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SEWAGE TREATMENT PLANT EVALUATION, GEORGE AIR FORCE BASE CALIFORNIA

Albert M. Elliott

Environmental Health Laboratory
Kelly Air Force Base, Texas

August 1969

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Report

SEWAGE TREATMENT PLANT EVALUATION

George AFB CA

August 1969

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USAF Environmental Health Lab
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Sewage receives only partial secondary treatment and industrial waste with high BOD_5 is discharged untreated at George AFB CA. Recommendations to correct hydraulic deficiencies, construct an additional stabilization pond and divert industrial waste to sanitary sewer are made. Present and projected loadings to the sewage treatment plant are provided from this survey conducted in 1969.

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USAF ENVIRONMENTAL HEALTH LABORATORY (AFLC)

UNITED STATES AIR FORCE

KELLY AFB, TEXAS 78241

SEWAGE TREATMENT PLANT EVALUATION
George AFB, CA

August 1969

EHL(K) 69-25

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

SEWAGE TREATMENT PLANT EVALUATION
George AFB CA

I. INTRODUCTION

The operational activity and resident population of George AFB CA have increased considerably during the past few years. This has resulted in increased loadings on the base's sewage treatment plant. Construction of 372 new family housing units is in progress or approved, 191 additional units are being programmed. As such, a FY 70 MCP project was initiated and approved for improvements of the sewage treatment plant to accept higher flows. Except for a new laboratory building and a grit chamber the improvements are mainly hydraulic. Appendix D contains the items in the FY 70 MCP project as of August 1969.

As there were no funds available for a concept investigation to determine the adequacy of the FY 70 project as programmed and to determine possible additional items of work not covered by the project for future programming, the Regional Civil Engineer, Western Region (HQ USAF) requested that the USAF Environmental Health Laboratory (Kelly AFB) evaluate the existing sewage treatment plant against present and projected loads.

This report contains the results of a field survey of the sewage treatment plant conducted between 13-19 August 1969. Projections of hydraulic and organic loadings for both 372 and 563 additional family quarters are provided. Comments are also contained as to the adequacy of the FY 1970 MCP project currently being designed and additional improvements required.

II. SUMMARY OF RESULTS

1. Sewage and industrial waste treatment at George AFB CA does not currently conform to Executive Order 11228 and AFR 161-22 in that only partial secondary treatment is being provided for the sewage and that a large quantity of industrial waste high in Biochemical Oxygen Demand (BOD) is being discharged with no treatment. The construction of additional family quarters on base with the resultant increase in sewage flow will place an additional burden on the sewage treatment plant and further reduce its effectiveness.

2. Adequate sewage and industrial waste treatment can be provided by:

a. Completion of a FY 70 MCP project to correct hydraulic deficiencies for the main sewage treatment plant.

b. Diversion of acceptable industrial waste after oil separation to the sanitary sewer.

c. Construction of one additional waste stabilization pond 7.5 acres in size and a more efficient discharge facility for the final pond or cell.

d. Reuse of a large quantity of the water from the stabilization ponds for irrigation (or disposal by irrigation) throughout the year.

e. Practicing land disposal of liquid digested sludge.

III. DISCUSSION

A. General

1. George AFB CA is an installation of the Tactical Air Command (TAC). The primary mission is that of fighter pilot training. The base is located in the higher Mojave Desert near Victorville CA somewhat remote from a metropolitan area that could support the base's military and dependent population in terms of off-base housing. This has led to the construction of some 1200 on-base family quarters. The construction of 172 additional housing units on base is in progress and an additional 200 prototype houses have been approved by DOD. In addition to the 372 quarters under construction or approved, 172 quarters are in the initial programming stage.

2. The average annual precipitation at George AFB is 4.1 inches. The coldest month is January with a mean temperature of 45^{o}F. The warmest month is August with a mean temperature of 80^{o}F. Appendix A contains monthly climatology summaries of the base.

3. The potable water consumption at the base is highly seasonal. During the colder months (October through February) the average demand is 1.5 MGD. During the warmer months (March through September) the average demand is 5.0 MGD. Peak daily demands during these warm months have reached 7-8 MGD. During the same warm months the sewage treated has averaged 1.1 MGD. Almost 80% of the potable water consumed during the warm months is used for irrigation or other exterior uses and is not processed through the sewage treatment plant.

B. Industrial Waste and Its Treatment

1. A survey of the base revealed that only one segment of the

storm drainage system is used for the discharge of industrial waste. This segment drains the flight line and ramp area and daylights to an open ditch approximately 300 ft WSW of the sewage treatment plant. Effluent from the base's sewage stabilization ponds is discharged to the same ditch approximately 1/2 mile downstream.

2. The result of chemical analysis of this industrial waste is contained in Appendix B under Station 10. The average BOD of 6 daily composite samples was 230 mg/l. The waste as expected was high in detergents having an average MBAS of 161 mg/l. The bulk of the waste originates at 4 aircraft washracks along the flight line. Oils and grease concentration averaged 6.9 mg/l, however, this concentration is not truly representative of the oils and grease due to the method of sampling. The samples were taken at mid-water depth behind a weir installed for flow measurement in the outfall culvert. Large quantities of free floating surface oil along with masses of grease floc were noted flowing over the weir during frequent visual observations. A large quantity of solids having the appearance of oil coated grit were also deposited behind the weir. The samples as analyzed would be similar to the waste after free oil and grease separation and to some extent settleable solids removal.

3. The average daily flow pattern of the waste measured during the survey is illustrated in Figure 1. Peak flow observed was 145 gpm and the six day average flow was 78,000 GPD.

4. Executive Order 11288 and AFR 161-22 requires secondary treatment of all waste. The industrial waste at George AFB can be effectively treated in combination with domestic sewage. Prior removal of the free

oil and grease and grit solids should be provided. A single conventional free oil separator with provisions for grit removal should suffice for prior treatment. The unit should be installed near the existing outfall. Provisions for automatic diversion of storm runoff should be provided. The effluent from the unit should be discharged to the most convenient sanitary sewer of sufficient size.

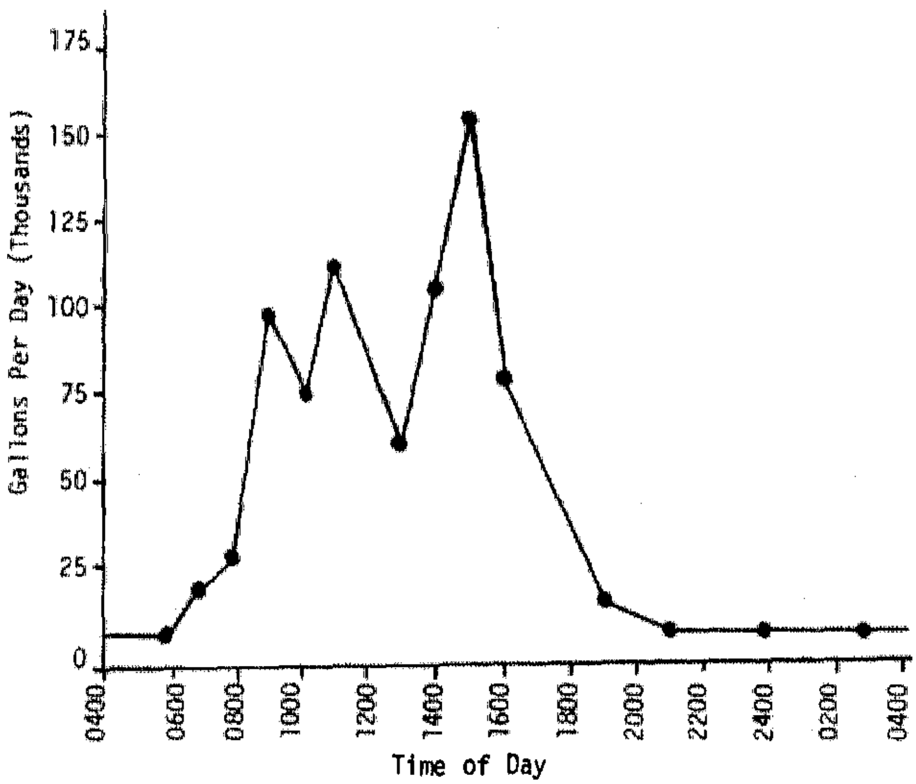

Figure 1 Industrial Waste Flow, Field Survey 13-19 Aug 69 George AFB, Calif

C. Current and Projected Sewage Flows

1. Appendix B contains sewage and industrial waste flows measured during the six day survey period. Appendix B also contains sewage flow data extracted from the sewage treatment plant's flow recorder charts for six warm months. Close agreement was found between calculated flows based upon direct depth measurements in the plant's Parshall flume during the survey and that of the plant's chart recorder.

2. The average daily sewage flow measured during the six day survey period was 0.97 MGD. Industrial waste water discharged to the storm drainage averaged 0.078 MGD. Figure 2 reflects these flows by time of day. There was good agreement between direct field measurements of flow and that of the plant's recorder at the same time. The average daily flow over six warm months during 1968 from the plant's recorder is therefore used as a base to project future flows.

3. The current average daily sewage flow is 1.12 MGD. The projected average daily sewage flow with 372 additional family quarters including 0.078 MGD of industrial waste is 1.36 MGD. The projected average daily raw sewage flow with 563 additional family quarters is 1.45 MGD. The projected flows provide an allowance of 425 GPD per family quarter in addition to the industrial waste. Figure 3 reflects the current and projected flows by time of day.

4. The hydraulic design of the plant should be based upon the expected peak day, peak flow. Twice the average day peak flow should suffice; i.e., approximately 4.0 MGD (2800 GPM) for 563 additional quarters.

FIGURE 2
AVERAGE DAILY SEWAGE AND INDUSTRIAL WASTE FLOWS

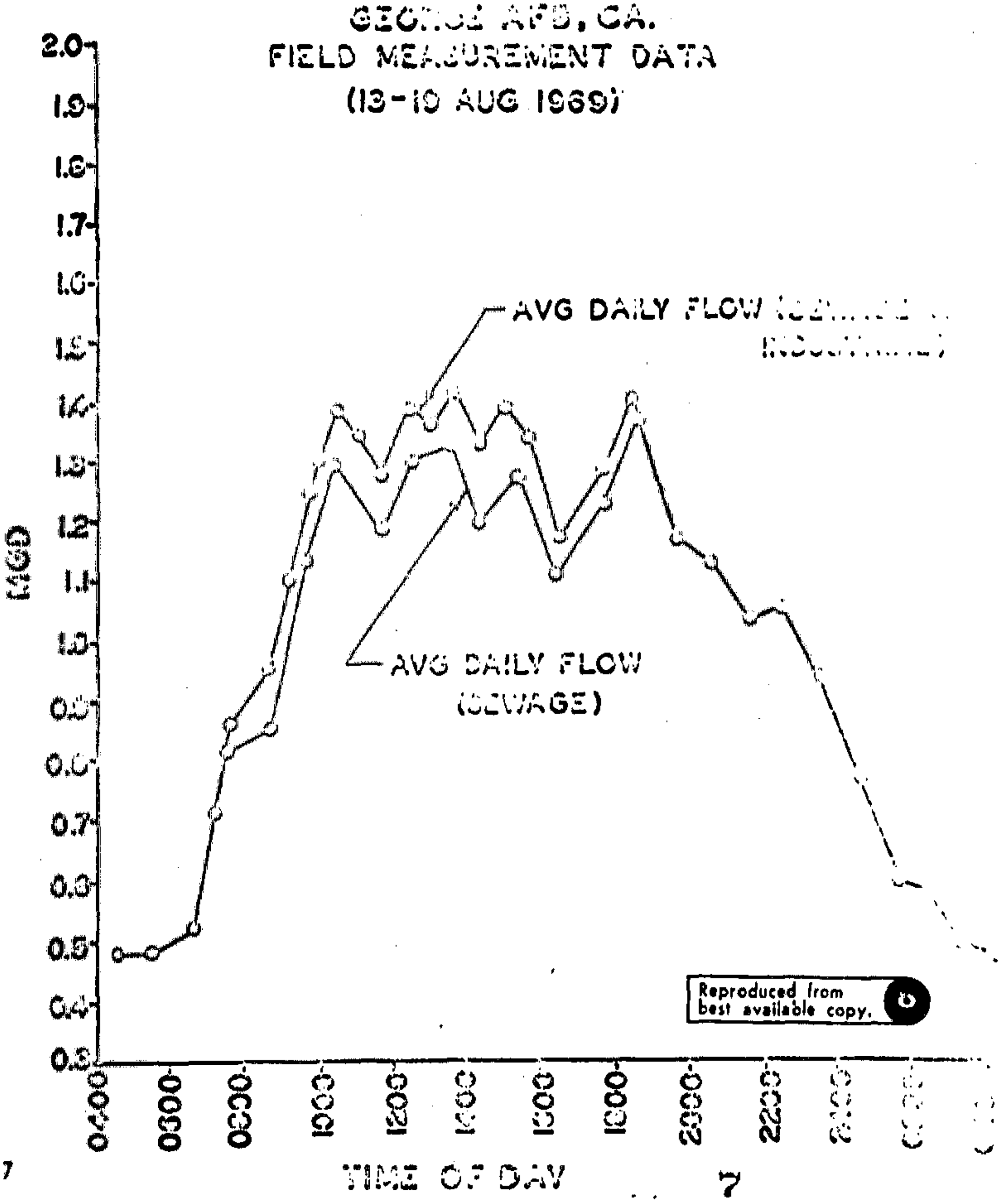

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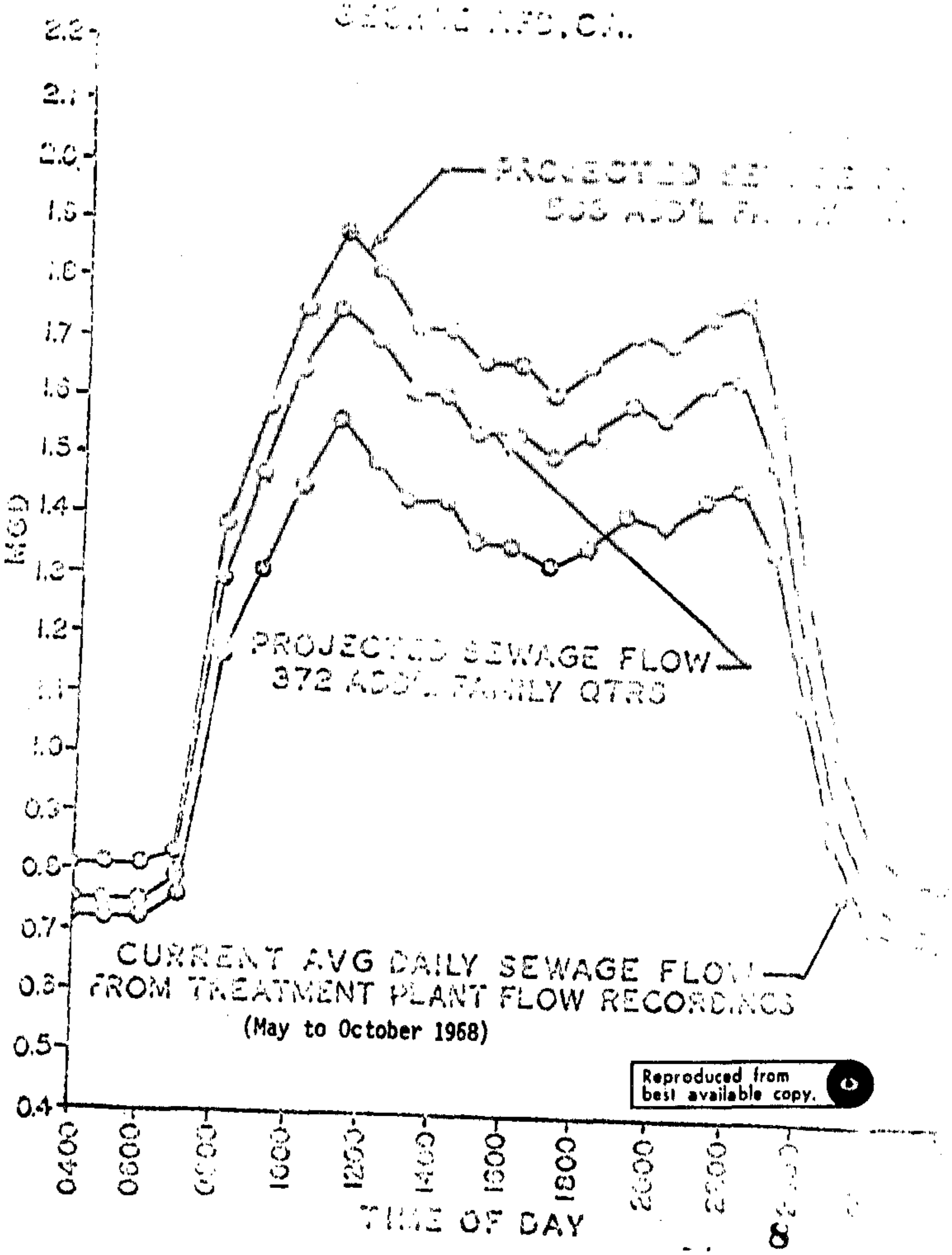
FIGURE 3

CURRENT AND PROJECTED SEWAGE FLOW



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D. Sewage Treatment Plant Projected Biochemical Oxygen Demand (BOD) and Suspended Solids (SS) Loadings

1. The two most commonly used parameters in the design of sewage treatment plants are BOD and SS in conjunction with the quantity of sewage. Appendix B contains chemical and physical analysis results performed during the survey.

2. The average BOD concentration of the raw sewage was 201 mg/l during the survey period and the average SS concentration was 151 mg/l. The BOD of the industrial waste was slightly higher (230 mg/l) than the sewage, however, its SS was only 27 mg/l. As the industrial waste flow represented only 8 per cent of the total sewage flow it is considered to have the same characteristics of the raw sewage provided prior treatment consisting of free oil removal is provided.

3. Due to lack of laboratory facilities, no BOD or SS determinations are being accomplished by plant operators, hence, not available for comparison with the survey data. The BOD and SS concentrations found during the survey, therefore, are used to project these loadings on the sewage treatment plant with the additional quarters. Table 1 lists the current and projected BOD, SS, and hydraulic loadings on the sewage treatment plant. The projections assume the BOD and SS concentrations remain constant with increased flows. Design and sizing of individual treatment processes for biological treatment are normally based on average daily flows.

TABLE 1
SEWAGE TREATMENT PLANT CURRENT AND PROJECTED BOD AND SS LOADINGS

	Current		Projected	
	Survey (6 Day Avg)	Plant Records (6 month Avg)	372 Addt'l Qtrs	563 Addt'l Qtrs
Hydraulic (MGD)	0.97	1.12	1.36	1.45
BOD				
mg/l	201	201	201	201
lbs/day	1622	1874	2270	2420
Suspended Solids				
mg/l	156	156	156	156
lbs/day	1262	1460	1795	1927

E. Current and Projected Unit Treatment Process Loadings and Efficiencies

1. Excluding separate sludge digestion and stabilization ponds which are discussed elsewhere, the main sewage treatment plant at George AFB involves the following processes in the order listed:

a. Comminutors (cutting bar screens).

b. Primary sedimentation.

c. First stage high rate trickling filters with recirculation through the primary clarifiers.

d. Second stage high rate trickling filter with recirculation through the final clarifier.

e. Final sedimentation.

2. Biochemical Oxygen Demand (BOD) Loadings and Removal Efficiencies:

a. BOD loadings and removal efficiencies of each of the above listed unit processes and the stabilization ponds found during the field survey are summarized in Table 2. There is good agreement between the efficiencies found for the main plant in the field survey and those calculated using National Research Council (NRC) equations based on a study of military installations. (See Appendix C for calculations and comparisons.) Tables 3 and 4 contain the projected BOD loadings and removal efficiencies of the units for 372 and 563 additional family quarters respectively. The projections assume the current FY 70 MCP project will correct hydraulic (pumping and piping) deficiencies except the lift pump to the second stage trickling filter. Replacement of this pump will have little effect on the plant's efficiency in that both the filter and the final clarifier will be hydraulically overloaded during peak daily flows impairing their effectiveness.

b. The overall BOD removal efficiency of the main sewage treatment plant is expected to decrease from a current 81 per cent to about 78 per cent with the additional quarters. In terms of total pounds of BOD in the plant effluent, this represents an increase from a current 306 lbs/day to 497 and 561 lbs/day with each increment of family quarters. This is a significant additional loading on the stabilization ponds following the main treatment plant.

3. Suspended Solids (SS) Loadings and Removal Efficiencies.

a. The SS loadings and removal efficiencies of each of the listed processes and stabilization ponds found during the field survey are summarized in Table 5. Tables 6 and 7 contain the projected SS removal efficiencies of the units for 372 and 563 additional family quarters respectively. The same assumptions are made as for BOD loadings.

b. The overall SS removal efficiency of the main sewage treatment plant is expected to decrease from a current 85 per cent to about 82 per cent with the additional quarters. In terms of total pounds of SS in the plant effluent this represents an increase from a current 194 lbs/day to 273 and 335 lbs/day with each increment of family quarters.

4. In addition to correcting hydraulic deficiencies for the main plant, the FY 70 MCP project provides for the installation of a grit chamber at the head of the plant prior to the comminutors. Operating problems have been experienced by plant personnel due to grit deposition in the digesters. Removal of the grit will also prolong pump life by reducing the grits

abrasive action. The new grit chamber will alleviate the grit problem.

5. The hydraulic capacity of each of the listed unit processes has been checked to insure they are within the projected hydraulic loadings as indicated in Tables 3, 4, 6 and 7. Appendix C contains a supplementary discussion of the listed unit processes of the main plant and other items of equipment which are of more concern in the plants operations and maintenance.

