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SOLVENT REFINED COAL (SRC) PROCESS

Environmental Program

Interim Report for Period January 1, 1980—November 30, 1981

April 1982

Work Performed Under Contract No. AC05-76ET10104

Alsid, Snowden & Associates
Bellevue, Washington

U. S. DEPARTMENT OF ENERGY

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SOLVENT REFINED COAL (SRC) PROCESS: ENVIRONMENTAL PROGRAM

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INTERIM REPORT NO. 74
VOLUME III: PILOT PLANT DEVELOPMENT WORK
PART 5: ENVIRONMENTAL PROGRAM
FOR THE PERIOD
JANUARY 1, 1980 THROUGH NOVEMBER 30, 1981

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APRIL 1982

PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
DIVISION OF COAL CONVERSION AND UTILIZATION
UNDER CONTRACT DEAC-0579-ET10104
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ABSTRACT

This report summarizes the environmental program under the Solvent Refined Coal (SRC) Contract from January 1980 through November, 1981. Three major areas are included in the program: 1) air quality; 2) water quality; and, 3) foliage effects. Baseline studies of air and water quality were performed before the plant was constructed. Similar studies were made in 1976-1979 during plant operation. These studies indicated that installation of the pilot plant had virtually no measurable impact on air and water quality in the surrounding environment. The results of the continuing monitoring efforts during 1980-81 indicate that no substantial change in the environment has taken place as a result of the operation of the SRC plant. Annual foliage observations also indicated no discernable effect upon the dominant vegetative species in the area around the plant. Partially as a result of a product fuel oil spill in the tank farm in December 1979, an additional groundwater quality monitoring program was conducted during this period. No evidence of contamination from this spill was observed in the groundwater sources near the pilot plant and nearby surface waters, although some contamination was observed in test wells drilled on the plant site itself.

I. SUMMARY

Environmental studies have been conducted in the vicinity of the solvent refined coal (SRC) pilot plant in Ft. Lewis, Washington, commencing with a baseline study and progressing to the current monitoring program. The baseline environmental study was conducted during the period of December, 1972, to December, 1973, prior to the construction of the plant (1). The study was designed to provide an accurate assessment of the air and water quality which could then be used as a basis for comparison to evaluate the impact of the plant operation on the environment. In general, the results of this study indicated ambient dust and particulate levels to be quite low. The quality of the surface waters in the area was found to be uniformly good to excellent.

After the construction of the plant was completed in 1974 and subsequent operation, a follow-up study was conducted during the period of April-December 1976 (1). This was Phase I of a two-phase program and consisted of an intensive three to four-month study to establish the effect, if any, of the plant operation on the surrounding community. Results indicated pollutants were generally at baseline levels, i.e. no measurable effect was discerned. Initially, higher particulate loading was observed at two plant operations: feed coal unloading and SRC-I solid product loading. However, subsequent operational changes significantly lowered particulate emissions from these sources to acceptable levels. Continuous monitoring at the fence line downwind of the main sulfur-producing areas indicated the maximum value of sulfur dioxide ambient concentrations arising from plant emissions was 0.2 ppm for one-hour average, with the majority of values below 0.05 ppm, well within standards. Hydrogen sulfide measurements were invariably below 0.01 ppm while hydrocarbon concentrations were all less than 0.01 ppm. Nitrogen oxides were not measured since the only sources were the boiler/steam generation area and gas fired heaters, where calculations indicated less than 1500 lbs. of NO_x per year would be emitted. No significant changes in the quality of the water at the various sampling points was observed. Studies of dominant vegetation within one-half mile of the plant did not show any instances of symptoms attributable to injury from sulfur dioxide, hydrocarbons or particulate matter.

Based on the results of this study, Phase II, a routine monitoring program, was designed and put into effect in June, 1977, and continued for the duration of the pilot plant operation. This monitoring program consisted of alternating monthly water and air quality sampling at the same locations as in previous studies and with essentially the same parameters. Some variations in the schedule were made, substituting water samples for air samples such that sulfate and phenol levels could be more closely monitored during the drought and resulting low water conditions. Results from the first three years of this routine monitoring program (2, 3), from July 1, 1977 through December 31, 1979 indicated only a few variations from previous monitoring results. Nitrate, sulfate and phosphate levels increased somewhat in Lake Sequelitchew and Hamer March. This was attributed to the abnormally low rainfall received in the area during the spring and summer of 1977 which in turn

lowered the water level, thus producing a concentrating effect. In the spring of 1978, the water levels returned to normal and the concentration of these compounds returned to the 1976 levels. Suspended particulate concentrations remained within the range of some background levels, with areas 01 and 08 showing the highest concentrations, partially due to road dust, construction in the area, and coal drying and handling operations. The sulfur dioxide levels were well within the federal, state and local standards, with levels of 0.01 to 0.03 ppm for 3-hour averages.

This report details the results from the continuation of the routine monitoring program for the period January 1, 1980 through November 31, 1981.

II. INTRODUCTION

In late 1972, prior to the construction of the Solvent Refined Coal Pilot Plant at Fort Lewis, Washington, the firm of Environmental Resources Associates (now Alsid, Snowden and Associates, Bellevue, Washington) Redmond, Washington, was awarded a subcontract to conduct an ambient air and water quality study around the plant site. The study was designed as a baseline assessment of the air and water quality in the vicinity of the plant. This would then be used as the basis for comparison with a similar study to be accomplished during full plant operation to assess the impact of the plant on the surrounding community.

The baseline study was conducted during the period of December 1972 to December 1973. An air quality network was established composed of 15 sampling locations around the new facility in areas where it would be reasonable to assume that a receptor would be exposed to a change in air quality. Measurements were made for suspended particulate, carbon monoxide, carbon dioxide, oxides of nitrogen, hydrocarbons, sulfur dioxide and hydrogen sulfide. Water quality was measured through a series of sampling stations at eight locations on the adjacent lake, streams, swamp and drainage ditches that might be influenced by the plant operation. Samples were collected during the period of December 1972 to August 1973 and were analyzed for dissolved oxygen, temperature, specific conductance, turbidity, color, pH, sulfate, phenol, chemical oxygen demand, total organic carbon, and coliform bacteria. Nitrogen, phosphorus, titanium and vanadium were also measured on a special set of samples. A biological examination of the lake, springs, creeks, and marshes adjacent to the facility was conducted in June 1973.

