Publication No. 78-e23
WA-27-2010

STATE OF WASHINGTON
Dixy Lee Ray
Governor

DEPARTMENT OF ECOLOGY
Olympia, Washington 98504 206/753-2800

M E M O R A N D U M

February 14, 1978

To: Doug Houck

From: Bill Yake

Re: Impact of International Paper Company's wood products mill effluent on the receiving waters of the Upper Chelatchie Creek Drainages

Introduction:

The purpose of this study was to characterize the effect of a wood products mill on the upper drainage waters of the South Fork of Chelatchie Creek under high flow conditions. The mill, owned by International Paper Company (IPCO), continuously discharges steam vat effluent, boiler blowdown, and sawmill cooling waters. In addition, intermittent discharges of oil from machinery and phenol from phenol holding tanks have been reported.

The effect of these effluents on an unnamed tributary bordering the mill premises and on the South Fork of Chelatchie Creek were studied under low flow conditions during the summer of 1977 (Paveza, 1977). During this period, no overland flow was reaching the South Fork of Chelatchie Creek. In addition, yard runoff and leachate flows from substantial woodwaste fills and a dump operated on IPCO property were minimal.

It was anticipated that this study would clarify impacts on receiving waters and provide data which would be considered closely when amendments to the present NPDES permit are considered and drafted.

Methods

The Class II inspection and receiving waters survey were conducted on January 10 and 11, 1978. Receiving water and effluent composite sample collection, as well as field analyses were conducted by Mike Morhous and Bill Yake (Ambient and Effluent Monitoring Staff). Collection of samples at stations #1A, #4A and #4B; as well as inspection of facility premises were conducted by Gerry Calkins and Doug Houck (Southwest Regional Staff).

This memorandum reports the results of field and laboratory analyses of effluent and receiving water samples. Flow was measured at the lagoon outfall using measurements taken at the outfall weir. All other flows were obtained from stream velocity profiles which were measured using a magnetic flowmeter. Temperature, conductivity and dissolved oxygen (Winkler Method) were measured in the field. Composite samplers were installed at the lagoon outfall and station #3. These samplers were left in place for 24 hours and sampled 250 ml every 30 minutes. Composite samples were continuously iced. These samples were split with mill personnel for independent analyses. Grab samples were taken at each of the other locations, iced and transported to the Department of Ecology Analytical Laboratory in Tumwater for analysis. These analyses were conducted in accordance with Standard Methods (American Health Association; et al., 1976). The portion of composite samples transferred to mill personnel were analyzed by Mogul Laboratories in Portland, Oregon. These samples were not iced, but were delivered to this laboratory approximately two hours after the cessation of composite sampling.

Macroinvertebrate samples were taken at stations #1, #2, #6 and #7. Three to six rocks were removed from stream riffles. All visible macroinvertebrates were removed and placed in 90% ethyl alcohol. The dimensions of the rocks were estimated by measuring the longest two right angle lengths of each rock. The invertebrates were keyed and counted by Greg Cloud (Ambient and Effluent Monitoring Staff).

Results

Figure 1 depicts the study area and locates sampling points. Tables 1, 2 and 3 report the results of field and laboratory analyses of samples taken at each of the sampling locations. Care should be exercised in interpreting the nutrient data as nutrient samples were inadvertantly discarded and nutrient analyses were performed on samples which were neither acidified nor continually iced. The daily loadings of major parameters at each of the stations are summarized in Table 4. The mass balances, based on these loadings, are presented in Table 5 and give some indication of the precision of technique. The results of analyses performed on the mill's portion of the composite sample are reported in Table 6. Sampling times are summarized in Table 7.