13

Table 2

BOD LOADINGS AND REMOVALS
Field Survey Data
(13-19 Aug 1969)

Unit(s)	Flow to Unit MGD	BOD Applied lbs/day	Applied BOD Removed %	BOD Removed as % of Raw Sewage BOD	Cumulative % BOD Removed Based on Raw Sewage BOD and % Remaining in Effluent Past Unit
Comminutor	0.97	1622	0	0	0
Primary Clarifiers	1.62[1]	2051[1]	50	63	37
(55' Clarifier)	1.30	1474	42	38	
(44' Clarifier)	.32	577	72	25	
1st Stage Trickling Flt.	1.62[1]	1017[1]	26	16	73
(60' Filter)	1.30	857	25	13	
(44' Filter)	.32	160	32	3	
2nd Stage Process	0.86[2]	378[2]	33	7	81
(44' Filter)	0.86	378	15	3	
(44' Final Clarifier)	0.86	321	21	4	
Stabilization Ponds	0.97	306	21(increase)[3]	4(increase)[3]	77
(Irrigation Golf Course)	0.26	148	100	9	
(Evaporation)	0.06	0	0	0	
Final Discharge	0.65[4]	369	0	0	77

NOTES: (1) Includes recirculation from 1st stage filters and sludge from final clarifier.
(2) 0.11 MGD and 51 lbs/day bypassed second stage process.
(3) BOD concentration increased from 38 mg/l in influent to pond to 68 mg/l in effluent due to algae carry-over.
(4) Indicates average daily discharge. Actual discharge from pond occurs about 5 days per week. No discharge 2 days per week.

14

Table 3

BOD LOADINGS AND REMOVALS
372 Additional Family Quarters

Unit(s)	Flow to Unit MGD	BOD Applied lbs/day	Applied BOD Removed %	BOD Removed as % of Raw Sewage BOD	Cumulative % BOD Removed Based on Raw Sewage BOD and % Remaining in Effluent Past Unit
Comminutor	1.36	2270	0	0	0
Primary Clarifiers	2.72[1]	3088[1]			35
(55' Clarifier)	1.82	2059	52	70	
(44' Clarifier)	0.90	1029	52	47	
			52	23	
1st Stage Trickling Flt	2.72[1]	1490[1]			70
(60' Filter)	1.82	994	8	5	
(44' Filter)	0.90	497	8	3	
			8	2	
2nd Stage Process	1.18[2]	602[2]			78
(44' Filter)	1.18	602	32	9	
(44' Final Clarifier)	1.18	543	10	3	
			25	6	
Stabilization Ponds	1.36	497			

NOTES: (1) Includes recirculation from 1st stage filters and sludge from final clarifier.
(2) 0.19 MGD and 86 lbs/day of BOD will bypass second stage process.

15

Table 4

BOD LOADINGS AND REMOVALS
563 Additional Family Quarters

Unit(s)	Flow to Unit MGD	BOD Applied lbs/day	Applied BOD Removed %	BOD Removed as % of Raw Sewage BOD	Cumulative % BOD Removed Based on Raw Sewage BOD and % Remaining in Effluent Past Unit
Comminutor	1.45	2420	0	0	0
Primary Clarifiers	2.90 (1)	3292 (1)	52	70	34
(55' Clarifier)	1.94	2195	52	47	
(44' Clarifier)	0.96	1097	52	23	
1st Stage Trickling Flt.	2.90 (1)	1597 (1)	5	3	69
(60' Filter)	1.94	1065	5	2	
(44' Filter)	0.96	532	5	1	
2nd Stage Process	1.19 (2)	627 (2)	32	9	78
(44' Filter)	1.19	627	11	3	
(44' Final Clarifier)	1.19	555	24	6	
Stabilization Ponds	1.45	560			

NOTES: (1) Includes recirculation from 1st stage filters and sludge from final clarifier.
(2) 0.16 MGD and 135 lbs/day of BOD will bypass second stage process.

16

Table 5

SUSPENDED SOLIDS (SS) LOADINGS AND REMOVALS
Field Survey Data
(13-19 Aug 1969)

Unit(s)	Flow to Unit MGD	SS Applied lbs/day	Applied SS Removed %	SS Removed as % of Raw Sewage SS	Cumulative % SS Removed Based on Raw Sewage SS and % Remaining in Effluent Past Unit
Comminutor	0.97	1262	0	0	0
Primary Clarifiers	1.62(1)	1738(1)	45	62	25
(55' Clarifier)	(1.30)	(1258)	(37)	(38)	
(44' Clarifier)	(0.32)	(480)	(65)	(24)	
1st Stage Trickling Flt.	1.62	959	24	18	66
(60' Filter)	(1.30)	(791)	(25)	(15)	
(44' Filter)	(0.32)	(168)	(22)	(3)	
2nd Stage Process	0.86(2)	378(2)	62	19	85
(44' Filter)	(0.86)	(378)	(15)	(5)	
(44' Final Clarifier)	(0.86)	(321)	(55)	(14)	
Stabilization Ponds	0.97	194	47(increase)(3)	14(increase)(3)	71
(Irrigation Golf Course)	0.26	(148)	(100)	(12)	
(Evaporation)	0.06	(0)	(0)	(0)	
Final Discharge	0.65(4)	368	0	0	71

NOTES:
(1) Includes recirculation from 1st stage filters and sludge from final clarifier.
(2) 0.11 MGD and 46 lbs/day of SS bypassed second stage process.
(3) SS concentration increased from 22 mg/l in influent to pond to 69 mg/l in effluent due to algae carry-over.
(4) Indicates average daily discharge. Actual discharge from pond occurs about 5 days per week. No discharge 2 days per week.

17

Table 6

SUSPENDED SOLIDS (SS) LOADINGS AND REMOVALS
372 Additional Family Quarters

Unit(s)	Flow to Unit MGD	SS Applied lbs/day	Applied SS Removed %	SS Removed as % of Raw Sewage SS	Cumulative % SS Removed Based on Raw Sewage SS and % Remaining in Effluent Past Unit
Comminutor	1.36	1795	0	0	0
Primary Clarifiers	2.72(1)	2624(1)	40	59	13
(55' Clarifier)	1.82	1764	38	37	
(44' Clarifier)	0.90	860	45	22	
1st Stage Trickling Flt	2.72	1572	23	20	67
(60' Filter)	1.82	1100	24	15	
(44' Filter)	0.90	472	21	5	
2nd Stage Process	1.18(2)	528(2)	57	15	82
(44' Filter)	1.18	528	15	4	
(44' Final Clarifier)	1.18	430	48	11	
Stabilization Ponds	1.36	273			

18

NOTES: (1) Includes recirculation from 1st stage filters and sludge from final clarifier.
(2) 0.18 MGD and 79 lbs/day of SS will bypass second stage process.

Table 7

SUSPENDED SOLIDS (SS) LOADINGS AND REMOVALS
563 Additional Family Quarters

Unit(s)	Flow to Unit MGD	SS Applied lbs/day	Applied SS Removed %	SS Removed as % of Raw Sewage SS	Cumulative % SS Removed Based on Raw Sewage SS and % Remaining in Effluent Past Unit
Comminutor	1.45	1927	0	0	0
Primary Clarifiers	2.90(1)	2790(2)	40	58	13
(55' Clarifier)	1.94	1875	37	36	
(44' Clarifier)	0.96	915	45	22	
1st Stage Trickling Flt	2.90(1)	1685(1)	23	20	66
(60' Filter)	1.94	1180	25	15	
(44' Filter)	0.96	505	21	5	
2nd Stage Process	1.19(2)	528(2)	59	16	82
(44' Filter)	1.19	528	17	5	
(44' Final Clarifier)	1.19	436	50	11	
Stabilization Ponds	1.45	335			

NOTES: (1) Includes recirculation from 1st stage filters and sewage from final clarifier.
(2) 0.26 MGD and 115 lbs/day of SS will bypass second stage process.

F. Stabilization Ponds and Reuse of Treated Waste Water

1. The existing stabilization ponds are well located on base in regards to prevailing winds and additional adjacent area is available for expansion. Their total surface area is 9 acres and originally consisted of three separate ponds with interconnections and influent and effluent header systems such that they could be operated in series or parallel. They are operated at a depth of about three feet. About one half of two of the ponds has been diked off and water from these two areas is pumped to the golf course after chlorination for irrigation. Figure 4 is a diagram of the ponds as they currently exist and indicates the area where an additional pond is suggested.

2. An estimated 0.26 MGD of treated sewage from the diked off sections is used for irrigation of the golf course during the grass growing season. The remaining pond areas are operated in series, first through the larger remaining pond and then to the two smaller as indicated in Figure 4. An estimated 1/4 in/day or 60,000 gal/day of water evaporates from the ponds. As the average annual precipitation at George AFB is only 4.1 in/year and so long as pond embankments are maintained in good repair, precipitation contribution to the ponds contents is insignificant. During the periods the influent to the ponds is diverted to the section for irrigation (about 2 days each week) there is no effluent discharged off base from the ponds.

3. Based on the survey data the BOD concentration in the influent to the ponds was 38 mg/l and increased to 68 mg/l in the effluent. Suspended solids also increased from 22 mg/l to 69 mg/l. These increases

are due to carry-over of algae suspended in the effluent from the ponds. The importance of these increased concentrations is somewhat reduced as the total volume of water in the effluent is reduced by the amount used for irrigation and that lost in evaporation. Considering the reduced volume of water in the final effluent the total pounds of BOD increased from 306 lbs/day in the influent to only 368 lbs/day in the effluent. Regardless of this overall increase in BOD, a prime function of the ponds is the reduction of fecal coliform and some pathogenic organisms due to an unfavorable environment in the ponds. Considerable reduction in the algae carry-over can be effected by a properly designed effluent structure such that the effluent can be taken at depths selected to contain the least algae and to reduce the velocity of approach. The existing 2 foot long overflow weir is not sufficient.

4. During the survey period the ponds were receiving an average of 306 lbs/day (34 lbs/acre-day) of BOD. With the higher BOD loadings on the main treatment plant and lowered removal efficiency of the main plant with the additional quarters the ponds will receive approximately 500 lbs/day (55 lbs/acre-day) and 560 lbs/day (62 lbs/acre-day) with 372 and 562 additional family quarters respectively. Detention times will decrease from the current 9 days to 6.5 and 6 days.

5. Design procedures for stabilization ponds are at best not precise. Involved at one and the same time are sedimentation, oxidation, and digestion, gas exchange and photosynthesis, mechanical aeration and evaporation and seepage. Chapter 3, AFM 88-11 states that oxidation ponds used for secondary treatment will be sized for a detention time of not less

than 30 days and for an organic loading that does not exceed 50 lbs/day of BOD per acre. A more realistic design criteria is that promulgated by the Texas State Department of Health where climatic conditions are somewhat similar to those at George AFB. The Texas criteria states:

> "The basic design for the organic loading of wastes entering stabilization ponds shall not exceed 35 pounds of BOD per acre per day based on the total surface area of ponds or cells. Where stabilization ponds are proposed to be operated in series, the loading on the initial pond or cell shall not exceed 75 pounds per acre per day."

As the waste entering the stabilization ponds will have received partial secondary treatment and due to the abundant sunshine and relatively warm temperatures that exist at George AFB a detention time of 30 days is unrealistic.

6. Using the Texas criteria, one additional pond of 7.5 acres would suffice for the projected loadings on the ponds without further modifications to the main treatment plant other than those included on the current FY 70 MCP project. Figure 4 shows the suggested location of the additional pond which will allow maximum use of existing piping and possibly a minimum of earth work.

7. The use of the treated waste water from the ponds for irrigation of the base golf course is an excellent example of reclaiming waste water. In effect this not only results in removal of the waste but an economical savings can be shown at George AFB by the reduction in potable water requirements currently used for irrigation. Potable water is currently pumped

from wells in the Mojave River Valley several miles distance from the base and requires a several hundred foot lift resulting in exceedingly high pumping cost. Additional use of the water for irrigation should be investigated by base personnel. Appendix E contains an excerpt from the California Administrative Code for the safe direct use of reclaimed waste water for irrigation and recreational impoundments. The standards contained in the code should serve as guidelines in the reuse of waste water at George AFB.

9. The existing ponds require maintenance, particularly on the south ends, to direct storm water around the ponds and otherwise protect the pond embankments.

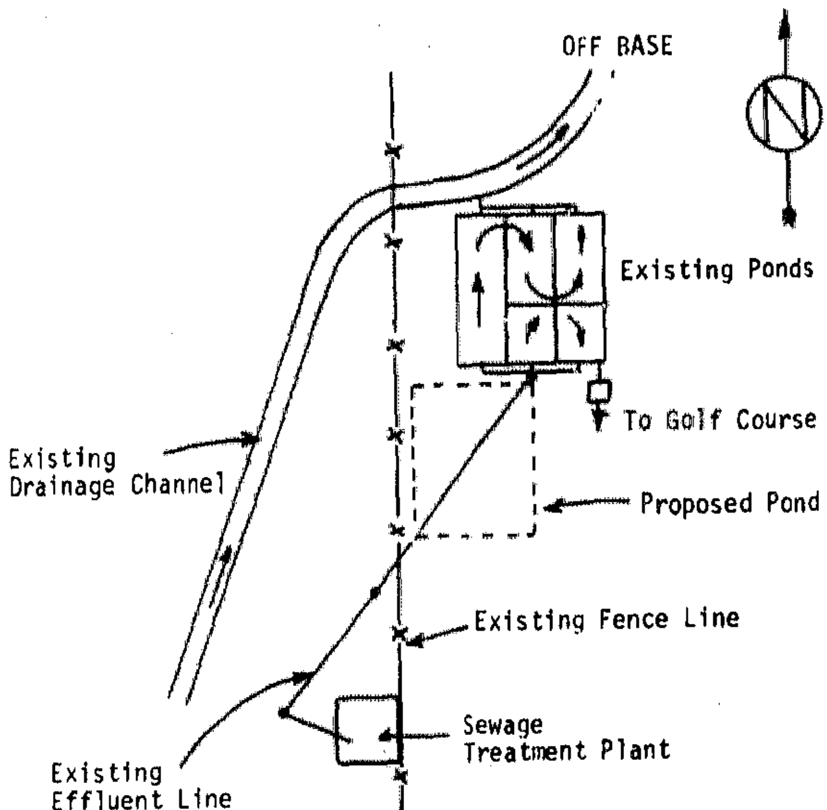


Figure 4 Existing and Proposed Stabilization Ponds George AFB, CA

G. Sludge Digestion and Disposal

1. Sludge Digestion:

a. Sludge digestion takes place in two separate digestion units: (1) the bottom compartment of the clarigester, and (2) a separate digester. The clarigester design is somewhat based on the Imhoff tank principal. Both digesters are heated to approximately 90°F and mechanical mixing is provided. Sludge from the final clarifier flows by gravity to the raw sewage lift station and then to the primary clarifiers. Sludge from the large (55') primary clarifier is currently pumped for 30 minutes each 2 hours to the digestion compartment of the clarigester. The pumps capacity is approximately 35 GPM. Sludge settled in the clarifier compartment of the clarigester is deposited directly (like an Imhoff tank) to its digester. Partially digested sludge from the clarigester is pumped for 30 minutes each day to the separate digester where further digestion takes place.

b. The current and projected loadings on the digesters and expected detention times for digestion and storage of the sludge is summarized in Table 8. Calculations are contained in Appendix C. The projections for the additional quarters indicate that the detention time for sludge digestion and volatile solids loading will be within design requirements to provide a well digested sludge. Final storage capacity and storage time for digested sludge, however, will be somewhat limited. This lack of storage capacity should prove to be of little problem with frequent withdrawal of digested sludge for final disposal.

c. The field survey data indicate that an excessive amount of sludge was being pumped from the large primary clarifier to the digester

Table 8

CURRENT AND PROJECTED DIGESTER LOADINGS AND SLUDGE DETENTION

	Volatile Raw Sludge Solids		Sludge Volume		Sludge Detention[3]	
	lbs/day Total	lbs/day/ 1000 ft^3 digester space	Raw ft^3/day	Digested ft^3/day	Digestion Days	Storage Days
Current						
Survey Data[1]	513	28.0	500	163	55	28
Improved[2] Concentration	513	28.0	315	135	84	34
Projected[2]						
372 Qtrs	684	37.2	421	181	61	25
563 Qtrs	718	39.0	442	189	58	24

NOTES:
(1) Based upon actual field survey data of 2% total solids in raw sludge pumped to clarigester @ 65% volatile solids and 5% total solids in digested sludge.
(2) Based upon 4% total solids in raw sludge @ 65% volatile and 6% total solids in digested sludge.
(3) Digestion period based upon volume of the digestion compartment of the clarigester and upper compartment of separate digester while storage period based upon volume of lower compartment of separate digester.

compartment of the clarigester. The concentration of this sludge was only 2 per cent. The settleable solids concentration of the raw sewage (including secondary sludge) averaged 5.3 ml/l and the trickling filter recirculation flow through the large clarifier averaged 0.7 mg/l. Equating these values to the total flow through the large clarifier, the sludge pumped to the clarigester should be about 3,900 gal/day whereas 12,600 gal/day was actually being pumped. The smaller volume also compares with a 4 per cent solids concentration in the sludge and the per cent suspended solids removal found in the large clarifier. A reduced sludge pumping rate (both in pumping time and/or frequency) should increase the concentration of sludge solids to approximately 4 per cent and allow an increased detention time for digestion in the clarigester. As such a 4 per cent sludge concentration is used in Figure 8 in estimating the projected loadings and detention times. The plant personnel should frequently monitor both the suspended and settleable solids concentrations of the influent to the large clarifier for estimating the volume of sludge that will require pumping to the clarigester and adjust pumping rates accordingly.

d. No direct measurement could be obtained of the solids concentration of the sludge being deposited directly from the clarifier of the clarigester to its digester. Sludge withdrawn from the clarigester, however, had a solids concentration of approximately 4 per cent. Considering the more dilute sludge from the larger clarifier, mixing of the sludges in the digestion compartment, and some concentration during digestion, it is reasonable to assume the concentration of the sludge being deposited directly in the clarigester was at least 4 per cent.

26

2. Digested Sludge Removal and Disposal:

a. The existing sludge drying beds consist of eight diked sections with a total surface area of 8,680 ft^2. Currently, on a weekly average, one bed is flooded per week to a depth of 3 inches. This would indicate on an average a digested liquid sludge removal rate from the digester of 40 ft^3/day. Calculations from the field survey data indicate that 3 to 4 times that amount (see Figure 8) should be currently withdrawn from the digester. Plant personnel do not currently perform volatile solids of the raw and digested sludges to determine when the sludge is well stabilized. There is a strong possibility that a significant portion of the sludge solids is being returned to the main plant's effluent. Periodically during the survey the plant's final effluent had exceedingly high concentrations of settleable solids and the blackish appearance of digested sludge.

b. The existing sludge drying beds are so constructed that manual removal of the dried sludge is required. From Figure 8 the volume of digested sludge projected for the additional quarters will require flooding of all of the existing beds to a depth of 9 inches on a 20 day cycle. The limited storage volume for digested sludge in the digester requires that the entire storage volume of the digester also be removed at least every 24 days. Indications are that the existing beds might suffice during the warmer months; however, twice their area would be required during the cold months. To manually remove and handle the required volume of dried sludge is impractical and an unnecessary waste of manpower. Existing conditions at George AFB appear ideal for direct land disposal of the liquid digested sludge, i.e., suitable land area and an almost ideal climate.

c. Appendix E contains a technical paper relating to the land disposal of digested sludge which contains guidelines and further references for this method. A combined method of disposal using the existing drying beds to the extent practical and land disposal of remaining liquid digested sludge for its moisture content and as a soil conditioner and fertilizer should prove most beneficial for the base.

28

IV. CONCLUSIONS

1. The main sewage treatment plant at George AFB is currently removing 81 per cent of the raw sewage's BOD and 85 per cent of the suspended solids. These efficiencies are expected to drop to 78 per cent BOD removal and 82 per cent suspended solids removal with the additional quarters. Eighty five per cent BOD and suspended solids removal is considered the minimum BOD and suspended solids removal acceptable in providing secondary treatment as required by Executive Order 11288 and AFR 161-22.

2. The efficiency of BOD and suspended solids removal including both the main treatment plant and stabilization ponds is 77 per cent and 71 per cent respectively. This decrease in efficiency from that of the main treatment plant alone is due to the carry-over of algae suspended in the effluent from the stabilization ponds.

3. The current FY 70 MCP project will correct existing and projected hydraulic deficiencies. Relocation of orfices on the distributors of each trickling filter by plant personnel can increase their hydraulic capacity.

4. No treatment is provided for a large quantity of industrial waste. This waste can be adequately treated in combination with domestic sewage. Prior oil and grit separation should be provided before discharge to the most convenient sanitary sewer for treatment at the sewage treatment plant.

5. Adequate sewage and industrial waste treatment in conformance with Executive Order 11288 and AFR 161-22 to the extent of 85 per cent BOD and suspended solids removal can be provided by:

a. The construction of one additional stabilization pond of 7.5 acres. This pond should be the first to receive partially treated waste from the main plant. Improvement of the effluent structure of the final pond in series is required to reduce carry-over of algae in the final effluent.

b. The increased use of the treated waste water. This not only reduces the BOD and suspended solids discharged off base from the stabilization ponds but also decreases the quantity of potable water production that must be pumped a long distance at an exceedingly increase in elevation.

6. The current facilities for the digestion of sludge will suffice for the projected increases. Additional sludge drying beds will be required or land disposal of liquid digested sludge will be required. The soil and climate are almost ideal at George AFB for the land disposal of liquid digested sludge.

