The Findlay Flume and Condenser Water System

S. L. Force[1]

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In the spring of 1955 The Great Western Sugar Company acquired two beet sugar factories in Ohio—one in the City of Fremont, the other in Hancock County immediately adjacent to Findlay.

Ohio law requires industry to obtain a license to discharge wastes of any kind into the water resources of the state. Fremont's lagoon system was acceptable. Findlay's was not and a temporary permit was issued to operate one campaign using the existing waste system, with the understanding that a satisfactory system would be developed to direct all out-flows through the City Sewage Treatment Plant.

The temporary permit specified wastes generated during the 1955-56 campaign would be handled in the same manner as during the 1954 factory operation, i.e., a closed recycle system. Basically, this system was as follows:

1. Pulp press and separator water returned to the cell type diffusion battery.
2. Condenser waters recycled in a closed system through spray ponds.
3. Flume water recycled through a large settling pond.
4. Lime mud water returned to the flume water.
5. The flume pond water to be pumped at a controlled rate to the Blanchard River after campaign and only during the high river flows during the spring runoff.

This system had three principal problems:

1. The flume water pond accumulated all of the excess water used in the plant. All waters had to be contained and none could be directed to the Blanchard River until after campaign. Thus water build-up had to be carefully controlled.
2. The flume water system had no heat in its cycle and made cold weather fluming difficult.
3. The degree of pollution in the system was high, approximately 2500 ppm BOD.

Late in 1955 the Ohio Highway Department appeared with plans for a bypass highway crossing the factory site. The road and right-of-way eliminated a major part of the land on which

[1] District Superintendent, The Great Western Sugar Company, Denver, Colorado.

the flume water ponds were built. This added to the problem by severely reducing the land areas available for ponds. Under these circumstances, the development and design of a waste treatment system for this factory was instituted. After considerable time and effort, a system was developed called "The Findlay Flume and Condenser Water System," which has worked very well, and much has been learned about its operation and maintenance.

The new facility was designed and built at the Findlay, Ohio, plant of the Northern Ohio Sugar Company, a subsidiary of The Great Western Sugar Company, in the spring and summer of 1956. The design objectives were:

1. Minimum volume of water.
2. Warmer flume water.
3. Separate impounding of lime and mud.
4. Reduced BOD content of the water.
5. Rigid control of inplant water use.
6. A closed system with all final wastes directed to the city sewage treatment plant.
7. Minimum land areas were available for ponds and any plan developed had to be compatable with this physical limitation.

The Findlay factory is a non-Steffen operation. It has a dryer and the pressed pulp water is returned to the diffuser. The basic features of the Findlay system are shown on the drawings of the flow sheet (Figure 1), and general plan (Figure 2). Referring to the flow sheet, the system is outlined in steps as follows:

1. Flume water carrying beets into the factory is separated from the beets at the beet wheel and flows to the flume sewer sump pump.
2. Two flume sewer pumps, each rated at 4000 gpm at 40 ft TDH are used to pump the flume water to the grit separator.
3. The grit separator is a liquid cyclone to remove heavy solids. The solids are pumped to the sludge pond.
4. The separator overflow is divided between 3 Link-Belt CA #1512 vibrating screens to remove light solids, tops, weeds and other organic debris. These solids are hauled away for use as feed, green fertilizer or other disposal. The screens are 5 ft wide and 12 ft long and are equipped with Tyler ton cap #740 Monel wire mesh screen.
5. Screened water is then divided equally between two 63 ft 8 in diam by 12 ft high Dorr clarifiers. These units

