
# SEWAGE TREATMENT

## CONSTRUCTION AND OPERATION COSTS

## INTERSTATE SANITATION COMMISSION - NEW YORK HARBOR

# SEWAGE TREATMENT PLANT COSTS

FEDERAL WORKS AGENCY

WORK PROJECTS ADMINISTRATION
FOR THE CITY OF NEW YORK

REPORT OF OFFICIAL PROJECT NO. 665-97-3-99

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# SEWAGE TREATMENT PLANT
# COSTS

# INTRODUCTION

## REASONS FOR MAKING STUDY

Whenever it is necessary for a municipality to construct a sewage treatment plant, one of the first questions raised by the tax payer relates to the cost of constructing and operating such works. The cost of sewage treatment plants, both in construction and operation, varies through very wide limits depending upon the methods used and whether or not there is only a partial or a complete purification of sewage. The particular methods used for the treatment of the sewage in any municipality depend upon the size of the municipality, the quantity of water available for dilution in the waterway, and the improvements in the condition of the water which are required. For example: Where a sewage treatment plant is so located that it is only necessary to remove most of the solid contents and the bacteria for the protection of some bathing beach situated perhaps on Long Island Sound several miles away, a much simpler plant can be used than if the treated sewage were discharged into a comparatively small stream, possibly used as recreational areas and for bathing and swimming.

In the Interstate Sanitation District there is a wide variety of sewage treatment plants. Most of them are for partial treatment of the sewage only. A study of these plants has been made for the purpose of supplying to the Interstate Sanitation Commission actual cost data for plants constructed in the district.

The only way in which this information can be obtained is from municipal records where sewage treatment plants have been constructed and sewage is being treated at the present time. Unfortunately, there is no standard method by which sewage treatment plant costs are segregated in the various municipal accounts.

For this reason, it is sometimes difficult to obtain the cost of constructing a sewage treatment plant alone as the original bond issue may have included a sewer system, trunk sewers, or other appurtenances as well as a sewage treatment plant. For the purpose of municipal accounting the bond issue is usually considered as a unit, without allocating part of this bond issue to the sewer system and part to the sewage treatment plant. It is probable that some of the wide differences found in the tables accompanying this report are due to the above causes.

## SCOPE OF THE WORK

In the Interstate Sanitation District there are approximately sixty sewage treatment plants. It was the endeavor of the project workers to obtain data for all of these, but in some cases the information was of such doubtful value or so incomplete that it has not been included in the final tabulations. One or two of the plants from which reports were obtained are not situated in the Interstate Sanitation District, but are located in the immediately adjoining areas.

## PLAN OF OPERATION

Project workers visited various municipalities where sewage treatment plants were in operation. From the municipal officials the required financial data was obtained, usually, from public records and annual departmental reports. This data was supplemented by obtaining information relative to sewage flow, population, and construction data supplied by the Commissioner of Public Works or some other official in charge at the sewage treatment plant. In some instances where plants had been constructed for a long period of time, it was difficult to obtain a clear statement of the facts. In other cases, as indicated above, it was not possible to obtain figures relating to the cost of constructung sewage treatment plants as other work had

been included in the contracts. After obtaining the data, the plant was visited in order to obtain a description of the units of which the plant was composed and to obtain any physical data which was missing from the record. At the same time a field sketch was made showing a plan of the works which was later used to draft a flow diagram to accompany the report on costs. A separate report has been compiled for each of the plants visited. In the appendix of this report will be found the field forms used in obtaining the required information.

All of the cost data has been assembled in tables, by groups in each of which the method of sewage treatment is practically the same.

## CHARACTER OF DATA

As the data relative to the cost of constructing and operating sewage treatment plants were to be tabulated for report purposes it was deemed advisable to consider this information as of a confidential nature. This is because of the fact that in collecting data of this character, it is found that the conditions are never standard, but vary over extremely wide ranges because of local conditions. Invidious and unjust comparisons could be made from figures used in the study. Therefore, each plant for which information was obtained was given an identification number and this has been used throughout the report.

## DETAIL DATA

This report includes only a summary of the figures which were obtained. The detailed data for each plant, together with the flow diagram and description of the purification process has been transmitted to the sponsors for their records. Copies of the forms used in collecting field data will be found in the appendix of this report. Any information taken from this report

should be used with the greatest circumspection unless additional detailed field data for each particular plant is obtained. This detailed data will often clearly show the reasons why the cost at particular places vary so widely from the average figures which have been derived from a consideration of all plants of the same general character.

## DIFFERENCES BETWEEN THE PLANTS

Even where sewage treatment plants are of the same general character as regards to the method of treating sewage used they often differ very widely in supplementary and costly items which are not necessarily part of the treatment process itself. As an example of this fact, we find that in some cases very elaborate and expensive buildings have been constructed to house the sewage treatment processes, while in other cases the buildings are of a simple, substantial, and inexpensive type of construction.