30

V. RECOMMENDATIONS

1. Continue with current FY 70 MCP project for hydraulic improvement of the main treatment plant and construction of a grit chamber and laboratory facility. Reference SPLED-MP ltr, Sewage Treatment and Disposal, FY 70 MCP, George AFB, CA, 17 Sep 1969 (See Appendix D).

2. Construct one additional waste stabilization pond of 7.5 acres. This pond or cell should be the first to receive wastes from the main treatment plant. Figure 4 contains a suggested location for this pond. The overflow structure from this pond should be constructed similar to that indicated in paragraph 3 below.

3. Construct a new overflow structure for the final pond used in series. The overflow structure should consist of a manhole or box equipped with multiple-valved pond draw off lines or an adjustable overflow device so that the liquid level of the pond can be adjusted to permit operation at depths of 2 to 5 feet. The lowest of the draw off lines to such structure should be 12 inches off the bottom to control eroding velocities and avoid pickup of bottom deposits. The overflow from the pond should be taken near, but below, the water surface to release the best effluent and insure retention of floating solids.

4. Continue the use of water from the stabilization ponds for irrigation of the golf course and extend this operation to other areas. (See Appendix E for standards.) Continued irrigation during the winter months in convenient areas as a method of waste disposal is suggested to reduce the liquid volume and total pounds of BOD and suspended solids discharged off base. Use of the water on the golf course "greens" during winter months,

however, is not recommended as some matting of suspended solids in the water may occur due to reduced decomposition in the soil of these solids from low temperatures.

5. Use existing sludge drying beds to the extent practical and practice land disposal of remaining liquid digested sludges. (See Appendix E for land disposal.)

32

Appendix A

MONTHLY CLIMATOLOGY SUMMARIES

George AFB, California

NOTE: The values contained in this summary have been obtained from 20 years of recorded data between the years of 1942-1965. It should be noted that these values are representative of average conditions and can fluctuate from the norm at any time.

JANUARY

1. TEMPERATURE: The average daily maximum temperature for January is 56.8°F with an average minimum of 33.2°F. The temperature extremes are a record high of 80°F and a low of 9°F.

2. PRECIPITATION: The amount of measurable precipitation reaches its maximum total in January with an average of 0.86 inches. January also receives the greatest amount of snow with an average of 1.7 inches; the snow falling once every two years. The greatest amount snow was 9.0 inches in a 24 hour period. The greatest amount of measurable precipitation was 2.74 inches.

3. SURFACE WINDS: The prevailing wind direction is southeasterly through southerly and accounts for 31.5% of the wind. The maximum wind gust was out of the south at 54 knots.

4. FLYING WEATHER: January will be slightly less cloudly than December. The sky condition will be clear to scattered 65.0% of the time. Conditions greater than 1000 foot ceilings and 3 miles visibility exists 98.7% of the time.

5. SEVERE WEATHER: Thunderstorms are rare during the month of January but high winds and associated turbulence as well as isolated instances of heavy rain (1.73 inches in 1963) can be expected with the numerous frontal passes during the month.

6. SUMMARY:

TEMPERATURE:

Absolute Maximum--------80.0°F	Average Maximum-------56.8°F
Absolute Minimum-------- 9.0°	Average Minimum-------33.2°F

MEAN-------45.2°F

PRECIPITATION:

Average	0.86 inches
Greatest	2.74 inches

FLYING WEATHER: (Greater than or equal to)

10,000/10	86.1%
3,000/3	96.1%
1,000/3	98.7%
1,000/1	99.3%

34

FEBRUARY

1. TEMPERATURE: The average daily maximum temperature for February is 59.8°F with an average minimum of 35.7°F. The temperature extremes are a record high of 79°F and a low of 13°F.

2. PRECIPITATION: During February there is an average of 0.59 inches of rain occurring on an average of 4 days. Snowfall averages only a trace.

3. SURFACE WINDS: The prevailing wind direction is from the South with a secondary maximum from the West (these account for 47% of all winds). Maximum winds (in excess of 30 knots) occur from the SW-W during the month.

4. FLYING WEATHER: The condition of clear to scattered clouds exist 59.4% of the time. Conditions greater than 1,000 foot ceilings and 3 miles visibility exists 99.1% of the time.

5. SEVERE WEATHER: There have been no thunderstorm occurrences recorded during February, but high winds and associated turbulence can be expected with numerous frontal passages during the month.

6. SUMMARY:

TEMPERATURE:

Absolute Maximum	79°F
Mean Daily Maximum	59.8
Mean	47.9
Mean Daily Minimum	35.7
Absolute Minimum	18

PRECIPITATION:

Average/Month	0.59 inches
Greatest/Month	1.91
Average No of days with measurable precip	4

FLYING WEATHER:

10,000/10	84.6%
3,000/3	96.3
1,000/3	99.1
1,000/1	99.7

35

MARCH

1. TEMPERATURE: The average daily maximum for March is 64.0°F with an average minimum of 38.7°F. The temperature extremes are a record high of 85°F and a low of 24°F.

2. PRECIPITATION: During March there is an average of 0.50 inches of rain occurring on an average of 3 days. Snow is infrequent, occuring an average of once every three years.

3. SURFACE WINDS: The prevailing wind direction is from the South with a secondary maximum from the West (these account for 56% of all the winds). One of the strongest gusts recorded was 62 knots from the SSE in 1954. Maximum winds (in excess of 30 knots) occur from the S-W during the month.

4. FLYING WEATHER: The condition of ceilings greater than 10,000 feet and visibility greater than 10 miles exists 84.9% of the time. Conditions greater than 1,000 foot ceilings and 3 miles visibility exists 99.1% of the time.

5. SEVERE WEATHER: The most severe weather to be encountered will be high winds (average peak gusts of 42 knots) associated with frontal passages during the month.

6. SUMMARY:

TEMPERATURE:

Absolute Maximum	85°F
Mean Daily Maximum	64.0
Mean	51.6
Mean Daily Minimum	38.7
Absolute Minimum	24.0

PRECIPITATION:

Average/Month	0.50 inches
Greatest/Month	1.46
Average No. of days with measurable precip	3 days

FLYING WEATHER: (Greater than or equal to)

10,000/10	84.9%
3,000/3	97.1
1,000/3	99.1
1,000/1	99.5

APRIL

1. TEMPERATURE: Average daily maximum during April is a 72°F while the average minimum is a 44°F. Records show that temperature extremes are a record high of 94°F and a low of 31°F. During the month one day with freezing temperatures may be expected.

2. PRECIPITATION: During the month of April an average of 0.26 inches of precipitation can be expected with 2 days of measurable precipitation. Snow is a rare occurance with an average snowfall of 0.1 inches lasting only a few hours.

3. SURFACE WINDS: The prevailing wind directions during April is S through W. Southerly winds (SSE-SSW) occur 33.3% of the time, while a westerly wind (SW-WNW) occurs 37.1%. During April an effective crosswind of 20 knots or greater may be expected 3.3% of the time. 84.9% of the April winds are less than 21 knots.

4. FLYING WEATHER: The predominate sky coverage is a clear to scattered condition with clear skies prevailing 45% of the time. A broken to overcast condition can be 28.5% of the time. Conditions greater than 1000/3 (VFR) occurs 99.6% of the time, while 90.4% of all ceilings are in excess of 10,000 ft.

5. SEVERE WEATHER: Although severe weather does occur at George these occurences are infrequent. Thunderstorms have been recorded during the month but these occurences are extremely rare. The most common severe weather occurance is high winds and usually occurs with a frontal passage.

6. SUMMARY:

TEMPERATURE:

Absolute Maximum	94°F
Mean Daily Maximum	72
Mean Daily Minimum	44
Absolute Minimum	31

PRECIPITATION:

Average Monthly Precip	0.26 inches
Average No. of days w/measurable precip	2 days

FLYING WEATHER

$\geq$5000/5	93.8%
$\geq$1000/3	99.6%
$<$1000/1	0.2
$<$ 200/½	0.1

MAY

1. TEMPERATURE: The average daily maximum during Ma; , a 79°F while the average minimum is a 50°F. Records show that temperature extremes are a record high of 100°F and a low of 36°F. There are no days during the month when temperatures will drop below freezing.

2. PRECIPITATION: During the month of May an average of 0.08 inches of precipitation can be expected with 0.5 days of measurable precipitation. Snow is a very rare occurance with only trace being recorded.

3. SURFACE WINDS: The prevailing wind direction during May is S through W. Southerly winds (SSE-SSW) occurs 35.0% of the time, while a Westerly wind (SW-WNW)occurs 37.7%. During May an effective crosswind of 20 knots or greater may be expected 2.5% of the time. 89.5% of the May winds are less than 21 knots.

4. FLYING WEATHER: The predominant sky coverage is a clear to scattered condition with clear skies prevailing 55% of the time. A broken to overcast condition can be expected 18.5% of the time. Conditions greater than 1000/3 (VFR) occurs 99.9% of the time while 96.2% of all celings are in excess of 10,000 ft.

5. SEVERE WEATHER: Severe weather does occur during May but these occurences are infrequent. Though thunderstorms have been recorded during the month these occurences are rare. The most common severe weather occurance is high winds and ususally occurs with a frontal passage.

6. SUMMARY:

TEMPERATURE:	
Absolute Maximum	100°F
Mean DAily Maximum	79
Mean Daily Minimum	50
Absolute Minimum	31
Precipitation:	
Average Monthly Precip	0.08 inches
Average No. of days with Measurable Precip	0.5 days
FLYING WEATHER	
≥5000/5	97.6%
≥1000/3	99.9
<1000/1	0.0
< 200/½	0.0

JUNE

1. <u>TEMPERATURE</u>: The average daily maximum during June is 88°F, with the average minimum of 57°F. Records show that temperature extremes are a record high of 111° and a low of 41°F. There are no days during June when temperatures will drop below freezing.

2. <u>PRECIPITATION</u>: During the month of June an average of 0.01 inches of precipitation can be expected with 0.5 days of measurable precip.

3. <u>SURFACE WINDS</u>: The prevailing wind direction for June is SE through W. Southerly winds (SE-SSW) occurs 30.1%. During June an effective cross-wind of 20 knots or greater may be expected 1.2% of the time. 90.7% of the June winds are less than 21 knots.

4. <u>FLYING WEATHER</u>: The predominant sky coverage is a clear to scattered condition with clear skies prevailing 73.6% of the time. A broken to overcast condition can be expected 9.2% of the time. Conditions greater than 1000/3 (VFR) occur 99.9% of the time while 98.7% of all ceilings are in excess of 10,000 ft.

5. <u>SEVERE WEATHER</u>: Severe weather is a rare occurance during June. The only occurances have been thunderstorms and winds with these being rare.

6. <u>SUMMARY</u>:

TEMPERATURE	
Absolute Maximum	111°F
Mean Daily Maximum	88°F
Mean Daily Minimum	57°F
Absolute Minimum	41°F
PRECIPITATION	
Average Monthly Precip	0.1 inches
Average No. of days with Measurable precip	0.5 days
FLYING WEATHER	
≥300/3	99.9%
≥1000/3	99.9%
≤1000/1	0.0%
≤ 200/½	0.0%

JULY 1967

1. TEMPERATURE: The average daily maximum during July is 96.4°F with the average minimum of 65.6°F. Records show that temperature extremes are a record high of 108° and a low of 50°F.

2. PRECIPITATION: During the month of July an average of 0.10 inches of precipitation can be expected with 2.4 days of measurable precipitation. The greatest amount of precipitation which has occured during July is 0.72 inches.

3. SURFACE WINDS: The prevailing wind direction for July is SE through SW. Southerly winds (SE-SSW) occur 55.9% of the time, while a Westerly wind (SW-W) occurs 19.7%. 94.1% of the July winds are less than 16 knots.

4. FLYING WEATHER: The predominant sky coverage is a clear to scattered condition prevailing 71.8% of the time. Conditions greater than 1000/3 (VFR) occurs 99.9% of the time while conditions greater than 10000/10 occur 95.6% of the time.

5. SEVERE WEATHER: July has an average of two days with thunderstorms.

6. SUMMARY:

TEMPERATURE:	
Absolute Maximum	108°F
Mean Daily Maximum	96.4
Mean Daily Minimum	65.6
Absolute Minimum	50
PRECIPITATION:	
Average Monthly Precip	0.1 inches
Average No. of days with Measurable Precip	2.4 days
FLYING WEATHER	
≥10000/10	95.6%
≥3000/3	99.8%
≥1000/3	99.9%
≥1000/1	100.0%

AUGUST

1. TEMPERATURE: The average daily maximum temperature for August is 94.6°F, with an average minimum of 64.4°F. The temperature extremes are a record high of 106°F and a low of 49°F.

2. PRECIPITATION: August has a mean of 0.17 inches of precipitation which is due primarily to thundershowers. The greatest amount that has occured in August is 1.27 inches.

3. SURFACE WINDS: The prevailing wind direction is SE through SW. Southerly winds (SSE-S-SSW) occurs 41.4% of the time and Westerly winds 13.0%. Calm winds are observed 71 hours during the month and winds in excess of 16 knots are observed 44 hours. The windiest time of the day is 1600L to 1800L. The maximum wind has been a SE wind at 35 knots.

4. FLYING WEATHER: August will be slightly more cloudly than July. The predominant condition of clear to scattered clouds exists 88.6% of the time. Conditions greater than 1000 feet ceilings and 3 miles visibility exists 99.9% of the time, greater than 10000/10 exists 96.2% of the time.

5. SEVERE WEATHER: August has an average of one day of thunderstorms.

6. SUMMARY:

TEMPERATURE:	
Absolute Maximum	106°F
Average Maximum	94.6°
Mean	79.9°
Average Minimum	64.6°
Absolute Minimum	49°
PRECIPITATION:	
Average	0.17 inches
Greatest	1.27 inches
FLYING WEATHER:	
≥10000/10	96.2%
≥ 3000/3	99.9
≥ 1000/3	99.9
≥ 1000/1	100.0

SEPTEMBER

1. TEMPERATURE: The average daily maximum temperature for September is 90.1°F, with an average minimum of 59.2°F. The temperature extremes are a record high of 107° and a low of 38°F.

2. PRECIPITATION: September has a mean of 0.19 inches of precipitation which is due primarily to thundershowers. The greatest amount that has occured in August is 2.46 inches.

3. SURFACE WINDS: The prevailing wind direction is SE through SW. Southerly winds (SSE-S-SSW) occurs 34.9 of the time and Southwestern winds 27.5%. Calm winds are observed 67 hours during the month and winds in excess of 16 knots are observed 33 hours. The maximum wind has been a S wind at 38 knots.

4. FLYING WEATHER: September will be slightly more cloudy than August. The predominate condition of clear to scattered clouds exists 69.3% of the time. Conditions greater than 1000 feet ceilings and 3 miles visibility exists 99.8% of the time, greater than 10000/10 exists 92.5% of the time.

5. SEVERE WEATHER: September has an average of two days of thunderstorms.

6. SUMMARY:

TEMPERATURE:

Absolute Maximum	107°F
Average Maximum	90.1
Mean	74.8
Average Minimum	59.2
Absolute Minimum	38

PRECIPITATION:

Average	0.19 inches
Greatest	2.46 inches

FLYING WEATHER:

10000/10	95.2%
3000/3	99.5
1000/3	99.8
1000/1	99.9

OCTOBER

1. TEMPERATURE: The average daily maximum temperature for October is 78.6°F, with an average minimum of 50.4°F. The temperature extremes are a record high of 95°F and a low of 31°F.

2. PRECIPITATION: October has a mean of 0.19 inches of precipitation which is due primarily to weather associated with frontal passage. The greatest amount that has occurred in October is 1.14 inches.

3. SURFACE WINDS: The prevailing wind direction is SE through S which occurs 36.2% of the time. Calm winds are observed 72 hours during the month and winds in excess of 16 knots are observed 36 hours. The maximum wind has been a NW wind at 44 knots.

4. FLYING WEATHER: October will be slightly more cloudy than September. The predominate condition of clear to scattered clouds exists 62.6% of the time. Conditions greater than 1000 feet ceilings and 3 miles visibility exists 99.8% of the time, greater than 10000/10 exists 90.6% of the time.

5. SEVERE WEATHER: Octooer has an average of one day of thunderstorms.

6. SUMMARY:

TEMPERATURE:

Absolute Maximum	95°F
Average Maximum	78.6
Mean	64.7
Average Minimum	50.4
Absolute Minimum	31

PRECIPITATION

Average	0.19 inches
Greatest	1.14 inches

FLYING WEATHER:

10000/10	90.6%
3000/3	99.5
1000/3	99.8
1000/1	99.9

NOVEMBER

1. TEMPERATURE: The average daily maximum temperature for November is 64.7°F, with an average minimum of 39.1°F. The temperature extremes are a record high of 85°F and a low of 10°F.

2. PRECIPITATION: November has a mean of 0.44 inches of precipiation which is due primarily to the weather associated with frontal passages. Snow is rare for this month; although 8.8 inches fell in 1964. Relatively high temperatures prevent a large snow cover on the ground.

3. SURFACE WINDS: The prevailing wind direction is SE accounting for 13% of all winds. Winds between south and east occur 39% of the time. Calm winds are observed 70 hours during the month and winds in excess of 16 knots are observed 42 hours. The maximum wind has been a SW wind at 51 knots.

4. FLYING WEATHER: November will be cloudier than October. The predominate condition of clear to scattered clouds exist 76.5% of the time. Conditions greater than 1000 foot ceilings and 3 miles visibility exist 99.3% of the time.

5. SEVERE WEATHER: Severe weather (thunderstorms, high winds, etc.) present some hazards during the month of November. Frontal passages become more frequent and will be accompanied in many cases by rain showers (and in some cases thunderstorms), wide spread cloudiness and high gusty surface winds.

6. SUMMARY:

TEMPERATURE:	
Absolute Maximum	85°F
Average Maximum	64.7
Mean	52.1
Average Minimum	39.1
Absolute Minimum	10
Precipitation	
Average	0.44 inches
Greatest	1.80 inches
FLYING WEATHER:	
10,000/10	88.6%
3,000/3	98.2
1,000/3	99.3
1,000/1	99.5

DECEMBER

1. TEMPERATURE: The average daily maximum temperature for December is 58.6°F, with an average minimum of 34.4°F. The temperature extremes are a record high of 86°F and a low of 17°F.

2. PRECIPITATION: December has a mean of 0.62 inches of precipitation which is due primarily to the weather associated with frontal passages and a closed low pressure system aloft off the coast of San Diego. The greatest amount that has occured in December is 3.86 inches of rain and 1.1 inches of snow.

3. SURFACE WINDS: The prevailing wind direction is southeasterly with a secondary maximum out of the south. Southeasterly, south-south easterly and southerly winds occur 33.0% of the time. Westerly winds occur 9.3% of the time. The maximum wind gust for December was out of the north at 56 knots.

4. FLYING WEATHER: December will be slightly more cloudy than November. The sky condition will be clear to scattered 71.8% of the time. Conditions greater than 1000 foot ceilings and 3 mile visibility exist 99.0% of the time.

5. SEVERE WEATHER: Severe weather (thunderstorms, high winds, etc.) present some hazards during the month as frontal passages become more frequent. Fronts will be accompanied in many cases by rain showers (and in some cases thunderstorms) widespread cloudiness and high gusty surface winds.

6. SUMMARY:

TEMPERATURE:	
Absolute Maximum	86.0°F
Absolute Minimum	17.0°F
Average Maximum	58.6°F
Average Minimum	34.4°F
Mean	46.7°F
PRECIPITATION:	
Average	0.62 inches
Greatest	3.86 inches
FLYING WEATHER: (Greater than or equal to)	
10,000/10	88.1%
3,000/3	97.3
1,000/3	99.0
1,000/1	99.4

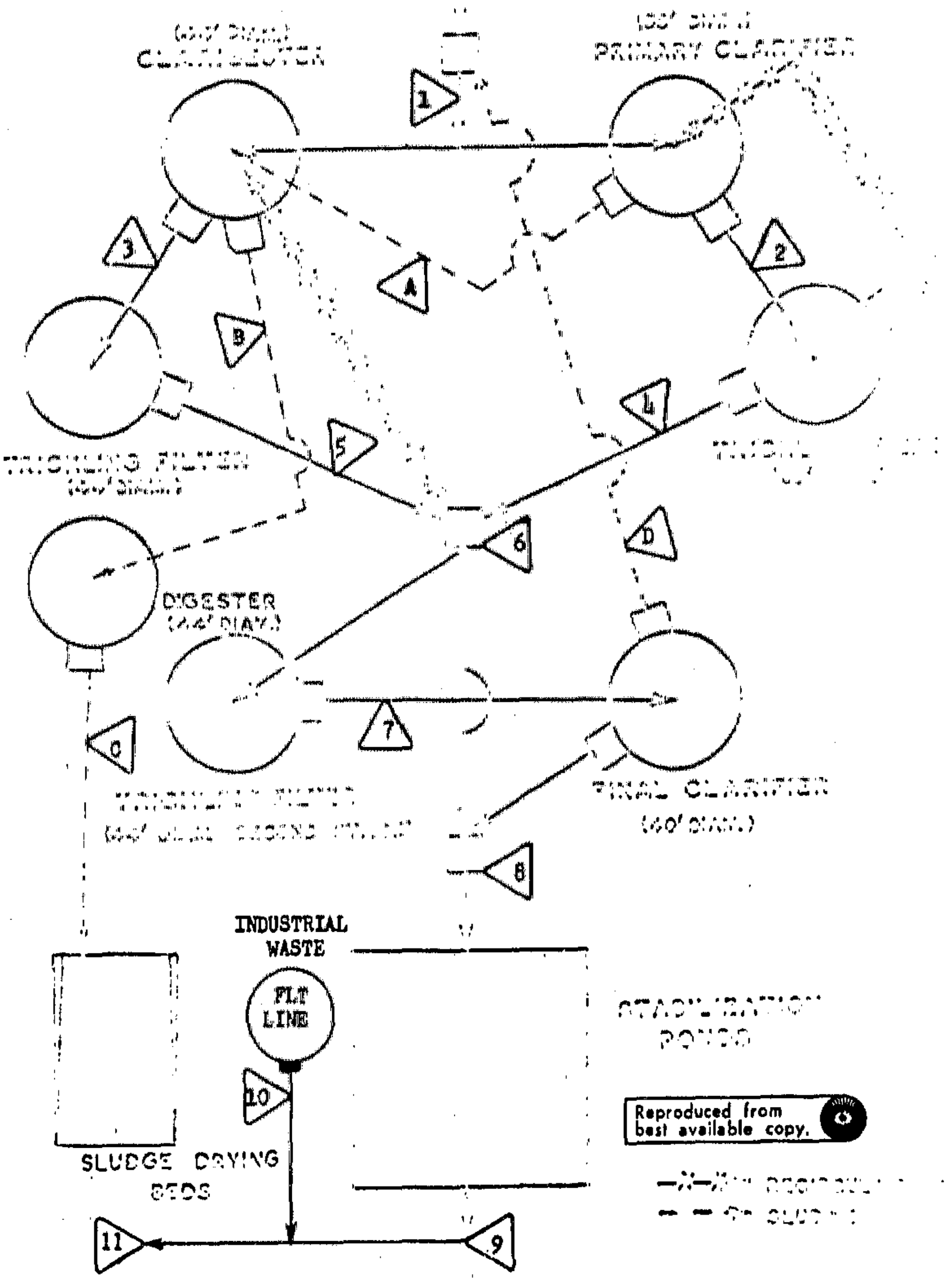
Appendix B

FIELD SURVEY DATA

(FLOW AND WASTE ANALYSIS)

46

GEORGE AFB, CA.