Start-up of the pilot plant began in late 1974 with integrated operation of the plant accomplished in February, 1975. SRC-I material balance runs and preliminary SRC-II (slurry recycle) operations were conducted from February, 1975, to September, 1975. The period from early September, 1975, to the end of November, 1976, was devoted to a production run of solid SRC. In April, 1976, a two-phase environmental study was initiated under subcontract to Alsid, Snowden & Associates of Bellevue, Washington, to assess the effect, if any, of the operation of the pilot plant on the surrounding community. The first phase of the study was

designed as an intensive three to four-month study similar to the baseline study but also included the main SRC emissions, treated water outflow, continuous sulfur dioxide monitoring, trace metals and foliage study. Air, water and foliage studies were conducted during the period of April to December, 1976. This included a survey of atmospheric hydrocarbon concentrations, both in-plant and out-plant, and trace metal analyses on 16 particulate and water samples. A special study was conducted in January, 1977, on the hydrocarbon emissions from the "whistle tube" (4) venting the vapors from the product solidification belt.

Based on the results of these studies, a limited monitoring program was then devised and put into operation in early summer of 1977 and continued for the duration of the pilot plant operations. This program consisted of alternating air and water quality studies using this same network and types of samples as in previous studies and with essentially the same air, water and foliage quality parameters. This report details the results from the continuation of this routine monitoring program (2) and covers the period from January 1, 1980 through November 30, 1981.

III. AIR QUALITY STUDY

A. Air Sampling Network

A sampling network was established around the pilot plant site before the plant was constructed. The sampling sites were selected to be locations around the new facility where the receptors might be affected by possible emissions. Sampling sites were also placed within and near the SRC facility. In general, the sites were also placed where access to electrical power was available. Two types of air sampling were conducted. The first was measurement of total suspended particulates (TSP) and used standard high volume air samplers which collected the suspended particulates on 8" x 10" glass fiber filters. The second sampling type was for determination of concentrations of gaseous sulfur compounds.

Table I shows the name and location of the sampling stations, and Figure I shows the air sampling locations on a map of Fort Lewis. However, in 1977, the number of particulate monitoring stations was reduced to location numbers 21, 22, 23, 25 and 35 near the SRC plant as particulate emissions from the plant consisted of coal pile fugitive dust which had a limited transport range. In 1979, the sulfur dioxide analyzer was relocated from an on-site location to location 25 which would representatively sample airborne sulfur emissions which could be released from elevated emission points if upsets occurred during the operation of the pilot plant.

B. Sample Frequency

During this period, high volume air samplers were operated on a bimonthly basis for 24-hour periods. No measurements were made for CO, CO₂ or NO_x. Sulfur dioxide samples were taken continuously except during plant and equipment maintenance during the study period.

TABLE 1

AIR QUALITY MONITORING STATIONS

11	Beachwood School
12	Hillside School
13	Parkway School
14	Clarkmore School
15	DuPont City Hall and PSAPCA Station 700' West
16	Well #3 in North Ft. Lewis
17	North Ft. Lewis pump station
21	20' South of fence near 01 area
22	50' South of fence near Coal Storage Area
23	20' South of fence near Water Treatment Area
25	Ft. Lewis Water Supply, Lake Sequalitchew
35	Ft. Lewis Greenhouse

NEIL ISLAND

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FORT LEWIS QUADRANGLE
WASHINGTON - PIERCE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SE 1/4 ANDERSON ISLAND 15' QUADRANGLE

Figure 1. Location of air stations

C. Analytical

Total suspended particulate concentrations were determined by collection on 8" x 10" glass fiber filters used in high volume air samplers. Particulate mass was determined gravimetrically and particulate concentration by comparison of total airflow through the filter to the particulate mass.

D. Findings

1. Suspended Particulates

a. Plant Operating

Total suspended particulate results during the entire period of plant operation are summarized in Table 2, and the 1980-1981 results are detailed in Table A-1 in the Appendix. The annual average results between 1980-1981 ranged from 40 to 64 micrograms per cubic meter and individual samples ranged from 42 to 927 micrograms per cubic meter. Total suspended particulates were within regulatory requirements for all averaged sample points.

The 1980-1981 data is similar to the preceeding years data and shows no appreciable change in levels. Station 21 and 22 were generally higher during the last four years due to the coal handling and storage operations which were in the general vicinity of the monitors.

b. Post-Plant Operations

The hi-volume samplers located near the coal storage area could not be operated as the power source was disrupted during the construction in the area. However, the remaining stations showed no abnormal changes during the monitoring period after the plant ceased operation on July 15, 1981.

c. Comparison

Average results for suspended particulates at the remote locations continued to be quite low. The levels are well below the 24-hour particulate standard of 150 micrograms per cubic meter.

2. Sulfur Dioxide

a. Plant Operating

Continuous monitoring of ambient sulfur dioxide was begun in late July, 1976, and operated through December, 1978, at station No. 26 near the south boundary of the SRC pilot plant adjacent to the outdoor coal storage area. In January, 1979, the monitor was moved to station No. 25. This location is directly downwind of the process areas in the pilot plant which are the sources of sulfur emissions, primarily during occasional upsets. Table 3 shows 1979-1981 levels at station No. 25. Table 4 shows the national, state and local standards for sulfur

TABLE 2

SUMMARY OF TOTAL SUSPENDED PARTICULATE MEASUREMENTS

(All values in grams per cubic meter)

STATION	LOCATION	1976-1979		1980-1981	
		MEAN	RANGE	MEAN	RANGE
21	01 Area	60	17-217	60	34-93
22	08 Area	54	17-130	59	14-77
23	09 Area	41	15-75	48	36-58
25	Spring #1	42	14-85	40	23-47
35	Greenhouse	45	21-85	44	31-52

TABLE 3

SULFUR OXIDE LEVELS
AT STATION NO. 25
(ppm)

<u>MONTH</u>	<u>1979 MAX 3 HR.</u>	<u>1980 MAX 3 HR.</u>	<u>1981 MAX 3 HR.</u>
January	—	0.012	—
February	0.011	0.020	0.012
March	0.015	0.015	0.016
April	0.021	0.010	—
May	0.012	0.012	0.012
June	0.011	0.010	0.010
July	0.015	0.016	—
August	0.016	—	—
September	0.013	0.014	0.010
October	0.02	0.015	0.010
November	0.03	0.012	0.008
December	0.010	0.010	—