It has not alwyas been easy, in compiling data, to accurately place some of the plants in the categories used in grouping them. This is due to the fact that some of the plants are more complicated than others in order to insure the least difficulty with neighbors under peculiarly disadvantageous conditions and the treatment processes are sometimes specially augmented.

## CLASSIFICATION OF SEWAGE TREATMENT PLANTS

The following classification of sewage treatment plants has been used in compiling this information.

TABLE I

| | |
|---|---|
| Group I | Screening Plants |
| Group II | Screening and Chlorination Plants |
| Group III | Sedimentation Plants |
| Group IV | Sedimentation and Chlorination Plants |

| | |
|---|---|
| Group V | Sedimentation and Chemical Precipitation Plants |
| Group VI | Sedimentation, Chemical Precipitation, and Magnatite Filter Plants |
| Group VII | Activated Sludge Plants |
| Group VIII | Activated Sludge Plants with Final Filtration |
| Group IX | Sedimentation and Sand Filters |

DIFFERENT SEWAGE TREATMENT METHODS USED

Due to the large bodies of water available for the dilution of treated sewage in the Interstate Sanitation District most of the plants investigated were found to consist only of primary treatment processes. In a few cases, where municipalities were situated inland, where small rivers or creeks only were available for the reception of the final purified sewage, types of sewage treatment plants were found discharging a highly purified effluent. Sewage treatment plants vary extensively, primarily, because of the amount of water into which the treated sewage is eventually discharged. The effluent from a sewage treatment plant may in the case of the screening plant consist of a soapy appearing water in which solids of larger diameter than a sixteenth of an inch only have been removed. At such a plant, approximately ten percent of the solid material in sewage is thus removed. From this condition, all variations of treatment will be found depending upon the type of sewage treatment processes used, until at the other extreme, effluents are often produced which are as clear as drinking water and which have a very low bacterial content. Naturally the higher the degree of purification of the sewage the greater are the costs both for construction and operation of the sewage treatment plant. The more costly type of plant is usually constructed only where it is necessary for the protection of municipal water supplies nearby recreation areas and shellfish beds or to protect high value real estate areas.

## SEWAGE TREATMENT COSTS

In the following TABLE 2, there is given in summary form, data showing the costs of constructing and operating sewage treatment plants. The information collected with reference to some types of plants was of such a limited character that no average figures of costs for the type could be ascertained. In other cases, whether or not it is due to the location of the sewage treatment plants in a metropolitan area, the average costs of construction and operation appear to be inordinately high. In preparing this table the cost of land required for the sewage treatment plant has been eliminated from the construction costs.

TABLE 2

| Plant No. | Present Population | Connected Population | M.G.D. Design Basis | M.G.D. Average Flow | Total Construction Cost of Plant Excl. of Land | Construction Cost of Plant Excl. of Land Per. M.G.D. Design Basis | Construction Cost of Plant Excl. of Land Per. M.G.D. Treated | Construction Cost of Plant Excl. of Land Per Capita | Total Operating Cost | Operating Cost Per M.G. Treated | Operating Cost per Capita Per Annum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SCREENS - GROUP #1 | | | | | | | | | | | |
| 49 | 61,000 | 61,000 | 26.0 | 8.1 | $440,000.00 | $ 16,923.07 | $ 56,410.25 | $ 7.21 | $ 40,000.00 | $14.05 | $ 0.66 |
| 50 | 42,000 | 42,000 | 15.0 | 6.1 | Not Available | | --- | --- | 13,000.00 | 5.09 | 0.31 |
| Average | --- | --- | --- | --- | --- | --- | --- | --- | --- | $ 9.57 | $ 0.49 |
| SCREENS & CHLORINATION - GROUP #2 | | | | | | | | | | | |
| 11 | 260,000 | 260,000 | 96.0 | 23.0 | $1,012,551.54 | $ 10,547.41 | $ 44,023.98 | $ 3.98 | $ 41,084.84 | $ 4.90 | $ 0.16 |
| 14 | 285,000 | 260,000 | 60.0 | 30.0 | 512,835.00 | 8,547.25 | 17,094.50 | 1.97 | 103,900.00 | 9.49 | 0.40 |
| 27 | 360,000 | 325,000 | 70.0 | 36.0 | 61,995.00 | 885.64 | 1,772.08 | 0.19 | 101,000.00 | 7.69 | 0.31 |
| 40 | 200,000 | 200,000 | 60.0 | 12.5 | 1,413,832.88 | 23,563.88 | 113,106.63 | 7.07 | 27,002.40 | 5.92 | 0.13 |
| 43 | 10,000 | 9,000 | 12.0 | 0.75 | 153,000.00 | 12,750.00 | 204,000.00 | 17.00 | 19,272.33 | 70.40 | 2.14 |
| 44 | 40,000 | 40,000 | 48.0 | 7.0 | 724,881.00 | 15,101.69 | 103,554.47 | 18.12 | 58,286.05 | 22.81 | 1.46 |
| 58 | 2,500 | 1,500 | 2.0 | 1.25 | 34,550.00 | 17,235.00 | 27,640.00 | 23.03 | 9,029.89 | 19.79 | 6.02 |
| Average | 165,358 | 156,500 | 49.71 | 15.77 | 559,092.25 | 12,661.55 | 73,027.39 | 10.19 | 51,367.93 | 20.14 | 1.51 |
| The elimination of the following treatment plants in this group from the average computation was deemed advisable because of inadequate information. | | | | | | | | | | | |
| 32 | 61,619 | 61,619 | ---- | 8.2 | 554,775.64 | ---- | 67,653.12 | 9.00 | 29,221.22 | 9.76 | 0.47 |
| 24 | 39,000 | 39,000 | 40.0 | 5.0 | ---- | ---- | ---- | ---- | 45,000.00 | 24.66 | 1.15 |
| 48 | 3,200 | 3,200 | ---- | --- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