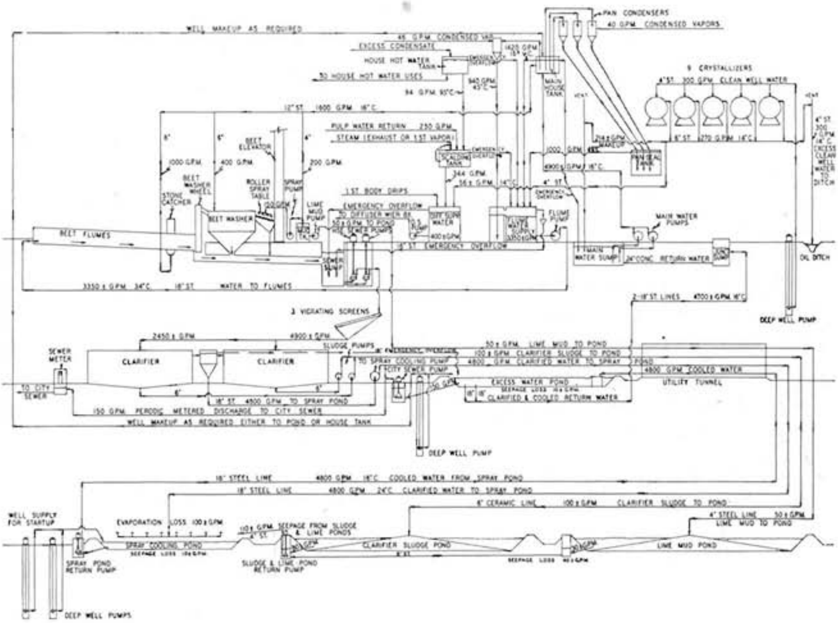

Figure 1.—Flow sheet of flume, condenser and fresh waters, Findlay, Ohio, plant, Northern Ohio Sugar Company.

work on a cross-flow principle and have a retention time of 67.5 min at 2450 gpm. Settleable solids fall to the bottom of these tanks, and are subjected to a center sludge drawoff by the sweep mechanism and pumped to the sludge pond with a 4 in manganese-lined pump.

6. The clarified flume water is pumped to the spray pond. This pump is rated at 5000 gpm at 48 ft TDH. The pipe line is 18 in OD steel pipe with Dressler couplings and is 1920 ft long.

7. The spray pond has four headers each having 30 spray nozzles spaced 15 ft apart. The nozzles are Marley #2004 one-piece design with a 1-1/16″ diam outlet orifice capable of passing 44.4 gpm at 10 psig pressure. Cooling realized ranged from 10° to 15° C depending on weather conditions.

8. The spray-cooled water is then pumped back to the main water "sump" through the excess water pond (Figure 2), which serves as a bumper tank. The spray pond return pump is rated at 5000 gpm at 40 ft TDH.

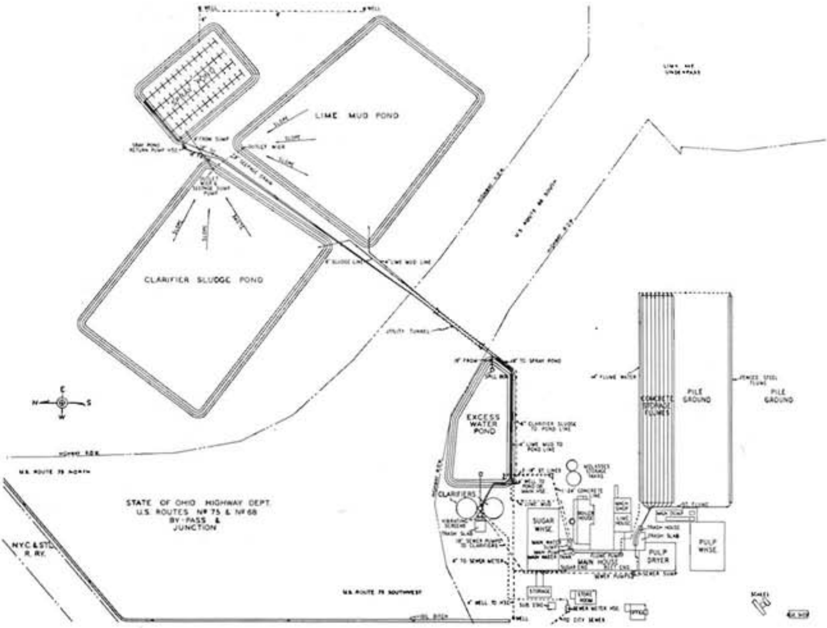

Figure 2.—General plan of water and waste system, Findlay, Ohio, plant, Northern Ohio Sugar Company.

9. From the main water sump the clarified and spray-cooled flume water is pumped to the "main water tank," which supplies all the condensers and other miscellaneous uses not requiring clean water.
10. The condenser water is collected in seal tanks and piped to the "flume water tank".
11. This condenser water is then pumped to the flumes by the 4000 gpm flume water pump to complete the closed system cycle.