The lagoon, which receives the steam vat discharge and a quantity of runoff and leachate, produces a black, turbid, anaerobic effluent. Effluent flow was approximately 0.6 cfs; and, as noted in the data summary, was high in BOD_5, COD, phosphorus and solids. The daily lagoon discharge of BOD_5 was 476 lbs/day. Flow measurement at the outfall weir was hampered because the weir is neither level nor sharp-crested. Flows reported from the lagoon effluent are based on conservative flow calculations. Total phosphate levels reported can be used with some confidence. Reported nitrate levels should be treated with more caution although it is likely that the anaerobic environment in the wastewater lagoon results in rapid denitrification, which is probably responsible for the nearly complete removal of nitrate and nitrite. The nitrogen deficient quality of the lagoon waters is further supported by the detection of substantial populations of Klebsiella which can fix nitrogen and therefore compete successfully in nitrogen deficient waters.

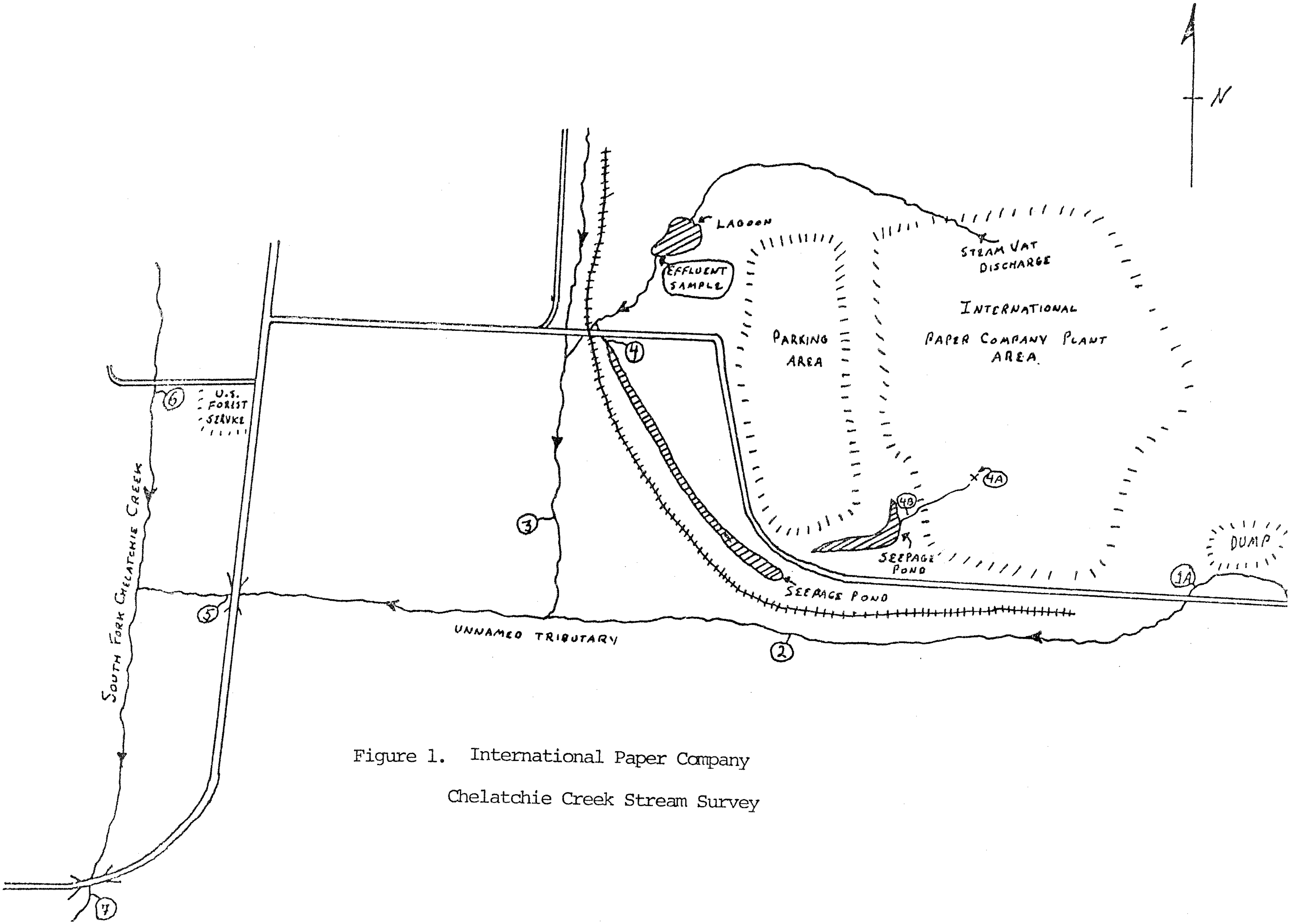


Figure 1. International Paper Company

Chelatchie Creek Stream Survey

TABLE 1 WATER QUALITY DATA

Parameter	Station #1		Station #2		Lagoon Eff.		Station #3		Station #4		Station #5		Station #6		Station #7	
	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan
Flow (cfs)	4.71				0.54	0.62	13.0				17.7[3]			8.54	26.2[3]	
pH	7.1	7.2	7.1	7.3	6.2	6.2[1]	6.9	6.9[1]		6.9	6.7	6.8	6.9	7.0	6.9	6.9
Specific Conductance (µmhos/cm)	50	49	56	57	225	216[1]		70[1]		94	66	65	48	48	60	59
Temperature (°C.)	7.0	6.5	7.5	7.0	9.0	8.0	9.0	8.0			8.0	7.0	8.0	7.0	8.0	8.2
Dissolved Oxygen (mg/l)	11.8	12.0	11.8	11.9	-0-	-0-	9.5	9.9		7.4	10.0	10.3	10.6	11.0	10.4	10.6