TABLE 4

AMBIENT AIR QUALITY STANDARDS
SULFUR OXIDES

	NATIONAL		WASHINGTON	PUGET SOUND
	PRIMARY	SECONDARY	STATE	REGION
	PPM	PPM	PPM	PPM
Annual Average	0.03		0.02	0.02
30-day Average				0.04
24-hr. Average	0.14		0.10	0.10
3-hr. Average		0.50		
1-hr. Average			0.25	0.25
1-hr. Average			0.40	0.40
5-min Average				1.00

oxides. In all cases, the concentrations measured near the emission sources and at the down wind site were within the more stringent local standards. Table A-2 provides a summary of sulfur dioxide data obtained in 1980 and Table A-3 provides a similar summary for 1981.

b. Baseline

Baseline sulfur dioxide measurements (1) were made during 1973 at various locations. All values were 0.05 ppm or lower.

c. Post-Plant Operations

Sulfur dioxide levels between July 15 and November 30, 1981, were essentially the same as during plant operations. The maximum 3-hour average was near 0.01 ppm.

d. Comparison

Average measured concentrations at Station 25 during 1980-1981 were below 0.03 ppm (3-hour average). This was not significantly higher than ambient SO₂ measurements made prior to the plant operations, those made during the 1976 monitoring period or those made near the plant in 1977-1978. Less peaking occurred during the 1978-1981 period mainly due to relocation of the trailer to a downwind station (#25) where SO₂ levels no higher than background levels were recorded.

E. Conclusions

Air quality around the SRC pilot plant during the study period was essentially unchanged from the air quality observed during the baseline study, the 1976 study, and the 1978-1981 monitoring period. The SO₂ levels were lower at the downwind stations than at the plant site.

IV. WATER QUALITY STUDY

A. Water Sampling Network

Eleven water sampling stations were established on the lake, streams, swamp and drainage ditches adjacent to the SRC pilot plant to monitor any changes in the water quality parameters that might be influenced by the plant operation. The location of water sampling points is described in Table 5 and shown on a map of the Ft. Lewis area in Figure 2.

B. Water Sampling Frequency

Water samples were generally collected twice per month from each station commencing in December, 1972, through August, 1973. One special set of samples for nitrogen, phosphorous, titanium and vanadium analyses was collected late in 1973.

Samples during the 1976 study were collected monthly between May 18 and August 18. One special set of samples was collected for heavy metals analysis (5).

TABLE 5SOLVENT REFINED COAL PILOT PLANT
WATER SAMPLING STATIONS

Station 1	Sullivan Well - a shallow-dug well used as an auxiliary water source for Ft. Lewis.
Station 2	Sequalitchew Spring - Ft. Lewis main water supply.
Station 3	Sequalitchew Lake - Along the south edge north of the plant.
Station 4	Sequalitchew Lake - South edge near pontoon bridge training area.
Station 5	Sequalitchew Lake - West end of lake at outlet.
Station 6	Hamer Marsh Canal - Near outlet of Lake Sequalitchew.
Station 7	Ft. Lewis drainage canal - South of P & M plant.
Station 8	Hamer Marsh ditch - Near Ft. Lewis asphalt plant.
Station 9	Treatment outfall pond - Upstream of final oilsorb filter.
Station 9B	Treatment outfall pond.
Station 10	American Lake - Control.
Station 11	DuPont water supply from tap.

Figure 2. Location of water stations.

Samples were taken approximately every other month in 1977-1981.

C. Water Quality Parameters

Water samples were analyzed for the following physical, chemical and bacteriological parameters in accordance with procedures outlined in "Standard Methods for the Examination of Water and Wastewater" (6):

Temperature - An important observation that is useful in indicating the solubility of gases in water and biological activity. Reported in degrees Centigrade.

Dissolved Oxygen (D.O.) - One of the most important water quality tests, which in natural waters and wastewaters is dependent upon the physical, chemical and bio-chemical activities in the water. The solubility of atmospheric oxygen in fresh water is dependent upon pressure, temperature, and dissolved constituents and ranges from 7 mg/l at 35 degrees C (95 degrees F) to 14.6 mg/l at 0 degrees C (32 degrees F).

Specific Conductance - A measure of the water's capacity to conduct an electric current. It is related to the total concentration of ionized substances in the water and to the temperature at which the measurement is made. Expressed as micromhos per cm at 25 degrees C.

Color - True color in water results from substances in solution. Apparent color includes not only the color due to substances in solution but also that due to substances in colloidal suspension. The values reported in this study are apparent color and are expressed in color units. The color of a natural stream or lake usually results from leaching of organic debris.

pH - The negative logarithm of the hydrogen ion concentration. It indicates whether a water is acidic or alkaline. The scale extends from 0, very acidic, to 14, very alkaline, with a value of 7 indicating neutrality. When photosynthetic organisms are present, a diurnal pH fluctuation may occur.

Sulfate - The sulfate ion is one of the most widely occurring anions in nature. Expressed in mg/l. Important in the study because of the sulfur content in the coal. The turbidimetric method was used for analysis (6).

Phenol - Phenol, or carbolic acid, can come from coal tar, other synthetic sources, or it can occur naturally. It frequently is in the waste products of oil refineries and coke plants. Expressed in micrograms per liter or parts per billion (ppb). It is toxic to aquatic life in low concentrations. During baseline studies, the method used had a lower detectable limit of 50 micrograms per liter. During the 1976-1980 studies, the amino antipyrine method 510 A & B was used (6), with a lower detectable limit of 2-5 micrograms per liter. During 1981, a 10 cm cell was employed, which lowered the detectable limit to 1 microgram/liter. Therefore, the early minimum and maximum values shown in the

summary for each station will show this 50 microgram per liter value as maximum even though the actual value was probably much lower.

Chemical Oxygen Demand (COD) - Chemical oxygen demand (COD) indicates the amount of oxidizable material present in the water and is a measure of the polluting strength of a waste. Expressed as mg/l.

Coliforms - The coliform bacteria are members of the family Enterobacteriaceae, which are normal inhabitants of the intestinal tract of warm blooded animals. These non-pathogenic organisms are used as indicators of fecal pollution and thus the possible presence of pathogenic organisms which are much more difficult to detect. The coliform density is the generally accepted criteria for the sanitary quality of a water sample. The results are reported as the number of organisms per 100 ml of sample. Very high concentrations of coliform are listed as "too numerous to count" (TNTC).

