbidity	1	3	10
Conductivity	64	75	118
COD	4	8	23
Total Coliform	620	400	1600
Fecal Colifrom	<20	<20	<20
NO_3-N-Filtered	.95	.77	.45
NO_2-N-Filtered	.01	.01	.02
NH_3-N-Unfiltered	ND	.01	.09
T. Kjeldahl N Unfiltered	.01	.02	.10
T. Phosphate	.02	.15	.59
Time	0945	1100	1030
Temperature	3.2	-	8.5
DO	12.4	-	-

The water quality of the drainage to Wildcat Creek from the municipal area was significantly lower than the creek itself.

The highwater flows and dilutional effect of the creek minimized the impact of the ditch. An increase of COD, turbidity and conductivity was measured.

A coliform sample was taken further downstream, at McKnight Road Bridge. Values were 1400 colonies/100mls. total and 35 colonies/100mls. fecal.

Summary

The drainage ditch flows westerly underneath town and emerges at 7th street. Above the culvert it was clear, downstream it was noticeably more turbid. By walking the culvert it was observed that there was no one particular discharge which changed the appearance. It was the combined effect of the numerous lateral sewers.

The fecal coliform at the outlet at 7th street (b) of 60 colonies/100 mls was not expected.

The ditch received additional degradation and organic loading from the treatment plant. The high volume of runoff tended to have a dilutional effect, and masked the effect of the sewage treatment plant. The quality of the water in the ditch was significantly lower than the quality of Wildcat Creek. As demonstrated, this is due to the combined effect of storm runoff and sewage effluent.

The storm drainage will always occur during periods of high flow. However the volume of sewage would remain more constant, despite infiltration and exfiltration and probably affect the creek most during low flows. Perhaps, an additional survey would be appropriate in the summer in conjunction with a standard efficiency survey.

Station Locations

Wildcat Creek

#1 - 200 yds. upstream of Summit Park - control- abandoned April 26, 1973, after that time station #2 was assumed to be the control.

#2 - 20 yds. above confluence with unnamed creek.

#3 - 15 yds. below confluence with unnamed creek, not established until April 26, 1973.

#4 - 20 yds. below the freeway #410 bridge.

Unnamed Creek

#5 - 20 yds. upstream from trash rack-behind firehall-near Fir Street-Control.

#6 - 5 yds. upstream in culvert at 7th St.

#7 - 200 yds. below the STP outfall.

Wildcat Creek

Flows:

On July 24, 1973, flow measurements were obtained using a pygmy Gurley meter. Unnamed creek above the treatment plant outfall had a width of 3 feet, an average depth of 6 inches and a flow of .75 CFS.

Wildcat Creek above the confluence of unnamed creek had a width of 7 1/2 feet, an average depth of 8 1/2 inches and a flow of 1.44 CFS.

Wildcat Creek Drainage Field Data

July 24, 1973

Location	Wildcat Creek	
	Time	Temp.(°C)
Above ditch	1025	12.05°
Below ditch	1000	13.9°

Location	Unnamed Creek	
	Time	Temp.(°C)
Above STP	1145	19.0°
Below STP	1110	18.5°

July 25, 1973

	Wildcat Creek			
Location	Time	Temp.(°C)	D.O(ppm)	DO%Sat.
Above Unnamed Cr.	1300	14.1°	9.5	91.3
Below Unnamed Cr.	1235	16.1°	7.9	79.0
15 yds. below Freeway Br.	1430	16.7°	7.1	71.7
80 yds. below Freeway Br.	1420	16.7°	7.15	72.2
100 yds. below Freeway Br.	1415	16.7°	7.2	72.7
@ McKnight Rd.	1330	16.4°	11.0	112.2

* Foxes Table - Standard Methods
Assuming Cl concentration 25
.0025 ppm DO correction factor becomes insignificant.

July 30, 1973

Above Unnamed Cr.	1200	15.8°	12.5	125
Below Unnamed Cr.	1205	16.9°	8.2	84

Wildcat Creek - McCleary, Washington July 24, 1973
Lab Data

	Upstream Wildcat Cr.	Unnamed Creek	Downstream Wildcat Cr.
pH	7.7	--	--
Turbidity(JTU)	5	--	--
Conductivity(umhos/cm)	150	--	--
COD	8	48	24
BOD	2	12	<8*
NO_3-N (F)	.26	.33	.21
NO_2-N (F)	.01	.10	.05
T.Kjeldahl-N (U)	.12	5.6	1.36
O-PO_4-P (F)	.02	1.68	.88
Total Phos.-P (U)	.02	1.72	.94
T.S.	91	167	121
T.N.V.S.	55	103	78
T.S.S.	0	14	12
T.N.V.S.S.	0	1	3
Total Coliform(col/100 ml)	550	>8000	>8000
Fecal Coliform	80	400	200
Fecal Strep. Col.	--	60	80
Fecal to Fecal Strep ratio	--	6.6	--**
Chlorides	--	25	--
NH_3-N (U)	.06	5.3	1.34

-- not determined
F = Filtered
U = Unfiltered
parameters in ppm unless otherwise noted.
* Estimate 4 ppm
** Not computed because of dilution.

