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JOHN SPELLMAN
Governor

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
7272 Cleanwater Lane, LU-11 • Olympia, Washington 98504 • (206) 753-2353

MEMORANDUM

June 7, 1984

To: Al Bolinger and Harold Porath

From: Marc Heffner

Subject: Class II Inspection at the Kittitas County Sewer District #1 Wastewater Treatment Plant, February 26-27, 1984

INTRODUCTION

The Kittitas County Sewer District #1 (KCSD) Wastewater Treatment Plant (WTP) is located near the Pac West ski slope at Snoqualmie Summit (Figure 1). The WTP facility combines aerated lagoons with land application of the effluent on forested land. The plant is in the final stages of the municipal grants process, but because of the unusual nature of the discharge, a Class II inspection was requested prior to release of the project from grants.

The WTP is presently operating under state waste discharge permit 9005. The permit sets a testing schedule for plant and sprayfield monitoring, but limits only effluent flow to the sprayfield (monthly average <0.368 MGD). Tests required for permit compliance are to be run on the lagoon influent and effluent, runoff from the land-application sprayfield and samples collected from monitoring wells. The permit specifies that the receiving water for the effluent is to be the groundwater.

The aerated lagoon portion of the facility is a rather typical two-cell system (Figure 2). Extra storage capacity has been included in the second cell for periods when spraying would be undesirable. The sprayfield consists of approximately 50 acres of forested land that has been divided into seven fields (Figure 3). Effluent application is rotated through the series with application rates of generally 0.15 to 0.20 MGD on one of the fields five days a week; well below the 0.368 MGD permit maximum. During a reconnaissance survey three weeks before the inspection, it was decided to concentrate inspection sampling in fields 1 and 7. This selection was made based on ease of sampling due to the drainage patterns. For the two weeks prior to the inspection, an attempt was made to spray at the design WTP flow (0.368 MGD) on fields 1 and 7. This loading better simulated plant design loads for the period immediately before the inspection. Runoff channels from the sprayfield eventually lead to Keechelus Lake, located approximately 1/2 mile from the sprayfield (Figure 1).