Nitrogen - Nitrogen components exist in various forms in natural waters. Water samples were analyzed for compounds of nitrogen, which are important indicators of pollution and the productivity of natural waters in terms of algal growths. Ammonia nitrogen (NH_3) and nitrite (NO_2) plus nitrate nitrogen (NO_3) were determined and are reported in mg/l. The chemistry of nitrogen in water is complex, but it is usually present in the form of organic (protein) nitrogen. As time passes, the organic nitrogen is gradually converted to ammonia nitrogen, and then, if aerobic conditions prevail, it is oxidized to nitrites and then to nitrates. Only one sample in 1973 was analyzed for nitrogen. Samples were analyzed regularly in 1976 through 1981 for this parameter. The Brucine method of analysis was used (6).

Phosphate - Phosphorus occurs in natural waters and wastewaters almost solely in the various types of phosphate. Phosphorus is a nutrient that is essential to the growth of organisms. The total phosphate of a sample includes all of the orthophosphates and condensed phosphates, both soluble and insoluble, and organic and inorganic species. Only one sample was taken for phosphates in 1973 (August 31, 1973). Samples were analyzed regularly for phosphates in 1976 through 1981. The persulfate digestion by the stannous chloride method of analysis was used (6).

D. Findings

The results of the physical and analytical water quality measurements are summarized in Tables 6 through 17. Mean values of the various parameters for the baseline period and the plant operating period are given.

The water quality measurements will be discussed by site or related sites as substantial differences exist among the various sites' water quality. These differences are, in general, much larger than changes at any site that could be attributed to the operation of the pilot plant.

1. Sullivan Well, Sequalitchew Spring (Stations 1 and 2)

The 1973-1981 water quality of Sullivan Well and Sequalitchew Spring

remained consistently very good (See Tables 6 and 7). Since these are the main and auxiliary sources of drinking water for Fort Lewis, this was to be expected. Sequalitchew Spring is a unique water source and a major asset to Fort Lewis. The water was uniformly cool (average 13 degrees C), clear, slightly acidic (pH 6.4), low in dissolved constituents (specific conductance average 135 micromhos per cm), and practically devoid of organisms (coliforms 0 organisms per 100 ml). The lack of saturation with dissolved oxygen is considered quite normal and typical of ground water. Phenol was consistently below 1 ug/l.

No significant change was noted during the 1980-1981 water quality study over the previous sampling periods.

2. Sequalitchew Lake (Stations 3, 4 and 5)

The waters of Sequalitchew Lake during the 1977-81 period were found to be of average quality (see Tables 8, 9, and 10). This was evidenced by their saturation with dissolved oxygen (mean range 6.7 mg/l), color (0 to 100 units), ionized constituents (mean average 158 to 184 micromhos per cm). The coliform density averaged high as one sample at each point had very high counts. The temperature of the lake exhibited a seasonal variation (with a mean range of 13-17° C.). The water was, on an average, near neutral (6.5 to 7.5). The phenol content was below 5 ug/l. During the summer months some algal growth occurred in the lake and there was some evidence of floating scums (probably blue-green algae) in protected areas and concentrated by wind action. Along the south shore, sizeable areas were shallow enough for rooted aquatic plants. The super-saturation with dissolved oxygen was indicative of photosynthetic activity by phytoplankton, a normal summertime occurrence for a shallow lake such as this. This lake is used as a rearing pond for salmon and winter feeding of the fish adds to the nutrient content of the lake.

The 1980-1981 period, when compared to the 1973-1979 period, indicates a decrease in the percent of dissolved oxygen. Specific conductivity and color, in addition to concentrations of phosphate and sulfate ions, were higher. These results are attributed to the drought condition which lowered the water levels during the sampling period as well as the addition of fish food to the water.

3. Hamer Marsh Drainage (Station 6)

This water drains from Hamer Marsh and exhibited a varying quality (see Table 11). It was usually deficient in dissolved oxygen averaging 7 mg/liter. This is indicative of biological activity in the marsh area which is considered normal for such an aquatic environment. The water was at times relatively high in color (mean of 27 units) but low in dissolved constituents as indicated by an average specific conductance of 136 micromhos per cm in 1980-1981. On the average, the water was slightly acidic (pH 6.5) and phenol was below 5 ug/l. Higher concentrations of coliform organisms were observed, with the one sample in the TNTC range. Water flowing from a marsh would be expected to exhibit this modest

TABLE 6
WATER QUALITY AT STATION NO. 1
SULLIVAN WELL

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, °C.	13	12	14
Dissolved Oxygen, mg/l.	6.8	8.2	6.7
Specific Conductance, uohm/cm., 25° C.	133	139	132
Color, units	2	0	0
pH	6.3	6.6	6.0
Sulfate, mg/l.	10.8	6.2	5.7
Phenol, ug/l.	<5	<1	<1
Chemical Oxygen Demand, mg/l.	8	5	2.7
Coliforms per 100 ml.	0	0	0
Phosphate, mg/l.	0.06	0.05	0.01
Nitrate, mg/l.	0.36	0.39	0.19

TABLE 7
WATER QUALITY AT STATION NO. 2
FT. LEWIS WATER SUPPLY SPRING

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, °C.	13	13	13
Dissolved Oxygen, mg/l.	6.2	5.9	7.1
Specific Conductance, uohm/cm., 25° C.	116	114	137
Color, units	2	0	0
pH	6.4	6.9	6.3
Sulfate, mg/l.	8	5.8	6.9
Phenol, ug/l.	< 5	< 1	< 1
Chemical Oxygen Demand, mg/l.	3.6	3.1	7.6
Coliforms per 100 ml.	0	0	1
Phosphate, mg/l.	0.04	0.04	0.02
Nitrate, mg/l.	0.26	0.20	0.37

TABLE 8
WATER QUALITY AT STATION NO. 3
SEQUALITCHEW LAKE

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, °C.	14.8	11	13
Dissolved Oxygen, mg/l.	10.2	6.7	4
Specific Conductance, uohm/cm., 25° C.	139	133	152
Color, units	13	27	16
pH	7.0	7.4	6.5
Sulfate, mg/l.	16.8	17	11.9
Phenol, ug/l.	< 5	3	1
Chemical Oxygen Demand, mg/l.	6.6	6.3	12.2
Culiforms per 100 ml.	10	3	3
Phosphate, mg/l.	0.08	0.10	0.28
Nitrate, mg/l.	0.13	0.09	0.05

TABLE 9
WATER QUALITY AT STATION NO. 4

SEQUALITCHEW LAKE

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, °C.	15.8	11	13
Dissolved Oxygen, mg/l.	10.3	6.8	9.5
Specific Conductance, uohm/cm., 25° C.	146	145	145
Color, units	11	20	14
pH	7.2	7.5	6.7
Sulfate, mg/l.	19.6	22	12.4
Phenol, ug/l.	<5	2	1
Chemical Oxygen Demand, mg/l.	7.6	7.2	9.3
Coliforms per 100 ml.	8	2	10
Phosphate, mg/l.	0.04	0.11	0.27
Nitrate, mg/l.	0.16	0.29	0.10