Turbidity (JTU)	1	1	4	5		80[1]		15[1]		2	11	7	2	3	8	5
COD (mg/l)						352[1]		31[1]	15							
BOD (mg/l)						152[1]		10[1]	2							
Total Coliform (col./100 ml)	5[2]	4[2]	< 20	20[2]	> 1000	> 1600	> 40	> 290			> 30	200[2]	500[2]	1500	> 30	170[2]
Fecal Coliform (col./100 ml)	< 2	< 1	< 4	< 2	1000[2]	1600	40[2]	290[2]		2	30	200[2]	96	600	30	160
<u>KLEBSELLIA</u> (% of fecal coliform colonies)					50%	60%	-0-	33%				55%				

1) 24 hour Composit Sample (Lagoon Eff. 1/10/78 (1030) to 1/11/78 (1035) (Station #3: 1/10/78 ((1115) to 1/11/78 (1120)
2) Estimated count
3) Flow based on Mass Balance, not measured.

TABLE 2 WATER QUALITY DATA

Parameter	Station #1		Station #2		Lagoon Eff.[1]		Station #3[1]		Station #4		Station #5		Station #6		Station #7	
	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan	10 Jan	11 Jan
*Orthophos.-P, filtered (mg/l	<.02	.06	<.02	<.02	0.15		<.02			<.02	<.02	<.02	<.02	<.02	<.02	<.02
*Total Phos.-P, unfiltered (mg/l)	<.02	.07	.02	<.02	0.16		.05			<.02	<.02	<.02	<.02	<.02	.02	.02
*Nitrate-N, filtered (mg/l)	1.26	1.26	1.22	1.24	<0.1		0.25			.70	.65	.66	.72	.70	.65	.59
*Nitrite-N, filtered (mg/l)	<.02	<.02	<.02	<.02	<.02		<.02			<.02	<.02	<.02	<.02	<.02	<.02	<.02
*Ammonia-N, filtered (mg/l)	.09	<.02	<.02	<.02	<.02		.07			<.02	<.02	<.02	<.02	<.02	<.02	<.02
Total Solids (mg/l)	50	48	51	54	424		74			71	63	54	44	44	65	74
Total Nonvolatile Solids (mg/l)	21	32	41	35	237		45			44	50	37	22	38	46	58
Total Suspended Solids (mg/l)	2	1	5	8	144		14			2	12	7	3	5	8	3
Total Nonvolatile Suspended Solids (mg/l)	2	1	4	7	104		11			2	10	6	2	5	7	3

1) Data from 24-hour Composite: Lagoon Eff.: 1/10/78 (1030) to 1/11/78 (1035)
Station #3: 1/10/78 (1115) to 1/11/78 (1120)

*Lab error - samples not continuously refrigerated nor preserved.