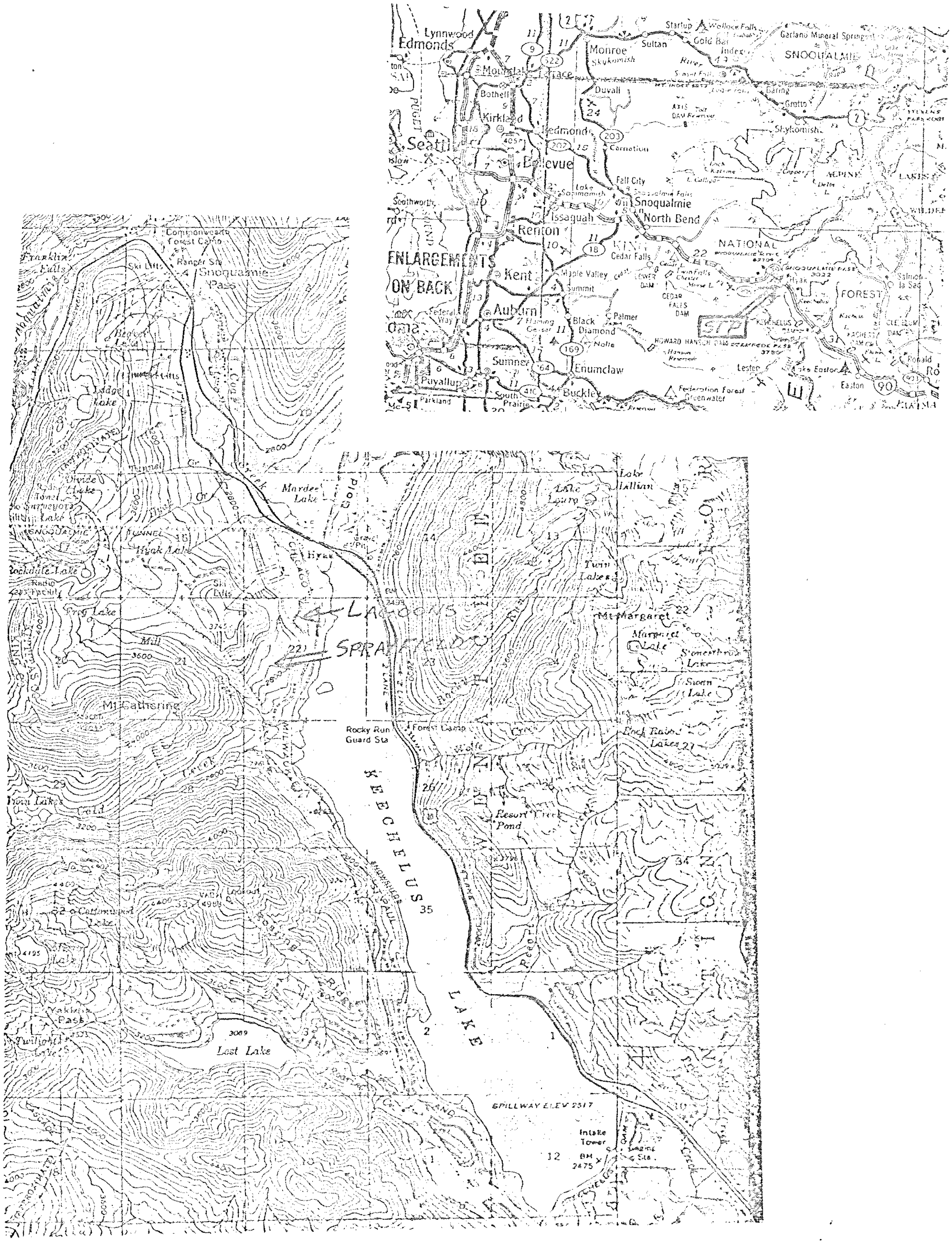

Figure 1. Plant location - KCSD, February 1984.