All parameters demonstrated a significant increase in all parameters sampled.

Wildcat Creek - McCleary, Washington July 24, 1973
Lab Data

	Unnamed Creek Above STP @ 7th St.	STP Effluent	Unnamed Cr. Downstream
pH	7.7	7.6	--
Turbidity(JTU)	8	17	--
Conductivity(umhos/cm)	260	550	--
COD	12	111	48
BOD	3	31	12
NO_3-N (F)	.25	--	.33
NO_2-N (F)	.02	--	.10
T.Kjeldahl-N (U)	.20	--	5.6
O-PO_4-P (F)	.04	--	1.68
Total Phos.-P (U)	.12	--	1.72
T.S.	114	267	167
T.N.V.S.	72	159	103
T.S.S.	12	27	14
T.N.V.S.S.	6	12	1
Total Coliform(col/100 ml)	>8000	<100	>8000
Fecal Coliform	>800	<20	400
Fecal Strep. Col.	>80	<20	60
Fecal to Fecal Strep ratio	--	--	6.6
Chlorides	--	44	25
NH_3-N (U)	.08	--	5.3

-- not determined
F = Filtered
U = Unfiltered
parameters in ppm unless otherwise noted.

All parameters demonstrated a significant increase excepting coliform. There is a source of coliform contamination upstream from 7th St. The fecal:fecal strep ratio is 6.6 (>4.0 indicates a human source); disinfection from the STP was good. Chlorine residuals were not taken in ditch.

Biological Data

A. Insect Survey.

On March 22, 1973, insect samples were taken from Wildcat and the unnamed creek. Estimated area of substrate disturbed was 1/3 yd^2. The following data was reported:

	Unnamed Creek		Wildcat Creek	
	Above STP	Below STP	Above unnamed creek	Below unnamed creek
Snails a	72		--	
b	2		3	
c	0		17	1
Tubificids	62	9	1	148
Fingernail clams	19		1	
Caddisflies a	5		--	
b	1		2	
Oligochaetes	1	1		
Chironomids	3	7		3
Mayflies baetids				
Heptagennids	7	2	149	42
Stoneflies a			1	
b			9	12
Odonata		1		
Diptera			1	
Unidentified			1	1
# Different	10	5	11	7
# Total	173	20	218	227

On July 24, 1973, similar results were obtained indicating that the unnamed creek was enriched above the treatment plant outfall and generally polluted below the outfall. The reduced numbers would indicate a possible toxic effect by the sewage. There was a "cleanwater" situation in Wildcat Creek above the confluence with high numbers of mayflies and a high diversity. Downstream in Wildcat Creek shows a decrease in diversity. The high numbers of tubificids are indicators of a decrease in water quality.

Biological Data (Cont.)

B. Freshwater Mussel Bioassay.

Mussels were placed at the described station locations: #1, #2, #4, #6 and #7 on December 31, 1972. On March 21, 1973, 6 of the 12 specimens below the treatment plant (station #7) were found dead. All other stations had 100% survival. On April 7, 1973, all the mussels at station #7 (below STP) were dead; the individuals at station #6 (above STP) were alive. This indicated that a toxic effect was definitely due to the sewage treatment plant effluent.

The station #7 was again restocked; these were all dead on April 26, 1973. Six mussels from station #6 were placed at station #7. These were dead May 10, 1973 and efforts to maintain live test organisms at this location were abandoned.

Also on April 26, 1973, station #3 downstream in Wildcat Creek was established. On July 24, 1973, all mussels at this location were dead.

The organisms at station #4 were found missing on July 24, 1973, presumably due to physical removal by floating debris. Other than stations #7 and #3, only two mortalities of the seventy-two mussels were observed from October 7, 1972 to July 24, 1973.

Biological Data (Cont.)

C. Fish Bioassay

On July 30, 1973, 150 young native salmonids were captured from Wildcat Creek in the vicinity of station #2. Twenty fish (40-50 mm in length) were retained as test specimens. Ten randomly selected fish were placed in Wildcat Creek 5 yards upstream from the confluence with unnamed creek. The other 10 were confined 15 yards downstream from the confluence.

The fish were observed periodically. On August 3, 1973, after four days, 100% mortality was observed at the downstream station. There was 100% survival upstream. In summary, the effluent from the treatment plant had rendered unnamed creek and Wildcat Creek below the confluence of unnamed creek, incapable of supporting native fish. The downstream limits of toxic conditions was not determined.