TABLE 10
WATER QUALITY AT STATION NO. 5

SEQUALITCHEW LAKE

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, ° C.	16	11	13
Dissolved Oxygen, mg/l.	12.1	6.9	8.9
Specific Conductance, uohm/cm., 25° C.	147	134	147
Color, units	18	13	16
pH	7.1	7.5	6.9
Sulfate, mg/l.	20.7	19.5	11.4
Phenol, ug/l.	< 5	2	1
Chemical Oxygen Demand, mg/l.	11	8.9	9.2
Coliforms per 100 ml.	5	6	1
Phosphate, mg/l.	0.10	0.14	0.05
Nitrate, mg/l.	0.19	0.09	0.06

TABLE 11
WATER QUALITY AT STATION NO. 6

HAMER MARSH CANAL

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, ° C.	11	12	13
Dissolved Oxygen, mg/l.	5	7	7.2
Specific Conductance, uohm/cm., 25° C.	148	136	138
Color, units	39	27	17
pH	6.6	6.3	6.6
Sulfate, mg/l.	19	23	13
Phenol, ug/l.	<5	3	1
Chemical Oxygen Demand, mg/l.	25	14.8	15.4
Coliforms per 100 ml.	60	5	11
Phosphate, mg/l.	0.14	0.18	0.07
Nitrate, mg/l.	0.23	0.08	0.26

bacteriological contamination. The 1980-1981 study showed levels of sulfates, phosphates and nitrates similar to the 1977-1979 levels.

4. Fort Lewis Drainage Ditch (Station 7)

This drainage canal receives surface runoff from some Fort Lewis roadways and a portion of the waste water from a car washing facility. Evidence of petroleum wastes was visible along the channel sides. During 1979, an oil separator unit was under construction to eliminate this condition. The water quality at times was visibly degraded. The results of the water quality analyses are summarized in Table 12 for 1973 through 1981. The conductivity decreased slightly in 1980-1981 over the average condition. The average pH was 6.6, the average sulfate content 8 mg/l, the phenol 7 ug/l, and the chemical oxygen demand 10 mg/l in 1980-1981, all of which were normal for the type of water and the conditions of flow observed. The average coliform concentration was also high at this station as one sample was TNTC which can be common for open surface water.

No significant change in water quality between the 1973-1979 average and the plant operating period was observed at the drainage ditch in 1980 through 1981.

5. Hamer Marsh Drainage (Station 8)

This water sampling station was on the drainage ditch in Hamer Marsh, and its water quality characteristics were very similar to those found at Station 6. The results are summarized in Table 13. It was consistently less than saturated with dissolved oxygen with an average of 5 mg/l. The dissolved constituents were quite low as evidenced by an average specific conductance of 130 micromhos per cm. There was considerable color (mean 57 color units). The mean pH was slightly acidic. The sulfate content was similar to 1977-78, averaging 13 mg/l and the phenol averaged 6 ug/l. While the chemical oxygen demand averaged 15.1 mg/l, it is considered to be typical of water emanating from a marshy area. The modest coliform concentration was expected with one sample TNTC. The results of the 1980-1981 monitoring indicates no significant change over the previous samples.

6. Treatment Plant Outlet (Stations 9, 9B and 9C)

Stations 9 and 9B are located approximately 200 yards south of the water treatment area of the SRC plant at the outflow from this treatment system. The treated water, as it leaves the discharge pipe, is filtered through a fibrous filter to trap any traces of oil and then flows into a pond. Originally, it was thought that this discharge water would flow directly into Hamer Marsh. However, after the plant was placed in operation, the discharge water formed a pond and percolated into the soil but did not rise high enough to flow into the marsh. The 1976 monitoring program was carried out to determine if this pond water was carrying any of the discharge chemicals into the lake or springs. During 1979, the plant water discharge was increased and water from the pond discharged into Hamer Marsh. Some lowering of sulfate levels occurred as well as a reduction in phenol levels. Otherwise, the 1980-1981 study indicates

TABLE 12
WATER QUALITY AT STATION NO. 7
FORT LEWIS DRAINAGE DITCH

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, ° C.	14	7	13
Dissolved Oxygen, mg/l.	7.1	8.3	8.3
Specific Conductance, uohm/cm., 25° C.	107	60	80
Color, units	40	60	29
pH	6.6	6.5	6.6
Sulfate, mg/l.	13.4	8.9	4.3
Phenol, ug/l.	<5	6	2
Chemical Oxygen Demand, mg/l.	46.7	8.7	11.6
Coliforms per 100 ml.	TNTC	17	1
Phosphate, mg/l.	1.0	0.4	0.13
Nitrate, mg/l.	0.22	0.11	0.12

TABLE 13
WATER QUALITY AT STATION NO. 8

HAMER MARSH

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, ° C.	13	10	12
Dissolved Oxygen, mg/l.	5.4	6.7	6.2
Specific Conductance, uohm/cm., 25° C.	104	95	186
Color, units	57	27	46
pH	6.3	6.5	6.2
Sulfate, mg/l.	12	22.8	11.7
Phenol, ug/l.	7	4	1
Chemical Oxygen Demand, mg/l.	16.0	30.0	12.8
Coliforms per 100 ml.	TNTC	13	18
Phosphate, mg/l.	0.17	0.10	0.03
Nitrate, mg/l.	0.12	0.38	0.22

that no significant change has occurred since the 1976 study. Results are summarized in Table 14.

7. American Lake (Station 10)

Wright Lake was used as the initial control station. It is located several miles south of the plant. Samples were taken at Wright Lake in 1976, 1978 and 1979. During 1980-1981, the control station was changed to American Lake which lies in the same water table as Lake Sequalitchew and Hamer Marsh. Results from the analyses are shown in Table 15.

E. Conclusions

Overall, very little change has occurred in the quality of the various waters sampled around the SRC pilot plant during this study period in comparison with previous sampling periods. Some measurable changes were observed in the chemical oxygen demand and phosphate levels in the Lake Sequalitchew water. This can be attributed to two principal factors: variations in the water level producing a concentration effect in such a shallow water body; and, the addition of nutrients to the lake as feed for the salmon fingerlings. Some high coliform counts were observed on occasion in several of the water bodies but this was not considered unusual for open surface waters. The drinking water sources were of consistently high quality throughout this period. Tables B-1, B-2 and B-3 in the Appendix show averages for 1980, January through July 15, 1981, and July 15 through November 30, 1981. The pilot plant ceased operations on July 15, 1981.