TABLE 2 (Cont'd)

| Plant No. | Present Population | Connected Population | M. G. D. Design Basis | M. G. D. Average Flow | Total Construction Cost of Plant Excl. of Land | Construction Cost of Plant Excl. of Land Per M. G. D. Design Basis | Construction Cost of Plant Excl. of Land Per M. G. D. Treated | Construction Cost of Plant Excl. of Land Per Capita | Total Operating Cost | Operating Cost per M. G. Treated | Operating Cost Per Capita Per Annum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEDIMENTATION - GROUP #3 | | | | | | | | | | | |
| 28 | 300,000 | 300,000 | 172.5 | 26.28 | $1,188,000.00 | $ 6,886.96 | $45,205.48 | $3.96 | $79,274.00 | $ 8.26 | $0.26 |
| SEDIMENTATION & CHLORINATION - GROUP # 4 | | | | | | | | | | | |
| 2 | 5,000 | 1,600 | 0.8 | 0.325 | $ 50,000.00 | $ 62,500.00 | $153,846.15 | $31.25 | $ 2,222.00 | $18.73 | $1.39 |
| 3 | 5,750 | 5,750 | 1.5 | 0.35 | 122,800.00 | 81,866.66 | 350,857.14 | 21.35 | 14,000.00 | 109.58 | 2.43 |
| 5 | 4,000 | 4,000 | 1.0 | 0.48 | 36,817.00 | 36,817.00 | 76,702.08 | 9.20 | 4,816.62 | 27.49 | 1.20 |
| 10 | 3,500 | 2,500 | 3.5 | 0.7 | 182,000.00 | 52,000.00 | 260,000.00 | 72.80 | 15,440.00 | 60.43 | 6.18 |
| 15 | 6,500 | 6,500 | 1.5 | 1.0 | 111,627.00 | 74,418.00 | 111,627.00 | 17.17 | 7,305.00 | 20.01 | 1.12 |
| 16 | 12,000 | 10,000 | 1.0 | 1.5 | 412,450.00 | 412,450.00 | 274,966.66 | 41.25 | 19,900.34 | 26.35 | 1.99 |
| 17 | 3,600 | 3,000 | 1.0 | 0.3 | 83,000.00 | 83,000.00 | 276,667.00 | 27.67 | 4,303.00 | 39.30 | 1.42 |
| 18 | 6,000 | 6,000 | 1.5 | 1.0 | 60,000.00 | 40,000.00 | 60,000.00 | 10.00 | 18,000.00 | 49.32 | 3.00 |
| 19 | 6,500 | 3,000 | 1.0 | 0.4 | 140,000.00 | 140,000.00 | 350,000.00 | 46.67 | 17,992.42 | 123.23 | 6.00 |
| 20 | 14,000 | 10,000 | 1.8 | 0.95 | 260,000.00 | 144,444.44 | 273,684.00 | 26.00 | 15,600.00 | 44.99 | 1.56 |
| 22 | 10,000 | 8,000 | 2.0 | 0.8 | 110,000.00 | 55,000.00 | 137,500.00 | 13.75 | 8,940.00 | 30.61 | 1.12 |
| 26 | 25,000 | 24,750 | 1.5 | 2.5 | 253,000.00 | 168,666.67 | 101,200.00 | 10.22 | 13,310.00 | 14.59 | 0.54 |
| 29 | 60,000 | 51,300 | 27.0 | 7.03 | 416,000.00 | 16,840.00 | 59,259.26 | 10.64 | 17,673.00 | 13.68 | 0.90 |
| 30 | 7,000 | 2,000 | 1.0 | 0.25 | 22,000.00 | 22,000.00 | 88,000.00 | 11.00 | 1,760.00 | 19.29 | 0.88 |
| 47 | 3,000 | 3,000 | 0.5 | 0.2 | 26,000.00 | 52,000.00 | 130,000.00 | 8.67 | 1,970.75 | 27.00 | 0.66 |