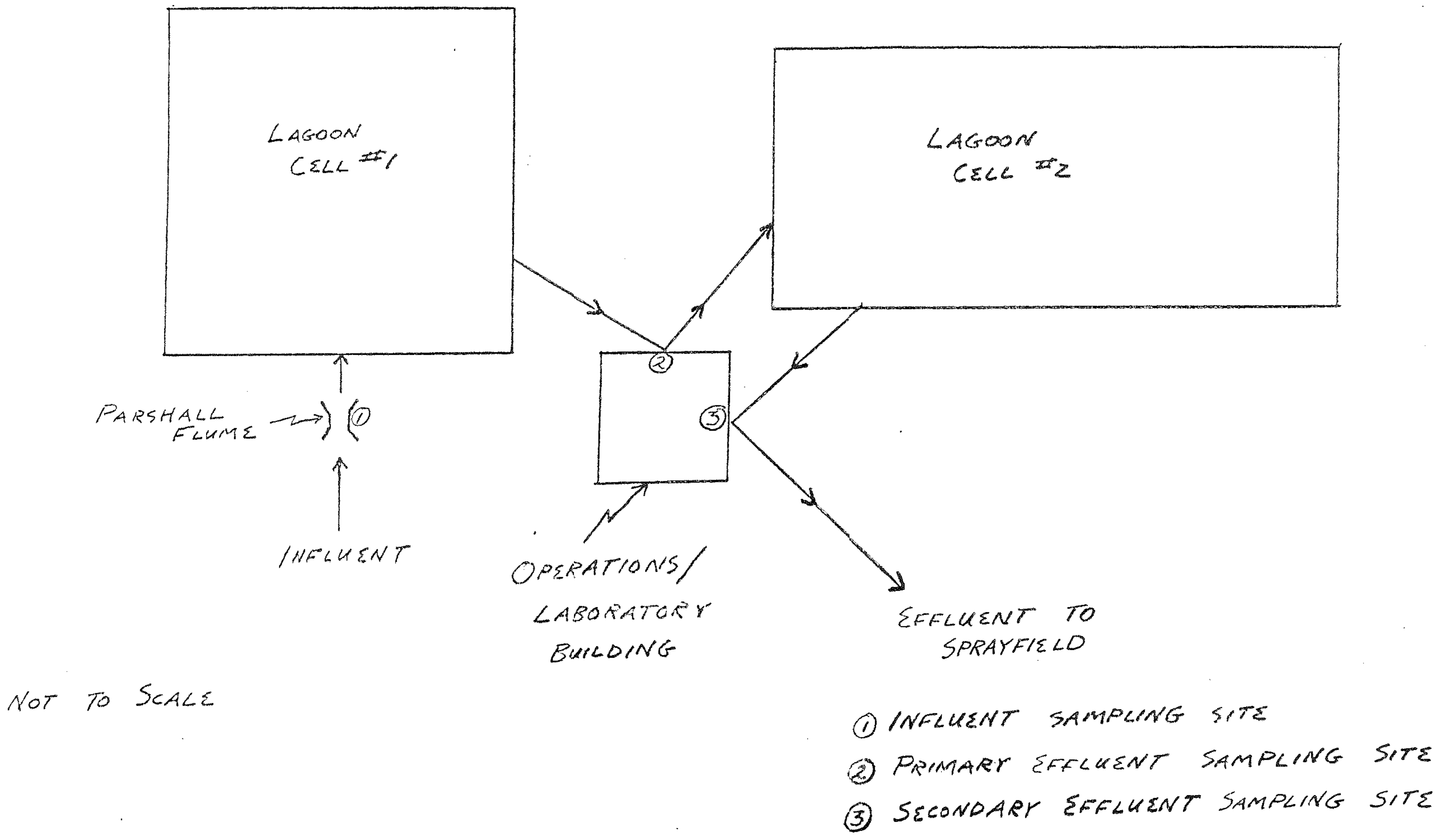

Figure 2. Lagoon schematic - KCSD, February 1984.