V. SPECIAL WATER MONITORING PROGRAM

On December 19, 1979, an accidental spill of SRC product fuel oil occurred in the tank farm during transfer operations. An extensive drilling program was then initiated to determine if the aquifer underlying the plant was contaminated by the spill and if so, the direction of movement of the aquifer to determine its potential impact, if any, on any of the immediate water bodies and drinking water sources. Test wells numbered 1, 2, 3, 6, 8, 9, 10, 11, 20, and 24 were drilled at the locations shown in Figure 3. Water samples were taken from each of these wells and analyzed for total phenol content since phenols were the most water soluble components of the fuel oil. A total of seven samples were taken from each well over the period February 29, 1980 through May 12, 1980. The average phenol levels measured are shown in Table 16. These results indicated that a certain amount of groundwater contamination did occur on the plant site as a result of the spill and other pilot plant activities although the degradation in water quality was considered to be minor. This monitoring program was done in conjunction with a more extensive program conducted by the SRC pilot plant personnel. Reference 7 contains a more detailed description and results of the total program.

TABLE 14
WATER QUALITY AT STATION NO. 9

TREATMENT PLANT OUTLET

<u>Parameter</u>	<u>MEAN</u>		
	<u>1973-1979</u>	<u>1980</u>	<u>1981</u>
Temperature, ° C.	18	18	14
Dissolved Oxygen, mg/l.	7.6	8.5	7.3
Specific Conductance, uohm/cm., 25° C.	362	402	510
Color, units	36	52	69
pH	6.4	7.5	6.1
Sulfate, mg/l.	95	33	22.7
Phenol, ug/l.	93	79	34
Chemical Oxygen Demand, mg/l.	17	26.4	22.1
Coliforms per 100 ml.	2	7	0
Phosphate, mg/l.	0.85	0.46	0.22
Nitrate, mg/l.	1.0	0.22	0.11

TABLE 15
WATER QUALITY AT STATION NO. 10

CONTROL - AMERICAN LAKE

<u>Parameter</u>	<u>MEAN</u>	
	<u>1980</u>	<u>1981</u>
Temperature, ° C.	10	12
Dissolved Oxygen, mg/l.	7.3	8.9
Specific Conductance, uohm/cm., 25° C.	105	94
Color, units	23	8
pH	7.3	6.7
Sulfate, mg/l.	6.4	6.0
Phenol, ug/l.	2	1
Chemical Oxygen Demand, mg/l.	10.7	11.9
Coliforms per 100 ml.	4	6
Phosphate, mg/l.	0.13	0.02
Nitrate, mg/l.	0.08	0.07

FIGURE 3. LOCATION OF GROUNDWATER WELLS

TABLE 16
AVERAGE PHENOL CONCENTRATIONS FOR GROUNDWATER WELLS

<u>WELL #</u>	<u>PHENOL CONC., mg/l</u>
1	0.235
2	0.290
3	0.144
6	0.054
8	0.100
9	0.034
10	0.092
11	0.012
20	0.038
24	0.001

On May 12, 1980, a monitoring program was initiated to detect any possible contamination that might reach the two water supply sources and Lake Sequalitchew through the ground water system. Monitoring stations 1, 2, 3 and 4 (Figure 2) and Well 24 were sampled as well as American Lake as a neutral background action. A total of 88 samples were taken during the period May 12, 1980 through February 17, 1981 on a schedule which varied from biweekly to bimonthly. The phenol levels in all of the samples were below the 0.001 mg/l. detectable limit of the analytical method.

Since Lake Sequalitchew is a salmon rearing area for the Washington State Department of Fisheries, another monitoring program was conducted to determine if phenols were present in the lake. Three monitoring stations were located 30 feet offshore with surface and 2 meter depth samples being collected at each station. A total of 27 sets of samples were collected between August 28, 1980 and March 3, 1981. The phenol level in these samples averaged 0.001 to 0.002 mg/liter. Elevated samples of 0.005 mg/liter were collected when the Army's bridge construction unit trained on the lake. The diesel exhaust from the boats in all probability contributed to the elevated phenol levels. The levels of phenol returned to 0.001 mg/liter after the training exercises.

Two additional sample sets were taken from the production wells and test wells on July 30, 1981 and October 5, 1981. The results are shown in Table 17. Wells 20, 25, 47 and 48 are production wells designed to be pumped in the event contamination of the ground water is detected. Pumping effectively contains the contamination plume. The pumped water was treated to meet all discharge requirements.

VI. FOLIAGE STUDY

A. Introduction

Certain hydrocarbons, when released to the atmosphere, can undergo photochemical reactions in the presence of sunlight, yielding ozone. Ozone can injure many types of plants. Ozone injury in conifers usually appears as a death of either needle tips or entire needles. Mottling may also occur in less severe cases and may be recognized by an alternating pattern of yellow or brown tissue with healthy green tissue. Many pines (Pinus) are susceptible, and spruces (Picea) and firs (Abies) are resistant. Broadleafed tree species affected by ozone injury show flecks or stipules of dead tissue under upper leaf surfaces. Coloration of damaged tissue ranges from white to tan or reddish purple. Poplars (Populus) are among the most sensitive trees to ozone.

Sulfur dioxide (SO₂) is one of the most important pollutants affecting trees. The gas enters plant tissue through the stomata and may either kill or injure. In conifers, damaged needles appear yellow with perhaps some tip burn, while dead tissue turns reddish brown. In broadleafed species, SO₂ injury appears as areas of yellow, ivory, or tan, intermixed with healthy tissue on leaves. Veined areas remain green. Pines are sensitive to SO₂ injury, while poplars and Douglas Fir (Pseudotsuga menziesii) are intermediate.

TABLE 17

PHENOL LEVELS IN MG/L FROM GROUNDWATER WELLS
JULY 30, 1981 AND OCTOBER 5, 1982

<u>WELL #</u>	<u>DATE</u>	<u>CONC. PHENOL</u>
20	7/30/81	0.010
20	10/5/81	0.001
22	7/30/81	0.190
22	10/5/81	0.050
24	7/30/81	0.001
24	10/5/81	0.001
25	7/30/81	0.001
25	10/5/81	0.001
41	7/30/81	0.003
41	10/5/81	0.001
42	7/30/81	0.004
42	10/5/81	0.001
43	7/30/81	0.001
43	10/5/81	0.002
44	7/30/81	0.002
44	10/5/81	0.001
45	7/30/81	0.001
45	10/5/81	0.001
46	7/30/81	0.011
46	10/5/81	0.470
47	7/30/81	0.006
48	7/30/81	0.001
48	10/5/81	0.001

of leaf surfaces and the degree of damage is dependent upon the extent to which photosynthesis and respiration are reduced.