TABLE 2 (Cont'd)

| Plant No. | Present Population | Connected Population | M.G.D. Design Basis | M.G.D. Average Flow | Total Construction Cost of Plant Excl. of Land | Construction Cost of Plant Excl. of Land Per M.G.D. Design Basis | Construction Cost of Plant Excl. of Land Per M.G.D. Treated | Construction Cost of Plant Excl. of Land Per Capita | Total Operating Cost | Operating Cost Per M.G. | Operating Cost per Capita Per Annum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | 6,400 | 6,400 | 0.8 | 1.75 | $100,000.00 | $125,000.00 | $ 57,142.86 | $15.62 | $ 7,756.00 | $12.14 | $1.21 |
| Average | 11,142 | 9,238 | 2.8 | 1.22 | 149,106.00 | 97,925.00 | 172,602.00 | 23.33 | 10,686.00 | 39.79 | 1.98 |
| The elimination of the following treatment plants in this group from the average computation was deemed advisable because of inadequate information. | | | | | | | | | | | |
| 9 | 75,000 | 45,000 | 3.0 | 2.7 | -- | -- | -- | -- | $21,935.00 | $22.26 | $ 0.48 |
| 21 | 3,000 | 1,235 | 0.5 | 0.13 | -- | -- | -- | -- | 3,573.56 | 75.32 | 2.89 |
| 23 | 1,877 | 1,408 | 1.2 | 0.35 | -- | -- | -- | -- | 6,300.00 | 49.31 | 4.47 |
| 41 | 2,000 | 1,800 | 0.6 | 0.2 | $80,000.00 | $133,333.33 | $400,000.00 | $44.44 | -- | -- | -- |
| 42 | 13,500 | 13,500 | 2.0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 45 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 51 | 2,834 | 2,834 | -- | -- | 128,000.00 | -- | -- | 44.46 | 1,180.00 | -- | 0.42 |
| SEDIMENTATION & CHEMICAL PRECIPITATION - GROUP 5 | | | | | | | | | | | |
| 7 | 23,000 | 15,000 | 3.0 | 1.48 | $ 177,811.00 | $ 59,270.00 | $120,122.00 | $11.85 | $18,021.35 | $33.36 | $1.20 |
| 33 | 150,000 | 145,000 | 35.0 | 20.0 | 1,868,000.00 | 53,371.43 | 93,400 | 12.88 | 89,000.00 | 12.19 | 0.61 |
| Average | -- | -- | -- | -- | -- | $ 56,320.71 | $106,761.00 | $12.36 | -- | $22.77 | $0.90 |

TABLE 2 (Cont'd)

| Plant No. | present Population | Connected Population | M. G. D. Design Basis | M. G. D. Average Flow | Total Construction Cost of Plant Excl. of Land | Construction Cost of Plant Excl. of Land Per M. G. D. Design Basis | Construction Cost of Plant Excl. of Land Per M. G. D. Treated | Construction Cost of Plant Excl. of Land per Capita | Total Operating Cost | Operating Cost per M. G. Treated | Operating Cost Per Capita Per Annum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEDIMENTATION, CHEMICAL PRECIPITATION & MAGNETITE FILTERS - GROUP #6 | | | | | | | | | | | |
| 4 | 11,000 | 10.000 | 0.9 | 0.9 | $ 152,000.00 | $ 168,888.88 | $ 168,888.88 | $ 15.20 | $ 13,681.00 | $ 41.65 | $ 1.37 |
| 34 | 44,000 | 44,000 | 10.0 | 3.5 | Not Available | Not Available | ---- | ---- | 17,500.00 | 13.70 | 0.40 |
| Average | ---- | ---- | --- | --- | ---- | ---- | ---- | --- | ---- | $ 27.67 | $ 0.88 |
| ACTIVATED SLUDGE - GROUP #7 | | | | | | | | | | | |
| 25 | 125,000 | 125,000 | 40.0 | 12.0 | $ 3,833,000.00 | $ 95,825.00 | $ 319,416.00 | $ 30.66 | Not Available | | --- |
| *31 | 1,168,000 | 1,168,000 | 180.0 | 180.0 | 15,188,958.38 | 84,383.10 | 84,383.10 | 13.00 | *$349,432.62 | $ 5.32 | $ 0.30* |
| 35 | 7,200 | 7,200 | 2.0 | 1.2 | Not Available | Not Available | ---- | --- | Not Available | | |
| Average | ---- | ---- | --- | --- | ---- | $ 90,104.05 | $ 201,899.55 | $ 21.83 | ---- | | |
| ACTIVATED SLUDGE & FINAL FILTERS - GROUP #8 | | | | | | | | | | | |
| 6 | 11,000 | 8,000 | 1.0 | 0.76 | $ 132,289.00 | $ 132,289.00 | $ 174,064.00 | $ 16.54 | Not Available | | --- |
| 9 | 18,000 | 18,000 | 2.0 | 1.69 | 561,000.00 | 275,500.00 | 326,035.50 | 30.61 | Not Available | | --- |
| 39 | 8,500 | 8,000 | 0.75 | 0.75 | 410,000.00 | 546,666.66 | 546,666.66 | 51.25 | $ 29,410.00 | $107.43 | $ 3.68 |
| Average | ---- | ---- | --- | --- | ---- | $ 318,151.88 | $ 348,922.05 | $ 32.80 | ---- | --- | --- |