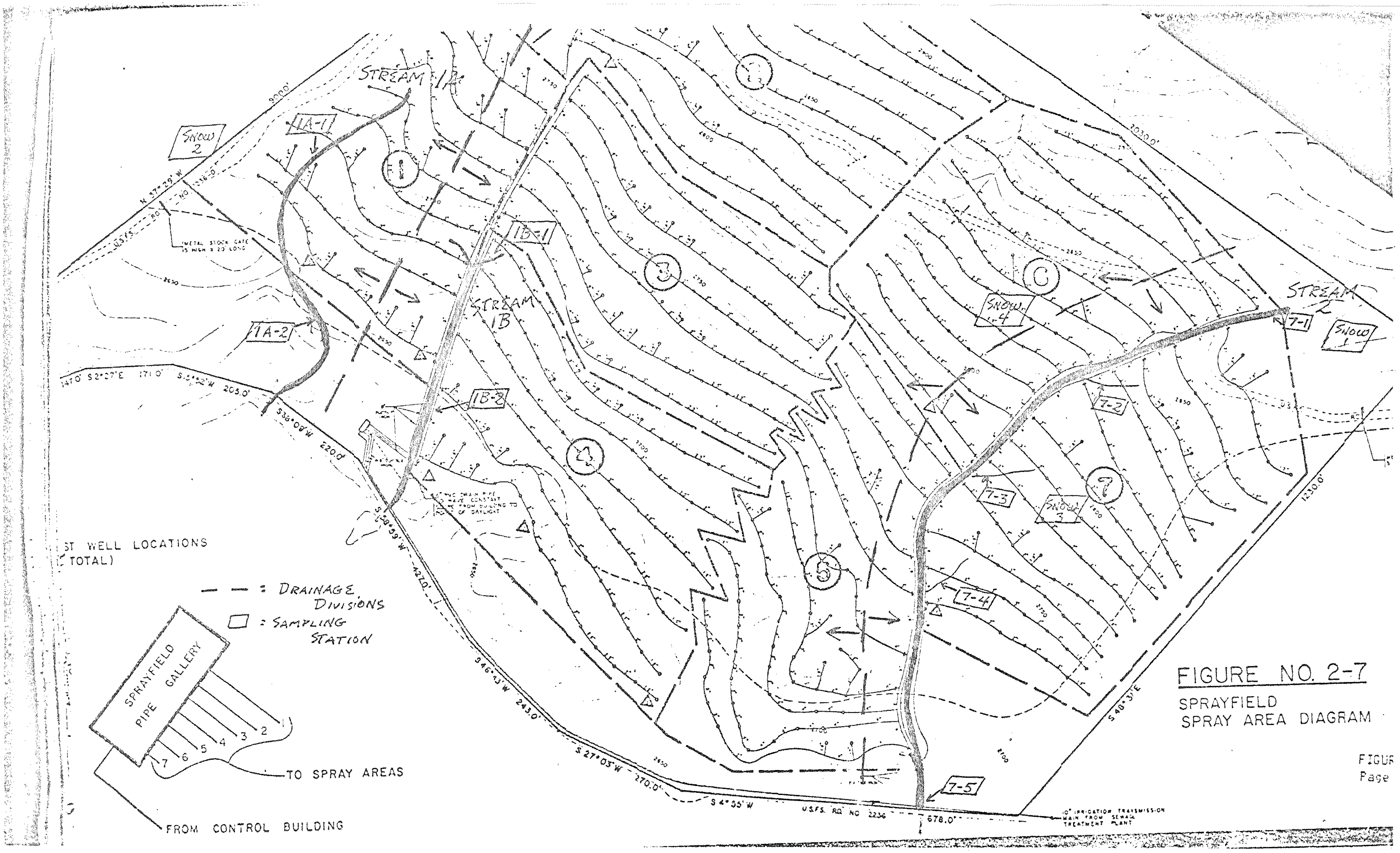

Figure 3. Sprayfield map - KCSD, February 1984.

The inspection was started on Sunday to include anticipated higher weekend loadings from the day-use ski and snow-tourist facilities to the aerated lagoons. Basic goals of the inspection included:

1. Sampling of the aerated lagoon facility to estimate loading and treatment efficiency of the lagoons.
2. Sampling sprayfield drainage. Because a one-time sampling of a unique and fluctuating system cannot define the system's efficiency, general observations and suggestions for monitoring the sprayfield were targeted.

The inspection was conducted on February 26-27, 1984 by Dale Clark and Marc Heffner (Washington State Department of Ecology [WDOE] Water Quality Investigations Section), Harold Porath and John Hodgson (WDOE, Central Regional Office), and Dick Klaus and Lee James (KCSD).

Procedures

The procedures and results discussions are divided into two portions. The lagoon portion includes lagoon influent, first-cell effluent, and second-cell effluent samples, while the sprayfield portion addresses only the sprayfield proper.

Lagoon Sampling

WDOE composite samplers were set up to collect influent, first lagoon cell effluent (primary effluent), and final lagoon effluent. The influent sample (collected from 0800 on February 26 to 0800 February 27) was a flow-proportional composite set up in conjunction with a WDOE Manning Dipper flow meter installed at the influent Parshall flume. The primary and final effluent samples were time-proportional. For each effluent sample, a hose was run from a spigot on the proper line to a bucket that was kept continuously overflowing with the sample to be collected. Composite samplers collected approximately 220 mLs of sample every 15 to 20 minutes while effluent was being pumped to the sprayfield. Effluent samplers were run from 0800 to 1400 on February 26 and 0900 to 1200 on February 27. WDOE samples were split for analysis by both KCSD and WDOE laboratories.

KCSD collected samples on March 1. This was representative of the normal practice of sampling on Wednesday or Thursday. The samples included a time-proportional influent composite (200 mLs every 30 minutes for 24 hours) and an effluent grab sample. The samples were split for KCSD and WDOE analysis.

Grab samples were also collected for field analysis and fecal coliform analysis (Table 1). Chlorine contact time at the plant is provided in the line between the lagoons and the sprayfields. Prior to neutralizing the sample with thiosulfate, a holding time of 15 minutes was allowed when effluent was being applied to fields 2, 6, or 7, and 10 minutes was allowed when effluent was being applied to fields 1, 3, 4, or 5, per the operator's calculation.

Table 1. WDOE grab sample results - KCSD, February 1984.

Sample	Date	Time.	Temp. (°C)	pH (S.U.)	Conductivity (umhos/cm)	Fecal Coliform (#/100 mL)	Total Chlorine Residual (mg/L)
Influent	2/26	0715	4.5	8.6	495		
		1200	4.9	8.3	680		
	2/27	0850	3.8	7.6	385		
	2/26-27	Comp.	0.9	8.9	740		
Primary Effluent	2/26	0815	2.4	7.3	420		
		1225	3.2	7.2	445		
	2/27	0815	2.5	7.4	500		
	2/26-27	Comp.	1.9	7.5	460		
Effluent	2/26	0750	1.4	7.2	270	31	0.1
		1220	1.0	7.2	250	150	0.2
		1300				41	
	2/27	0815	1.0	7.3	285		
		1000				150	
		1015*				220*	
	2/26-27	Comp.	1.8	7.4	270		

*Unchlorinated sample.