The SRC pilot plant releases some gaseous hydrocarbons, sulfur dioxide, particulate matter, and other materials into the environment. The objective of this investigation (8) was to determine if the dominant vegetative cover in the vicinity of the pilot plant showed any visible evidence of damage attributable to pollutants originating from the plant.

B. Area Vegetation

North Fort Lewis is in a region of western Washington where there is deep outwash material deposited by the Vashon glaciation. The vegetation and successional patterns in these "prairie" areas are more typical of the region east of the Washington Cascades than they are of the western region. Moisture appears to be a limiting factor and, as a consequence, Douglas Fir is the climax species rather than western hemlock (Tsuga heterophylla) and western cedar (Thuja plicata). Grass, lodgepole pine (Pinus contorta) and ponderosa pine (Pinus ponderosa) precede Douglas Fir in normal succession.

The undisturbed forest cover in the vicinity of the SRC plant is dominated by Douglas Fir. Recently disturbed areas support mixture of grass and shrub species, primarily Scots' Broom (Cystis scoparius).

C. Foliage Sampling Network

A preliminary survey of the SRC plant vicinity was conducted to determine: 1) the identity of dominant vegetative cover types, 2) the location of unusual or potential problem areas, and 3) prevailing wind patterns. Following the preliminary survey, four areas of similar vegetation and representative of local conditions were chosen as sampling sites. Their locations are shown in Figure 4. Three of these sites (Sites A, B, and C) are within one-half mile of the processing plant and line up with the plant in relation to the prevailing north-east and south-west winds. The fourth site (Site D) is approximately one mile west of the SRC plant and not in the path of prevailing winds. This site is considered to be a control location. A control location was chosen rather than observing the same location before and during plant operation to avoid the strong compounding effects on foliage analysis of temporary changes in rainfall, insect infestation and disease.

The foliage sampling sites shown on Figure 4 are described below:

Site A: Discharge Pond - The sampling area was approximately 200 yards south of the SRC plant near the point of treated waste water discharge from the plant. Dominant plant species included Douglas Fir, Black Cottonwood (Populus trichocarpa), Red Alder (Alnus rubra), California Hazel (Corylus cornutta), Pacific Madrone (Arbutus menziesii), and Scots' Broom.

Site B: Cramer Woods - The sampling area was approximately one-quarter mile south of the SRC plant above the existing gravel pit. Dominant plant species included Douglas Fir, Pacific Madrone, California Hazel, Scots' Broom, Oregon Oak (Quercus garyana), and Willow (Salix spp.).

Figure 4 Location of foliage study areas.

Site C: Sequalitchew Lake - Samples were taken at a point approximately one-quarter mile north of the SRC plant and just south of the road bordering Sequalitchew Lake. Dominant plant species at the site included Red Alder, Black Cottonwood, and California Hazel.

Site D: Bell Woods - This sample station is approximately one mile west-southwest of the SRC plant and is considered to be outside the influence of any airborne SRC plant pollutant discharge. Dominant plant species at the site include Douglas Fir, Black Cottonwood, Pacific Madrone, Red Alder, California Hazel, Willow, and Scots' Broom.

D. Foliage Sampling

In the summer of 1980 and 1981, foliage samples were taken from randomly-selected plants of dominant species occurring on each site. Any foliage damage due to the pilot plant would have occurred by August. All samples were exterior foliage collected at a height from three to eight feet above ground level.

Collected samples were examined to determine if growth abnormalities were present and samples from all sites were compared in the field to determine variation among sites.

E. Findings

Foliage collected from the sites around the SRC pilot plant in 1976, 1978, 1979, 1980 and 1981 did not exhibit any of the injury attributable to sulfur dioxide, hydrocarbon, or particulate matter when subjected to visual inspection. Foliage at sites A, B, C and the control site D did possess similar growth characteristics. Blemishes occurred on most of the leaves, but these injury symptoms were attributable to insects or disease and appeared uniformly throughout the sample areas including the control site D, as well as other sites visited in western Washington.

F. Conclusions

Foliage studies in areas adjacent to the SRC pilot plant that would be probable receptors of airborne pollutants from the plant indicate no discernable effect upon the dominant vegetative species in the area around the plant.

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APPENDIX

TABLE A-1
 SUSPENDED PARTICULATES
 Monthly Averages
 (Grams per Cubic Meter)

	STATION				
<u>1980</u>	<u>21</u>	<u>22</u>	<u>23</u>	<u>25</u>	<u>35</u>
February	52	41	36	23	31
May	68	56	51	35	36
July	92	77	58	42	--
September	34	--	55	47	52
November	--	57	49	44	41
<u>1981</u>					
January	52	50	47	38	51
March	61	53	42	--	44
May	93	76	46	44	49
July	- Construction -		48	46	51
September	- Construction -----			42	48
November	65	59	48	40	44

TABLE A-2
SULFUR DIOXIDE DATA
MONTHLY SUMMARIES

1980

(ppm)

	<u>Maximum 1-Hour</u>	<u>Maximum 3-Hour</u>	<u>Maximum 24-Hour</u>
January	0.018	0.012	0.005
February	0.025	0.020	0.003
March	0.022	0.015	0.004
April	0.020	0.010	0.006
May	0.016	0.012	0.003
June	0.015	0.010	0.002
July	0.015	0.016	0.003
August	--	--	--
September	0.017	0.014	0.004
October	0.015	0.015	0.003
November	0.020	0.012	0.005
December	0.015	0.010	0.002

TABLE A-3
SULFUR DIOXIDE DATA
MONTHLY SUMMARIES

1981

(ppm)

	<u>Maximum 1-Hour</u>	<u>Maximum 3-Hour</u>	<u>Maximum 24-Hour</u>
January	---	---	---
February	0.018	0.012	0.006
March	0.019	0.015	0.005
April	---	---	---
May	0.017	0.012	0.002
June	0.010	0.010	0.003
July	---	---	---
August	---	---	---
September	0.015	0.010	0.001
October	0.010	0.010	0.003
November	0.010	0.008	0.002

TABLE B-1
WATER QUALITY PARAMETERS
1980 AVERAGES

STATION:	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Temperature, ° C.	12	13	11	11	11	12	7	10	18	10
Dissolved Oxygen, mg/l.	8.2	5.9	6.7	6.8	6.9	7.0	8.3	6.7	8.5	7.3
Specific Conductance, uohm/cm., 25° C.	139	114	133	145	134	136	60	95	402	105
Color, units	0	0	27	20	13	27	60	27	52	23
pH	6.6	6.9	7.4	7.5	7.5	6.3	6.6	6.5	7.5	7.3
Sulfate, mg/l.	6.2	5.8	17	22	20	23	8.9	23	33	6.4
Phenol, mg/l.	0.001	0.001	0.003	0.002	0.002	0.003	0.006	0.004	0.079	0.002
Chemical Oxygen Demand, mg/l.	5.0	3.1	6.3	7.2	8.9	14.8	8.7	30.0	26.4	10.7
Coliforms per 100 ml.	0	0	3	2	6	5	17	13	7	4
Phosphate, mg/l.	0.05	0.04	0.10	0.11	0.14	0.18	0.40	0.10	0.46	0.13
Nitrate, mg/l.	0.39	0.20	0.09	0.29	0.09	0.08	0.11	0.38	0.22	0.08

Station	1. Sullivan Well	6. Hamer Marsh Drainage
	2. Ft. Lewis Water Supply Spring	7. Fort Lewis Drainage Ditch
	3. Lake Sequalitchew	8. Hamer Marsh
	4. Lake Sequalitchew	9. Treatment Outlet
	5. Lake Sequalitchew Outlet	10. Control

TABLE B-2
WATER QUALITY PARAMETERS

AVERAGES

JANUARY 1, 1981 - JULY 15, 1981

STATION:	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Temperature, ° C.	13	13	12	12	12	12	12	11	14	10
Dissolved Oxygen, mg/l.	7.1	6.3	9.4	9.3	8.4	5.8	8.3	7.6	7.9	9.9
Specific Conductance, uohm/cm., 25° C.	137	132	143	135	139	135	82	290	460	108
Color, units	0	0	10	5	10	20	13	30	80	5
pH	6.2	6.4	6.7	7.0	7.1	6.5	6.8	6.4	6.6	6.8
Sulfate, mg/l.	5.5	6.3	11	11.3	10.9	17	4.0	20	25	60
Phenol, mg/l.	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.043	0.001
Chemical Oxygen Demand, mg/l.	2.4	6.5	9.9	6.3	6.0	12.3	5.9	7.9	25.2	11.3
Coliforms per 100 ml.	0	2	3	16	0	21	1	29	0	6
Phosphate, mg/l.	0	0	0.03	0.02	0.02	0	0.18	0.01	0.39	0
Nitrate, mg/l.	0.31	0.22	0.02	0.05	0.05	0.25	0.12	0.37	0.14	0.05

STATION

1. Sullivan Well
2. Ft. Lewis Water Supply Spring
3. Lake Sequalitchew
4. Lake Sequalitchew
5. Lake Sequalitchew Outlet

6. Hamer Marsh Drainage
7. Fort Lewis Drainage Ditch
8. Hamer Marsh
9. Treatment Outlet
10. Control

TABLE B-3
WATER QUALITY PARAMETERS
AVERAGES

JULY 15, 1981 - NOVEMBER 30, 1981

STATION:	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Temperature, ° C.	14	13	14	15	14	13	14	12	14	14
Dissolved Oxygen, mg/l.	6.3	7.8	8.6	9.6	9.4	8.6	8.3	4.7	6.6	7.9
Specific Conductance, uohm/cm., 25° C.	126	142	160	155	155	141	78	81	560	79
Color, units	0	0	22	24	23	15	43	63	58	12
pH	6.0	6.2	6.4	6.6	6.7	6.7	6.5	6.1	6.5	6.7
Sulfate, mg/l.	5.8	7.4	12.7	13.5	11.8	9.8	4.5	3.4	20.1	5.0
Phenol, mg/l.	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.025	<0.001
Chemical Oxygen Demand, mg/l.	3.1	8.6	14.4	12.3	12.4	18.5	17.2	17.7	18.9	12.4
Coliforms per 100 ml.	0	0	2	4	1	0	0	7	0	5
Phosphate, mg/l.	0.02	0.03	0.52	0.52	0.07	0.14	0.08	0.05	0.05	0.04
Nitrate, mg/l.	0.06	0.51	0.08	0.14	0.07	0.26	0.12	0.06	0.08	0.09

Station	1. Sullivan Well	6. Hamer Marsh Drainage
	2. Ft. Lewis Water Supply Spring	7. Fort Lewis Drainage Ditch
	3. Lake Sequalitchew	8. Hamer Marsh
	4. Lake Sequalitchew	9. Treatment Outlet
	5. Lake Sequalitchew Outlet	10. Control

TABLE B-4
WATER QUALITY PARAMETERS
AVERAGES

JANUARY 1, 1981 - NOVEMBER 30, 1981

STATION:	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Temperature, ° C.	14	13	13	13	13	13	13	12	14	12
Dissolved Oxygen, mg/l.	6.7	7.1	9.0	9.5	8.9	7.2	8.3	6.2	7.3	8.9
Specific Conductance, uohm/cm., 25° C.	132	137	152	145	147	138	80	186	510	94
Color, units	0	0	16	14	16	17	29	46	69	8
pH	6.1	6.3	6.6	6.8	6.9	6.6	6.7	6.2	6.5	6.7
Sulfate, mg/l.	5.7	6.9	11.9	12.4	11.4	13.4	4.3	11.7	22.7	6.0
Phenol, mg/l.	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.034	0.001
Chemical Oxygen Demand, mg/l.	2.7	7.6	12.2	9.3	9.2	15.4	11.6	12.8	22.1	11.9
Coliforms per 100 ml.	0	1	3	10	1	11	1	18	0	6
Phosphate, mg/l.	0.01	0.02	0.28	0.27	0.05	0.07	0.13	0.03	0.22	0.02
Nitrate, mg/l.	0.19	0.37	0.05	0.10	0.06	0.26	0.12	0.22	0.11	0.07

Station

1. Sullivan Well
2. Ft. Lewis Water Supply Spring
3. Lake Sequalitchew
4. Lake Sequalitchew
5. Lake Sequalitchew Outlet

6. Hamer Marsh Drainage
7. Fort Lewis Drainage Ditch
8. Hamer Marsh
9. Treatment Outlet
10. Control