Reproduced from best available copy.

Figure 5: SEWAGE TREATMENT PLANT SAMPLING STATIONS
FIELD SURVEY 13-19 AUG 69

Constituent	STATION 1 Maximum Recorded Value	Average Composite Value	Average Lbs/Day	STATION 2 Maximum Recorded Value	Average Composite Value	Average Lbs/Day
pH	7.4	7.3	-	7.5	7.4	-
Color	-	-	-	-	-	-
Turbidity	-	-	-	-	-	-
PARAMETERS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
BOD	-	214	1731	101	64	857
COD	967	438	-	181	131	-
TOD	-	-	-	200	170	-
Total S.	800	579	4684	-	-	-
Sett. S.	8.0*	5.3*	-	0.3*	0.2*	-
Susp. S.	305	178	1440	110	73	791
[illegible]	9.2	5.2	42	-	-	-
[illegible]	21.0	18.8	152	-	-	-
MBAS	25.0	21.1	170	-	-	-
PHENOLS	.019	.008	0.1	-	-	-
OILS & GREASE	19.0	11.6	94	8.0	4.0	[illegible]
METALS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
CADMIUM	0.02	0.01	0.1	-	-	-
CHROMIUM	0.08	0.05	0.4	-	-	-
COPPER	0.07	0.06	0.5	-	-	-
IRON	0.31	0.30	2.4	-	-	-
LEAD	0.05	0.05	0.4	-	-	-
MANGANESE	0.08	0.08	0.6	-	-	-
SILVER	0.21	0.16	1.3	-	-	-
ZINC	0.27	0.20	1.6	-	-	-
MEAN FLOW						
MGD	-	0.97	-	-	0.67	-
GPM	-	674	-	-	465	-

* Reported as ml/l

Table 9: Stations 1 & 2 Physical and Chemical Analysis Data

Constituent	STATION 3 Maximum Recorded Value	Average Composite Value	Average Lbs/Day	STATION 4 Maximum Recorded Value	Average Composite Value	Average Lbs/Day
pH	7.4	7.3	-	7.6	7.5	-
Color	-	-	-	-	-	-
Turbidity	-	-	-	-	-	-
PARAMETERS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
BOD	108	60	160	61	59	640
COD	148	116	-	159	121	-
TOD	145	129	-	155	126	-
Total S.	-	-	-	-	-	-
Sett. S.	0.6*	0.3*	-	1.0*	0.7*	-
Susp. S.	100	63	168	90	55	596
NO3	-	-	-	-	-	-
PO4	-	-	-	-	-	-
MBAS	-	-	-	-	-	-
PHENOLS	-	-	-	-	-	-
OILS & GREASE	3.8	2.6	7	-	-	-
METALS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
CADMIUM	-	-	-	-	-	-
CHROMIUM	-	-	-	-	-	-
COPPER	-	-	-	-	-	-
IRON	-	-	-	-	-	-
LEAD	-	-	-	-	-	-
MANGANESE	-	-	-	-	-	-
SILVER	-	-	-	-	-	-
ZINC	-	-	-	-	-	-
MEAN FLOW						
MGD	-	0.32	-	-	0.67	-
GPM	-	222	-	-	465	-

*Reported as ml/l

Table 10: Stations 3 &4 Physical and Chemical Analysis Data

	STATION 5			STATION 6		
Constituent	Maximum Recorded Value	Average Composite Value	Average Lbs/Day	Maximum Recorded Value	Average Composite Value	Average Lbs/Day
pH	7.7	7.5	-	7.6	7.5	-
Color	-	-	-	-	-	-
Turbidity	-	-	-	-	-	-
PARAMETERS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
BOD	53	41	109	67	53	429
COD	110	87	-	148	103	-
TOD	117	88	-	148	115	-
Total S.	-	-	-	-	-	-
Sett. S.	0.4*	0.2*	-	1.3*	1.0*	-
Susp. S.	90	49	131	85	50	404
NO3	-	-	-	-	-	-
PO4	-	-	-	-	-	-
MBAS	-	-	-	-	-	-
PHENOLS	-	-	-	.018	.011	0.1
OILS & GREASE	-	-	-	-	-	-
METALS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
CADMIUM	-	-	-	-	-	-
CHROMIUM	-	-	-	-	-	-
COPPER	-	-	-	-	-	-
IRON	-	-	-	-	-	-
LEAD	-	-	-	-	-	-
MANGANESE	-	-	-	-	-	-
SILVER	-	-	-	-	-	-
ZINC	-	-	-	-	-	-
MEAN FLOW						
MGD	-	0.32	-	-	0.97	-
GPM	-	222	-	-	674	-

* Reported as ml/l

Table 11: Stations 5 & 6 Physical and Chemical Analysis Data

Constituent	STATION 7 Maximum Recorded Value	Average Composite Value	Average Lbs/Day	STATION 8 Maximum Recorded Value	Average Composite Value	Average Lbs/Day
pH	7.6	7.4	-	7.6	7.4	-
Color	-	-	-	-	-	-
Turbidity	-	-	-	-	-	-
PARAMETERS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
BOD	65	45	364	40	38	306
COD	88	71	-	119	79	-
TOD	103	97	-	117	86	-
Total S.	-	-	-	575	459	3292
Sett. S.	0.6*	0.4*	-	0.3*	T*	-
Susp. S.	65	44	356	35	22	178
NO3	-	-	-	13.2	10.6	76
PO4	-	-	-	25.0	16.0	114
MBAS	-	-	-	8.5	6.5	47
PHENOLS	-	-	-	.004	.004	0.1
OILS & GREASE	-	-	-	3.0	1.2	9
METALS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
CADMIUM	-	-	-	0.1	0.1	0.7
CHROMIUM	-	-	-	0.05	0.05	0.4
COPPER	-	-	-	0.2	0.2	1.4
IRON	-	-	-	0.1	0.1	0.7
LEAD	-	-	-	0.05	0.05	0.4
MANGANESE	-	-	-	0.05	0.05	0.4
SILVER	-	-	-	0.1	0.09	0.6
ZINC	-	-	-	0.1	0.09	0.6
MEAN FLOW						
MGD	-	0.86	-	-	0.97	-
GPM	-	597	-	-	674	-

* Reported as ml/l

Table 12: Stations 7 & 8 Physical and Chemical Analysis Data

51

Constituent	STATION 9 Maximum Recorded Value	STATION 9 Average Composite Value	STATION 9 Average Lbs/Day	STATION 10 Maximum Recorded Value	STATION 10 Average Composite Value	STATION 10 Average Lbs/day
pH	9.0	8.7	-	8.0	7.6	-
Color	160	127	-	100	76	-
Turbidity	155	106	-	0	0	-
PARAMETERS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
BOD	90	68	-	504	230	149
COD	187	160	-	1140	602	-
TOD	190	147	-	1170	535	-
Total S.	580	529	-	970	606	394
Sett. S.	0.2*	0.1*	-	T*	0*	-
Susp. S.	105	69	-	55	27	18
NO3	4.4	3.9	-	20.0	6.9	5
PO4	10.8	6.6	-	50.0	18.1	12
MBAS	-	-	-	400	161	105
PHENOLS	.014	.011	-	.049	.021	0.1
OILS & GREASE	2.4	1.6	-	12.9	6.9	5
METALS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
CADMIUM	0.01	0.01	-	0.04	0.02	0.1
CHROMIUM	0.05	0.05	-	0.15	0.08	0.1
COPPER	0.02	0.01	-	0.08	0.04	0.1
IRON	0.06	0.06	-	0.30	0.18	0.1
LEAD	0.05	0.05	-	0.33	0.12	0.1
MANGANESE	0.05	0.05	-	0.10	0.07	0.1
SILVER	0.10	0.06	-	0.17	0.09	0.1
ZINC	0.05	0.05	-	0.17	0.08	0.1
AVG FLOW						
MGD	-	0.65	-	-	0.078	-
GPM	-	451	-	-	54	

*Reported as ml/l

Table 13: Stations 9 & 10 Physical and Chemical Analysis Data

Constituent	STATION 11 Maximum Recorded Value	STATION 11 Average Composite Value **	STATION 11 Average Lbs/Day	STATION Maximum Recorded Value	STATION Average Composite Value	STATION Average Lbs/Day
pH	-	8.0	-			
Color	-	150	-			
Turbidity	-	-	-			
PARAMETERS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
BOD	-	-	-			
COD	-	239	-			
TOD	-	100	-			
Total S.	-	610	-			
Sett. S.	-	0.2*	-			
Susp. S.	-	100	-			
NO3	-	5.3	-			
PO4	-	6.8	-			
MBAS	-	7.0	-			
PHENOLS	-	.011	-			
OILS & GREASE	-	0.9	-			
METALS	(mg/l)	(mg/l)		(mg/l)	(mg/l)	
CADMIUM	-	0.01	-			
CHROMIUM	-	0.05	-			
COPPER	-	0.01	-			
IRON	-	0.08	-			
LEAD	-	0.05	-			
MANGANESE	-	0.05	-			
SILVER	-	0.11	-			
ZINC	-	0.05	-			
MEAN FLOW						
MGD	-	-	-			
GPM	-	-	-			

* Reported as ml/l

** Single Grab Sample

Table 14: Station 11 Physical and Chemical Analysis Data

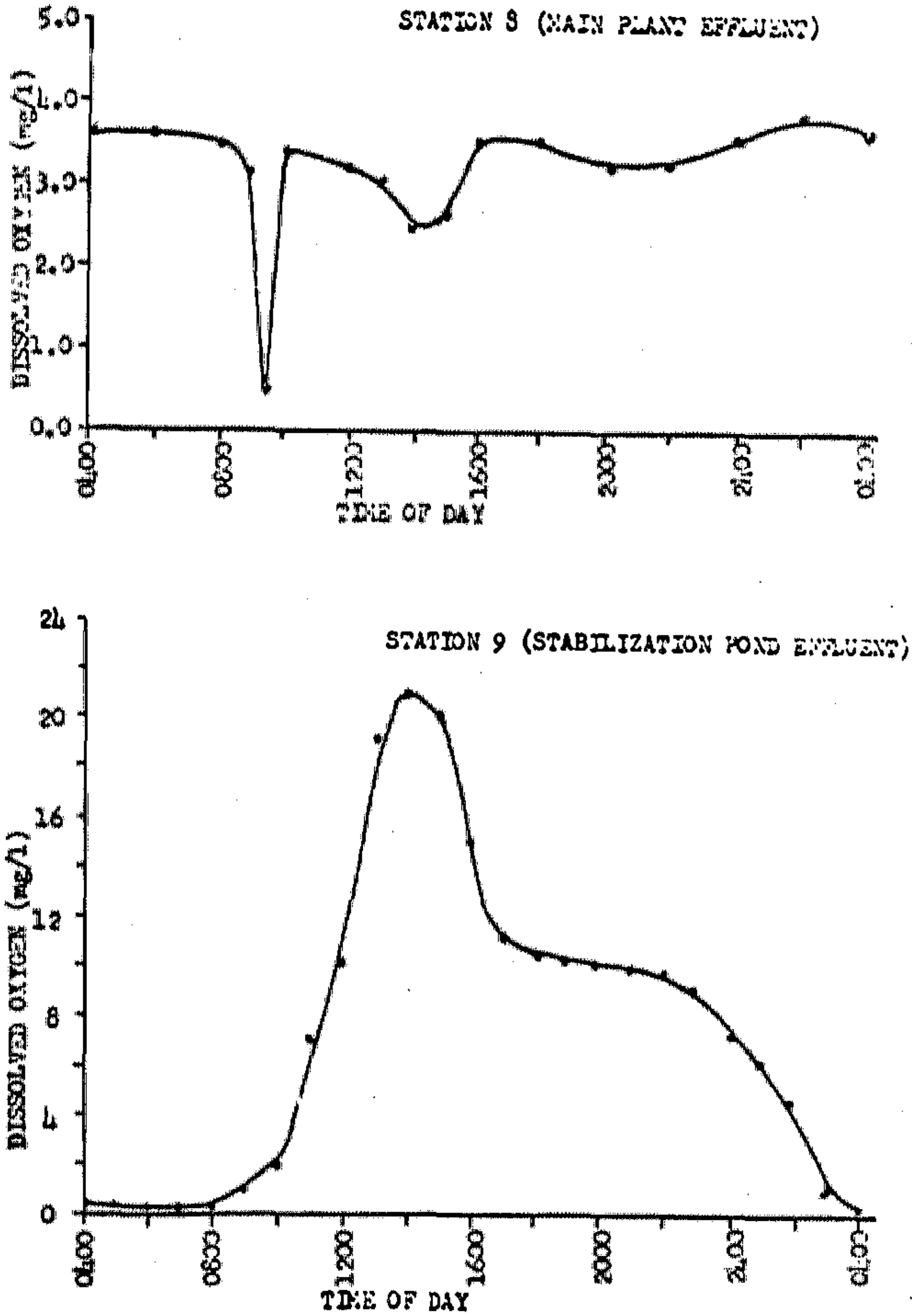


Figure 6: DIURNAL VARIATION IN DISSOLVED OXYGEN CONCENTRATIONS AT STATIONS 8 & 9

54

SLUDGES

Constituent	Station A	Station B	Station C*	Station D
pH	6.1	6.3	7.1	7.3
Total Solids (%)	1.9	4.0	5.0	0.2
Volatile Solids (%)	62.5	51.0	59.0	45.9
Ash (%)	37.5	49.0	41	54.1

*Insufficient digested sludge withdrawn to be representive.

Table 15: Stations A,B,C and D Physical and Chemical Analysis Data

55

Station 8

SEWAGE FLOWS

Hour of Day	13-14 Aug	14-15 Aug	15-16 Aug	16-17 Aug	17-18 Aug	18-19 Aug	Avg Daily
	Flow in MGD						
0730	0.89	0.89	0.94	0.59	0.42	1.27	0.83
0830	0.81	0.85	0.85	0.81	0.63	1.15	0.85
0930	0.94	1.10	1.15	0.89	0.99	1.62	1.13
1030	1.21	0.99	1.50	1.04	1.50	1.50	1.29
1130	1.10	1.15	1.15	1.15	1.21	1.33	1.18
1230	1.21	1.15	1.39	1.27	1.45	1.39	1.31
1330	1.33	1.27	1.39	1.27	1.21	1.33	1.32
1430	1.21	1.15	1.27	1.15	1.15	1.33	1.21
1530	1.15	1.21	1.39	1.27	1.15	1.39	1.26
1630	1.21	1.04	0.94	1.21	0.99	1.27	1.11
1730	1.45	1.15	1.10	1.21	1.10	1.33	1.23
1830	1.39	1.45	1.33	1.39	1.21	1.39	1.36
1930	1.27	0.94	1.10	1.33	1.15	1.10	1.15
2030	1.21	1.04	1.15	1.15	1.05	1.10	1.12
2130	0.99	1.15	0.89	0.99	1.15	1.04	1.04
2230	1.21	1.10	0.89	1.04	0.99	1.04	1.05
2330	0.99	0.99	0.89	0.89	0.94	0.94	0.94
0030	0.67	0.67	0.85	0.85	0.81	0.85	0.78
0130	0.59	0.63	0.67	0.81	0.55	0.46	0.60
0230	0.50	0.50	0.67	0.67	0.55	0.67	0.59
0330	0.42	0.42	0.50	0.59	0.50	0.55	0.50
0430	0.37	0.37	0.50	0.59	0.50	0.50	0.48
0530	0.42	0.37	0.46	0.55	0.55	0.59	0.49
0630	0.42	0.37	0.55	0.55	0.59	0.67	0.53

Table 16: Station 8, Sewage Flows

Station 10

INDUSTRIAL WASTE FLOWS

Date	Time	Flow (GPD)	Flow (GPM)
Wed 13 Aug	2100	10,100	7
	2315	10,000	7
Thurs 14 Aug	0730	14,500	10
	0900	90,000	63
	1000	75,000	52
	1100	85,000	69
	1300	36,000	24
	1520	210,000	146
	1605	120,000	84
	1635	61,000	42
	1900	15,700	11
	1950	14,500	10
Fri 15 Aug	0830	15,500	11
	0900	96,000	67
	0910	105,000	73
	1050	140,000	97
	1400	50,000	35
	1510	75,000	52
	1625	50,000	36
	1945	17,000	12
Mon 18 Aug	0730	50,000	35
	1050	112,000	78
	1250	85,000	59
	1345	160,000	111
	1430	210,000	146
	1520	130,000	90

Table 17: Station 10, Industrial Waste Flows

Table 18

Monthly Average Hourly and Daily Flows From Plant Records in MGD

Hour of Day	May 1968	June 1968	July 1968	Aug 1968	Sep 1968	Oct 1968	Avg of Six Months
0001	0.87	0.92	1.01	1.02	1.17	1.19	1.03
0100	0.59	0.70	0.87	0.88	0.96	0.85	0.81
0200	0.55	0.62	0.68	0.70	0.84	0.71	0.68
0300	0.53	0.62	0.63	0.63	0.78	0.67	0.64
0400	0.52	0.63	0.63	0.63	0.76	0.69	0.64
0500	0.53	0.60	0.64	0.65	0.77	0.67	0.64
0600	0.53	0.61	0.63	0.65	0.78	0.66	0.64
0700	0.57	0.62	0.66	0.66	0.80	0.70	0.67
0800	0.94	1.00	1.05	1.06	1.26	1.23	1.09
0900	1.04	1.14	1.19	1.20	1.44	1.43	1.24
1000	1.20	1.31	1.33	1.33	1.52	1.59	1.38
1100	1.27	1.38	1.40	1.41	1.65	1.72	1.47
1200	1.25	1.34	1.37	1.42	1.55	1.59	1.42
1300	1.21	1.28	1.31	1.31	1.49	1.53	1.36
1400	1.22	1.27	1.32	1.32	1.51	1.52	1.36
1500	1.14	1.23	1.26	1.27	1.43	1.48	1.30
1600	1.15	1.24	1.27	1.27	1.42	1.47	1.30
1700	1.13	1.21	1.26	1.27	1.42	1.47	1.28
1800	1.13	1.22	1.29	1.29	1.43	1.44	1.30
1900	1.13	1.25	1.30	1.51	1.51	1.54	1.34
2000	1.12	1.25	1.31	1.31	1.49	1.50	1.33
2100	1.19	1.28	1.35	1.36	1.52	1.52	1.37
2200	1.22	1.29	1.36	1.37	1.51	1.53	1.38
2300	1.14	1.22	1.25	1.25	1.39	1.41	1.28
2400	0.87	0.92	1.01	1.02	1.17	1.19	1.03
Daily Avg	0.96	1.05	1.10	1.11	1.26	1.24	1.12

58

Appendix C

SUPPLEMENTARY DISCUSSION OF UNIT PROCESSES AND DESIGN AND ANALYSIS CALCULATIONS

59

SUPPLEMENTARY DISCUSSION OF UNIT PROCESSES

1. Comminutors (cutting bar screens)

Two comminutors are currently installed. The larger has a capacity of up to 6 MGD and will suffice for a maximum expected flow of 4 MGD. The smaller has a capacity of up to 2 MGD, however, is not currently used. Plant operators claim the smaller comminutor rotates in the wrong direction for cutting. This condition should be checked by an electrician to insure the motor is properly connected and wound. The blades should also be checked to insure they are correctly mounted. The smaller unit will handle most flows and can serve as a standby unit. Depth of flow to the comminutors should be controlled so that the cutting blades are completely submerged. This provides for even wear on the cutting blades.