None of the recycled water enters the sugar-making process. Diffuser supply make-up comes from a fresh well water circuit which serves as cooling water for crystallizers, pump jackets and other uses requiring clean, cold water. This is then directed into the process water as diffuser make-up water. Excess well and city water not required for make-up is sent to the Blanchard River. This is permissible since this excess well water does not contain any pollutants and prevents an undesirable volume build-up in the recycle system.

Water accumulating in the sludge and lime ponds is reused in the system thus eliminating a build-up of water from these sources.

In the early summer the lagoon water is pumped at a controlled rate of 150 gpm during the hours from 6:00 pm to 6:00 am to the Municipal Sewage Plant. There is a waste water disposal contract with the city with a service fee figured on the basis of pounds of BOD and suspended solids passing through the city disposal system.

As would be expected, the BOD and suspended solids are subject to wide variations. In October and early November the BOD is generally around 700 ppm. By the end of the operating season, approximately the 1st of January, the BOD approaches 2600 ppm, total solids range from 1500 to 2000 ppm, the water temperature is 1°C and the pH approximately 6.5. By mid-March the water temperature is 8°C, pH 7.7 and the BOD 700 ppm. When the final wastes are retained until June 1st, BOD's as low as 70 ppm have been obtained with water temperature approximately 16°C and a pH in the neighborhood of 7.7.

No serious odor problems have been encountered by holding the waste waters until late May. For a short period in March odors are noticeable downwind from the ponds for a distance of about 200 ft, but about two weeks later they become less noticeable. The odors emanating from the lime pond, the mud pond and the spray pond are always a great deal more pronounced than from water stored in the excess water pond. Longer retention time during warm weather reduces the discharge costs.

The total volume of water delivered to the city treatment plant varies from a low of 1,616,700 gal in 1958 to a high of 6,446,100 gal in 1959. The system is estimated to hold 9,500,000 gal.

The Findlay system originally went into operation during the 1956-57 campaign. The contract with the city called for payment of $20 per 100 lb of BOD disposed through the city system. Immediately prior to the 1961-62 campaign the contract was revised, and service charges are presently $16 per 100 lb BOD in excess of 200 ppm and $12.50 per 100 lb of suspended solids in excess of 240 ppm. Fifty per cent is then added to the bill because the factory is outside the city limits.

Table 1 shows the volumes treated and the costs for the past nine years. The 1955-56 data was included to show a comparison between the old and new systems. The treatment costs up to the 1961-62 sugar year were based on the BOD average for the preceding year. For the first year a BOD of 1500 was assumed. It is interesting to note the amount of water pumped to the treatment plant during the operating season. With proper in-plant water use and control, it is not necessary to unload the system during campaign. During the 1963-64 campaign, the

Table 1.—Nine-year costs and volumes treated, Findlay flume and condenser water system.

SLICING DATA				WASTE TREATMENT DATA					
Year	Date & time started	Date & time finished	Total tons sliced and avg./day	Date pumped to city treatment	Total gal. pumped	BOD PPM	Total lbs. BOD	Treatment costs $	Solids in suspension
1955-56	10/5/55	1/6/56	89545	2/13/56	1997840	2400	38400		20
Old system	(8:00 a.m.)	(11:30 p.m.)	(956)						
1956-57	10/8/56	12/5/56	59663	5/31/57	1965900		24574	$491.48	
New system	(9:00 a.m.)	(3:00 a.m.)	(1035)	7/31/57	156200		1952	39.06	
1957-58	10/2/57	12/27/57	107710	10/31/57	364500		4556	91.12	
	(12:30 p.m.)	(7:30 p.m.)	(1248)	12/31/57	240400		3005	61.10	
				6/31/58	333700		751	15.02	
1958-59	10/1/58	1/8/59	136349	12/31/58	1283000		2887	56.84	
	(5:00 p.m.)	(11:00 a.m.)	(1381)	1/30/59	148300		334	6.68	
				2/28/59	366800		924	18.48	
				7/31/59	3270000		7357	147.14	
				7/31/59	181300		408	8.16	
1959-60	9/24/59	1/7/60	138568	11/3/59	1498800		3340	66.80	
	(11:30 a.m.)	(2:00 p.m.)	(1527)	12/31/59	980900		2171	43.78	
1960-61	9/28/60	1/2/61	138384	10/3/60	960000		2219	44.38	
	(10:30 a.m.)	(12:30 p.m.)	(1442)	11/3/60	3372300		7588	151.76	
				12/1/60	874000		1959	39.18	
1961-62	9/30/61	12/22/61	139734	12/1/61	310700	1385	3576	88.74	545
	(12:30 p.m.)	(10:00 p.m.)	(1676)	1/1/62	502500	858	3570	282.41	2997
1962-63	9/29/62	1/17/63	175324	11/1/62	634700	1620	8505	266.64	1020
	(2:00 p.m.)	(8:00 a.m.)	(1597)	12/1/62	769800	1407	9025	260.09	933
				2/1/62	262500	2791	6107	218.91	2262
				6/18/63	766632	71	458	0.00	98
1963-64	9/26/63	1/11/64	152273	None to 7/1/64 and feel evaporation and seepage will be sufficient to make discharge to city sewage plant unnecessary.					
	(5:00 p.m.)	(11:00 p.m.)	(1420)						