Sprayfield Sampling

Sprayfield 7 was sampled on February 26, and Sprayfield 1 was sampled on February 27. One to two hours before sampling, application of effluent was begun on the field to be sampled. On February 26, 186,100 gallons of effluent were applied to field 7 between 0730 and 1430, and on February 27, 114,500 gallons of effluent were applied to field 1 between 0810 and 1230. The lower borders of the sprayfield were walked using snowshoes, and grab samples collected from observed runoff streams or streamlets draining the sprayfield area (Figure 3). Also a sample of sprayer discharge and an icicle were collected in field 1 for fecal coliform analysis.

In addition to runoff samples, several snow samples were collected. Two background samples were collected above the sprayfields along with one sample from field 7 the day after effluent application and one sample from field 6 five days after the previous effluent application.

RESULTS AND DISCUSSION

Lagoon Monitoring

WDOE laboratory results of the WDOE and KCSD samples are presented in Table 2. The primary problem associated with KCSD lagoon monitoring was the lack of an influent flow meter. Operators reported that there was a meter between lagoons, but because the levels were not kept constant, an accurate depiction of flow was not portrayed. A Parshall flume was in place in the influent channel and was used by WDOE to measure flows using a Manning dipper. A flow meter at the flume compatible with the KCSD composite sampler would allow influent flow measurement and collection of flow-proportional samples.

Flow measured during the Class II inspection using the WDOE Manning dipper was approximately 0.10 MGD. A large difference was noted between the Sunday and Monday morning flows (0.164 MGD Sunday at 0800; 0.054 MGD Monday at 0800). Also, there was a wide variation in WDOE and KCSD influent sample concentrations including BOD_5 and TSS concentrations (Table 2). The higher weekend concentrations were probably due to the higher weekend usage. To accurately monitor lagoon loading, both weekday and weekend sampling would appear necessary--possibly rotating sampling days (two weekend and two weekday samples/month).

The KCSD effluent sample was a single grab sample. A better technique would be collecting a grab composite (equal volumes every two hours during the pumping period) to assure a representative sample. The lagoon appears to provide adequate detention time so that influent flow fluctuations have little effect on treatment, as was evidenced by the uniformness of WDOE and KCSD effluent sample results.

Table 2. WDOE lagoon monitoring results - KCSD, February 1984.

						Solids (mg/L)							Nutrients (mg/L)						
Sample	Date	Flow (MGD)	BOD_5 (mg/L)	Inh. BOD_5 (mg/L)	COD (mg/L)	TS	TNVS	TSS	TNVSS	pH (S.U.)	Conductivity (umhos/cm)	Turbidity (NTU)	T. Kjeldahl-N	NH_3-N	NO_2-N	NO_3-N	O-PO_4-P	Total-PO_4-P	Alkalinity (mg/L)
WDOE Influent	2/26-27	.10	280	270	480	630	220	290	22	8.6	598	160	66	49	<.10	<.10	6.9	8.8	290
KCSD Influent	3/1		120		200	290	140	90	4	7.5	468	53		26	<.25	<.25	3.0	4.3	150
WDOE Primary Effluent†	2/26-27		41	30	84	200	110	27	3	7.6	500	34	32	29	<.05	.05	3.7	4.0	160
WDOE Secondary Effluent	2/26-27	*	9	6	27	120	66	2	1	7.5	281	9	15	15	<.05	1.5	1.8	1.9	80
KCSD Secondary Effluent	3/1		9		30	140	81	3	<1	7.3	286	10		15	<.10	1.5	2.0	2.1	90

†Sample collected between the first and second lagoon cells.
*On 2/26 - 186,100 gallons pumped to sprayfield 7 between 0730 and 1430.
On 2/27 - 114,500 gallons pumped to sprayfield 1 between 0810 and 1230.