2. Primary Pump Station

The existing three pumps (750 GPM ea) will not have the capacity to handle peak day, peak flow estimated at 4.0 MGD considering one pump out of service for maintenance or repair. The current FY 70 MCP project provides for the replacement of the existing pumps with new pumps of sufficient size to accommodate the estimated peak flow. Sludge from the secondary clarifier is returned to this pump station.

3. Primary Sedimentation

a. Raw sewage and secondary sludge from the primary pump station passes through a distribution box which divides the flow to 2 primary clarifiers. The FY 70 MCP project provides for a new distribution box such that the incoming flow from the primary pump station will be divided, 2/3 to the large primary clarifier and 1/3 to the smaller clarigester.

(1) Large Primary Clarifier (55 ft diam):

A check of the capacity of this clarifier indicates it can accommodate a flow rate of approximately 2.0 MGD (1400 GPM) including the recirculation from the larger 60 ft diam first stage trickling filter. This is considering a maximum overflow rate of 800 gal/day per ft^2 of surface area. Sludge from this clarifier is pumped to the digestion compartment of the clarigester.

(2) Smaller Clarigester (44 ft diam):

A similar check of this clarifier indicates it can handle approximately 1.0 MGD (700 GPM) including recirculation from the smaller 44 ft diam first stage trickling filter and not exceed an overflow rate of 800 gal/day per ft^2 of surface area. The bottom compartment of this unit serves as a digester.

b. The combined capacity of the 2 clarifiers is 3.0 MGD (2100 GPM) including recirculation from the first stage filters and not exceeding the overflow rate of 800 gal/day per ft^2. As a large percentage of the entire sewage treatment plant's performance is dependent upon primary sedimentation it is suggested that this overflow rate not be exceeded which includes recirculation unless required by the volume incoming raw sewage alone. A maximum peak day, peak flow of 4.0 MGD (2800 GPM) can be accommodated with reduced efficiency of sedimentation. At an average daily design flow of 1.45 MGD (563 additional family quarters) an average recirculation ratio of one can be provided for each of the first stage trickling filters through the primary clarifiers. When the influent raw sewage exceeds

1.5 MGD (1050 GPM) recirculation must be decreased to less than one and stopped when the raw sewage influent reaches 3.0 MGD (2100 GPM). When the influent flow of raw sewage is less than 1.5 MGD (1050 GPM) recirculation may exceed a ratio of one. During low night time flows such as below 0.9 MGD (625 GPM) a recirculation of two could be maintained.

c. Figure 7 is a graph that illustrates the maximum recirculation ratios, based on the influent raw sewage flow rate, that can be maintained from the trickling filters and not exceed the maximum suggested overflow rate for the primary clarifiers.

4. First Stage Trickling Filters

a. Two first stage, high rate trickling filters are in use. The larger filter follows in line with the larger 55 ft diam primary clarifier, the smaller filter follows in line with the clarigester.

(1) 60 ft x 3.5 ft Filter:

The maximum design flow for the distributor of this filter is 2.48 MGD (1720 GPM). This maximum flow rate can be increased up to 3.6 MGD (2500 GPM) by relocation of the orfices on the ends of the distributor from the rear to the front. Maximum rotation of the distributor should not exceed 1.5 RPM in any event. The efficiency of the filter decreases somewhat with higher organic loadings.

(a) The speed of rotation (RPM) of the filter distributor should provide a good indication of the flow to the filter and be used as a guide in controlling recirculation. The manufacturer should be contacted

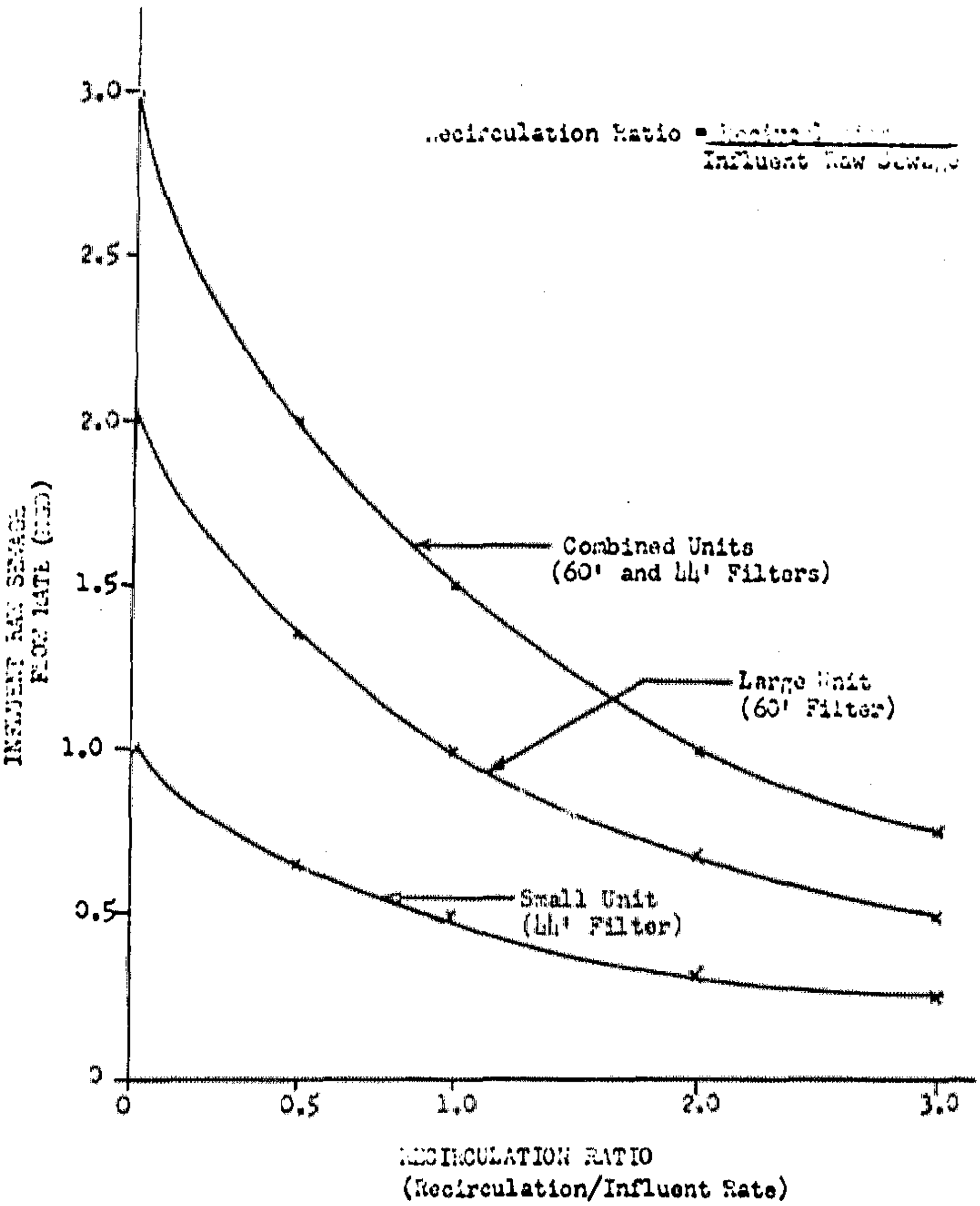


Figure 7 Maximum Allowable Recirculation Ratios

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by plant personnel as he may have available a flow versus RPM curve for the specific distributor installed. If not, plant operators can roughly calibrate the flow versus RPM by stopping all recirculation and timing the RPM based upon various influent sewage flows using the plants flow recorder. The total plant flow should be diverted to the large primary clarifier during this period. Sufficient time should be allowed before timing the rotation to allow flows to balance throughout the plant.

(b) This filter is provided with 2 recirculation pumps, each has a capacity of 0.86 MGD (600 GPM) and one is variable speed. Their combined capacity is 1.72 MGD (1200 GPM).

(2) 44 ft x 3.0 ft Filter:

The maximum design flow for the distributor of this filter is 0.86 MGD (600 GPM). This maximum flow may be increased to 1.41 MGD (980 GPM) by relocation of the orfices like that indicated for the larger filter. Maximum rotation of the distributor of this filter is 1.5 RPM. The RPM of the distributor can also serve as a guide in controlling recirculation.

(a) This filter is provided with one variable speed, 0.86 MGD (600 GPM) recirculation pump.

(b) The performance of this filter is rather poor which is caused primarily by a large portion of the filter being clogged reducing its effective volume. Another factor is that essentially no recirculation was being provided during the survey period. These conditions require immediate correction. Super chlorination sometimes helps to unclog a filter as well as a high dosing rate. In any event, the stone can be removed, under drains cleaned, and the stone cleaned or replaced with new stone.

b. Based upon the hydraulic capacities of the filters, reasonable overflow rate of the primary clarifiers, and to maximize plant performance, an average recirculation ratio of approximately one should be provided. In actual plant operations this will require a recirculation ratio of less than one during peak daily flows and greater than one during low flow periods (See Figures 3 and 7).

5. Second Stage Trickling Filter

a. Except for stone size this filter is similar to the 44 ft x 3 ft first stage filter and likewise has a maximum design flow for the distributor of 0.86 (600 GPM) which can be increased to 1.41 MGD (980 GPM) by relocation of its orfices from the rear to the front. Maximum design rotation is 1.5 RPM.

b. Unrecirculated underdrainage from both the first stage filters is pumped to this second stage filter by a variable speed pump. Maximum pump capacity was measured at 1.3 MGD (900 GPM) at maximum water level in the pump's wet well. At this maximum pump rate the rotation of the filters distributor was slightly over 2 RPM. Plant personnel should take immediate action to relocate the orfices to slow the rotation to within 1.5 RPM such that the filter may be operated at the maximum pump capacity.

c. Underdrainage from this filter flows directly to the final clarifier. All other flows bypass both the filter and final clarifier. The pump serving these units should be operated up to its maximum capacity each day during high daily flows and bypass only that flow in excess of the pumps capacity. During low night time flows, recirculation may be practiced such that the total flow rate, recirculation included, to the filter and final clarifier does not exceed 1.0 MGD (700 GPM).

6. Final Sedimentation

Based on a surface overflow rate of 800 gal/day per ft^2 the final clarifier is designed to handle a design (average) flow of 1.0 MGD. A slight increase in flow will not decrease the units efficiency appreciably. The performance of trickling filters is highly dependent upon sedimentation following the filter. This final clarifier should receive all flows pumped to the final filter within the maximum pump capacity of 1.3 MGD (900 GPM). The FY 70 MCP project provides for improvement of the effluent structure and effluent line from the clarifier.

I. SURVEY

A. PRIMARY CLARIFIERS

1. SIZE

(a) 55' DIAM. CLARIFIER

SURF. AREA = $3.14/4 (55^2 - 5^2)$

= 2360 ft^2

= 0.0542 ACRE

VOLUME = SURF. AREA X AVG. DEPTH

= 2360 (10.7)

= 25,200 ft^3

= 0.580 ACRE - FT

(b) 40' DIAM CLARIGESTOR

SURF AREA = $3.14/4 (40^2)$

= 1255 ft^2

= 0.0288 ACRE

VOLUME = 1255 (7.5)

= 9330 ft^3

= 0.214 ACRE - FT

2. OVERFLOW RATE

(a) 55' DIAM. CLARIFIER

OR = FLOW / SURF AREA

= $2(2/3)(.97 \times 10^6 / 2360)$

= 548 gal/day/ft^2

1:1 RECIRCULATION

(b.) 40' Diam Clarigestor

$OR = (\frac{1}{3})(.97 \times 10^6) / 1255$

$= 257$ gal/day/ft²

No Recirculation

3. Detention Time

(a.) 55' Diam. Clarifier

D_t = Volume / Flow

$= \dfrac{25200\ ft^3 (7.48\ gal/ft^3)}{(2)(\frac{2}{3})(.97 \times 10^6)\ gal/day}$

= .142 days

= 3.4 hrs (1:1 Recirc.)

(b) 40' Diam Clarigestor

$D_t = \dfrac{9330(7.48)}{\frac{1}{3}(.97 \times 10^6)}$

= .214 days

= 5.1 hrs (No Recirc.)

4. BOD Removal and Efficiency

(a) 55' Diam. Clarifier

lbs BOD applied $= \frac{2}{3}(.97)(214)(8.34) + \frac{2}{3}(.97)(59)(8.34)$

= 1154 + 320

= 1474 #

% of applied BOD removed $= \dfrac{1474 - 857}{1474}$

= 42%

% of raw sewage BOD removed $= \dfrac{1774 - 857}{1774}$

= 38%

(b) 44' DIAM CLARIGESTOR

lbs BOD APPLIED = 1/3(.49)(214)(8.34)

= 577#

% OF APPLIED BOD

REMOVED = $\frac{577 - 160}{577}$

= 72%

% OF RAW SEWAGE

BOD REMOVED = $\frac{577 - 160}{1622}$

= 25%

(C) COMBINED UNITS

lbs BOD APPLIED = 1474 + 577

= 2051#

% OF APPLIED BOD

REMOVED = $\frac{2051 - 1017}{2051}$

= 50%

% OF RAW SEWAGE

BOD REMOVED = $\frac{2051 - 1017}{1622}$

= 63%

CUMMULATIVE BOD REMOVAL

RAW SEWAGE REMAINING PAST UNIT = $\frac{1622 - 1017}{1622}$

= 37%

USING FIG. 13-13 – FAIR & GEYER

ELEMENTS OF WATER SUPPLY AND WASTE-WATER DISPOSAL, p. 330

@ COMBINED HL = 37.0 gal/day/ft²

EFFICIENCY = 37%

5. SS REMOVAL AND EFFICIENCY

(a) 55' DIAM CLARIFIER

lbs SS APPLIED = 2/3(.49)(178)(8.34)

+ 1/3(.97)(321)(8.34)

= 1010 + 248

= 1258 #

% of applied SS removed = $\frac{1258 - 791}{1258}$

= 37%

% of raw sewage SS removed = 467/1258

= 38%

(b.) 44' Diam. Clarigestor

lbs SS applied = 1/3(.97)(178)(8.34)

= 480 #

% of applied SS removed = $\frac{480 - 169}{480}$

= 65%

% of raw sewage SS removed = 312/1258

= 24%

(c) Combined Units

lbs SS applied = 1258 + 480

= 1738 #

% of applied SS removed = $\frac{1738 - 959}{1788}$

= 45%

% of raw sewage SS removed = 779/1258

= 62%

B. 1st Stage Trickling Filters

1. Size

(a) 60' Diam. Filter

Surf. Area = 3.14/4 $(60^2 - 2.75^2)$

= 2820 ft^2

= 0.0649 acre

Volume = 2820 (3.5)

= 9850 ft^3

= 0.336 acre-ft

(b) 44' Diam Filter

Surf. Area = $3.14/4 (44^2 - 2.5^2)$

= 1495 ft²

= 0.0344 acre

Volume = 1495 (3.0)

= 4480 ft³

= 0.1035 acre-ft

2. Hydraulic Loading

(a) 60' Diam Filter

HL = 2 (.97)(2/3)/2320

= 462 gal/day/ft²

(b) 44' Diam Filter

HL = (.97)(1/3)/1495

= 216 gal/day/ft²

Range — 200 to 1000 gal/day/ft²

WPCF, MOP #8

3. Organic Loading

(a) 60' Diam. Filter

Raw Sewage = 537/.336

= 2380 #/acre-ft/day

Sewage w/ Recir. = 857/.336

= 3800 #/acre-ft/day

(b) 44' Diam Filter

Raw Sewage = 160/.1035

= 1550 #/acre-ft/day

Range — 1100 to 13000 #/acre-ft/day

WPCF, MOP #8

4. BOD Removal and Efficiency

(a) 60' Diam. Filter

lbs BOD Applied = 857 #

% of Applied BOD

Removed = $\frac{857 - 630}{857}$

= 25%

% of Raw Sewage
BOD Removed = 219/1622

= 13%

Efficiency of
Filter Unit (Actual) = $\frac{1159 - 330}{1159}$

= 72%

Efficiency of
Filter Unit (NRC) = 71%

[National Research Council Formula for Trickling Filter, WPCF MOP # 8 p. 167]

W = 857
V = .336
F = 1.65

(b.) 40' Diam. Filter

lbs BOD Applied = 160#

% of Applied BOD
Removed = $\frac{160 - 109}{160}$

= 32%

% of Raw Sewage
BOD Removed = 51/1622

= 3%

Efficiency of Filter
Unit (Actual) = $\frac{577 - 109}{577}$

= 81%

Efficiency of Filter
Unit (NRC) = 75%

[National Research Council Formula for Trickling Filter, WPCF MOP # 8 p 167]

W = 160
V = .1085
F = 1.0

(c.) Combined Units

lbs BOD Applied = 857 + 160

= 1017#

% of Applied BOD
Removed = $\frac{1017 - 749}{1017}$

= 26%

% of Raw Sewage BOD Removed = 268/1682

= 16%

Efficiency of Filter Unit (Actual) = (1731 − 429)/1731

= 75 %

Efficiency of Filter Unit (NRC) = 72%

[National Research Council Formula for Trickling Filter, WPCF MOP #8 p. 167]

W = 857
V = .726
F = 1.65

5. SS Removal and Efficiency

(a) 60' Diam. Filter

lbs SS Applied = 791 #

% of Applied SS Removed = (791 − 596)/791

= 25%

% of Raw Sewage SS Removed = 195/1262

= 15%

(b) 44' Diam Filter

lbs SS Applied = 168 #

% of Applied SS Removed = (168 − 131)/168

= 22%

% of Raw Sewage SS Removed = 37/1262

= 3%

(c) Combined Units

lbs SS Applied = 791 + 168

= 959 #

% of Applied SS Removed = (959 − 727)/959

= 24%

% of Raw Sewage SS Removed = 232/1262

= 19%

73 C. 2nd Stage Process

1. 5120

(b) 44' Diam Filter

SURF. AREA = 3.14/4 (44² - 2.5²)
= 1455 FT²
= 0.0334 ACRE
VOLUME = 1455 (3)
= 4490 FT³
= 0.1035 ACRE - FT
(b) 40' DIAM. CLARIFIER
SURF. AREA = 3.14/4 (40² - 4²)
= 1250 FT²
= 0.0287 ACRE
VOLUME = 1250 (7.5 + 1.5)
= 9840 + 1870
= 11,210 FT³
= 0. 258 ACRE - FT

2. HYDRAULIC LOADING & OVERFLOW RATE
(a) 44' DIAM. FILTER
HL = .86/1459
= 586 GAL/DAY/FT²
RANGE - 200 - 1000 GAL/DAY/FT²
WPCF, MOP # 8
(b) 40' DIAM. CLARIFIER
OR = .86/1250
= 688 GAL/DAY/FT²

3. ORGANIC LOADING
(a) 44' DIAM. FILTER
OL = 378/.1035
= 3650 #/ACRE-FT/DAY
RANGE - 1100 TO 13000 #/ACRE-FT/DAY
WPCF, MOP # 8

4. BOD REMOVAL AND EFFICIENCY
(a) 44' DIAM FILTER
lbs BOD APPLIED = 378 #
% OF BOD APPLIED
REMOVED = $\frac{378 - 321}{378}$
= 15%
% OF RAW SEWAGE
BOD REMOVED = 57/1632
= 3%
EFFICIENCY OF FILTER
UNIT (ACTUAL) = $\frac{378 - 255}{378}$
= 33%

EFFICIENCY OF FILTER UNIT (NRC) = 32%

W = 378
V = .1035
F = 1.0

(6) 40' DIAM. CLARIFIER

lbs BOD APPLIED = 321#

% OF APPLIED BOD REMOVED = $\frac{321 - 255}{321}$ = 21%

% OF RAW SEWAGE BOD REMOVED = 66/1632 = 4%

5. SS REMOVAL AND EFFICIENCY

(c) 44' DIAM FILTER

lbs SS APPLIED = 378#

% OF APPLIED SS REMOVED = $\frac{378 - 321}{378}$ = 15%

% OF RAW SEWAGE SS REMOVED = 57/378 = 5%

(6) 40' DIAM CLARIFIER

lbs SS APPLIED = 321#

% OF APPLIED SS REMOVED = $\frac{321 - 143}{321}$ = 55%

% OF RAW SEWAGE SS REMOVED = 178/1262 = 14%

D. STABILIZATION PONDS

1. 3 PONDS SIZE
SURF. AREA = 391,500 ft² = 9 ACRES

VOLUME = 9 (3) = 27 ACRE-FT

2. POND LOADING

lbs BOD APPLIED = 306# @ .97 MGD

EVAPORATION LOSS = 0# @ .06 MGD

[FAIR & GEYER, ELEMENTS OF WATER SUPPLY AND WASTE-WATER DISPOSAL p. 37]

E = 15(.52 - .26)(1 + 2.2)(1 - 99/[illegible])
= 7.9 in/30 day
≈ .25 in/day

E(POND) = 391500(.25)(7.5)/12

= .06 MGD

LOSS TO GOLF COURSE = 148# @ .26 MGD

LOADING = $\frac{306 - 148}{9}$

= 17.5 lbs/acre/day

INITIAL POND
LOADING = 158/3

= 59 lbs/acre/day

10 STATES BOD LOADING ⇒ 22 lbs/acre/day

TEXAS BOD LOADING ⇒ 35 lbs/acre/day

75 lbs/acre/day
(INITIAL POND)

WPCF, MOP #8 ⇒ 50 lbs/acre/day

E. SLUDGE DIGESTION

1. SIZE

(a) PRIMARY CLARIGESTER (40' DIAM)

VOLUME = 3.14/4 (40²)(10)

= 12500 ft³

(b) SECONDARY DIGESTER (24' DIAM)

VOLUME = 3.14/4 (24²)(10)

= 4520 ft³

(c) STORAGE

VOLUME = 3.14/4 (24²)(10)