NOTE: 1. Plant #6. Final Filters are Sand Filters
2. Plant #9. Final Filters are Vacuum Filters
3. Plant #39. Final Filters are both Sand and Vacuum Filters

* Operating 6 Months

TABLE 2 (Cont'd)

| Plant No. | Present Population | Connected Population | M. G. D. Design Basis | M. G. D. Average Flow | Total Construction Cost of Plant Excl. of Land | Construction Cost of Plant Excl. of Land Per M. G. D. Design Basis | Construction Cost of Plant Excl. of Land Per M. G. D. Treated | Construction Cost of Plant Excl. of Land per Capita | Total Operating Cost | Operating Cost Per M. G. Treated | Operating Cost Per Capita Per Annum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SEDIMENTATION & SAND FILTERS - GROUP #9 | | | | | | | | | | | |
| 1 | 25,000 | 15,000 | 0.5 | 1.8 | $ 400,000.00 | $ 800,000.00 | $ 222,222.00 | $ 26.67 | $ 37,056.50 | $ 56.40 | $ 2.47 |
| 12 | 10,627 | 10,627 | 2.0 | 1.2 | 234,000.00 | 117,000.00 | 195,000.00 | 22.02 | 4,437.00 | 10.13 | 0.42 |
| 13 | 8,400 | 8,400 | 3.0 | 0.76 | 200,000.00 | 66,666.67 | 263,157.89 | 23.81 | 2,647.75 | 9.54 | 0.32 |
| Average | ---- | ---- | ---- | ---- | ---- | $ 327,888.89 | $ 226,793.29 | $ 24.17 | ---- | $ 25.36 | $ 1.07 |

GROUP 1, SCREENING PLANTS

This group consists of sewage treatment plants where the sewage is treated by being strained through what are commonly designated as fine screens. The opening in the screen is usually 5/16's of an inch wide and allows all particles smaller than that dimension to pass through the plant. There were only two plants of this type. No definite data could be obtained at either of these plants and the data which is included here was obtained from published accounts describing them. For Plant No. 50 a considerable portion of the data could not be obtained. Due to the small number of plants included in this part of the table, no great reliability can be placed upon the average figures shown. In both cases, the actual sewage flow was approximately one-third of the capacity for which the plant was designed.

GROUP 2,, SCREENING AND CHLORINATION PLANTS

There were ten sewage treatment plants in this group which were visited for the purpose of obtaining the necessary cost data. For three of these plants, namely, numbers 32, 24, and 48, the data was of such an inadequate character that they were eliminated from the table in obtaining the average figures. The average cost of the remaining seven plants in this classification are shown in the table given above. These plants varied in size from one designed for two million gallons per day, serving 1,500 people to plants having a designed daily capacity of seventy million gallons of sewage, serving 325,000 people and another designed for ninety six million gallons of sewage daily, serving 260,000 people. The cost of these sewage treatment plants which consist of screens with the addition of chlorination for the destruction of disease bacteria varied from $886 to $24,564 per million gallons daily capacity for which the plant was designed.

The average cost per million gallons daily on the basis of the designed capacity for these screening and chlorination plants was found to be $12,660. The highest figure on this basis was $23,563 for Plant No. 40 and the minimum cost was $886 for Plant No. 27.

On the basis of the cost of construction per million gallons daily of sewage actually treated, a much wider range was found. The average cost being $73,027 while the lowest figure was at Plant No. 27 of $1,772 and the highest cost at Plant No. 43 being $204,000. It should be kept in mind when comparing these figures that some of these construction costs are for work built twenty or thirty years ago, while others are for recent construction which is in general considerably higher.

The construction costs on a basis of per person served varies considerably also. Again, the lowest amount was found for Plant No. 27, being nineteen cents and the maximum at Plant No. 58 which was twenty three dollars and three cents. The average per capita cost for construction of this type of plant was ten dollars and nineteen cents.

The operating costs per million gallons of sewage treated range from four dollars and ninety cents at Plant No. 11 to seventy dollars and forty cents at Plant No. 43. The average cost per million gallons of sewage treated was found to be twenty dollars and fourteen cents.