Lagoon effluent was of good secondary quality (BOD = 9 mg/L and TSS = 2-3 mg/L, NH_3-N = 15 mg/L and T-PO_4-P (T-P) = 2 mg/L) (Table 2). Fecal coliform concentrations were fairly low (range 31/100 mL to 150/100 mL) for all chlorinated samples collected (Table 1). Contact time was below the one hour recommended by criteria (10 to 15 minutes in the force main to the sprayfield) and chlorine residual was approximately 0.1 mg/L (WDOE, 1978). An unchlorinated effluent sample was collected and yielded a count of 220/100 mL, suggesting that chlorination may be having a minimal effect. Coliform counts should be watched as plant flow increases, and if the counts increase substantially, chlorination techniques re-evaluated.

Sprayfield Monitoring

During the inspection, lagoon effluent BOD_5 and TSS concentrations were low enough that they were of little concern in the sprayfield. They may become more of a concern as flow to the plant increases and effluent quality declines. Fecal coliform counts were also low in the lagoon effluent.

Several equipment problems in the sprayfield preventing optimum operation during the inspection were noted. These included:

1. In field 7, a valve linking the main distribution line to a lateral was leaking. The discharge, which appeared fairly minor, was feeding into a rivlet running into stream 2.
2. Several sprinklers were not spraying properly. The operator reported that rocks plugging the line are generally the problem.
3. In field 1, the cap to the end of one of the laterals was broken off. This discharge was flowing into stream 1A at a rate judged sufficient to bias the data collected from stream 1A below that point. The resulting pressure drop probably influenced the spray pattern throughout the field, making spray application and resulting data somewhat atypical.

Problems 1 and 2 were minor, and probably had little effect on the inspection data, whereas problem 3 greatly affected sprayfield performance. All three problems should be corrected.

Data collected during the inspection are presented in Table 3. Station 7-1 was sampled to represent background conditions. Changes from background, thought to be associated with normal sprayfield operation, included increases in COD, total inorganic nitrogen (TIN; TIN = NH3-N + NO2-N + NO3-N), total phosphorus (TP), and conductivity. Fecal coliform bacteria were detected in less than one-half of the samples collected from the sprayfield. Interest in nutrient removal in the sprayfield and an assumption that effluent runoff from the

Table 3. WDOE sprayfield runoff monitoring results - KCSD, February 1984.

			Solids (mg/L)							Nutrients (mg/L)							
Station	Date	COD (mg/L)	TS	TNVS	TSS	TNVSS	pH (S.U.)	Conductivity (umhos/cm)	Turbidity (NTU)	NH_3-N	NO_2-N	NO_3-N	TIN	O-PO_4-P	Total-PO_4-P	Alkalinity (mg/L)	Fecal Coli. (#/100 mL)
WDOE Eff.	2/26-27	27	120	66	2	1	7.5	281	9	15	<.05	1.5	16.5	1.8	1.9	80	31-150†
7-1	2/26	4	50	28	2	<1	6.4	24	2	.01	<.01	.02	.03	<.01	.01	11	<1
7-2	2/26	57	240	160	140	94	7.3	173	59	6.4	<.05	.90	7.30	.50	.55	63	<1
7-3	2/26	30	130	80	11	5	7.3	217	10	12	<.05	1.4	13.4	1.2	1.2	68	<1
7-4	2/26	27	120	71	8	4	7.3	153	9	6.8	<.05	1.4	8.2	.60	.65	39	1 Est.
7-5	2/26	15	100	55	11	6	7.2	121	6	5.0	<.05	.95	5.95	.45	.45	36	<1
	2/27	4	53	34	2	1	7.0	36	2	.30	<.01	.20	.50	.01	.02	17	<1
1A-1	2/27	15	98	66	4	2	7.1	137	4	6.4	<.01	1.4	7.8	.65	.65	39	2 Est.
1A-2	2/27	15	130	77	17	12	7.4	175	14	8.7	<.05	2.4	11.1	.80	.80	49	6 Est.
1B-1	2/27	4	45	20	1	<1	6.0	28	1	.06	<.05	.32	.38	<.01	.01	8	<1
1B-2	2/27	4	50	24	2	1	6.8	36	1	.32	<.01	.51	.83	.02	.02	10	<1
	2/26	4	67	23	2	<1	7.3	32	3	.08	<.01	.50	.38	<.01	.02	12	<1
Sprayer*	2/27																20
Icicle**	2/27																<1

Est. = Estimated.
†Four samples collected - see Table 1 for individual results.
*Sample taken from a sprayer near the bottom of field 1.
**Sample taken from an icicle hanging from a tree in field 1.

sprayfield was the only source of nutrients in greater concentration than background conditions led to calculating ratios of effluent to background flows in runoff based on TIN and TP concentrations (Table 4). Effluent concentrations in runoff ranging from 23 to 83 percent were noted during spraying in streams 1A and 2 (stations 1A-1 and 1A-2 on February 27 and 7-2 through 7-5 on February 26).