= 4520 ft³

2. SLUDGE PUMPING

(a) FROM CLARIFIER TO CLARIGESTER

PUMP RATE = 35 gal/min

lbs SS (ACTUAL) = 467 #/day

lbs (SETT. SOLIDS) = 2/3 (.0053)(.97)

= 3420 - 1.3(.0062)

= 3160 gal/day

= 3160(8.34)(.0189)

= 495 #/day

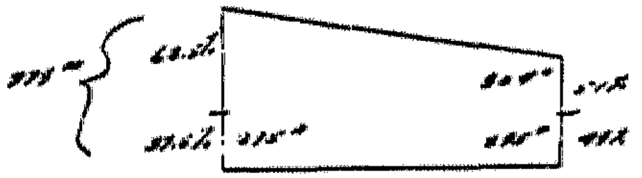
PUMPING TIME = 3160 gal/day (min/35 gal)(day/24 hr)

≅ 15 min/4 hrs

(b) FROM CLARIGESTER TO DIGESTER

PUMP RATE = 35 gal/min

lbs SS APPLIED
1ST STAGE DIGESTION = 779 #/day



lbs SS AFTER 1st
STAGE DIGESTION = 295 + 300
= 595 #/DAY
PUMPING TIME = 595/.339 (.041)(35)
≅ 50 MIN/DAY

3. VOLUME OF SLUDGE
(a) RAW SLUDGE
lbs/DAY = 779/.0179
= 4.17 × 10⁴ lbs/DAY

ft^3/DAY = 4.17 × 10⁴/63.4
= 670 ft^3/DAY

(b) DIGESTED SLUDGE
163/DAY = ① 779(.35) = 276
② 276/.545 = 506
③ 506/.04 = 1.08 × 10⁴ lbs/DAY

ft^3/DAY = 1.08 × 10⁴/63.4
= 163 ft^3/DAY

4. SLUDGE DETENTION
(a) DIGESTION
TIME = 18420/(506 + 113/2)
= 55.2 DAYS

(b) STORAGE = 9520/313
= 27.7 DAYS

5. LOADING
.65(779) = 513 lbs VOLATILE SOLIDS/DAY

513/18420 = 28.0 #/1000 ft^3/DAY

RANGE → 40 to 80 #/1000 ft^3/DAY

10 STATES STANDARDS

6. DRYING BEDS
(a) VOLUME DIGESTED SLUDGE = 163 ft^3/DAY
(b) AREA OF BEDS = 8680 ft^2
(c) DEPTH SLUDGE APPLIED = 9 INCHES
(d) APPLICATION (FOR MAX DRYING) = 8680(.75)/163
= 40 DAYS
= 9 TIMES/YR

(c) LOADING = (504#/DAY)(365 DAY/YR)/3600 FT²
= 21.3 #/FT²/YR

II. PROJECTED FOR 372 ADD'L FAMILY UNITS
A. PRIMARY CLARIFIERS
1. OVERFLOW RATE
(a) 55' DIAM CLARIFIER
OR = 2(2/3)(1.36×10⁶)/2360
= 768 GAL/DAY/FT²
1:1 RECIRCULATION
(b) 40' DIAM CLARIGESTOR
OR = 2(1/3)(1.36×10⁶)/1255
= 724 GAL/DAY/FT²
1:1 RECIRCULATION
2. DETENTION TIME
(a) 55' DIAM. CLARIFIER
t_d = 25300(7.48)/2(2/3)(1.36×10⁶)
= .104 DAYS
= 2.5 HRS
(b) 40' DIAM. CLARIGESTOR
t_d = 9330(7.48)/2(1/3)(1.36×10⁶)
= .0768 DAYS
= 1.8 HRS
3. BOD REMOVAL AND EFFICIENCY
(a) COMBINED UNITS
USING FIG. 18-13 FAIR & GEYER, ELEMENTS OF WATER SUPPLY AND WASTE-WATER DISPOSAL, P. 330
@ COMBINED H_L = 754 GAL/DAY/FT²
EFFICIENCY = 34.5%
INITIAL BOD TO UNIT = 1.36/.97 (1622)
= 2270#
CUMULATIVE BOD
REMAINING PAST UNIT = .655(2270)
= 1490#
(b) 55' DIAM CLARIFIER
LBS BOD APPLIED = 2/3(1.36)(214)(8.34)
+ 1.36/.97(104)(2/3)
= 1513 + 87
= 1600# + RECIRC.
CUMULATIVE BOD
RAW SEWAGE REMAINING
PAST UNIT = 2/3(1490)
= 994#

(c) 44' DIAM. CLARIGESTOR
lbs BOD APPLIED = 1/3 (1.36)(244)(8.34)
+ 1/3 (1.36/3)(104)
= 757 + 43
= 800 # + RECIRC.

CONVENTIONAL BOD REMOVAL
THROUGH FIRST UNIT = 1/3 (1.434)
= 797 #

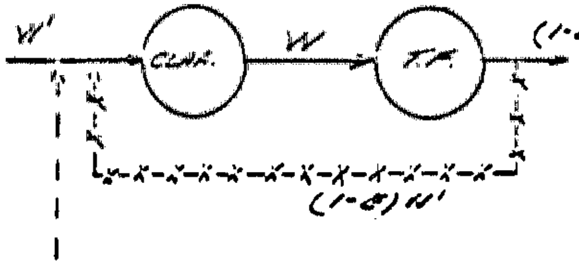
4. SS REMOVAL AND EFFICIENCY
(a) 55' DIAM. CLARIFIER
lbs SS APPLIED = 2/3 (1.36)(178)(8.34)
+ 2/3 (1.36)(55)(8.34)
= 1347 + 417
= 1764 #
lbs SS PAST UNIT = 2 (2/3)(1.36)(73)(8.34)
= 1100 #

(b) 44' DIAM. CLARIGESTOR
lbs SS APPLIED = 1/3 (1.36)(178)(8.34)
+ 2(1/3)(1.36)(50)(8.34)
= 673 + 187
= 860 #
lbs SS PAST UNIT = 2 (1/3)(1.36)(63)(8.34)
= 472 #

B. 1 ST STAGE TRICKLING FILTERS
1. HYDRAULIC LOADING
(a) 60' DIAM. FILTER
$HL = 2(1.36 \times 10^6)(2/3) / 2820$
= 644 GAL/DAY/FT^2
(b) 44' DIAM. FILTER
$HL = 2(1.36 \times 10^6)(1/3) / 1495$
= 608 GAL/DAY/FT2
RANGE ⇒ 200 TO 1000 GAL/DAY/FT^2
WPCF, MOP #8

2. ORGANIC LOADING
(a) 60' DIAM. FILTER
OL = 992/.226
= 4380 #/ACRE-FT/DAY
(b) 44' DIAM. FILTER
OL = 508/.1035
= 4910 #/ACRE-FT/DAY
RANGE ⇒ 1100 TO 13000 #/ACRE-FT/DAY
WPCF, MOP #8

3. BOD REMOVAL AND EFFICIENCY
(a) COMBINED UNITS



$W = .655\,W'$ $= 1490\#$

$F = \frac{1+1}{(1+.1)^2} = \frac{2}{1.21} = 1.65$

EFFICIENCY 1ST STAGE TRICKLING FILTER INCLUDING PRIMARY CLARIFIER $= \dfrac{1}{1+.0085\left[\frac{W}{VF}\right]^{1/2}}$

$= 69.7\%$

RECIRC. $= (1-E)W' = .303(2280) = 690\#$

4. SS REMOVAL & EFFICIENCY

(a) 60' DIAM. FILTER

lbs SS APPLIED = 1100#

lbs SS PAST UNIT = 1.82(55)(8.34) = 834#

(b) 44' DIAM. FILTER

lbs SS APPLIED = 472#

lbs SS PAST UNIT = .90(50)(8.34) = 375#

C. 2ND STAGE PROCESS (FILTER AND CLARIFIER)

1. HYDRAULIC LOADING AND OVERFLOW RATE

(a) 44' DIAM. FILTER

HL = 1.18/1459 = 809 gal/day/ft^2

HL (MAX PUMPING) = 1.3/1459 = 892 gal/day/ft^2

RANGE = 200 - 1000 gal/day/ft^2 WPCF, MOP #8

(b) 40' DIAM. CLARIFIER

OR = 1.18/1250 = 944 gal/day/ft^2

(MAX PUMP BY PASSES)

2. ORGANIC LOADING

(a) 44' DIAM. FILTER

OL = 528/.1035 = 5100 #/acre-ft/day

OL (with pumping) = 654/.1005 [illegible]

= 5850 #/acre-ft/day

Range → 1100 to 13000 #/acre-ft/day

WPCF, MOP-8

3. BOD Removal and Efficiency

Q_{total} = 1.36 MGD BOD_{total} = 688#

Q_{bypass} = 0.18 MGD BOD_{bypass} = $\frac{.18}{1.36}$(688)

= 86#

$Q_{to\ filter}$ = 1.18 MGD $BOD_{to\ filter}$ = $\frac{1.18}{1.36}$([illegible])

= 602#

Efficiency of 2nd Stage Trickling Filter and Clarifier

$$E_2 = \frac{1}{1 + \frac{.0085}{1-E_1}\left[\frac{W}{VF}\right]^{1/2}}$$

E_2 = 31.8% W = 602#

F = 1.0

E_1 = .817

4. SS Removal and Efficiency

(a) 44' Diam Filter

lbs SS Applied = 1.18/1.36 (609)

= 528#

lbs SS Bypass = .18/1.36 (604)

= 76#

lbs SS Raw Sewage Past Unit = 1.18 (44)(8.34)

= 436#

(b) 40' Diam Clarifier

lbs SS Applied = 436#

lbs SS Raw Sewage Past Unit = 1.18(22)(8.34)

= 218#

D. Stabilization Ponds

1. Pond Loading

lbs BOD Applied = 497# @ 1.36 MGD

Evap. (Pond) = 0# @ 0.06 MGD

lbs BOD Golf Course = 148# @ 0.26 MGD

Loading = (497-148)/9

= 38.8 lbs/acre/day

Initial Pond Loading = 249/3

= 83.0 lbs/acre/day

10 States Std Loading → 22 lbs/mile/day

Texas S-D Loading → 35 lbs/1000/day
75 lbs/1000/day (Natural Ponds)

WPCF, Man #3 → 50 lbs/1000/day

E. Sludge Digestion

1. Sludge Pumping

(a) From Clarifier to Clarigester

Pump Rate = 35 gal/min

lbs SS (actual) = 664 $\left(\frac{.09}{.0134}\right)$ = 1408 #/da

lbs (Sett. Solids) = $\frac{3}{4}$ (.0050)(1.86)

= 4810 - 260

= 4550 gal/day

= 4550 (8.34)(.04)

= 1420 #/day

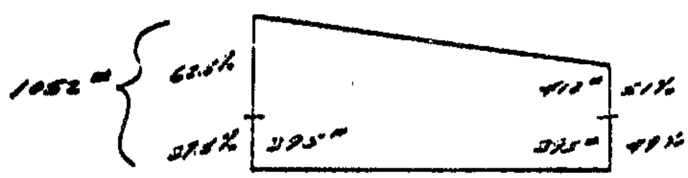
Pumping Time = 4550/35(24)

≅ 20 min/day

(b) From Clarigester to Digester

Pump Rate = 35 gal/min

lbs SS arriving 1st Stage Digestion = 1052 #/day



lbs SS after 1st Stage Digestion = 395 + 412

= 807 #/day

Pumping Time = 807/8.34(.06)(35)

≅ 45 min/day

2. Volume of Sludge

(a) Raw Sludge

lbs/day = 1052/.04

= 2.63 × 10⁴ lbs/day

ft³/day = 2.63 × 10⁴/62.4

= 421 ft³/day

(b) Digested Sludge

lbs/day = ① 1052 (.35) = 368

② 368/.545 = 675

③ 675/.06 = 1.13 × 10⁴ lbs/day

ft³/day = 1.13 × 10⁴/62.4

= 181 ft³/day

3. SLUDGE DIGESTION

(a) DIGESTION = $13920 / 181 + \frac{421}{2}$

= 61.1 DAYS

(b) STORAGE

TIME = $4520/181$

= 25.0 DAYS

4. LOADING

$.65 (1052) = 684$ lbs VOLATILE SOLIDS/DAY

$684/18920 = 37.2$ lb/1000 FT^3/DAY

RANGE ⟹ 40 TO 80 lb/1000 FT^3/DAY

10 STATES STANDARDS

5. DRYING BEDS

(a) VOLUME DIGESTED SLUDGE = 131 FT^3/DAY

(b) AREA OF BEDS = 3680 FT^2

(c) DEPTH SLUDGE APPLIED = 9 INCHES

(d) APPLICATION (FOR MAX DRYING) = $3680(.75)/131$

= 36 DAYS

= 10 TIMES/YR

(e) LOADING = $675(365)/3680$ = 28.3 lb/FT^2/YR

III. PROJECTED FOR 563 ADD'L FAMILY UNITS

A. PRIMARY CLARIFIERS

1. OVERFLOW RATE

(a) 55' DIAM. CLARIFIER

$OR = 2(2/3)(1.45 \times 10^6)/2360$

= 818 GAL/DAY/FT^2

1:1 RECIRCULATION

(b) 40' DIAM. CLARIGESTER

$OR = 2(1/3)(1.45 \times 10^6)/1255$

= 770 GAL/DAY/FT^2

1:1 RECIRCULATION

2. DETENTION TIME

(a) 55' DIAM. CLARIFIER

$D_t = 25200(7.48)/2(2/3)(1.45 \times 10^6)$

= .093 DAYS

= 2.3 HRS

(b) 40' DIAM. CLARIGESTER

$D_t = 9330(7.48)/2(1/3)(1.45 \times 10^6)$

= .0720 DAYS

= 1.7 HRS

3. BOD REMOVAL AND EFFICIENCY

(a) COMBINED UNITS

USING FIG. 13-13 FAIR, & GEYER, ELEMENTS OF WATER SUPPLY AND WASTE - WATER DISPOSAL, P. 330

@ COMBINED H_L = 800 gal/day/ft²

EFFICIENCY = 34.0%

INITIAL BOD TO UNIT = 1.45/.97 (1620)

= 2420 #

CUMULATIVE BOD

REMAINING PAST UNIT = .66 (2420)

= 1597 #

(b) 55' DIAM. CLARIFIER

lbs BOD APPLIED = 2/3(1.45)(214)(8.34)

+ 1.45/.97 (109)(2/3)

= 1613 + 74

= 1687 + RECIRC.

CUMULATIVE BOD REM.

SEWAGE REMAINING PAST UNIT = 2/3 (1597)

= 1065 #

(c) 44' DIAM. CLARIGESTER

lbs BOD APPLIED = 1/3 (1.45)(214)(8.34)

+ 1/3 (1.45/.97)(109)

= 807 + 36

= 843 # + RECIRC.

CUMULATIVE BOD REM.

SEWAGE REMAINING PAST UNIT = 1/3(1597)

= 532 #

4. SS REMOVAL AND EFFICIENCY

(a) 55' DIAM. CLARIFIER

lbs SS APPLIED = 2/3 (1.45)(178)(8.34)

+ 2/3(1.45)(55)(8.34)

= 1430 + 445

= 1875 #

lbs SS PAST UNIT = 2(2/3)(1.45)(73)(8.34)

= 1180 #

(b) 44' DIAM. CLARIGESTER

lbs SS APPLIED = 1/3 (1.45)(178)(8.34)

+ 2(1/3)(1.45)(50)(8.34)

= 715 + 200

= 915 #

lbs SS PAST UNIT = 2(1/3)(1.45)(63)(8.34)

= 505 #

B. 1 ST STAGE TRICKLING FILTERS

1. HYDRAULIC LOADING

(a) 60' DIAM. FILTER

HL = 2(1.45)(95)/2830

= 635 gal/day/ft²

(b) 44' DIAM FILTER

HL = 2(1.45)(45)/1485

= 647 gal/day/ft²

RANGE ⇒ 200 to 1000 gal/day/ft²

WPCF, MOP #8

2. ORGANIC LOADING

(a) 60' DIAM. FILTER

OL = 1065/.226

= 4710 #/acre-ft/day

(b) 44' DIAM. FILTER

OL = 553/.1035

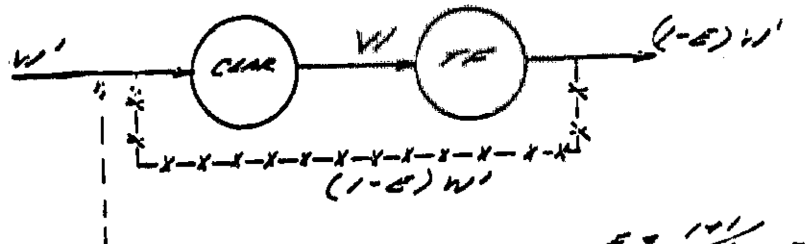
= 5350 #/acre-ft/day

RANGE ⇒ 1100 TO 13000 #/acre-ft/day

WPCF, MOP #8

3. BOD REMOVAL AND EFFICIENCY

(a) Combined Units



W = .66 W'

= 1597

F = 141/(1.15)

= 1.65

EFFICIENCY 1ST STAGE

TRICKLING FILTER INCLUDING

PRIMARY CLARIFIER = 63.5%

RECIRC. = (1-E) W'

= .315 (2420)

= 762#

4. SS REMOVAL AND EFFICIENCY

(a) 60' DIAM FILTER

lbs SS APPLIED = 1180#

lbs SS PAST UNIT = 1.90 (55)(8.34)

= 850#

(b) 44' DIAM. FILTER

lbs SS APPLIED = 505#

lbs SS PAST UNIT = .96(50)(8.34)

= 400#

C. 2ND STAGE PROCESS (FILTER AND CLARIFIER)

1. HYDRAULIC LOADING AND OVERFLOW RATES

(a) 43' DIAM. FILTER

HL = 1.19 x 10^6/1453
= 822 gal/day/ft²

HL (MAX PUMP) = 1.3/1453
= 894 gal/day/ft²

RANGE ⟶ 200 TO 1000 gal/day/ft²
WPCF, MOP #8

(b) 40' DIAM. CLARIFIER

OR = 1.19/1250
= 950 gal/day/ft²
(MAX PUMP BYPASSES)

2. ORGANIC LOADING

(a) 43' DIAM. FILTER

OL = 627/.1035
= 6060 #/acre-ft/day

OL (MAX PUMPING) = 633/.1035
= 6100 #/acre-ft/day

RANGE ⟶ 400 TO 1000 #/acre-ft/day
WPCF, MOP #8

3. BOD REMOVAL AND EFFICIENCY

Q_{TOTAL} = 1.45 MGD BOD_{TOTAL} = 762#

Q_{BYPASS} = 0.36 MGD BOD_{BYPASS} = $\frac{.36}{1.45}(762)$
= 189#

$Q_{TO\ FILTER}$ = 1.19 MGD $BOD_{TO\ FILTER}$ = $\frac{1.19}{1.45}(762)$
= 627#

EFFICIENCY OF 2ND STAGE TRICKLING FILTER AND CLARIFIER

E_2 = 33.3% W = 627#
F = 1.0
E_1 = .685

4. SS REMOVAL AND EFFICIENCY

(a) 43' DIAM. FILTER

lbs SS APPLIED = 1.19/1.45(645)
= 528#

lbs SS BYPASS = .36/1.45(645)
= 117#

lbs SS RAW SEWAGE PAST UNIT = 1.19(44)(8.34)
= 436#

(b) 40' DIAM. CLARIFIER

lbs SS APPLIED = 436#

lbs SS RAW SEWAGE PAST UNIT = 1.19(22)(8.34)
= 218#

D. [illegible] OF PONDS

1. POND LOADING

lbs BOD APPLIED = 560 # @ 1.45 MGD

EVAP. (POND) = 0 # @ 0.05 MGD

lbs BOD COMBINED = 148 # @ 0.26 MGD

LOADING = (560 − 148)/9

= 45.3 lbs/ACRE/DAY

INITIAL POND LOADING = 412/3

= 137 lbs/ACRE/DAY

10 STATES BOD LOADING ⇒ 22 lbs/ACRE/DAY

TEXAS BOD LOADING ⇒ 35 lbs/ACRE/DAY

75 lbs/ACRE/DAY (PRIMARY POND)

WPCF, MOP #8 ⇒ 50 lbs/ACRE/DAY

E. SLUDGE DIGESTION

1. SLUDGE PUMPING

(a) FROM CLARIFIER TO CLARIGESTOR

PUMP RATE = 35 gal/min

lbs SS (ACTUAL) = 695 (%/101) = 1390 #/DAY

lbs (SEPT. SLUDGE) = 4/3 (.0053)(1.45)

= 5130 − 260

= 4860 GAL/DAY

= 4860 (8.34)(.04)

= 1623 #/DAY

PUMPING TIME = 4360/35(24)

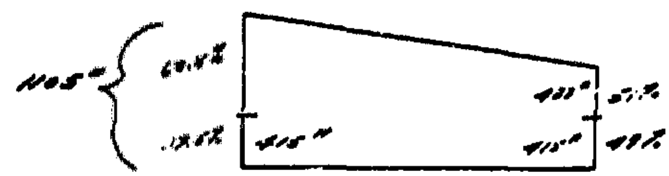
≃ 35 min/6 hrs

(b) FROM CLARIGESTOR TO DIGESTOR

PUMP RATE = 35 gal/min

lbs SS APPLIED TO

1ST STAGE DIGESTOR = 1105 #/DAY



lbs SS AFTER 1ST

STAGE DIGESTION = 432 + 415

= 847 #/DAY

PUMPING TIME = 847/8.34(.04)(35)

≃ 50 min/DAY

2. VOLUME OF SLUDGE

(a) Raw Sludge

lbs/day = 1105/.04

= 2.76 × 10^4 lbs/day

ft³/day = 2.76 × 10^4 / 62.4

= 442 ft³

(b) Digested Sludge

lbs/day = ① 1105 (.35) = 387

② 387/.545 = 710

③ 710/.06 = 1.18 × 10^4 lbs/day

ft³/day = 1.18 × 10^4 / 62.4

= 189 ft³/day

3. Sludge Detention

(a) Digestion

Time = 18900 / ((189 + 442)/2)

= 58.5 days

(b) Storage = 4520/189

= 23.9 days

4. Loading

.65 (1105) = 718 lbs volatile solids/day

718/18420 = 39.0 #/1000 ft³/day

Range => 40 to 50 #/1000 ft³/day

10 States Standards

5. Drying Beds

(a) Volume Digested Sludge = 189 ft³/day

(b) Area of Beds = 8630 ft²

(c) Depth Sludge Applied = 9 inches

(d) Application (For Max Drying) = 8630 (.75)/189

= 34 days

= 10 times/yr

(e) Loading = 710 (365)/8630

= 30.0 #/ft²/yr

Appendix D

SEWAGE TREATMENT AND DISPOSAL, FY70MCP,

GEORGE AFB CA, BASIS FOR DESIGN

BASIS FOR DESIGN

GEORGE AIR FORCE BASE

Victorville, California

SEWAGE TREATMENT AND DISPOSAL

Architect-Engineer Contract No. DACA09-69-C-0161

Prepared in the offices of
STRECKER ASSOCIATES, INC.
3540 Wilshire Boulevard
Los Angeles, California 90005

By________________________
John A. Alford R.C.E. 8638

INDEX

Design for this project proceeded under directive dated 7 April 1969 DD Form 1391, dated 4 September 1968 and SPLED-MN dated 18 July 1969. Design is based upon applicable provision of AFM 88-15, AFM 88-11 (TM5-814-3.2) and AFM 88-10 (TM5-813-2).