TABLE 3 WATER QUALITY DATA

Parameter	Station 1A 10 Jan	Station 4A 10 Jan	Station 4B 10 Jan
pH	6.9		
Specific Conductance (μmho/cm)	82		
COD (mg/l)	4		
*Orthophosphate-P, filtered (mg/l)	< .02		
*Total Phosphate-P, unfiltered (mg/l)	< .02		
*Nitrate-N, filtered (mg/l)	1.12		
*Nitrite-N, filtered (mg/l)	< .02		
*Ammonia-N, unfiltered (mg/l)	< .02		
Chromium (μg/l)	< 20		
Copper (μg/l)	< 20		
Cadmium (μg/l)	< 20		
Lead (μg/l)	< 20		
Zinc (μg/l)	40		
Iron (μg/l)	900		
Phenols (mg/l)		0.22	0.022

*Lab Error: Samples not continuously preserved.

Table 4. Total Loadings (lbs/day)

Parameter	Station #1 10 Jan.	Station #2 10 Jan.	Lagoon Eff. 10,11 Jan.	Station #3 10,11 Jan.	Station #5 10 Jan.	Station #6 11 Jan.	Station #7 10 Jan.
Total Solids	1270	1300	1330	5200	6020	3410	9200
Total Suspended Solids	50.9	127	451	983	1150	138	1132
Total Nitrogen-N	34.3	31.2	< 0.31	22.5	63.1	32.3	94.8
Total Phosphate-P	- -	0.51	0.50	3.51	- -	- -	- -
Dissolved Oxygen	300	300	0	667	956	507	1470
COD			1100	2180			
BOD_5			476	702			

Table 5. Mass Balance Closure (lbs/day)

Parameter	Station #2 & #3	Station #5	% Closure	Station #5 & #6	Station #7	% Closure
Total Solids	6490	6022	+ 7.8%	9434	9196	+ 2.6%
Total Suspended Solids	1100	1147	- 4.3%	1285	1132	+ 13.5%
*Total Nitrogen	53.7	63.08	- 17.5%	95.4	94.8	+ 0.6%
Dissolved Oxygen	967	956	+ 1.2%	1463	1471	- 0.5%

* $(NH_3\text{-}N) + (NO_2\text{-}N) + (NO_3\text{-}N)$

Table 6. IPCO Analyses of Lagoon Effluent

Parameter and Units	Lagoon Effluent (24 hr. composite)
BOD_5 (mg/l)	165
Total Suspended Solids (mg/l)	156
Oil and Grease (mg/l)	3
Phenol (mg/l)	0.106
Total Coliforms (MPN/100 ml)	46,000 *
Fecal Coliforms (MPN/100 ml)	4,600 *

* Sample collection not aseptic. These data, therefore, highly questionable.

Table 7. Sampling Times

Location	Grab Samples and Field Analyses		Composite Samples	
	1-10-78	1-11-78	1-10-78 to	1-11-78
Station #1	1255	0930		
Station #1A	1240			
Station #2	1345	0945		
Lagoon Effluent	1635	1035	1030	1035
Station #3	1605	1120	1115	1120
Station #4		1145		
Station #4A	1310			
Station #4B	1320			
Station #5	1550	1010		
Station #6	1450	0900		
Station #7	1525	1000		

The lagoon effluent is almost certainly the source of the black sludge found at downstream locations by Paveza (1977). It should be noted that in a drainage such as this one, with considerable fluctuations in flow, solids will accumulate near the outfall in periods of low flow and be intermittently flushed to downstream reaches during periods of higher flow. This could lead to the clogging of spawning gravels as well as deposition of oxygen-demanding sediments at downstream locations.