The per capita cost of operating this group of sewage treatment plants varied from a minimum of thirteen cents per annum at Plant No. 40 to six dollars and two cents at Plant No. 58. It was found that the average cost per annum per capita served was one dollar and fifty one cents.

There is no doubt but that some of the computed high costs are due to the differences between the design capacity of the plant and the actual quantity of sewage being treated. This difference is also reflected in the per capita costs of construction and operation.

It should be noted that at Plant No. 11 and 40 sludge de-waterers are used in conjunction with the disposal of the sludge to facilitate its incineration. Plant No. 44 also has an incineration plant. At Plant No. 32 an incineration plant is being constructed. At Plant No. 58 the high cost of treatment is, in a large part, due to tne fact that it serves a large non-resident summer population. It should be also noted that there is only one plant in the table which is treating sewage up to 82 percent of its capacity. Two of the remaining plants are treating approximately 50 percent of the quantity of sewage for which they were designed, while the remaining plants vary from 7 percent to 30 percent of sewage being actually treated as compared with the design capacity.

A summary of the above figures is given in the following TABLE 3:

TABLE 3

SUMMARY GROUP 2

(Exclusive of Land)

| | LOWEST | | HIGHEST | | AVERAGE |
|---|---|---|---|---|---|
| | NO. | AMOUNT | NO. | AMOUNT | AMOUNT |
| Construction Costs | | | | | |
| Per M.G.D. Design | 27 | $ 886 | 40 | $ 23,564 | $ 12,662 |
| Per M.G.D.Treated | 27 | 1,772 | 43 | 204,000 | 73,027 |
| Per capita | 27 | $ 0.19 | 58 | $ 23.03 | $ 10.19 |
| Operating Costs | | | | | |
| Per M.G. Treated | 11 | 4.90 | 43 | 70.40 | 20.14 |
| Per capita | 40 | 0.13 | 58 | 6.02 | 1.51 |

GROUP 3 - SEDIMENTATION PLANTS-

Only one plant was found, belonging to this group, where the sewage is treated by sedimentation only. About the only comment that can be made with reference to this plant (No. 28) is that the design capacity of the plant is 172 M.G.D., while the present flow of sewage is approximately 26 M.G.D. Under these conditions, the cost of constructing the plant on the basis per million gallons daily treated would be unusually high.

GROUP 4 - SEDIMENTATION AND CHLORINATION PLANTS -

This comprises the largest number of plants in any of the groups. It is the type of plant usually used where large volumes of water are available for the dilution of the sewage. In this group there are twenty-three different sewage treatment plants. For seven of them, however, the information available was found to be inadequate for the purposes of the study. For this reason, the average figures were obtained from data on the remaining sixteen plants.

The average cost of construction per million gallons daily design capacity is $97,900. The lowest cost of construction on this basis was $16,640 for plant No. 29, while the highest figure is $412,450 for plant No. 16. It should be noted that plant No. 29 was designed for a 27 M.G.D. flow; while plant No. 16 was designed for 1 M.G.D. flow.

The average cost of construction per million gallons daily flow of sewage actually treated was found to be $172,602. The lowest cost of construction on this basis is $57,142 at plant No. 62. The highest cost of construction per M.G.D. of sewage treated is $350,857, this being at Plant No. 3.

The cost of construction per capita of population served is lowest at plant No. 47, it being $8.67, and highest at Plant No. 10, where it is $72.80. It was found that the average cost of construction per capita for the group is $23.33.

The average cost for operating this type of plant per million gallons sewage treated was found to be $39.79. The lowest cost of operating a plant in this group, Plant No. 62, is $12.14 per million gallons, and on the same basis the highest cost is $123.23 at Plant No. 19.

The average cost per capita per annum for operating this type of plant was found to be $1.98; the lowest cost being $0.54 at Plant No. 26, and the highest cost $6.18 at Plant No. 10.

In connection with this group of sewage treatment plants, it should be noted that three of the plants are receiving a greater flow of sewage than the plants were designed for; three others are operating between 50 and 75 percent of their design flow, while at the remaining plants the flow varies from 17 to 49 percent of the design capacity.

The highest, lowest, and average costs for this group are summarized in the following table:

TABLE 4

SUMMARY - GROUP 4

| | LOWEST | | HIGHEST | | AVERAGE |
|---|---|---|---|---|---|
| | No. | Amount | No. | Amount | Amount |
| Construction Costs | | | | | |
| Per M.G.D. Design | 29 | $16,640 | 16 | $412,450 | $97,925 |
| Per M.G.D. Treated | 29 | 59,259 | 3 | 350,857 | 172,602 |
| Per capita | 47 | 8.67 | 10 | 72.80 | 23.33 |
| Operating Costs | | | | | |
| Per M.G. Treated | 62 | 12.14 | 19 | 123.23 | 39.79 |
| Per capita | 26 | 0.54 | 10 | 6.18 | 1.98 |

Again, we find that the high cost of construction of some of these plants is due to the comparatively small quantity of sewage actually treated as compared with the capacity for which the plant was designed, and, conversely, some of the low cost figures are due to the fact that the plant is treating a greater flow of sewage than it was designed for. At Plant No. 3, the high operation costs appear to be due to the low daily flow received at the plant; at Plant No. 10, the high operation costs appear to be due to the same cause, and this is also apparently true at Plant No. 17.