Table 4. Percent effluent in runoff - KCSD, February 1984.

		TIN		TP	
Station	Date	(mg/L)	Percent Effluent in Stream† (%)	(mg/L)	Percent Effluent in Stream† (%)
WDOE Eff.	2/26-27	16.5		1.9	
7-1	2/26	.03		.01	
7-2	2/26	7.3	43	.55	29
7-3	2/26	13.4	83	1.2	62
7-4	2/26	8.2	50	.65	33
7-5	2/26	5.95	36	.45	23
7-5	2/27	.50	3	.02	<1
1A-1	2/27	7.8	48	.65	33
1A-2	2/27	11.1	67	.80	42
1B-1	2/27	.38	2	.01	<1
1B-2	2/27	.83	5	.02	<1
1B-2	2/26	.58	3	.02	<1

†Calculated using station 7-1 as background stream conditions. The percent represents the theoretical amount of effluent, expressed as a percentage, that would have to be mixed with background stream water to obtain the nutrient concentration found at the sampling station. The calculation assumes that the effluent is the only nutrient loading source available to raise concentrations to greater than background conditions.

Table 5 summarizes data for stations of particular interest. The stream 2 sample collected below the sprayfield area (station 7-5) contained substantially elevated TIN and T-P concentrations when field 7 was sprayed, and elevated TIN concentations the day after spraying took place. Data from streams 1A and 1B are more difficult to interpret because of the line blowout during the inspection. The stream 1A sample taken above the rupture had high TIN and TP concentrations, but how much would have run off the sprayfield was questionable. Spraying during the inspection seemed to have little direct effect on stream 1B although TIN and TP concentrations were above background levels for both samples collected.

Table 5. Sprayfield runoff summary - KCSD, February 1984.[†]

	Stream 1A*		Stream 1B**		Stream 2***	
	TIN	T-P	TIN	T-P	TIN	T-P
Above sprayfield	No flow		No flow		.03	.01
Day before spraying			.58	.02		
During spraying	7.8[††]	.65[††]	.83	.02	5.95	.45
Day after spraying					.50	.02

[†] All units mg/L.
[††] Sample taken above ruptured line.

*Station 1A-1
**Station 1B-2
***Station 7-1 above sprayfield, other data collected at station 7-5.

Snow sample data are presented in Table 6. The TIN concentrations of the background snow samples were higher than the background water sample, but still below runoff concentrations. TP background concentrations were the same in the snow and water samples. The field 7 snow sample, taken the day after effluent was applied, had elevated TIN and TP concentrations. The field 6 sample, taken five days after the last effluent application, had lower TIN and TP concentrations, but the concentrations were still greater than background; by approximately three times for TIN and six times for TP.

Table 6. WDOE snow sampling data - KCSD, February 1984.

	COD (mg/L)	pH (S.U.)	Conductivity (umhos/cm)	Nutrients (mg/L)						Alkalinity (mg/L)
				NH_3-N	NO_2-N	NO_3-N	TIN	O-PO_4-P	T-PO_4-P	
Snow 1	0	5.9	6.32	.03	<.01	.07	.10	<.01	.01	6
Snow 2	0	5.0	9.63	.04	<.01	.13	.17	<.01	.01	4
Snow 3	4	6.7	19.6	1.0	<.01	.17	1.17	.12	.14	10
Snow 4	11	6.4	7.20	.27	<.01	.07	.34	.03	.06	6

The elevated TIN and TP concentrations suggest a need to quantify sprayfield runoff to describe the treatment efficiency. Flow and concentration data with which to calculate a mass balance for the system would be necessary. During the inspection, accurate instantaneous measurements could not be made using the WDOE Marsh-McBernie meter because of the shallow rocky streambeds. Flow measurements of the streams exiting the sprayfield area would probably require construction of primary flow devices in each channel. Differences in the background TIN concentrations could be associated with the measured flows to determine the load associated with the WTP effluent.

The frequency of sampling and time necessary to do a systems balance are important considerations. Two factors suggesting the need for frequent sampling and a long-term mass balance are:

1. Runoff during sprinkling is a function of different factors including temperature, snowpack, soil saturation, sprayfield being used, and application rate and volume. Data collected for different variables at different times into the spraying cycle would be necessary.

2. The data suggest that there is some nutrient retention in the snow. An estimate of effluent runoff associated with snowmelt would be needed. A timeframe equal to the duration of the snowpack would be necessary to complete this portion of the balance.

While a mass balance of the system is preferable, it appears that outside help would be necessary to aid the KCSD staff. If securing outside help is unfeasible, gaging runoff during spraying (3 to 4 instantaneous measurements per spray cycle) and collecting flow-weighted grab composites might be considered as a minmum weekly requirement for sprayfield monitoring. Pertinent weather data (temperature and precipitation) should also be collected.

LABORATORY DISCUSSION

The laboratory instruction portion of the O&M Division start-up procedures had not been completed at the time of the Class II inspection, so laboratory procedures were not reviewed with the operators in depth. Several sample splits were made with the operator for WDOE and KCSD analyses (Table 7). The operator performed the analyses listed as KSCD results.

Table 7. Comparison of WDOE & KCSD laboratory results - KCSD, February 1984.

	NO_3-N (mg/L)		NH_3-N (mg/L)		BOD_5 (mg/L)		TSS (mg/L)		F. Coli. (#/100 mL)	
	WDOE	KCSD	WDOE	KCSD	WDOE	KCSD	WDOE	KCSD	WDOE	KCSD
Stream 2										
*2/26 (7-1)	.02	.44	.01	.18						
(7-5)	.95	4.4	5.0	3.54						
*2/27 (7-5)	.20	.88	.30	.49					<1	0
Stream 1B										
2/26 (1B-2)	.50	2.20	.08	.37						
*2/27 (1B-2)	.51	.88	.32	.62					<1	1
Stream 1A										
2/27 (1A-2)	2.4	5.28	8.7	3.66					6 Est.	1
*Effluent grab									41	22
*WDOE Effluent	1.5	8.63	15	4.27						
*KCSD Influent					120	84	90	340		
*KCSD Effluent	1.5	4.84	15	3.66	9	7.5	3	4		

*Samples taken at same time.
Est. = Estimated.

WDOE and KCSD effluent BOD_5 and TSS results and fecal coliform test results compared closely. Influent BOD results compared marginally, and influent TSS results compared poorly. KCSD NO_3-N and NH_3-N results compared poorly with WDOE results. The KCSD NO_3-N and NH_3-N tests are run using Hach kit test methods, and no easily identifiable deviations from the accompanying instructions were noted when the operator (Lee James) briefly demonstrated his technique. One problem noted was the test scale being used for the NO_3-N test. The range was 0 to 30 mg/L which appeared too high for most of the samples being run. NH_3-N and NO_3-N test procedures should be carefully reviewed during start-up laboratory instruction and additional splits made with the WDOE laboratory as adjustments are made.

SUMMARY AND RECOMMENDATIONS

1. The lagoon portion of the facility was operating well during the inspection. An influent flow meter at the plant is needed to allow collection of flow-proportional influent composites and for use in calculating plant loadings.

2. Because of heavy weekend tourism in the service area during the winter months, collecting alternate weekend and weekday influent composite samples would be necessary to accurately determine treatment plant loads.

3. Total inorganic nitrogen (TIN) and total phosphorus (TP) data collected during the inspection indicated that effluent runoff from the sprayfield was occurring; thus the goal of discharging to the groundwater was not being met. Precise quantification of this facility-generated runoff was not possible considering the scope of this survey. Ideally, a mass balance would have to be performed by KCSD, possibly with assistance from an outside consultant. Runoff flow using primary flow devices in streambeds, NO_3, and NH_3 would have to be measured.

4. Several results of samples analyzed by both the WDOE and KCSD laboratories did not compare favorably. After the O&M Division laboratory instruction is completed at KCSD, samples should again be split for analysis by both the WDOE and KCSD. Particular attention should be paid to the NO_3-N and NH_3-N comparisons.

MH:cp

REFERENCES

WDOE, Criteria for Sewage Works Design, DOE 78-5, February 1978, Revised March 1980.