The average daily flow and peak flor for design, from projections of existing measured quantities as set forth in directive AFOCEHW-B dated 30 June 1969 as follows: Average daily flow 1.45 M.G.D. and peak flow for design 4.0 M.G.D. were used for all design for this project.

The grit chamber design is based upon the peak flow of 4.0 M.G.D. or 6.189 cubic feet per second. The calculated velocities at minimum flow, average flow, and at peak flow are 0.96 feet per second, 1.10 feet per second and 1.21 feet per second. These velocities should allow the grit chamber to function adequately. The calculated water surface elevations indicate adequate provision for the projected head loss. Directive AFOCEHW-B dated 29 July 1969 indicates a desire for a mechanical means of removing grit from the chamber. A sump is provided in each chamber with a pipe leading to a grit pump whereby the grit can be pumped to the surface where a mechanical grit, organic and water separator will be provided, if the funds are sufficient. Design is such that clearing stoppages can be accomplished with only minor disassembly. The location of the grit chamber is such that the existing outfall line can remain in use during construction, and yet can be used as a bypass in the future.

A peak flow of 4.0 M.G.D. requires that the pumps, in the lift station in the pump house, be capable of pumping 2780 G.P.M. Since directive AFOCEHW-B dated 30 June 1969 states that the flow shall be pumped by two of the pumps with the third not working, each of the three pumps must be capable of pumping 1400 G.P.M. against a head of 30 feet. The Review Comments request that the two of the pumps be planned for variable speed. It is planned to provide 3 each 6" x 6" pumps, each with a 20 HP constant speed electric motor. Pumps 1 and 2 will be connected using a mechanical hydraulic, integral, variable torque, adjustable speed drive, with a speed range of 1150 to 290 R.P.M. This drive is controlled with a Nema 2 pre-wired bubble control panel which will increase the speed of the motors with the increase of water depth. Included is a transfer switch, to cycle from pump No. 1 to pump No. 2 and back, as the lead pump. Pump No. 3 will act as a stand-by, switching on when the water level in the wet well reaches a "high water mark". This switch is connected to a high water alarm light and bell to alert personnel of possible problems.

An addition is planned to the wall between the comminutor chamber and the wet well, so that the comminutor will pass the peak design flow of 4.0 M.G.D. through it, instead of overflowing a portion of the raw sewage directly into the wet well. The existing communitor is designed to pass up to 6.0 M.G.D. according to the manufacturer.

The new distribution box, designed to be stable for seismic forces, is designed to pass 0.67 percent of the flow to the clarifier No. 1 and 0.33 percent of the flow to the clarigestor, by means of sharp edged, overflow weirs. These weirs are calculated to divide the flow as specified, regardless of the head. Also, the length of each weir can be changed somewhat to vary the relative amounts of flow, should changed conditions require some adjustment. Because of the new location of this box and the new pipe connecting, most of the work can be accomplished without disturbing the operation of the plant.

Recirculation from recirculation pump pit No. 1 to clarifier No. 1 is accomplished by means of a 6" x 6" pump driven by a 5 HP, variable speed, 3-phase, 10-pole, 240/480 volt slip ring type electric motor and a 6" x 6" pump in tandem connected to a 5 HP single-speed, 3-phase, 240/480 electric motor. The variable speed motor is controlled by a manually operated 4-position switch, and the single-speed motor by a manually operated off-on switch. Recirculation from recirculation pump pit No. 2 to the clarigestor is accomplished by a single 6" x 6" pump driven by a 5 HP variable speed, 3-phase, 10-pole, 240/480 volt slip ring type electric motor. This motor is controlled by a manually operated 4-position switch. It is possible that failure to turn off these recirculating pumps during peak flow periods may contribute to some of the hydraulic problems of the plant. By utilizing the same bubble control type sensors proposed for the wet well of the pump station and providing electronic controls for the motor speeds, the operation of these two recirculating pumps will be controlled and coordinated to function opposite to the Lift Station motors i.e. when the Lift Station pumps increase flow, the recirculating pumps will decrease their flow and vice-versa.

The existing 12-inch recirculating line between recirculating pump pit No. 1 and 2 enabling the effluent from Filter No. 1, not recirculated, to flow to recirculating pump pit No. 2, where it must be recirculated through the clarigestor or pumped on to the secondary H.R. Filter, unless the water surface in pit No. 2 happens to be higher than the water surface in pit No. 1. If this situation occurs, the flow will be from pit No. 2 back to pit No. 1, where it has no place to go, since the gate on the 12-inch overflow line from pit No. 1 to the plant bypass line is usually closed. It is planned to add a weir pit on the southerly side of recirculating pump pit No. 1, and remove the gate covering the end of the existing 12-inch overflow line. When stop logs are placed in this pit with the top at elevation 2858.50 feet, an overflow weir will be provided for this portion of the plant which will be lower than the overflow elevations of the secondary H.R. filter, which is at 2859.57', the distribution box between the secondary H.R. filter, and the secondary clarifier which is at 2859.70'; the secondary clarifier which is at 2859.90'; and the H.R. filter No. 1 which is at 2859.70'. The addition of this weir will provide for automatic containment of overflow of this portion of the plant; a feature that the existing plant does not now have.

The existing sludge line from the base of the clarigestor to the existing sludge pump near the clarifier No. 1 apparently has been plugging up regularly, and since the stoppage is usually in that portion of the line which lies under the clarigestor requires considerable effort to clear the line. To alleviate this situation, a pit will be constructed alongside the clarigestor and a new sludge pump installed in the sludge line, where it emerges from under the clarigestor bottom. This portion of the line will be valved at each end with valves which can be operated from the surfaces to prevent the pit from being flooded from the clarigestor. A bypass will be constructed around the pump to provide for servicing the pump. Installing the pump in this location, where it will have a minimum of suction head, should enable the pump to move the sludge from this problem section of pipe.

The "Recommended Flow Diagram" accompanying the "Preliminary Sewage Treatment Plant Evaluation" appended to AFOCEHW-B, dated 30 June 1969, shows a flow of 2.5 M.G.D. to and from the second-stage trickling filter, but Item 5 of the narrative portion of this report, indicates flows between 1.0 and 1.6 M.G.D. and a possible use of this filter at 1.45 M.G.D. It is assumed that the drawing is in error and a flow of 1.45 M.G.D. or 1040 G.P.M. is used for design. According to the Dorr-Oliver Company, manufacturers of the existing distributing arms, the existing arms on this filter, can, by minor alterations of the orifices, handle a flow of 1.41 M.G.D. or 979 G.P.M. Since the existing motor connected to this pump is a 5 HP, variable speed electric motor, with maximum speed of 686 R.P.M., replacing this motor with a constant speed 7-1/2 HP motor will furnish the required flow. Since the overall benefit of this replacement is marginal, the installation of a new motor is made an additive alternate to the base bid.

The distribution box for the effluent of the secondary clarifier is divided into two sections with an adjustable weir opening from the clarifier into each side, and with an adjustable weir on an opening in the wall between the two sections. The minimum setting of these weirs is at the elevation of 2855.72 ft. At the present time, the flow from the clarifier flows simultaneously into both sections. The easterly section is connected to the recirculation pump pit No. 2 by a 12-inch pipe. When the water surface in the distribution box is higher than the water surface in the recirculation pump pit, that portion of the effluent that flows into this side of the distribution box will recirculate back to the recirculation pump pit, but when the water surface elevations are reversed, the flow is from the pump pit back to the distribution box. That portion of the effluent from the clarifier, that flows into the westerly section of this distribution box, fills the box until the water surface rises higher than the water surface in the outfall line marked 1-1. The invert of this outfall line is at an elevation of approximately 2856.0, so the water surface in the west side of the distribution box must rise to at least this elevation to cause flow from the clarifier to the outfall line. To relieve some of the overflows that have occured because of this bottleneck situation, it is planned to construct a relief line from the bottom of this distribution box, at an elevation of 2853.73 feet, to a new manhole 2-A on the plant outfall relief line, at an elevation of 2850.00 feet. If both the east and west adjustable weirs in the wall between the clarifier and the distribution box are left at the same level, one half of the effluent of the clarifier will run directly to the outfall and only the other half will be available for recirculation. If the westerly weir is raised, so that all the flow will go only to the easterly side of this distribution box, then all of the effluent will be available for recirculation, and only that portion which cannot flow to the recirculation pump pit No. 2, will flow over the weir in the dividing wall between the sections to the westerly section and so to the outfall line. The openings controlled by the weirs will all pass the peak flow for design of 4.0 M.G.D., with a water surface 1.0 above the weir.

The existing 12-inch effluent line from the secondary clarifier to the 15-inch outfall line, between the distribution box lying between the secondary clarifier and the secondary H.R. filter, restricts the effluent flow considerably, so it is planned to construct a new 15-inch outfall from the clarifier to a new manhole, to be constructed in the existing 15-inch plant overflow line near existing manhole No. 2. Calculations indicate that the existing 15-inch plant outfall will not be adequate for the peak flow of 4.0 M.G.D., so it is planned to extend the new manhole, to be constructed near existing manhole No. 2, westerly, so that an 18-inch relief line can be constructed paralleling the existing line at manhole No. 4, from which the existing 18-inch apparently is adequate to carry the flow. The existing 15-inch line, from the distribution box between the secondary clarifier and the secondary H.R. filter to existing manhole No.2, and the existing 15-inch line, from manhole No. 4, will remain in service. To improve flow conditions in this line, the existing weir, which was placed in manhole No. 2 many years ago to act as a control for a chlorination system, will be removed, since the chlorination system has already been removed.

Since a considerable portion of the effluent flow from the plant will be removed from the line containing the existing recording flow meter sensing device, it is planned to move this sensor and its transmitting equipment from the existing location and place it in the new grit chamber, where provisions will be made to install it. The readout equipment will remain in its present location in the pump house. When the instrument is relocated, it will be necessary to recalibrate it.

As an additive alternate to the basic bid, plans are made to pave the drive into the plant and the plant parking lot with asphaltic concrete pavement, and to construct several portland cement concrete sidewalks to provide the plant personnel with a more efficient plant, which is easier to keep clean and in order. Pavement design is according to memorandum, dated 10 June 1969 titled "Basis for Design for Foundations and Pavements".

The existing outfall sewer from the housing area to the treatment plant is heavily loaded and with the projected addition of 372 units of new family housing, will need relief. The originally indicated point of connection for this relief line is in an area far removed from any sanitary sewer, so an investigating party made up of Mr. John A. Alford of Strecker Associates, Inc. - the A-E; Mr. George Hartski, Project Manager and Mr. Al Henzel, Base Project Engineer, surveyed the general area and decided that the point of connection should be made at the existing manhole located 75 feet westerly of Carolina Street, north at a point approximately 200 feet northerly of the intersection of Carolina Street, north with Oregon Street. Base coordinates North, 395,909.76; East, 2,192,289.38. There is sufficient fall from this point to allow flow by gravity to the treatment plant, so no lift station will be needed on this line. It has been determined that if the relief line is 12 inches in diameter, it will carry sufficient flow to serve the area adequately.

The existing space in the pump house now set aside for laboratory procedures is quite inadequate for efficient operation. It is in a poor location and does not contain proper facilities for sanitation. It is planned to construct a new building, removed from the gas hazard location. This building will contain, in addition to the standard laboratory facilities, a scrub type wash basin operated by knee or elbow control, so that an operator coming inside with contaminated hands, or a laboratory worker recently handling contaminated material can wash without contaminating the faucet handles. Also, lockers for clean clothes and personal belongings, rest room facilities and showers for the use of personnel working in contaminated areas, will be provided.

Architectural consideration are as follows:

A. Type of construction shall be permanent, unprotected.
B. Materials of construction.
   1. Foundation, reinforced concrete.
   2. Exterior walls, concrete masonry units.
   3. Interior partitions, wood stud.
   4. Roof, wood framing.
   5. Roofing, built-up composition.
   6. Doors and Frames, Wood.
   7. Windows, Metal with Screen.
   8. Interior finish.
      a. Laboratory; floor, vinyl asbestos, wall: conc block and drywall; ceiling, drywall.
      b. Toilets; floor, ceramic tile; wall, ceramic tile; ceiling, drywall.
      c. Shower and drying rooms; floor, vinyl asbestos; wall, conc. block and drywall; ceiling, drywall.
      d. Lounge; floor, vinyl asbestos; wall, conc. block and drywall; ceiling, drywall.

STRUCTURAL:

A. Foundation material, silt, sand-silty sand, clayey sands and sandy silt. Material is medium dense from ground surface to a depth of 3 feet and poorly graded and medium dense between 3 feet and 8 feet. The building will be supported on thickened edge slab using allowable soil pressure of 1500 psf. No vapor barrier is required.

B. Floor slab will be concrete with welded wire mesh and placed on soil compacted to 95% of the maximum optimum density.

C. Roof system will be wood frame with CMU, bearing walls and one bearing wall through center of building.

D. Lateral Loads, carried to CMU Bearing walls by horizontal diaphragm in roof.

E. Live Loads.
1. Roof, 20 psf plus evaporative cooling unit.
2. Wind, 18.8 psf.
3. Earthquake: Seismic Zone 3.

ELECTRICAL:

A. Interior Distribution System - shall be 240 volt three phase for power and 120/208 volt three phase four wire for lighting loads.

B. Exterior Distribution System - (a) The Sewage Treatment Plant is served by a transformer bank on a Power Pole at the east side of Digester No. 1. The secondary service conductors extend overhead from the Power Pole to the Pump House at 240 volt three phase, four wire with a vertical clearance of only six feet above the westerly side of the clarifier digester. It is proposed to remove the existing transformer bank at the East side of Digester No. 1 and extend the preimary at 4160 volt three phase to a New Pole at the Southwest corner of the Pump House with a transformer bank consisting of three (3) 50 KVA transformers at 240 volt three phase delta.
(b) The Secondary Service Conductors shall extend overhead to the Pump House at 240 volt, three phase to a new distribution panel with a Dry Type Transformer at 120/208 volt three phase four wire for the existing lighting and receptacle loads.
(c) The electric service to the Lab Building shall be underground at 120/208 volt three phase, four wire from the Pump House.

C. Loads - Lighting and convenience outlet estimated connected load shall be approximately 8 KW. Power load for heating: two (2) cabinet - type unit heaters at 2KW each at 208 volt single phase and Evaporate Cooler at 1/16 HP at 120 volt single phase.

D. Type of Conductors - Wiring systems shall consist of rigid conduit for underground and flexible steel conduit for electrical above ground.

E. Lighting Design - Lighting intensities for the laboratory area shall be rapid start fluorescent at 70 foot candles. Lighting intensities for the lounge area and toilet areas shall be incandescent fixtures at a 20 foot candle.

HEATING:

A. Design Temperatures.
1. Indoor design temperature
a) Winter - 75° F
b) Summer 75° F

2. Outdoor design temperature.
a) Wet bulb - 69° F
b) Dry bulb - 101° F

3. "U" Factors.
   a) Walls - 0.33, Glass 1.13
   b) Roof - 0.10

B. Heating System.
   1. Type of system will be cabinet convector, electrical.

   2. Control of heating will be built-in thermostat.

PLUMBING:

A. Piping
   1. Water service to the building and cold water piping underground, within the building shall be type K copper tubing.

   2. Cold water piping above ground and inside the structure shall be type L copper tubing or iron pipe size brass-pipe insulated.

   3. Domestic hot water piping above ground within the building shall be type K copper tubing insulated.

   4. Underground soil, waste, drain and vent piping and fittings shall be hub type cast iron. Above ground this piping shall be galvanized steel, galvanized wrought iron or cast iron.

B. The number of fixture units will be 32 with a demand of 42 G.P.M.

C. Hot water heater will be gas fired, domestic type, 30 gal. 40 C.F.H.

FIRE PROTECTION:

A. The fire protection system - none.

AIR CONDITIONING AND VENTILATION:

A. The laboratory and lounge areas will be air conditioned by evaporative coolers, roof mounted.

B. All shower areas, toilet rooms and drying rooms shall be ventilated by means of roof exhausters.

FUEL DISTRIBUTION:

A. Natural gas will be furnished by service from existing 3-inch main, 1000 B.T.U. per cu. ft. at 10" water pressure.

B. Gas piping shall be wrought iron or steel, with malleable iron fittings and cast iron body valves.

WATER SUPPLY DISTRIBUTION:

A. Water service will be furnished by extending on of the 3-inch service lines within the treatment plant area.

B. Building Service lines shall be constructed of type K copper tubing.

WALKS:

Walks will be of Portland Cement concrete.

DRAINAGE:

Drainage will be by sheet flow.

LANDSCAPING:

Landscaping will be limited to replacing any disturbed grass.

CONSTRUCTION ESTIMATE 2 September 1969

Deleted

DORR-OLIVER Incorporated

66 Jack London Square
Oakland, California 94607

July 30, 1969

Mr. John A. Alford
Pacific Architects and Engineers
3540 Wilshire Boulevard
Los Angeles, California 90005

Subject: George Air Force Base--S
Victorville, California

Dear Mr. Alford:

The rotary distributors presently in operation at this plant were rebuilt in 1966 to the following design criteria:

Two (2) 44' 0 x 3' depth of stone Bio-Filters, 24" 0 turn-table with two (2) fabricated double compartment arms equivalent to four 5" 0 pipe arms. Maximum design flow 0.86 mgd.
These machines are hydraulically capable of handling up to 1.41 mgd with minor alterations to the orfices.

One (1) 60' 0 x 3'-6" depth of stone Bio-Filter, 24" 0 turn table with two (2) fabricated double compartment arms equivalent to four 8" 0 pipe arms. Maximum design flow 2.48 mgd.
This machine is hydraulically capable of handling up to 3.6 mgd with minor alterations to the orfices.

All three of the turntables were rebuilt in 1966.

Just a word of caution on increasing the design flow on these units. As you increase the maximum flow you also will increase the head loss through the distributor. Also as you increase the flows you will increase the dosing rate which already appears to be fairly high.

Should you require a check on the head loss in each distributor, Mr. Alford, I can calculate this for you if you will furnish me the maximum and minimum design flow the distributors will be required to operate under.

Please give me a call if you require any additional information or have any questions.

Very truly yours,

DORR-OLIVER INCORPORATED

Jack L. Wander, Regional Manager
WATER MANAGEMENT SYSTEMS - SALES

JWL:sm

International Headquarters
Stamford, Conn. 06904, USA

101

Appendix E

CALIFORNIA'S STANDARDS FOR THE SAFE DIRECT USE OF RECLAIMED WASTE WATER FOR IRRIGATION AND RECREATIONAL IMPOUNDMENTS AND LAND DISPOSAL OF LIQUID DIGESTED SLUDGE ON AIR FORCE INSTALLATIONS.

STATEWIDE STANDARDS FOR THE SAFE DIRECT USE OF RECLAIMED WASTE WATER FOR IRRIGATION AND RECREATIONAL IMPOUNDMENTS

An Excerpt From the

CALIFORNIA ADMINISTRATIVE CODE

TITLE 17—PUBLIC HEALTH

May, 1968

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC HEALTH

2151 Berkeley Way

BERKELEY, CALIFORNIA 94704

Group 12. Statewide Standards for the Safe Direct Use of Reclaimed Waste Water for Irrigation and Recreational Impoundments

Article 1. Intent of Standards

8025. Intent. The intent of these standards is to prescribe levels of waste water constituents which will assure that the practice of directly using reclaimed waste water for the specified purposes does not impose undue risks to public health. Experience indicates that with sufficient treatment of waste waters, their use for the purpose specified is without known health hazard. In order to avoid health hazards, adequate and reliable treatment and distribution facilities, operations, controls, surveillance, and monitoring systems must be included in any operation which uses reclaimed waste water. Precautions must also be taken to avoid direct public contact with reclaimed waste waters which do not meet at least the standards specified in Article 6 for unrestricted recreational impoundments.