water build-up and inplant water usage was so well controlled that no water was pumped to the city treatment plant. Since no serious odor problems have developed up to July 1, 1964, the water is still in the lagoons and it will probably not be necessary to discharge any wastes to the city sewage plant.

When the pond water was emptied June 18, 1963, the BOD and suspended solids were so low that treatment costs were eliminated. This system can be operated so that no water is discharged during the processing period and if the ponds are drained after the first of June, the BOD and solids content will be such that under the existing treatment contract, the cost will be eliminated.

Table 2 shows some of the information developed during the first and last part of campaign as well as the campaign averages at various points in the system. Note the suspended solids in the lime pond overflow. This reflects the fact that there was an insufficient volume for the lime mud and when freezing weather added its contribution of ice, there were practi-

Table 2.—Findlay waste water system—1963-64 campaign

		PPM BOD	PPM suspd. solids	PPM disslvd. solids	Temp.	pH
1. Water to the flumes	10-26-63	1310	600	2400	42	7.8
	12-29-63	1620	1700	2000	24	7.2
	Camp 63-64	1195	750	2292	35	7.7
2. Water to the Dorr	10-26-63	1605	1200	2800		6.9
	12-29-63	1860	1700	2800		7.1
	Camp 63-64	1461	1333	2492		7.3
3. Dorr over-flow	10-26-63	1410	1400	2400	35	7.0
	12-29-63	1840	1200	2800	22	7.2
	Camp 63-64	1370	1058	2425	28	7.3
4. Dorr under-flow	10-26-63	1540	4600	2800		7.0
	12-29-63	1890	4500	2800		7.2
	Camp 63-64	1525	4767	2633		7.3
5. Mud pond over-flow	10-26-63	1905	1000	2600		7.3
	12-29-63	1490	800	2800		7.3
	Camp 63-64	1455	717	2483		7.4
6. Lime pond over-flow	10-26-63	3390	1000	4400		6.9
	12-29-63	9000	136900	9000		9.4
	Camp 63-64	4179	28160	6182		6.6
7. Lime sewer	10-26-63	5000	47200	3000		9.3
	12-29-63	10650	178400	9400		9.2
	Camp 63-64	10115	133775	5550		8.9
8. Main water tank	10-26-63	1650	600	2600		7.5
	12-29-63	1600	1000	2900		7.3
	Camp 63-64	1382	833	2433	22	7.6
9. Well water	10-26-63	-------	-------	-------	15	---
	12-29-63	-------	-------	-------	15	---
	Camp 63-64	-------	-------	676	14	---

cally no solids eliminated. This was not good for the condenser leg lines and as a matter of fact, caused a shutdown to clean the low raw pan condenser leg line.

Figure 3 shows BOD build-up during the 1963-64 campaign on the main water tank and Dorr overflow water. Also shown is the build-up of suspended solids in the main water tank as well as the effluent from the lime pond and the BOD drop during the first part of campaign. All previous data generated at both Ohio factories during each campaign since 1956 shows this same basic trend. This is no doubt due to the fact that slicing is started with the ponds relatively empty and the reduction is accomplished by dilution. Insufficient lime pond settling volume is apparent from December 9 to the end of

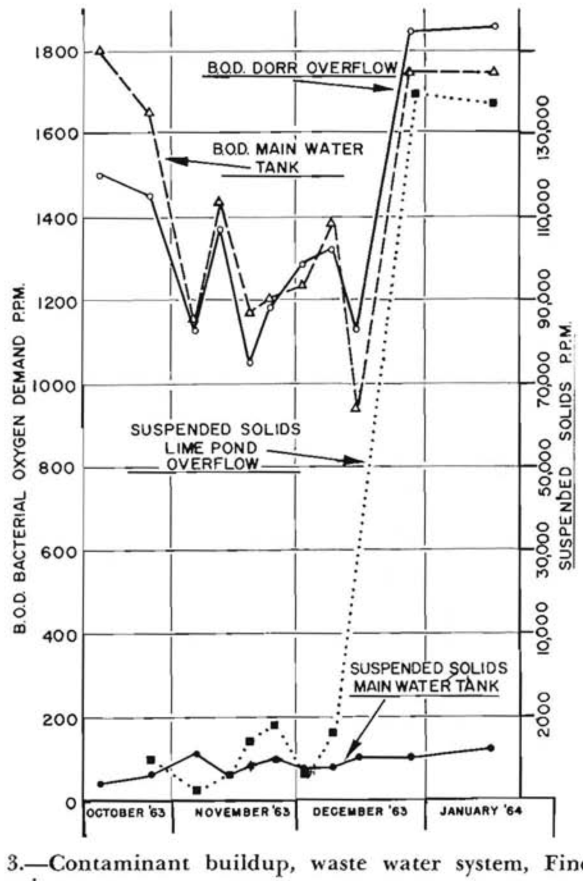

Figure 3.—Contaminant buildup, waste water system, Findlay, Ohio, 1963-64 campaign.

campaign. The spectacular rise in the suspended solids in the lime pond overflow indicates there were very few solids removed. Another interesting observation is that the BOD seems to level out at the end of campaign at a point lower than would be expected.

Figure 4 is a water balance. The flows were obtained by pump curves, amperage readings and pressure. A BOD balance can be made based on this table, using the campaign average BOD's shown on Table 2. A BOD balance has not been included in this report as it does not balance as well as was hoped. Figure 4 did show there was not a significant drop in total pounds of BOD's across the spray pond which averagely reduces the pond water temperature 21°F.

Dike areas are as follows:

	Acres
1. Excess Water Pond	1.11
2. Dorr Sludge Pond	5.80
3. Lime Settling Pond	5.40
4. Spray Pond	1.36

The Fremont water recycle system is based on a closed circuit flume system with the condenser water returned to the river.

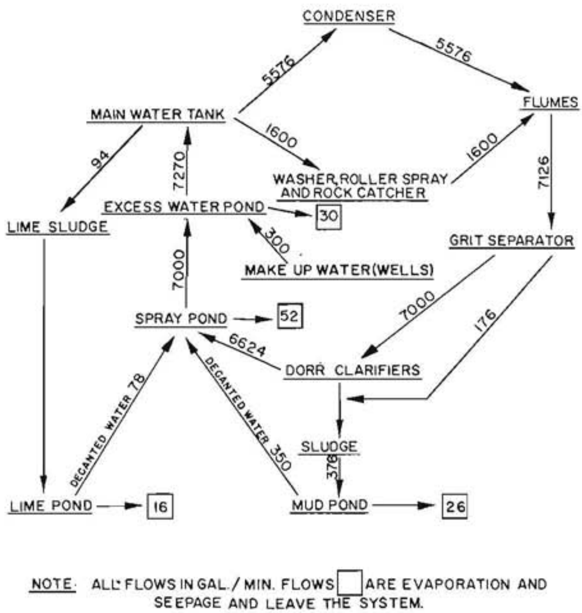

Figure 4.—Diagram of the flume and condenser water system, Findlay, Ohio, 1963.

Table 3.—Average figures on Fremont waste water in the lagoons for the campaign and the discharge period.

CAMPAIGN INDUSTRIAL WASTE DATA Freemont, Ohio Lagoon - Factory Ponds					INDUSTRIAL WASTE DATA ON DISCHARGE TO RIVER Freemont, Ohio Lagoon - Factory Ponds						
Campaign	°C Temp.	pH	BOD	Total solids	Date discharge completed	°C Temp.	pH	BOD	Total solids	Total tons BOD to river	Total discharge gallons
1955-56	—	6.3	2,460	3,631	3-5-56	3.2	6.7	1,284	—	53.78	10,080,000
1956-57	—	7.0	2,532	4,108	3-9-57	2.0	7.5	630	—	5.86	2,232,000
1957-58	8.1	7.2	1,558	3,139	3-7-58	4.0	6.6	1,506	3,744	11.29	1,800,000
1958-59	11.0	6.8	2,228	4,172	Year of big flood. No controlled discharge. Lagoons submerged with river water.						
1959-60	9.3	6.5	2,288	—	3-12-60	1.0	7.5	835	2,650	6.01	1,728,000
1960-61	18.2	7.1	1,847	—	3-24-61	7.0	—	1,756	—	13.73	1,878,000
1961-62	28.2	7.0	1,780	—	3-15-62	5.2	—	1,602	—	18.08	2,706,000*
1962-63	7.0	7.0	1,903*	—	3-15-63*	4.3	6.5	922	2,023	—	—
1963-64	8.6	6.2	2,089	—	3-12-64	2.5	7.1	2,857	3,050	17.07	1,440,000

* B.O.D. samples heavily diluted with water pumped into lagoon from flooded area.

Table 4.—BOD, suspended solids, dissolved solids, temperature and pH on the spray pond, Findlay, Ohio, Intercampaign.

Date	BOD	PPH S.S. solids	PPH Dis. solids	Temp. °C.	pH	Comments
Feb. 3	900	220	1,980	....	10.3	1" Ice sample difficult. Condition abnormal due to lime kiln emptied, slacked and pumped to spray pond via lime pond.
Feb. 12	816	......	2,300	0	6.3	Radical pH change in short period at these temperatures indicates some type of fast action. Pond frozen, sampling difficult.
Feb. 26	960	170	2,640	0	6.3	Water most difficult to filter indicating very fine material in suspension.. Water still coming to spray pond from lime pond. Increase in dissolved solids indicates desirability of removing lime pond water from this system.
Apr. 8	590	65	1,790	8	7.7	Water decolorized but still turbid & difficult to filter. Note again pH change. Spray pond, which relieves water from lime & mud ponds, now has very noticeable odor. Excess pond has no odor.
Apr. 22	355	120	1,335	15	7.7	Water has green color. Turbid & difficult to filter. Heavy rains & strong winds. Odor distinctly greater than excess water pond.
May 6	393	231	1,014	20	7.7	Rain & heavy rains. Turbidity & color increased over previous sample. Very slight odor.
May 19	372	240	960	18	7.8	First B coli determinations run on this water. A 1 ml. sample diluted to 1 liter gave a 500+ (TNC) with no sanitary sewage in the ponds. We were surprised to obtain a "too numerous to count" determination at this dilution.
Lime pond	1,980	480	3,740	18	8.2	
Mud pond	525	530	1,270	18	7.5	
May 27	....*	250	900	22	8.4	Waste water much easier to filter for determinations. Did take 1 hr. to obtain 25 ml. now obtained 100 ml. in 5 min. Ponds now have considerable green growth.
June 3	....*	137	800	18	8.3	Filterability still improved. Pond now choked with green scum-like algae growth.
June 11	380	200	1,000	22	8.0	Rapid changes in pond this week. Green color disappeared & now has yellowish cast. Swarming with millions of small rust-colored bugs identified as "Daphnia". Lime pond water now looks like green pea puree.
June 17	71	148	900'	28	8.5	Again rapid changes in pond. Color has gone back to green & bugs have disappeared. Last week's sample showed no D.O. Now again over 100% saturation.

* BOD determinations actually 42 and 38 respectively. These results were incorrect because the ponds now contain dissolved oxygen which we failed to consider.

Table 5.—Same data as in Table 4 on the excess water pond, 1964.

Date	BOD	PPM S.S. solids	PPM Dis. solids	Temp. °C	pH	Comments
Feb. 5	580	30	1,420	2	7.3	Partial ice cover. BOD reduction from end of campaign probably mainly due to rain and snow dilution.
Feb. 19	210	220	1,130	0	7.7	
Apr. 1	15	42	660	0	8.3	Completely frozen over. Heavy snow & rain. Water clear and completely decolorized. Still difficult to filter for laboratory determinations.
Apr. 15	18	5	840	12	8.5	Water decolorized but still difficult to filter.
Apr. 27	15	5	685	15	8.8	
May 19	13	5	700	18	8.2	
June 11	32	100	705	22	8.3	Green algae now growing well in this pond. D.O. now above 11 PPM. This same week green algae left the spray pond and was replaced by small rust-colored bugs identified as "Daphnia".
June 24	43	60	700	24	8.3	Algae present.

Lagoon water is discharged to the Sandusky River only during the period of high river flows in the spring. Table 3 shows average figures from data obtained on Fremont waste water in the lagoons both for the campaign and the discharge periods to the Sandusky River. This is included as a matter of interest and for comparison with the Findlay system.

Table 6.—Coliform counts on samples taken June 10, 1964, from the spray, lime and excess water ponds.

Location	Sample number	Plate count	Most probable number of coliform organisms*	Presence of escherichia coli **
Spray pond—middle	1	150.000/ml	93/100ml	present
—outlet	2	210.000/ml		
—SE	3	160,000/ml		
Lime pond	4	80.000/ml	1100/100ml	prεsent
Excess water pond				
—SE	5	19.000/ml		
—SW	6	4,400/ml	93/100ml	present

A word of explanation might be in order regarding the techniques used and the interpretation of this data. One hundred millileter samples were collected on June 10, 1964 in sterile bottles. Serial dilutions of 100. 1000, and 10,000 were made and plated for a colony count on nutrient agar. Also. 0.1, 1.0, and 10ml samples were inoculated into lactose broth. This is a method of approximating the numbers of coliform organisms based on statistical probability. It also constitutes a presumptive test for the presences of the coliform organisims. After 24 hours, samples were taken from the positive lactose broth tubes and streaked on EMB agar. After an additional 24 hours, all plates showed the presence of Escherichia coli. This test is considered a confirmation test in the standard analysis of water supplies.

The plate count shows the numbers of bacteria to be verv high in the spray pond with fewer bacteria per millileter in the lime and excess water ponds.

The most significant aspect of this analysis is the LARGE NUMBERS of coliform organisms, particularly *E. coli*. This means that this water is heavily polluted from a water sanitation viewpoint. It does not mean that these impoundments were necessarily contaminated directly with domestic sewage. Although the human colon is the primary source of the coliform organisms in nature, these organisms are not necessarily parasites but can establish themselves wherever the proper conditions of nutrients, temperature, etc. prevail. It does mean however, that these bodies of water are of a potential danger to domestic sources of drinking water if the water is not treated or disposed of in the proper way.

* Using lactose broth which is a presumptive test for the coliform group of bacteria.

** Using EMB agar which is selective for Escherichia coli.

Data by Dr. John W. McClymont, Professor of Botany and Bacteriology, Findlay College, Findlay, Ohio.

Table 4 shows BOD, suspended solids, dissolved solids, temperature and pH on the spray pond with comments from the end of campaign through June 17, 1964. Table 5 shows the same data on the excess water pond. This is the first time the ponds have been closely checked after campaign and prior to discharge. There were some surprising rapid changes: the marked increase in filterability of the waste water on May 27, which coincided with the appearance of the green algae on the spray pond; the disappearance of the green algae during the week ending June

11th in the spray pond, and the take-over of the small bugs followed one week later by the disappearance of the bugs and reappearance of the green algae. These tables generate the following questions:

1. Could the dissolved solids be chemically precipitated?
2. Could nutrients be added to lagoon water to aid the desired growths?
3. Could innoculation with a specific organism, after the temperatures become acceptable, speed up the reduction of solids or BOD?

Table 6 shows coliform counts on samples taken June 10, 1964, from the spray pond, the lime pond and the excess water ponds. These determinations, as well as the explanations, were made by Dr. John W. McClymont, Professor of Botany and Bacteriology of Findlay College, Findlay, Ohio. Dr. McClymont identified the small bugs in the spray pond as *Daphnia*.

In conclusion, this system fulfilled its design objectives. Since wastes are discharged through the city sewage treatment plant, a permit is not necessary each year to discharge wastes. This is most desirable since the costs of waste water treatment by the city have not been excessive. The following deficiencies were noted:

1. Flume water is too hot in October. This could be corrected by having two closed water systems:
   a. A closed flume water system.
   b. A closed spray pond condenser water system. When the weather gets cold, the heat in the flume system is not excessive and is desirable. At this time the separate systems could be combined.
2. Lime and mud pond effluent is undesirable. If the lime mud transport water could be reduced to the point where the lime pond overflow could be disposed of by open field irrigation, this would improve the system. Another possibility would be to use the lime pond overflow as lime mud transport water. The same procedures could be considered for the mud pond overflow, but this is not as critical as the lime pond overflow. The lime pond overflow should be eliminated from the recycle water system.

Acknowledgment

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