GROUP 5 - SEDIMENTATION AND CHEMICAL PRECIPITATION PLANTS -

Only two of the plants found were classified in this group, viz plants No. 7 and No. 33. In each of these, the quantity of sewage being treated is approximately 50 percent of the design capacity. For this reason, the figures relative to the cost of construction are fairly close together. The operation costs, however, differ considerably at these two plants.

GROUP 6 - SEDIMENTATION, CHEMICAL PRECIPITATION, and

MAGNATITE FILTER PLANTS -

Only two plants (No. 4 and No. 34) were classified in this group. At Plant No. 34, the construction costs were not available. The costs of operation of these two plants differ considerably.

GROUP 7 - ACTIVATED SLUDGE PLANTS -

There were only three plants of this type found in the Interstate Sanitation District. At one of these, the construction costs were not available, and at two of them the operation costs could not be obtained. Operation costs were obtained for only one plant and this plant had been operating for a six-months' period only.

GROUP 8 - ACTIVATED SLUDGE AND FINAL FILTER PLANTS -

Plants No. 6, No. 9, and No. 39 comprise this group. The operation costs were obtained for only one of the plants. The construction costs per M.G.D. design capacity varies considerably, from $132,289 to $546,666. The costs of construction per capita of the population served also varies widely from $16.54 to $51.25.

GROUP 9 - SEDIMENTATION AND SAND FILTER PLANTS -

Only three plants were found that could be classified in this group - plants No. 1, No. 12, and No. 13. The construction costs per M.G.D. design capacity varies very widely from $66,666 to $800,000. It will be noticed that the operation costs also vary rather widely.

The information contained in these tables is of value for comparison with data from other sources, but, in themselves, the

tables do not give a very satisfactory picture either of the construction or of the operation costs, due to the difficulty in obtaining a sufficient amount of proper basic data.

# APPENDIX

In the following pages, there is given, a copy of the forms that were used for the purpose of collecting field data relative to the cost of sewage treatment plants.

PLANT NUMBER _____

FIELD INVESTIGATION REPORT OF SEWAGE TREATMENT PLANT

PRELIMINARY DATA Date _____

1- Location of plant by Streets and Avenues _____

2- Information obtained from _____ Title _____

_____ Title _____

_____ Title _____

3- Population: Total _____ Connected to sewer _____

4- Sewage combined or sanitary _____

5- Storm water diversion _____

6- Is sewage pumped to plant _____

7- Industrial waste (a) Kind of waste _____ (b) Quantity _____

(c) prior treatment before disposal in sewer system _____

8- Reasons for plant (a) protection of aquatic life

(b) Abatement of nuisance

(c) protection of recreation area

(d) protection of water supply

(e) Improvement of local conditions

9- Statement of character of final plant effluent required

10- Annual Report

CONSTRUCTION DATA

11- Area of land required _____ % in use _____

12- Cost of land

13- Design basis of plant

(a) Million gallons per day of sewage _____ by year _____

(b) Future population _____ by year _____

14- Total cost of plant (excl. of land, sewers, pumping station, force mains)

a- preliminary costs
b- Physical cost of plant
c- Engineering fees
d- Total cost

15- Date plant placed in operation

16- List of treatment processes in sequence of flow

17- Date of additions or improvements _____ COST _____

OPERATING DATA

18- Volume of sewage flow M.G.D. (a) Maximum _____ (b) Minimum _____
(c) Average _____

19- Total fixed charges on plant: (a) Bond Interest _____
(b) Insurance _____
(c) Amortization _____

20- Total yearly operation cost: (Sewage treatment plant only)

a- Supervision and Labor _____
b- Electric power _____
c- Chemicals _____
d- Miscellaneous _____
e- Total

21- Analysis of raw sewage (influent) a- 5 day 20° B.O.D. _____ P.P.M.
b- Suspended Solids _____ P.P.M.

22- Analysis of final plant effluent: a- 5 day 20° B.O.D. _____ P.P.M.
b- Suspended Solids _____ P.P.M.