NOTE: Authority cited for group 12: Section 102, Health and Safety Code. Reference: Section 13521, Water Code.

History: 1. New Group 12 (Sections 8025 through 8050) filed 5-20-68; effective thirtieth day thereafter (Register 68, No. 20).

Article 2. Definitions

8026. Reclaimed Waste Water. Reclaimed waste waters means waters, originating from sewage or other waste, which have been treated or otherwise purified so as to enable direct beneficial reuse or to allow reuse that would not otherwise occur.

8027. Direct Reuse. Direct reuse means the use of reclaimed waste water transported from the point of production to the point of use without an intervening discharge to waters of the State.

8028. Produce. Produce means any food for human consumption which may be used in its raw or natural state without physical or chemical processing sufficient to destroy pathogenic organisms.

8029. Spray Irrigation. Spray irrigation means application of reclaimed waste water from orifices in piping installed above or along the ground.

8030. Surface Irrigation. Surface irrigation means application of reclaimed waste water by means other than spraying such that contact between the edible portion of any food crop and reclaimed waste water is prevented.

8031. Oxidized Waste Water. Oxidized waste water means waste water in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen.

8032. Coagulated Waste Water. Coagulated waste water means oxidized waste water in which finely divided suspended matter has been agglomerated by the addition of a suitable chemical or by an equally effective method.

8033. Filtered Waste Water. Filtered waste water means coagulated waste water which has been passed through natural undisturbed soils or filter media, such as sand or diatomaceous earth, so that the final turbidity determined by an approved laboratory method does not exceed ten (10) Turbidity Units.

8034. Disinfected Waste Water. Disinfected waste water means waste water in which the pathogenic organisms have been destroyed by chemical, physical, or biological methods.

8035. Most Probable Number. Most Probable Number is a statistical expression of the most likely number of bacteria present in a unit volume of sample, and which is determined by an approved laboratory method.

8036. Primary Effluent. Primary effluent is the effluent from a sewage treatment process which provides partial removal of sewage solids by physical methods so that it does not contain more than one (1) milliliter per liter of settleable solids as determined by an approved laboratory method.

8037. Approved Laboratory Methods. Approved laboratory methods are those specified in "Standard Methods for the Examination of Water and Wastewater," prepared and published jointly by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation and which are conducted in laboratories approved by the State Department of Public Health.

8038. Restricted Recreational Impoundment. A restricted recreational impoundment is a body of water in which recreation is limited to fishing, boating, and other non-body-contact water sport activities.

8039. Non-Restricted Recreational Impoundment. A non-restricted recreational impoundment is a body of water in which no limitations are imposed on body-contact water sport activities.

8040. Landscape Impoundment. A landscape impoundment is a body of water which is used for esthetic enjoyment or which serves a function not intended for public contact.

Article 3. Irrigation of Produce

8041. Spray Irrigation. Reclaimed waste water used for the spray irrigation of produce shall be at all times an adequately disinfected filtered waste water. The waste water shall be considered adequately disinfected if the median Most Probable Number of coliform organisms in samples collected from the irrigation piping does not exceed two and two-tenths (2.2) per one hundred (100) milliliters. The median value shall be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

8042. Surface Irrigation. (a) Reclaimed waste water used for surface irrigation of produce shall be at all times an adequately disinfected oxidized waste water. The waste water shall be considered adequately disinfected if at some point in the treatment process the median Most Probable Number of coliform organisms does not exceed two and two-tenths (2.2) per one hundred (100) milliliters. The median value shall be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

(b) Orchards and vineyards may be surface irrigated with reclaimed waste water that has the quality at least equivalent to that of primary effluent provided that no fruit is harvested that has come in contact with the irrigating water or the ground.

Article 4. Irrigation of Fodder, Fiber, Seed, and Processed Food Crops

8043. Fodder, Fiber, Seed. Reclaimed waste water used for the surface or spray irrigation of fodder, fibre, and seed crops shall have the quality at least equivalent to that of primary effluent.

8044. Food Crops. (a) Reclaimed waste water used for the surface irrigation of food for human consumption which will be processed sufficiently by physical or chemical methods to destroy pathogenic organisms shall have the quality at least equivalent to that of primary effluent.

(b) Reclaimed waste water used for the spray irrigation of food for human consumption which will be processed sufficiently by physical or chemical methods to destroy pathogenic organisms shall be at all times an adequately disinfected oxidized waste water. The waste water shall be considered adequately disinfected if at some point in the treatment process the Most Probable Number of coliform organisms of samples collected does not exceed a median of twenty-three (23) per one hundred (100) milliliters. The median value shall be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

8045. Pasture for Milking Animals. Reclaimed waste water used for the irrigation of pasture to which milking cows or goats have access shall have the quality and sampling control program as specified in Article 5, Section 8046.

Article 5. Landscape Irrigation

8046. Landscape Irrigation. Reclaimed waste water used for the irrigation of golf courses, cemeteries, lawns, parks, playgrounds, freeway landscapes, and landscapes in other areas where the public has access shall be at all times an adequately disinfected oxidized waste water. The waste water shall be considered adequately disinfected if at some point in the treatment process the median Most Probable Number of coliform organisms does not exceed twenty-three (23) per one hundred (100) milliliters of sample. The median value will be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

Article 6. Recreational Impoundments

8047. Non-Restricted Recreational Impoundment. Reclaimed waste water used as a source of supply in a non-restricted recreational impoundment shall be at all times an adequately disinfected filtered waste water. The waste water shall be considered adequately disinfected if at some point in the treatment process the median Most Probable Number of coliform organisms does not exceed two and two-tenths (2.2) per one hundred (100) milliliters. The median value shall be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

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8048. Restricted Recreational Impoundment. Reclaimed waste water used as a source of supply in a restricted recreational impoundment shall be at all times an adequately disinfected oxidized waste water. The waste water shall be considered adequately disinfected if at some point in the treatment process the median Most Probable Number of coliform organisms does not exceed two and two-tenths (2.2) per one hundred (100) milliliters. The median value shall be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

8049. Landscape Impoundment. Reclaimed waste water used as a source of supply in a landscape impoundment shall be at all times an adequately disinfected oxidized waste water. The waste water shall be considered adequately disinfected if at some point in the treatment process the median Most Probable Number of coliform organisms does not exceed twenty-three (23) per one hundred (100) milliliters. The median value shall be determined from the bacteriological results of the last seven (7) days for which analyses have been completed.

Article 7. Sampling and Analysis

8050. Sampling and Analysis. (a) Samples for analysis shall be collected at least daily and at a time when waste water flow and characteristics are most demanding on the treatment facilities and disinfection procedures.

(b) For uses requiring a quality at least equivalent to primary effluent, a sample shall be analyzed by an approved laboratory method for settleable solids.

(c) For uses requiring an adequately disinfected oxidized waste water, a sample shall be analyzed by an approved laboratory method for coliform bacteria content.

(d) For uses requiring an adequately disinfected filtered waste water, a sample shall be analyzed by approved laboratory methods for turbidity and coliform bacteria content.

USAF ENVIRONMENTAL HEALTH LABORATORY (AFLC)

UNITED STATES AIR FORCE

KELLY AFB, TEXAS 78241

FEASIBILITY OF LAND DISPOSAL OF LIQUID DIGESTED SLUDGE ON AIR FORCE INSTALLATIONS

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I. INTRODUCTION

The common method of disposal of digested sludge in the Air Force today is by dewatering on sludge drying beds followed by ultimate disposal of the dried sludge in landfill areas. This disposal method requires the following operation:

1. Pumping the sludge onto drying beds.
2. Leaving the sludge on the beds until it is adequately dried.
3. Manually scraping and removing the dried sludge from the beds.
4. Loading the sludge onto dump trucks.
5. Hauling the sludge to landfill disposal areas.

Although sludge drying beds are more economical than many other sludge disposal methods such as vacuum filtration and incineration, they have the following disadvantages: (1) they require manual labor to remove the dried sludge, thus additional manpower, (2) sludge does not adequately dry in the winter months and in rainy seasons, (3) the fertilizer value of the sludge is lost, (4) periodic maintenance and renovation is required to insure liquid percolation, and (5) they have a high capital cost - 18 new sludge drying beds for McGuire AFB would cost approximately $100,00C.

Land disposal of liquid digested sludge has been extensively practiced in the United States and in other countries throughout the world. Disposal of sludge by this method reduces sludge handling to a minimum, utilizes the fertilizer value of the sludge, and requires minimum capital costs. This report presents the Public Health and Engineering aspects of land disposal of liquid sludges along with specific recommendations for this disposal method on Air Force Bases.

II. PUBLIC HEALTH ASPECTS OF LAND DISPOSAL OF LIQUID DIGESTED SLUDGE

A recent FWPCA report[1] indicates that adequate digestion is almost always required before disposing of liquid sewage sludge. One of the reasons for this is to destroy nuisance causing constituents such as complex odorous compounds and pathogenic and parasitic organisms.[2] Fair and Geyer[3] state that pathogenic bacteria, viruses, protozoa (cysts), and worms (eggs) can survive sewage treatment and be included in the sludge. There they will persist for a long time and cannot be fully destroyed by digestion or air drying. Although the numbers of surviving organisms decrease appreciably in the normal course of events, only heat dried sludge can be considered fully safe. Because of this the public health aspects of land disposal of liquid sludge must be considered before applying it throughout the Air Force.

The control of pathogens in sewage treatment is based on stimulating competition between the pathogens and the saprophytes and adjusting the environment so that the saprophytes are in a better competitive position.[4] In sludge digestion a decrease in pathogens is obtained since they cannot compete successfully with the bacteria responsible for active digestion. However, all pathogens will not be completely destroyed. As an example, *Salmonella typhosa* obtains sufficient tryptophan in an anaerobic digester to sustain life at a slowly decreasing level for a long period. McKinney and Howell[5] have shown that the population of *S. typhosa* which was innoculated into a digester decreased 92.4% for a 20 day digestion time. It is interesting to note that the Boston sewage sludge used in their experiments did not contain sufficient numbers of enteric bacteria for quantitative enumeration before and after digestion. Some conclusions of this study were that addition of large quantities of enteric bacteria to anaerobic digesters with variable detention periods results in a rapid die-off of the enteric bacteria and high rate digestion of sewage sludge with retention periods between 6 and 20 days should not result in a significant increase in the health hazard from enteric bacteria.

According to the FWPCA report,[1] a study of Escherichia coli in primary sludge digestion showed that they survive for 7 weeks at 37°C and for 2 weeks at 22°C. The coli organisms disappeared because of competition from other microorganisms better adapted to the digestion environment. The report further states that disease organisms such as typhoid-dysentery bacilli, polio virus, anthrax, ova of parasitic worms and Brucella have been thought to have a rapid mortality rate due to their sensitivity to the unacceptable digestion environment. One study where raw and digested sludges were exposed to 55°C for 2 hours resulted in 100% destruction or inactivation of Ascaris lumbricoides ova. It was also reported that thermophilic digestion for 24 hours destroyed all ova of parasitic worms and cysts of amoebae parasitic to man.

The opinion has been expressed by numerous people that there is no record of disease transmission to humans as a result of using the sludge as a fertilizer.[1] This good record may be a reflection of various health department regulations. The Ontario Water Resources Commission restricts the use of sludge fertilizer to crops that are cooked before consumption. However, California has adapted regulations allowing the use of sludge for fertilizing vegetables, berries and low growing fruit as long as the sludge has been digested for 30 days, is practically odorless, drains readily, and has a volatile solids concentration less than 50%.

III. ENGINEERING ASPECTS OF LAND DISPOSAL OF LIQUID DIGESTED SLUDGE

A survey of consulting engineers and state pollution control agencies[1] revealed that disposal of liquid digested sludge to open land surfaces is very common among smaller waste treatment plants. MacLaren considered land disposal of liquid sludge to be applicable to all plants serving less than 50,000 persons. Large cities such as New York, San Diego and Miami Beach have also used this technique of sewage sludge disposal in conjunction with land reclamation projects. In England the disposal of liquid sludge to farmland is very popular. The process is often economically attractive because it eliminates the costly solids-liquid separation step.

Liquid digested sludge along with supernatant liquid are being applied to land for final disposal to fertilize grass and agricultural crops and to condition soils on sandy parkland. These operations have been satisfactory with few exceptions. The success of this disposal method depends on availability of suitable land close to the waste treatment plant.

Sludge is distributed on the land and processed in a variety of ways. Treatment at small plants may include only digging of shallow trenches, filling them with liquid digested sludge, and covering the sludge with soil to prevent nuisance conditions. Sludge may be pumped or gravity fed by pipeline to agricultural fields or land to be reclaimed. At some orchards, the liquid sludge is injected into the topsoil under pressure. A very common technique is disposal of liquid digested sludge directly to land by spraying from tank wagons having a capacity of 1000 gallons.

Studies at San Diego, California, have generated significant performance data concerning liquid sludge disposal.[1] The following conclusions were made as a result of these studies: (1) liquid sludge can be used to reclaim wasteland for agricultural purposes at a lower cost than heat dried sewage sludge, (2) sludge can be applied at a rate of 100 tons/acre without impairing the growth of crops, (3) applying the sludge at a rate of 25 tons/acre achieves a crop growth rate equal to that of commercial fertilizer applied at conventional rates, (4) superior crops can be obtained over a two year period at a sludge dosing rate of 50 tons/acre without applying sludge the second year, and (5) liquid land disposal can be achieved without serious handling or nuisance problems. The San Diego studies demonstrate the usefulness of liquid sludge as a fertilizer for agricultural crops, grasses and shrubs, and as a soil conditioner for relatively sterile dredged sand.

In New York City land proposed for future parks has been reclaimed by spreading liquid sludge in place of natural topsoil. In 1956, 5 million cubic feet of liquid digested sludge were sprayed on landfill areas prior to addition of topsoil. The sludge was also used on sandy tidal areas devoted to a bird sanctuary. These land sludge disposal operations were satisfactory both on the basis of cost and performance.

There is no doubt that liquid digested sludge is excellent as a fertilizer according to Dalton et al.[6] Well digested sludge is approximately 3% solids, 98% water, and is rich in nitrogen, phosphorous and potassium - the three basic elements necessary for vigorous plant growth. Separation of the sludge components into liquid and solid states shows that the liquid (water) contains only a small portion of the nitrogen and phosphorous but a large amount of the potassium, while the solids portion contains most of the nitrogen and phosphorous but only a small portion of the potassium. The great advantage of applying the solids via the water vehicle is that water will not only serve for irrigation, but also will allow the complete fertilizer content to remain. This would not be the case if the sludge were applied in a dry form.

Coker[7] assessed the effects of liquid digested sludge on the growth of grass and barley. In a well-designed experiment, the yield from the fields fertilized with sludge gave increases in organic matter similar to those obtained using equivalent nutrient dosages of artificial fertilizer. No adverse toxicological effects appeared, even though the sludge contained significant levels of heavy metals.

In a 1968 Water Pollution Control Federation literature review a resurgence of land application of sludge in the liquid form has been noted.[8] Dalton et al[6] and Bacon[9] described the Chicago Metropolitan Sanitary District's search for a solution to their present disposal problems which would be low in cost, not produce air, water or land pollution, obtain a beneficial use of sludge constituents and solve the problem in perpetuity. Application of liquid digested sludge to agricultural lands was thought to meet these criteria. These papers also cited cities which currently dispose of sludge by this method and described the studies sought by the sanitary district to gain additional insight into this method of sludge disposal.

Some cities sell liquid digested sludge to private groups. Others less fortunate must give it away or must even pay someone to haul it off the treatment plant property. A few examples of these situations have been reported: (1) Orlando, Florida, sells liquid digested sludge to fruit growers for $1.00 per 1000 gallons, (2) two northwestern cities sell the liquid sludge for $2.00 - $10.00 per 1000 gallons, (3) in California liquid sewage sludge is often blended with other materials and sold as fertilizer - the sludge is usually given free of charge to commercial fertilizer companies or sold at a cost less than $2.00 per dry ton, (4) Olympia, Washington, is paid $4.00 per ton and Chehalis, Washington, $10.00 per ton for liquid sludge, (5) some cities and industries in the Midwest pay $7.00 - $10.00 per 1000 gallons to have the waste sludge hauled to disposal sites.

In summary, disposal of liquid digested sludge on land areas is quite popular in the United States and foreign countries. Basically the reasons for this popularity are simplicity and economy. A close look at the advantages reveals[1]:

1. The process represents final disposal because the sludge is normally hauled off the treatment plant grounds by someone assuming responsiblity for the material.

2. The sludge is useful as a soil conditioner and fertilizer therefore often can be sold for $1.00 - $10.00 per 1000 gallons.

3. Small capital investment is required particularly if a contract for hauling is negotiated.

4. Complex mechanical operation and the use of chemicals is avoided.

5. Related to item 4, solids-liquid separation processes can be eliminated, thereby improving treatment plant economics and efficiency. Overall treatment plant efficiency is improved because there is no need for sludge elutriation and dewatering steps which usually recycle fine sludge solids through the treatment processes.

This method of sludge disposal should be extremely useful on Air Force bases since hauling distances to disposal areas are minimal. During winter months when golf courses and outdoor recreational areas are not in use, digested sludge could be spread on these areas. This practice should produce some of the greenest fairways in the country. Any major construction on Air Force bases involving significant landscaping could use liquid digested sludge as a fertilizer and soil conditioner.

Most Air Force bases are located in rural areas. Neighboring farmers and ranchers should be amenable to picking up liquid digested sludge from Air Force treatment plants for use on their lands. At times when the above cannot be accomplished, liquid digested sludge could be disposed of directly on remote areas of the base, on the sides of base roads, and on the sides of runways. In these cases, assistance may have to be given to Roads and Grounds in that an additional gang mower may need to be purchased to keep the grass trimmed in these areas.

If digested sludge were to be used in habitated areas, housing areas, to insure completely safety concerning the public health aspects, the liquid digested sludge should be chlorinated. The FWPCA report[1] shows chlorine costs from $11.00 to $60.00 per dry ton of solids depending on chlorine dose and contact time.

IV. CONCLUSIONS

1. Land disposal of liquid digested sludge is an extremely attractive method for sludge disposal from Air Force installations.

2. This disposal method requires minimal capital and operating costs.

3. This method is an ultimate disposal method which reduces sludge handling to a minimum thereby markedly simplifying sewage treatment plant operation.

4. Applying liquid digested sludge to new development areas as a soil conditioner and fertilizer, to large recreational areas such as golf courses and parks during off-use winter months, and to remote areas of the base will not endanger the health of Air Force personnel.

5. If liquid digested sludge is to be used in habitated areas, chlorination of the sludge must be practiced.

6. The Air Force has continually assumed its role of leadership in water pollution abatement (Executive Order 11288) as evidenced by the following actions:

a. Combined treatment of industrial wastes with domestic sewage on Air Force installations throughout the country, thus eliminating the need for expensive and difficult to operate chemical treatment plants.

b. Advanced treatment with water reuse by using chlorinated sewage treatment plant effluent for golf course irrigation (now under design at McGuire AFB, NJ).

c. A new secondary treatment system (aerated lagoon) to produce a high quality effluent with minimal operation and minimal capital costs (now under design at Travis AFB CA).

The Air Force should continue its role of leadership in waste treatment and water pollution abatement by adding to the above list land disposal of liquid digested sludge.

V. RECOMMENDATIONS

1. In lieu of constructing additional sludge drying beds and renovating existing drying beds on Air Force installations, land disposal of liquid digested sludge should be practiced.

2. Land disposal can be accomplished on Air Force bases in the following manner:

a. Use liquid digested sludge as a soil conditioner and fertilizer in new construction areas requiring large amounts of landscaping.

b. Use liquid digested sludge as a fertilizer and soil conditioner on golf courses and other large outdoor recreational areas in the off season when these facilities are not utilized.

c. When the above methods cannot be utilized for on base disposal, dispose of liquid digested sludge off base or on remote areas of the base. An additional gang mower may be needed to keep grass trimmed on remote areas of the base.

3. For Air Force bases located in rural areas, the possibility of disposing of liquid digested sludge on neighboring farm and pasturelands should be investigated.

4. Before using liquid digested sludge in habitated areas, such as base housing areas, disinfect the sludge by chlorination to minimize danger to the public health.

VI. BIBLIOGRAPHY

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Appendix F

AUTHORITY FOR SURVEY

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE LOGISTICS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: MCDPE/76231 22 April 1969

SUBJECT: FY 70 MCP, Sewage Treatment and Disposal, George AFB

TO: USAF Environmental Health Laboratory, Kelly (HKG)
Kelly AFB TX 78241

1. Request qualified personnel from your organization be placed on TDY to determine the adequacy of the FY 70 MCP project described on the DD Form 1391, and whether additional work is required to provide adequate sewage treatment at George AFB. Direct communication is authorized to establish mutually agreeable dates for the survey. Personnel performing the survey will be considered as serving on the staff of the Surgeon, 831 TAC Hospital, George AFB, during this period of TDY.

2. It is a sincere pleasure to pass on to you the expression of appreciation extended by the Regional Civil Engineer, Western Region, on the excellent service rendered them by your Laboratory. Your continued high standards of performance are a credit not only to the Laboratory, but to the entire Air Force.

FOR THE COMMANDER

H G Wallace

H. G. WALLACE, Colonel, USAF, MC
Surgeon

1 Atch
Ltr, 11 Apr 69,
fr AFOCEHW-B,
subj as above, w/1
atch n/c

Cy to
AFOCEHW-B
831 TAC Hosp (SG),
George AFB CA 92393