Flow at station #3 includes the discharge from the settling lagoon, seepage pond #2, and a substantial flow from a drainage ditch which borders plant property on the west and north. Flow to this drainage ditch is comprised primarily of yard runoff. The flow at station #3 was approximately 13 cfs during the study period. This represents about 50% of the total flow of the South Fork of Chelatchie Creek below its confluence with the unnamed tributary.

Table 8 compares measured flows and loadings with current NPDES permit limitations.

Table 8. Flows and Loadings at International Paper Company Mill, Amboy

	NPDES Permit Limitations		24 Hour Composite Samples		
	Daily Average	Daily Maximum	Lagoon Eff. Mogul Labs	Lagoon Eff. DOE Labs	Station #3 DOE Labs
Flow (gpd)	331,600	400,000	374,700	8,400,000	
BOD_5 (lbs/day)	173	520	517	476	702
COD (lbs/day)	- -	- -		1100	2180
pH	6 - 9	6 - 9		6.2	6.9

Although present BOD_5 limitations address steam vat discharges specifically, it is apparent that organic loadings in the mill's discharge are substantial. The effect of these organic loadings is visually apparent in the unnamed tributary and the South Fork of the Chelatchie Creek below the confluence with the unnamed tributary. Solids deposition and heavy Sphaerotolis-like growths mark channels below the lagoon discharge.

Above the mill and associated landfill, the unnamed tributary has the appearance of a small, clean stream with a well balanced benthic community including stoneflies, mayflies, and caddisflies (See Table 9). The only unusual characteristic detected in the analyses of these waters was a rather high nitrate concentration. The very low phosphate levels, however, appear to result in a phosphate-limited, oligotrophic stream with a diverse benthic community primarily limited to residence in occasional aquatic moss growths.

Table 9. Benthic Invertebrates in Study Area

Phylum / Family / Genus Species	Station 1		Station 2		Station 6		Station 7	
	Count	d *	Count	d	Count	d	Count	d
Diptera								
unidentified species 1.	6+	8.0						
unidentified species 2.							7	21
Simuliidae								
unidentified species	6	8.0						
Trichoptera								
Hydropsychidae								
Smicridea sp.	1	1.3						
Rhyacophilidae								
Glossoma sp.					27	25	2	5.9
Plecoptera								
unidentified species 1.	1	1.3						
unidentified species 2.							1	2.9
Perlodidae								
unidentified species	1	1.3						
Nemouridae								
Brachyptera sp.							1.	2.9
Ephemeroptera								
Ephemerellinae								
unidentified species	4	5.3						
Ephemerella doddsi	1	1.3						
Heptageniidae								
Rhithrogena decora	4	5.3			8	7.3		
Baetidae								
Baetis sp.	2	2.7					5	15
Mollusca								
Gastropoda								
Pleuroceridae								
Goniobasis silicula					1	0.9	1	2.9
Pelecypoda								
Margaritiferidae								
Margaritifera falcata					1 **	0.9 **		

* density per sq. ft.
** shell only

At station #2, there were neither macrophytes nor benthic invertebrates. The responsible agent for this lack of aquatic life was not isolated by the water analyses. The stream-bed stones were, however, covered with an oil-like substance. Paveza (1978, personal communication) noted numerous small fish in this stretch of stream during his summer 1977 study.

The visual character of the unnamed tributary below its confluence with mill effluent changes radically. The stream-bed profile deepens and Sphaerotolis-like growth covers most available substrate. The introduction of phosphate from the lagoon effluent may well increase the trophic status of the stream. Paveza (1977) reported that under low flow conditions this stretch of stream-bed was covered with a black deposition.

Above its confluence with the unnamed tributary, the South Fork of the Chelatchie Creek has the appearance of a relatively clean stream. The benthic community consisted primarily of larvae and pupae of the genus Glossoma and the mayfly Rhithrogena decora. Both of these taxa are specifically adapted to high velocity flows. Invertebrate sampling was done just below a culvert and this location probably biased the sample in favor of these two organisms. No Sphaerotolis-like growths were noted near station #6. The relatively high fecal counts at this station indicate that there are probably unidentified fecal coliform sources upstream.

Figure 2 is a photograph of Sphaerotolis-like growths at station #7. Similar growths were noted on many of the invertebrates collected at this site. Although a relatively diverse community of benthic invertebrates was collected at this station, Sphaerotolis-like growths have a deleterious effect on fish propogation (Hynes, 1960). Discharge of low nutrient organic wastes (i.e. silage effluent, pulp mill effluent, wood-waste effluent, etc.) has often been implicated in the growth of sewage fungus (Sphaerotolis), (Hynes, 1960; Funk, 1977, personal communication).

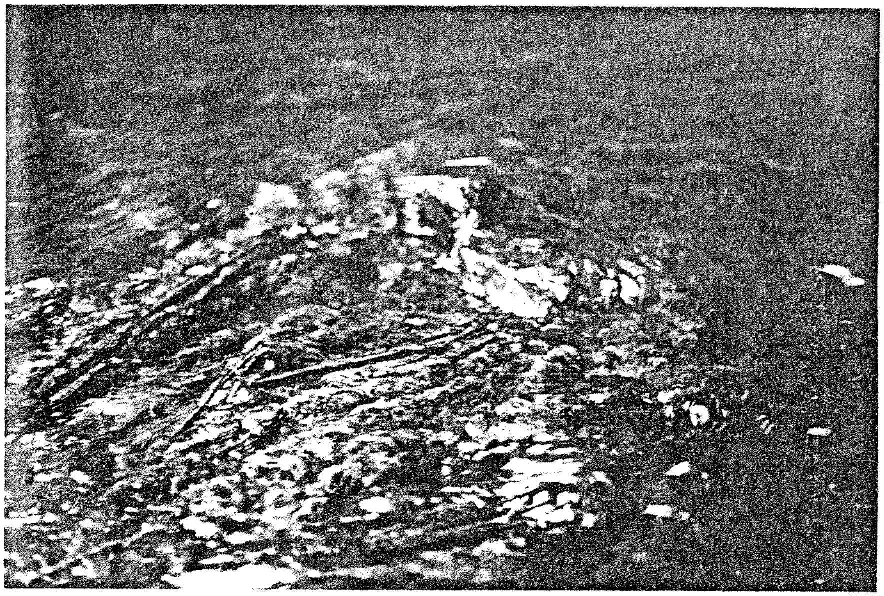
Conclusions

The primary deleterious effects of the IPCO mill effluent on the upper drainage waters of the South Fork of Chelatchie Creek under high flow conditions appear to be linked to:

1) Substantial organic loadings.
2) Total suspended solids loadings.
3) Intermittent phenol and oil discharges.

Organic loadings are probably responsible for substantial Sphaerotolis-like growths at points below the lagoon discharge. These growths, along with deposition of solids, are potentially deleterious to fish propogation and certainly have an adverse aesthetic impact on the stream.

Figure 2. Sphaerotolis-like growths at station #7



Suggestions

The design of future studies in this drainage might note the following suggestions:

1) The flow measuring weir at the lagoon outfall should be improved to provide accurate discharge flows. A sharp-edged, V-notch weir with an automatic flow recorder at this point would be very helpful.

2) Installation of a similar device at the steam vat discharge would be helpful in quantifying flows from this major source.

3) Collection of COD and nutrient samples at each of the stations would allow better interpretation of data reported here. In conjunction with flow measurements, the COD data would allow more precise inferences about organic loading and the specific sources of the responsible discharges.

4) The location of a new station to characterize lagoon influent would allow determination of the treatment efficiency of the present lagoon.

5) An expanded macroinvertebrate sampling program would improve the reliability of these data. Collection of at least 100 individuals at each station sampled in this study would allow use of species diversity indices. Adding a macroinvertebrate station at the mouth of the unnamed tributary would provide additional useful data.

Bibliography

Hynes, H. B. N., 1960. The Biology of Polluted Waters. Liverpool University Press.

Paveza, J., 1977. Memorandum to Howard Steeley: International Paper Company. Chelatchie Prairie.