23- Percentage reduction: a- 5 day 20° B.O.D. _____
b- Suspended Solids _____

24- Grit Chamber: a-Type _____ b- dimensions _____
c- No. of units
d- Method of handling grit
e- Quantity of grit per month _____ cubic feet
f- Disposal of grit

25- Grease Removal (a) Type _____
(b) Method of handling _____
(c) Disposal of grease _____
(d) Quantity of removal per month _____ cubic feet

26- Screens- (a) Type _____ (b) No. of units _____
(c) Clear opening _____
(d) Quantity of screenings per month _____cubic feet ____
(e) Method of handling screenings _____
(f) Disposal of screenings _____

27-Settling Tank; (a) Type of tank _____
(b) Dimension of tank _____
(c) Number of units _____(d) Quantity per unit _____
(e) Mechanical Equipment _____
(f) Detention period (based on average sewage flow)
(g) Quantity of sludge removed per month _____ cubic feet
(h) Method of handling sludge _____
(i) Disposal of effluent _____
(j) Dispossl of sludge _____

28- Imhoff Tank (a) Type_____(b) Dimensions _____
(c) No. of units _____
(d) Volumetric capacity (1) Sedimentation ____(2)Digestion
(e) Detention period _____
(f) Quantity of sludge removed per mo. _____
(g) Method of handling sludge _____
(h) Disposal of effluent _____
(i) Disposal of sludge _____

29- Dosing Tank (a) Type _____ (b) Capacity_____(c) No. of units ___
(d) Type of siphon___(e) Cost of operation _____

30-Trickling Filters: (a) Type ___(b) No. of units _____
(c) Filter media: kind ____ area _____depth _____
(d) Quantity of sludge removed per month_____ cubic feet ____
(e) Disposal of effluent _____
(f) Disposal of sludge _____

31-Contact Beds: (a) No. of units _____(b) Contact period _____
(c) Filter media: Kind _____area _____depth _____
(d) Quantity of sludge removed per month _____ cubic feet ____
(e) Disposal of effluent _____
(f) Disposal of sludge _____

32-Intermittent Sand Filters: (a) Type _____(b) No. of units _____
(c) Filter media: Kind _____ area _____ depth _____
(d) Quantity of sludge removed per month _____ cubic feet ____
(e) Disposal of effluent _____
(f) Disposal of sludge _____

33-Aeration Tank-(Activated Sludge) (a) Type _____

(b) Dimension _____

(c) No. of units _____ (d) Type of diffuser _____

(e) Quantity of air used per gallon of sewage _____

(f) Aeration period based on sewage flow plus returned sludge _____

(g) Ratio of sludge return _____

(h) Total cu. ft. of sludge removed per month _____

(i) Disposal of: effluent _____

(j) Disposal of sludge _____

34-Chemical precipitation: (a) principal or supplementary process _____

(b) Total Weight of each chemical used per mo. _____

(c) Points of application _____

(d) Detention period of mixing _____

(e) Type of feeding equipment _____

(f) Cost of chemicals _____

35-Secondary Settling Tank: (a) Type _____ (b) No. of units _____

(c) Dimensions _____

(d) Capacity _____ (e) Mechanical equipment _____

(f) Detention period _____

(g) Sludge removed per mo. _____

(h) Method of handling sludge _____

(i) Disposal of: effluent _____

(j) Disposal of sludge _____

36-Sludge Digestion Tank: (a) Type _____ (b) Capacity _____

(c) No. of units _____

(d) Quantity of sludge removed per month _____

(e) Method of handling sludge _____

(f) Disposal of: effluent _____

(g) Disposal of Sludge _____

37-Sludge Drying Beds: (a) Type _____ (b) No. of units _____

(c) Area of beds _____

(d) Amount of wet sludge applied per month _____

(e) Amount of Chemical conditioner _____

(f) Amount of air dried sludge removed per month _____

(g) Disposal of: effluent _____

(h) Disposal of Sludge _____

38-Sewage or Sludge Dewatering (a) Type _____

(b) Rating of equipment _____

(c) No. of units _____

(d) Method of handling filter cakes _____

(e) Amount of water filter cakes per month _____ pounds. _____

(f) Total filter hours in use per month _____

(g) Disposal of: effluent _____

(h) Disposal of sludge _____

39-Incineration: (a) Type _____ (b) Kind of fuel _____

(c) Number of units _____

(d) Temperature _____

(e) Amount of fuel used per mo. _____

(f) Amount incinerated per mo. _____

(g) Total hours in use per month _____

(h) Disposal of ashes _____

(i) Cost of fuel per mo. _____

40-Gas Collection & Utilization (a) Type of gas collector _____

(b) Capacity _____

(c) Average amount of cu. ft. of gas per month _____

(d) General uses made of gas _____

(e) Type of equipment using gas _____

(f) No. of equipment using gas _____

(g) Total cost of equipment _____

41-Chlorination: (a) Type of units _____ (b) No. of units _____

(c) Point of application _____

(d) Weight of chlorine used per month _____

(e) Cost of chemical _____

42-COMMENTS: