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FINAL SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Wastewater Treatment Facilities for the Columbus, Ohio Metropolitan Area

Prepared by the

United States Environmental Protection Agency

Region V

Chicago, Illinois

and

Science Applications International Corporation
McLean, Virginia

With

Triad Engineering Incorporated
Milwaukee, Wisconsin

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Approved by:

Valdas V. Adamkus
Regional Administrator

APPENDIX A

BRIEFING PAPER NO. 1
WASTEWATER FLOWS AND LOADS

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WASTEWATER FLOWS AND LOADS

Supplemental Environmental Impact Statement
USEPA Contract No. 68-04-5035, D.O. No. 40
Columbus Ohio Wastewater Treatment Facilities

Prepared By:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TRIAD ENGINEERING INCORPORATED

WASTEWATER FLOWS AND LOADS

INTRODUCTION

Under the direction of USEPA, a series of briefing papers are being prepared addressing key issues in the development of the Supplemental Environmental Impact Statement for the Columbus, Ohio, Wastewater Treatment Facilities. The briefing papers form the basis of discussions between Triad and USEPA to resolve important issues. The following paragraphs present the background of the facility planning process, a description of the briefing papers, and the purpose of this paper on flows and loads.

FACILITY PLANNING PROCESS

At the time this paper was prepared (March-August 1987) the city of Columbus was proceeding to implement improvements at the Jackson Pike and Southerly Wastewater Treatment Plants to comply with more stringent effluent standards which must be met by July 1, 1988. These improvements were based on the consolidation of wastewater treatment operations at the Southerly plant. This one-plant alternative is a change from the two-plant operation proposed by the city in the 1970's and evaluated in the 1979 EIS.

The development and documentation of wastewater treatment process and sludge management alternatives for the Columbus metropolitan area has been an extended and iterative process. The design and construction of various system components have progressed, because of the 1988 deadline, while planning issues continue to be resolved. As a result, numerous documents have been prepared which occasionally revise a previously established course of direction.

The concurrent resolution of planning issues and implementation of various project components has made preparation of the EIS more difficult because final facility plan recommendations are not available in a single document.

BRIEFING PAPERS

To facilitate preparation of the EIS, a series of briefing papers are being developed. The purpose of the briefing papers is to allow USEPA to review the work of the EIS consultant and to identify supplemental information necessary for the preparation of the EIS. Six briefing papers are being prepared as follows:

- Flows and Loads
- Sludge Management
- CSO
- Process Selection
- One Plant vs. Two Plant (Alternative Analysis)
- O&M and Capital Costs

The specific focus of each briefing paper will be different. However, the general scope of the papers will adhere to the following format:

- Existing conditions will be documented.
- Evaluations, conclusions, and recommendations of the facilities planning process will be reviewed using available documentation.
- Where appropriate, an independent evaluation of the future situation and viable alternatives will be prepared.
- The facility plan and EIS briefing paper conclusions will be compared.

The briefing paper process is intended to:

- Prompt the resolution of any data deficiencies.
- Clearly establish and define existing and future conditions.
- Identify the final recommended plan which the city desires to implement.
- Provide a data base of sufficient detail to allow preparation of the draft EIS.

WASTEWATER FLOWS AND LOADS

This briefing paper presents an independent evaluation of wastewater flows and loads which is based on an analysis of operating records from the Jackson Pike and Southerly Wastewater Treatment Plants and the 1985 Revised Facility Plan Update. The determination of wastewater flows and loads is a key factor in the sizing of facilities, the evaluation of treatment alternatives, and the evaluation of solids management scenarios. Design flows and loads are presented for the 20-year planning period which ends in 2008. This document is divided into six sections.

- Terms and definitions
- Available data
- Analysis of available data
- Existing and projected flows and loads
- Facility plan methodology
- Comparison of facility plan and briefing paper flows and loads

1. TERMS AND DEFINITIONS

BOD or Biochemical Oxygen Demand: An index of the amount of oxygen required for the biological and chemical oxidation of the organic matter in a liquid.

Combined Sewer: A sewer which transports both wastewater and storm or surface water in a single pipe.

Commercial/Industrial Flow: Wastewater flows from commercial businesses and industry.

Design Average Flow: The 24-hour average flow which the upgraded and expanded treatment facilities will be sized and designed to process.

Diurnal Peaking Factor: The factor applied to the design average flow to account for the maximum flow rate occurring at the wastewater treatment plant over a given 24-hour period. The peaking factor is calculated as the maximum hourly flow rate divided by the average hourly flow rate.

Domestic Flow: Residential sewage flow.

*Dry Weather/No Bypass Flow Condition: Dry weather days when there were no reported raw or settled sewage bypasses at the Southerly WWTP and no recorded hours of operation at the Whittier Street Storm Tanks.

*Dry Weather Flow Condition: Any day when precipitation does not occur on a particular day or during the day immediately preceding it.

Effluent: The flow out of a process.

High Groundwater Infiltration: Infiltration to sewers that occurs during periods of extended wet weather when the level of the groundwater is high.

Infiltration: Water other than wastewater that enters a sewerage system, including sewer service connections, from the ground through such sources as defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinquished from, inflow.

Inflow or Rain Induced Flow: Water other than wastewater that enters a sewerage system, including sewer service connections, from sources such as roof leaders, cellar drains, yard drains, area drains, foundation drains, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, storm waters, surface runoff, street wash waters, or drainage. Inflow does not include, and is distinguished from, infiltration.

Force Main: A sewer conduit which is pressurized by pumping.

Influent: Flow into a process.

Low Groundwater Infiltration: Infiltration that occurs during periods of extended dry weather when the level of the groundwater is low.

Sanitary Sewer: A conduit intended to carry liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions together with minor quantities of ground, storm, and surface waters that are not admitted intentionally.

Storm Sewer: A sewer designed to carry only storm waters, surface run-off, street wash waters, and drainage.

*Wet Weather Flow Conditions: Any day (or days) on which measurable precipitation occurred and the single day following any day on which precipitation occurred. The day following any day on which precipitation occurred is defined as wet weather due to the lag in the peak rain-induced flow which is seen at the plants as a result of in-system travel time. Defining the following day as wet weather also accounts for the effect of in-line storage following extended periods of wet weather.

*These definitions were developed for the analysis contained in this document. They are not standard definitions.

2. AVAILABLE DATA

The 1985 and 1986 operating records from the Southerly and Jackson Pike WWTPs were reviewed to determine existing and projected design flows and loads. The following plant records were obtained from the city of Columbus and Ohio EPA.

- Monthly Operating Reports for both plants from January 1985 through December 1986.
- Monthly Report of Operations for the Jackson Pike WWTP from January 1985 through December 1985.
- Monthly Report of Operations for the Southerly WWTP from January 1985 through September 1986.
- Hours of operation of the Whittier Street Storm Tanks from January 1985 through December 1986.
- Hourly flow data for both plants for February and September 1985.
- 1985 monthly water consumption records for the Columbus Area.
- 1983 Industrial Pretreatment Report - Malcolm Pirnie.
- Sewer lengths and sizes for the Columbus Sewer System.

The Monthly Operating Reports (MORs) are submitted to Ohio EPA in accordance with the NPDES permits. Influent flow and load data were obtained from these reports. However, these reports did not contain precipitation data. This information was obtained from the Monthly Report of Operations which is submitted to the Ohio Department of Health.

The Southerly MORs include data on amounts of raw sewage bypassed and settled sewage bypassed as well as treated flow. The Southerly plant has a method of treatment termed Blending of Flows. When incoming flows increase to the point where the biological portion of the plant begins to show signs of potential washout, the flow to the biological part of the plant is fixed. The increase in flow above this fixed flow, but less than the capacity of the primary tanks, is bypassed around the biological portion and blended with the final effluent, thus, receiving only primary treatment and chlorination.

These flows are reported on the MORs as settled sewage bypassed. If the primary treatment facilities are operating at capacity, then all excess flows are bypassed directly to the Scioto River through a 108-inch diameter pipe originating in the screen building. These flows are reported on the MORs as raw sewage bypassed. After August of 1986, no blending of flows was recorded in the MORs for the Southerly WWTP, however, bypassing was still reported.

The Jackson Pike MORs provide flow monitoring data for the plant. Jackson Pike does not blend as Southerly does, nor do they bypass raw sewage. The major diversion point for Jackson Pike flows occurs at the Whittier Street Storm Tanks before the flows even reach the plant. The tanks are capable of acting as a holding system for the excess flows until the flow in the interceptor subsides and they can be bled back into the system and carried to the Jackson Pike plant. If the flows exceed the capacity of the tanks, they overflow to the Scioto River. Flows can also be directly bypassed along side the tanks, through an emergency bypass, to the Scioto River.

Flow monitoring did not take place at the Whittier Street Storm Tanks until November of 1986. However, hours of operation of the storm tanks were recorded during 1985 and 1986 on the Monthly Report of Operations. The fact that hours of operation were reported does not necessarily mean there was bypassing or overflowing occurring at the tanks. It only means that the gates were open and flows were being diverted into the tanks. In November of 1986, the city began monitoring the overflow but not the bypass. Therefore, the data is still incomplete with respect to determining the total volume of flow entering the Scioto River at the Whittier Street facility.

Hourly flow data was obtained for February and September of 1985 for both plants. These months represent the periods of minimum and maximum water consumption respectively. This hourly flow data was used to determine a diurnal peaking factor which is calculated by dividing the peak hourly flow by the average hourly flow. This diurnal peaking factor is multiplied by the design average flow to determine a peak hourly flow for use in sizing the wet stream treatment facilities.

Dry weather flows were determined through an analysis of 1985 and 1986 flow data. However, only 1986 flow data was used to determine wet weather flows. An analysis of 1985 MORs showed that data on raw and settled sewage bypasses at Southerly were not complete. Up until August of 1985, only a bypass flow rate (MGD) was reported with no duration specified. These bypasses did not always occur 24 hours a day, therefore, these rates could not be converted to the volume bypassed during that day. In August of 1985, monitoring of the duration of the bypasses began which provided a more accurate determination of the volume of the bypasses. Therefore, the 1986 calendar year data were used to estimate wet weather flows.

Wet weather total system flow can not be determined solely based on the volume of flow arriving at the Jackson Pike and Southerly WWTPs. There are numerous points of combined sewer overflow throughout the Columbus Sewer System. The Jackson Pike service area has several regulator chambers and overflow structures in addition to the Whittier Street Storm Standby Tanks discussed previously. The Southerly service area includes an overflow structure at Roads End and the Alum Creek Storm Standby Tank. There is no comprehensive flow monitoring data available for the regulators, overflows, and storm tanks. The city began monitoring the overflows at the Whittier Street facility in November of 1986. However, they did not monitor the bypass line at the Whittier Street facility. The city also began monitoring some of the other points of combined sewer overflow; but according to the MORs, the flow monitoring equipment malfunctioned frequently which provided no data. Thus, the only flow data included in the wet weather analysis, other than plant flow data, was that which was reported for the Whittier Street overflow during November and December.

The Industrial Pretreatment Report prepared by Malcolm Pirnie in 1983 was used to estimate the industrial and commercial flows. This report quoted figures on industrial and commercial flows based on 1980 water and sewage records. Due to the lack of more recent quantification of industrial and commercial flows, these figures were updated for this document using 1985 population figures.

3. ANALYSIS OF AVAILABLE DATA

The following sections present an analysis of the wastewater flow data. This analysis was developed independently of that presented in the facility plan as a check of the assumptions and methodologies. It was prepared using Monthly Operating Reports (MORs) for the Jackson Pike and Southerly WWTPs and precipitation data and water usage records for the city of Columbus. Using these records, wet weather and dry weather flows were developed for each plant. Dry weather flows were compared to water consumption data to aid in the interpretation of monthly flow variations.

3.1 GENERAL

Jackson Pike and Southerly MORs and precipitation data for the 1985 and 1986 calendar years were used to establish existing wastewater flows. The following sections will discuss existing wet weather and dry weather flows.

In order to determine wet and dry weather flows, each daily record was categorized accordingly. Wet weather was defined as any day on which measurable precipitation occurred and the single day following the last day on which precipitation occurred. The day following one on which precipitation occurred is defined in this analysis as wet weather due to the lag in the peak rain induced flow which is seen at the plants. This lag is a result of in-line storage and in-system travel time. The remainder of the daily records were categorized as dry weather. Weather conditions for 1985 and 1986 are summarized in Table 3-1 using these classifications. There were a total of 144 days in 1985 and 130 days in 1986 on which measurable precipitation occurred. Wet weather days totaled 212 for 1985 and 197 for 1986. There were 153 dry weather days for 1985 and 168 for 1986.

TABLE 3-1. WEATHER CONDITION SUMMARY

Month	Precipitation* (inches)	Days of Measurable Precipitation (Count)	Wet Weather Days (Count)	Dry Weather Days (Count)
1985				
January	1.26	16	21	10
February	1.67	12	17	11
March	3.78	17	24	7
April	0.56	11	17	13
May	4.96	12	17	14
June	1.41	12	20	10
July	6.88	5	7	24
August	2.34	10	16	15
September	1.18	4	6	24
October	1.98	11	18	13
November	10.67	21	28	2
December	1.81	13	21	10
TOTAL	38.50	144	212	153
1986				
January	1.54	12	16	15
February	2.96	16	22	6
March	2.61	11	17	14
April	1.31	13	21	9
May	2.47	13	19	12
June	5.53	11	17	13
July	3.60	8	13	18
August	1.61	6	11	20
September	3.44	8	13	17
October	4.16	9	13	18
November	3.00	11	18	12
December	2.81	12	17	14
TOTAL	35.04	130	197	168

* Measured at Port Columbus Airport

3.2 DRY WEATHER FLOWS

Construction Grants 1985, which is the USEPA guide for the preparation of facility plans, recommends that design flows for treatment works be determined based on existing base flow; estimated future flows from residential, commercial, institutional and industrial sources; and nonexcessive I/I. Traditionally, base flows are established using dry weather flow.

Dry weather days were classified as indicated in the previous section. By definition, they include any day on which measurable precipitation does not occur that day or during the day immediately preceding it. In applying this definition to plant data, it was found that bypasses occurred in the system on several days which would be categorized as dry weather. Bypasses are monitored at the Southerly WWTP and reported in the records as settled sewage bypassed and raw sewage bypassed. The Jackson Pike WWTP does not bypass at the plant. However, when flows increase beyond plant capacity, the gates are opened at the Whittier Street Storm Tanks and flows are diverted to the tanks before they reach the Jackson Pike WWTP. When the gates are open at the Whittier Street facility, it is considered to be in operation. Flows diverted through the Whittier Street Storm Tanks were not monitored until November of 1986, but the hours of operation of the storm tanks are reported on the Jackson Pike WWTP records. Days with reported hours of operation were considered as bypass days.

Closer examination of the days with reported bypassing and storm tank hours showed that the majority occurred after an extended wet weather period. Those that did not follow an extended wet weather period were assumed to be related to operational problems at the plant. Therefore, in establishing dry weather flows, only dry weather/no bypass days were considered.

Using the classification of dry weather/no bypass, monthly average flows were determined for the 1985 and 1986 calendar year. These flows are presented in Table 3-2. In evaluating these flows, the 1985 and 1986 averages for each plant were very close. The maximum and minimum combined values both

TABLE 3-2. DRY WEATHER/NO BYPASS MONTHLY AVERAGE FLOWS (MGD)

Month	Count	Jackson Pike	Southerly	Combined
1985				
January	7	75.86	56.44	132.30
February	5	79.20	60.74	139.94
March	2	82.00	60.55	142.55
April	3	81.30	58.92	140.22
May	8	83.88	60.88	144.76
June	9	78.89	55.14	134.03
July	19	80.47	58.40	138.87
August	11	75.18	51.85	127.03
September	24	73.38	50.64	124.02
October	11	72.31	52.57	124.88
November	0	ND	ND	ND
December	5	81.62	61.54	143.16
TOTAL	104			
AVERAGE		77.27	55.40	132.67
1986				
January	10	78.53	56.23	134.76
February	0	ND	ND	ND
March	1	80.73	62.50	143.23
April	8	82.52	57.69	140.21
May	11	76.66	48.21	124.87
June	10	80.33	58.34	138.67
July	13	81.32	55.79	137.12
August	20	77.13	55.74	132.87
September	17	75.87	55.18	131.05
October	10	78.08	53.25	131.33
November	2	70.30	54.30	124.60
December	8	79.06	60.98	140.04
TOTAL	110			
AVERAGE		78.33	55.52	133.85

ND - No dry weather/no bypass days

occurred in 1985. The dry weather combined maximum monthly average of 145 MGD occurred in May of 1985, and the dry weather combined minimum monthly average of 124 MGD occurred in September of 1985.

The maximum monthly average dry weather flow of 145 MGD which occurred in May is considered to represent a high groundwater condition due to the large amount of precipitation and extended wet weather periods in this month. It had the second highest monthly precipitation for 1985 of 3.92 inches. The highest occurred in November, but there were no dry weather/no bypass days in November. May had eight dry weather/no bypass days which occurred during two 4-day periods.

The minimum monthly average dry weather flow of 124 MGD which occurred in September of 1985 is considered to represent a low groundwater condition due to the extended dry period which occurred during that month. September of 1985 had 24 dry weather/no bypass days which occurred during one 22-day period and one 2-day period. This was the highest number of dry weather/no bypass days recorded in one month for the 24 month (1985 and 1986) data base that was evaluated.

The 1985 flows closely approximate the 1986 dry weather/no bypass maximum monthly average of 143 MGD and the minimum monthly average of 125 MGD.

3.3 WATER USAGE

Information on water usage for the Columbus area was obtained from the Columbus Division of Water - 1985 Annual Report. These flows were evaluated to gain further insight into the groundwater condition. The total amount of water pumped to residential, commercial, and industrial customers in the Columbus area during the 1985 calendar year was 44 billion gallons. Using the 1985 population figure of 870,000 people, developed by Ohio Data Users Center, the water usage figure was converted to 139 gallons per capita per day (gpcd).

The 1985 average dry weather/no bypass flow of 136 MGD from Table 3-2 can be converted to 156 gpcd using the population figure for 1985 of 870,000 persons. The per capita water pumpage (139 gpcd) value is 17 gpcd or approximately 12 percent less than the wastewater (156 gpcd) value. This 17 gpcd difference may be the result of high infiltration in the sewer system, not all the sewer customers being water customers, or a result of illegal connections to the sewer system.

Table 3-3 compares the monthly average water pumped to the Columbus area vs. monthly average dry weather/no bypass wastewater flows. The table shows a higher wastewater flow than water pumpage for the spring months. This could be due to more sewer customers than water customers as discussed in the previous paragraph. However, it could also be a result of a greater amount of infiltration from a high groundwater condition. September, on the other hand, which had 24 dry weather/no bypass days had an average water pumpage figure 17.72 MGD greater than the wastewater figure. The high water pumpage figure could be attributed to lawn sprinkling due to the extended dry period. The low wastewater flow indicates that less infiltration is entering the system, which is a result of a low groundwater condition.

TABLE 3-3 1985 WATER PUMPAGE VS. WASTEWATER FLOW

Month	Average Water Pumped (MGD)	Average Dry Weather/ No Bypass Flow (MGD)
January	111.23	132.30
February	108.32	139.94
March	109.65	142.55
April	115.60	140.25
May	120.33	144.75
June	128.53	134.03
July	127.15	138.87
August	130.66	127.03
September	141.74	124.02
October	124.88	124.88
November	117.23	ND
December	116.46	143.16

3.4 WET WEATHER FLOWS

A limited data base was reviewed with respect to wet weather flows. Insufficient data was available to quantify the total wet weather flow for the entire Columbus system.

The only data evaluated in determining wet weather flows was that which was reported from monitoring flows arriving at the plants from January through December 1986 and data reported from monitoring overflows at the Whittier Street Storm Tanks during November and December of 1986. The flow data collected at the Southerly and Jackson Pike plants is the only data that was collected for an entire year. Flow data was collected at the overflow located at the Whittier Street Storm Tanks during November and December of 1986. However, no flow data was gathered from the bypass at Whittier Street. From October through December of 1986, flow monitoring was performed at various other overflows and regulators within the Columbus combined sewer system. However, it was never performed at all the points of combined sewer overflow during the same month, and according to the MORs, the flow monitoring equipment malfunctioned frequently.

Wet weather days were categorized as discussed in Section 3.1. Wet weather being defined as any day on which measurable precipitation occurs and the single day immediately following any day on which measurable precipitation occurs.

A total flow was calculated for each wet weather day during 1986. This total flow includes the following:

- Southerly treated sewage.
- Southerly settled sewage bypassed.
- Southerly raw sewage bypassed.
- Jackson Pike treated sewage.
- Whittier Street sewage overflow volumes (November and December only).

Table 3-4 shows the average and maximum daily wet weather flows for January through December of 1986. As shown in the table, the maximum wet weather flow of 309.52 MGD occurred in March. The actual day was March 14, 1986. On March 12, the reported precipitation was 0.71 inches and 0.51 inches was reported for March 13. It must be remembered that this flow only includes the flow arriving at the plants. It does not include any bypassing that may have occurred at the numerous points of combined sewer overflow throughout the system.

Wet weather flows are discussed in more detail in the CSO briefing paper.

TABLE 3-4. WET WEATHER FLOW DATA

Month	Wet Weather Days (Count)	Maximum Daily Average (MGD)	Average (MGD)
January	16	165.31	147.73
February	22	298.62	183.01
March	17	309.52	181.62
April	21	155.02	143.68
May	19	160.98	137.46
June	17	227.60	152.45
July	13	184.29	154.75
August	11	158.61	137.00
September	13	165.23	147.27
October	13	266.00	161.47
November	18	223.73	149.80
December	17	294.24	178.64
Total	197		
1986		309.52	156.24

4. EXISTING AND PROJECTED FLOWS AND LOADS

This chapter describes the development of average daily and peak hourly flow rates and daily loadings of TSS (total suspended solids) and BOD which are used to evaluate facility planning recommendations. The following sections present the existing flows and loads developed for the Columbus WWTPs from an independent analysis of the 1985 and 1986 plant data, as well as projected flows and loads for the 2008 design year.

An analysis of existing conditions established the current average day flows. This current condition is subsequently dissagregated into domestic, infiltration, industrial, and commercial flows. A diurnal peaking factor and a process peaking factor are established to project peak flow rates which will be used in sizing some of the WWTP unit processes. Wet weather flows are discussed briefly with a more detailed discussion included in the CSO packet.

The analysis also includes a review of existing influent BOD and TSS loads. BOD and TSS loads are used to determine sizings for WWTP unit processes and to aid in the selection of the alternative treatment processes.

Wastewater flows and loads are projected for the design year (2008) using existing per capita flows and loads and 2008 population projections.

4.1 EXISTING WASTEWATER FLOWS

This section presents the existing average flow, maximum hourly flow, peak process flow, and wet weather flow as determined from analysis of available data.

4.1.1 Existing Average Flows

According to USEPA guidelines, WWTP design flows are determined based on existing dry weather flows and non-excessive I/I. As discussed in Section 3.2, dry weather flows were determined based on a dry weather/no bypass condition. Therefore, the existing average flow was determined through an analysis of dry weather/no bypass flows. The 1985 and 1986 combined Jackson Pike and Southerly maximum monthly average dry weather/no bypass flow from Table 3-2 was selected. This combined flow of 144.76 MGD occurred in May of 1985 and was based on 83.88 MGD for Jackson Pike and 60.88 MGD for Southerly.

In subsequent paragraphs, this flow of 145 MGD is further broken down into infiltration, industrial, commercial, and domestic flows. In Section 4.3, population projections are used to increase this flow for the design year.

4.1.1.1 Infiltration

No current infiltration/inflow report was available for the Columbus sewer system; therefore, wastewater flow, water use, and precipitation data were evaluated to estimate infiltration.

The maximum monthly average dry weather/no bypass flow of 145 MGD occurred in May of 1985. The data base consists of two 4-day periods of dry weather/no bypass conditions. This month, which had 3.92 inches of precipitation, had the second highest monthly rainfall recorded during 1985. Therefore, it is safe to assume that May would represent a high groundwater condition resulting in increased infiltration. November had the highest precipitation with 10.67 inches, but there were no dry weather/no bypass days during that month.

September of 1985 had the lowest combined monthly average dry weather/no bypass flow of 124.02 MGD for the 1985 and 1986 calendar years; and it had 24-dry weather/no bypass days which occurred in one 2-day period and one 22-day period. Due to the extended dry weather period, it is assumed to represent a low groundwater condition. Water usage figures presented in Section 3.3 reinforce May and September as representing high and low groundwater conditions. The difference of 20.74 MGD between the high groundwater month (May) and the low groundwater month (September) represents that portion of the total infiltration which is attributable to a high groundwater condition. However, this is only a portion of the total amount of infiltration occurring since there is also some infiltration occurring during low groundwater conditions. Therefore, the amount of infiltration occurring during low groundwater conditions must be determined and added to the 20.74 MGD in order to establish a total infiltration rate.

In the absence of a current infiltration/inflow report other methods of estimating infiltration must be used. A common method involves using monthly water records to establish the domestic, commercial, and industrial portion of the wastewater flow. The remainder of the wastewater flow is then assumed to be infiltration.

Since September 1985 has been established as a low groundwater month, water usage rates from this month will be used. As reported in Table 3-3, the September 1985 water pumpage rate is 141.74 MGD. Literature states that approximately 60 to 80 percent of water becomes wastewater. The 20 to 40 percent which is lost includes water consumed by commercial and manufacturing establishments and water used for street washing, lawn sprinkling, and extinguishing fires. It also includes water used by residences that are not connected to the sewer system as well as some leakage from water mains and service pipes. If it is assumed that 70 percent of the water becomes wastewater, then the return flow for September would be 99.22 MGD. Referring to Table 3-3, the wastewater flow for September is 124.02 MGD. The difference between the actual wastewater flow (124.02) and the expected wastewater flow (99.22) is 24.80 MGD. This value is assumed to represent the amount of infiltration occurring during a low groundwater condition. Thus, the total infiltration occurring during high groundwater conditions is obtained by adding 20.74 MGD to 24.80 MGD. This total infiltration figure of 45.54 MGD, converts to 52 gpcd.

It must be remembered that 52 gpcd is only a rough estimate of infiltration. It is not known if all of the water customers are sewer customers or if all the sewer customers are water customers. Some sewer customers may have their own private wells. In addition, the consumptive use of the brewery and the other industries is unknown.

It is, however, considered to be a non-excessive infiltration rate when compared to infiltration rates in the USEPA document entitled Facility Planning - 1981 Construction Grants Programs. This document states that 2000 to 3000 gpd/inch-diameter mile is considered a non-excessive infiltration rate for sewer systems with lengths greater than 100,000 feet. The Columbus Sewer System has a total length of 9,975,000 feet which converts to an estimated 32,930 inch-diameter miles. Multiplying the inch-diameter miles by 2000 gpd/inch-diameter mile results in 66 MGD or 76 gpcd. Therefore, 52 gpcd of infiltration would be considered non-excessive.

The Revised Facility Plan Update uses a peak infiltration rate of 72 gpcd. Divided between the two plants, it is 82 gpcd for Jackson Pike and 58 gpcd for Southerly. Assuming more detailed information was available to establish this number for the facility plan and considering 72 gpcd is also a non-excessive infiltration rate according to the USEPA document, it will be used in this briefing paper as the existing infiltration rate. It converts to 22.1 MGD for Southerly and 40.1 MGD for Jackson Pike, totaling 62.2 MGD for the entire Columbus Sewer System. This number will be held constant throughout the planning period.

4.1.1.2 Industrial and Commercial Flows

Current information on industrial and commercial wastewater flows was not available. Therefore, estimates were made by updating those values presented in the Columbus Industrial Pretreatment Program Report as prepared by Burgess and Niple. The Burgess and Niple values were updated proportional to the increase in population from 1980 to 1985 since they were based on 1980 water consumption records. The 1985 Estimates of industrial and commercial flows are presented in Table 4-1.

TABLE 4-1. INDUSTRIAL AND COMMERCIAL FLOW ESTIMATES

	1980 Population	1980 Industrial Flow (MGD)	1980 Commercial Flow (MGD)	1985 Population	1985 Industrial Flow (MGD)	1985 Commercial Flow (MGD)
Jackson Pike	472,503	8.7	4.3	489,000	9.0	4.5
Southerly	368,228	6.7	3.1	381,000	6.9	3.2
TOTAL	840,731	15.4	7.4	870,000	15.9	7.7

The analysis of variations in the dry weather/no bypass flows between weekdays and weekends gives an indication of the magnitude of the industrial and commercial flows. Table 4-2 presents a summary of the weekly flow variations for the two plants.

TABLE 4-2. 1985 DRY WEATHER/NO BYPASS WEEKLY FLOW VARIATIONS (MGD)

	Jackson Pike	Southerly	TOTAL
Weekday	78.71	55.37	134.08
Weekend	73.80	54.92	128.72
Difference	4.91	0.45	5.36
% Difference From Weekday	6.2	0.8	4.0

Referring to Table 4-1, it can be seen that the total commercial and industrial flow for Jackson Pike in 1985 is 13.5 MGD. Relating this to the 4.91 MGD difference in flow between weekdays and the weekend, suggests that approximately 35 percent of the flow from commercial and industrial sources in the Jackson Pike service area is from sources which operate on a weekday schedule. Southerly, on the other hand, with 10.1 MGD industrial and commercial flow, appears to have only 4 percent of its industrial and commercial contributing flow sources operating on a weekday schedule.

4.1.1.3 Domestic Flows

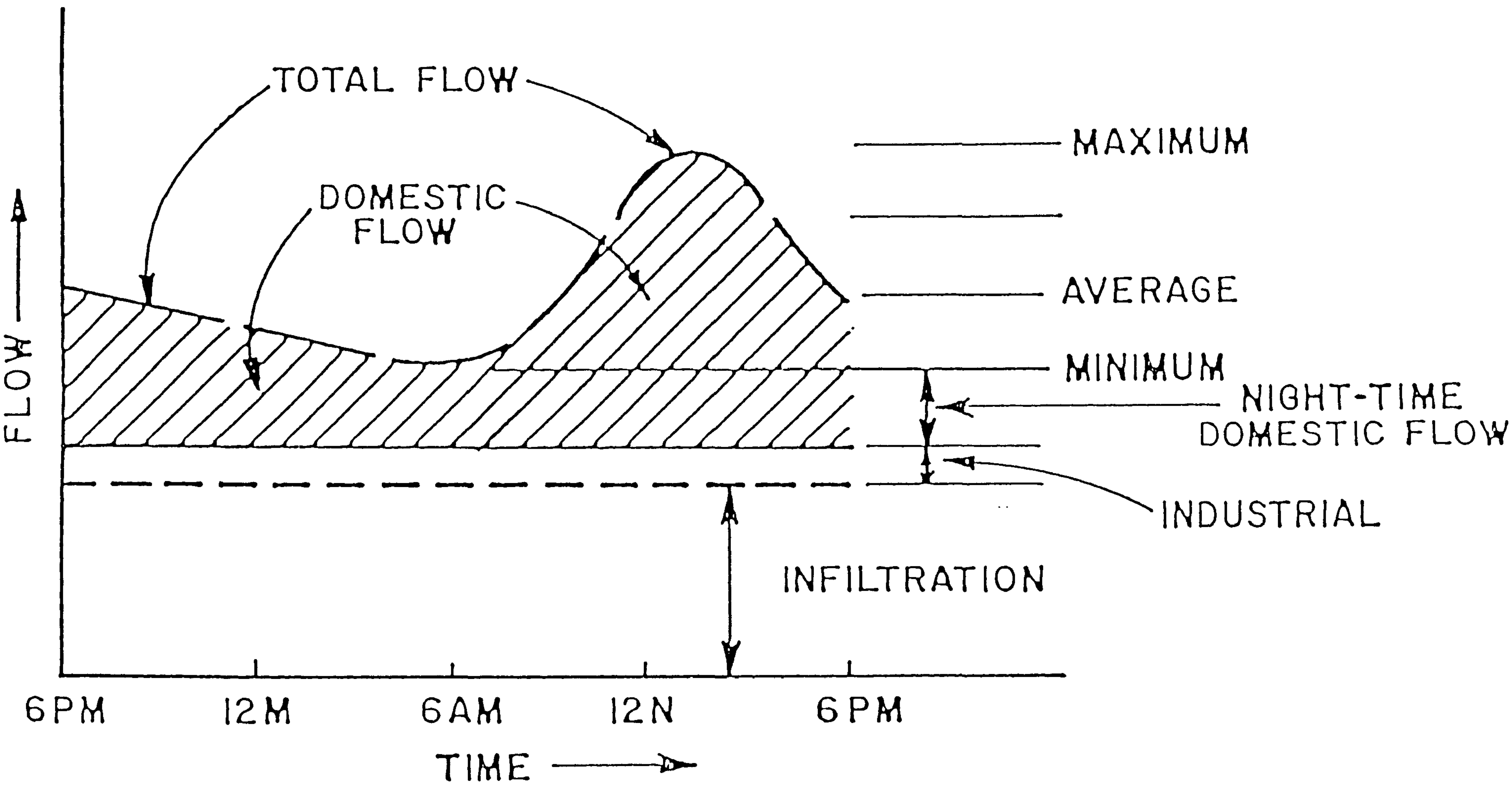
Domestic flows were estimated simply by subtracting infiltration, industrial, and commercial flows from the maximum dry weather/no bypass flow of 145 MGD. The Jackson Pike domestic flow is 30.4 MGD and Southerly is 28.8 MGD. Table 4-3 presents the breakdown of the existing flow for each plant and the two plants combined.

TABLE 4-3. 1985 ESTIMATED FLOWS

	Jackson Pike	Southerly	Total
Design Average Flow (MGD)	84	61	145
• Infiltration	40.1	22.1	62.2
• Industrial	9.0	6.9	15.9
• Commercial	4.5	3.2	7.7
• Domestic	30.4	28.8	59.2

4.1.2 Maximum Hourly Flow

Just as demand for water fluctuates on an hourly basis, so do wastewater flow rates. Fluctuations observed in wastewater flow rates tend to follow a diurnal pattern. (See Figure 4-1.) Minimum flow usually occurs in the early morning hours when water use is low. The flow rates start to increase at approximately 6 a.m. when people are going to work, and they reach a peak value around 12 noon. The flow rate usually drops off in the early afternoon, and a second peak occurs in the early evening hours between 6 p.m. and 9 p.m. In general, where extraneous flows are excluded from the sewer system, the wastewater flow-rate curves will closely follow water-use curves. However, the wastewater curves will be displaced by a time period corresponding to the travel time in the sewers.



SOURCE: Existing Sever Evaluation and Rehabilitation

Published by the American Society of Civil Engineers (ASCE) and the Water Pollution Control Federation (WPCF), 1983.

FIGURE 4-1
DIURNAL FLOW VARIATIONS

Diurnal curves are also affected by the size of the community. Large communities with more industrial and commercial flows tend to have flatter curves due to industries that operate on a 24-hour schedule, stores and restaurants that are open 24 hours a day, and to the expansiveness of the collection systems. These 24-hour operating schedules also result in more people working second and third shift, thus altering normal flow patterns. Longer travel times in the collection system dampen peak flows observed at the WWTP.

An existing average flow of 145 MGD was determined in Section 4.1.1. This flow was determined from average dry weather flows and it is generally used in the design of wastewater facilities to determine quantities of chemicals needed, O&M costs, labor, and energy requirements. However, the peak hourly flow must be used for hydraulic sizing of pumps. Therefore, a diurnal peaking factor must be determined and applied to the design average flow to provide a peak hourly design flow.

Figure 4-2 presents wastewater flow rate curves for the Jackson Pike and Southerly plants compiled from September 1985 dry weather/no bypass days. The diurnal peaking factor was determined for the Jackson Pike and Southerly WWTPs through an analysis of hourly wastewater flows for February and September 1985. These two months represent minimum and maximum water consumption, respectively for 1985. The 1985 months were chosen since the existing average flow occurred in May of 1985. Diurnal peaking factors were calculated by dividing the maximum hourly flow by the average hourly flow for each dry weather/no bypass day during February and September. These values are listed in Tables 4-4 and 4-5.

The maximum diurnal peaking factor seen at Jackson Pike during this period was 1.40, and at Southerly it was 1.51. Jackson Pike's value of 1.40 occurred several times and was selected as the diurnal peaking factor for Jackson Pike. Southerly's maximum value of 1.51, however, was considered to be excessive. It occurred, only once, on September 21 when the average hourly flow was at a low of 45 MGD. The next peaking factor in the series was 1.37

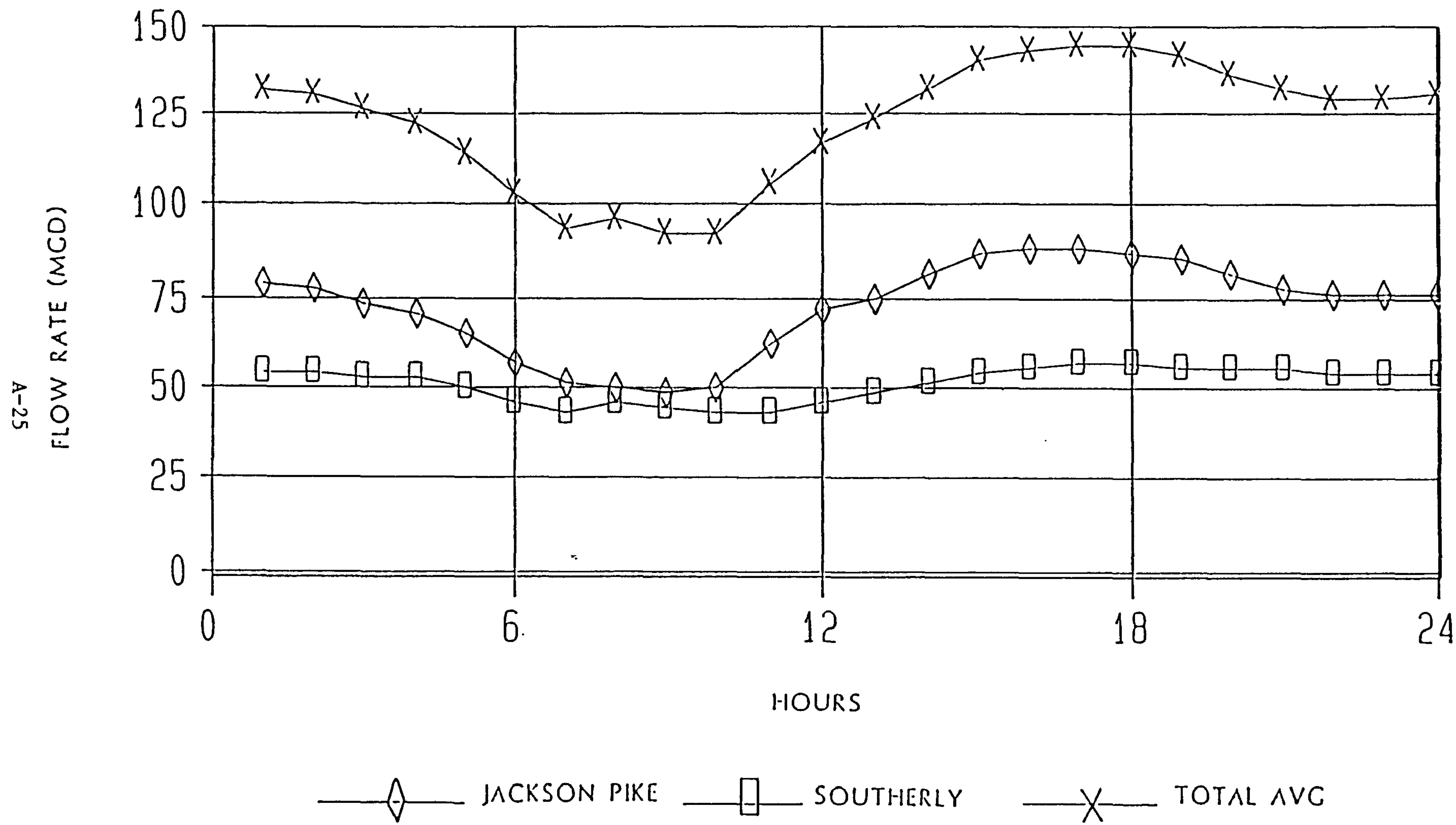


FIGURE 4-2
DIURNAL FLOW VARIATIONS
FOR DRY WEATHER

TABLE 4-4. HOURLY FLOW DATA SOUTHERLY WWTP

Date	Average Hourly Flow (MGD)	Peak Hourly Flow (MGD)	Peaking* Factor	Weather Condition
2/4/85	56.2	58.0	1.03	DRY
2/8/85	55.8	63.0	1.13	DRY
2/9/85	54.6	65.0	1.19	DRY
2/16/85	69.5	83.0	1.19	DRY
2/17/85	67.6	79.0	1.17	DRY
2/18/85	69.0	78.0	1.13	DRY
2/19/85	71.2	78.0	1.10	DRY
2/20/85	75.0	81.0	1.08	DRY
2/26/85	87.1	97.0	1.11	DRY
2/27/85	81.3	90.0	1.11	DRY
2/28/85	82.5	85.0	1.03	DRY
9/1/85	48.8	56.0	1.14	DRY
9/2/85	49.4	62.0	1.26	DRY
9/3/85	53.1	62.0	1.17	DRY
9/4/85	52.2	59.0	1.13	DRY
9/5/85	52.5	57.0	1.09	DRY
9/6/85	50.4	57.0	1.13	DRY
9/7/85	51.3	60.0	1.17	DRY
9/8/85	49.0	56.0	1.14	DRY
9/9/85	50.7	54.0	1.07	DRY
9/10/85	53.2	57.0	1.07	DRY
9/11/85	53.9	61.0	1.13	DRY
9/12/85	51.9	59.0	1.14	DRY
9/13/85	40.1	55.0	1.37	DRY
9/14/85	54.0	64.0	1.19	DRY
9/15/85	49.8	57.0	1.14	DRY
9/16/85	52.0	64.0	1.23	DRY
9/17/85	51.2	55.0	1.07	DRY
9/18/85	52.2	58.0	1.11	DRY
9/19/85	51.8	57.0	1.10	DRY
9/20/85	49.9	58.0	1.16	DRY
9/21/85	45.0	68.0	1.51	DRY
9/22/85	51.3	68.0	1.33	DRY
9/28/85	51.3	62.0	1.21	DRY
9/29/85	50.3	59.0	1.17	DRY

$$* \text{ Peaking Factor} = \frac{\text{Peak Hourly Flow}}{\text{Average Hourly Flow}}$$

TABLE 4-5. HOURLY FLOW DATA JACKSON PIKE WWTP

Date	Average Hourly Flow (MGD)	Peak Hourly Flow (MGD)	Peaking* Factor	Weather Condition
2/4/85	76.0	94.0	1.24	DRY
2/8/85	73.0	96.0	1.32	DRY
2/9/85	69.0	89.0	1.29	DRY
2/16/85	91.0	102.0	1.12	DRY
2/17/85	87.0	106.0	1.22	DRY
2/18/85	92.0	102.0	1.11	DRY
2/19/85	91.0	98.0	1.08	DRY
2/20/85	92.0	103.0	1.12	DRY
2/26/85	98.0	106.0	1.08	DRY
2/27/85	95.0	104.0	1.09	DRY
2/28/85	99.0	102.0	1.03	DRY
9/1/85	69.3	86.0	1.24	DRY
9/2/85	72.0	89.0	1.24	DRY
9/3/85	76.9	104.0	1.35	DRY
9/4/85	81.0	96.0	1.19	DRY
9/5/85	81.3	95.0	1.17	DRY
9/6/85	79.5	94.0	1.18	DRY
9/7/85	75.6	94.0	1.24	DRY
9/8/85	72.1	92.0	1.28	DRY
9/9/85	78.7	96.0	1.22	DRY
9/10/85	79.0	92.0	1.16	DRY
9/11/85	76.0	90.0	1.18	DRY
9/12/85	71.7	85.0	1.19	DRY
9/13/85	73.7	86.9	1.18	DRY
9/14/85	69.3	96.8	1.40	DRY
9/16/85	72.4	88.0	1.22	DRY
9/17/85	72.3	96.0	1.33	DRY
9/18/85	73.4	92.0	1.25	DRY
9/19/85	72.9	88.8	1.22	DRY
9/20/85	72.6	89.0	1.23	DRY
9/21/85	70.0	90.0	1.29	DRY
9/22/85	67.0	94.0	1.40	DRY
9/28/85	70.6	99.0	1.40	DRY
9/29/85	68.5	83.0	1.21	DRY

$$* \text{ Peaking Factor} = \frac{\text{Peak Hourly Flow}}{\text{Average Hourly Flow}}$$

which is more representative of the maximum diurnal peaking factor seen at the Southerly plant. Thus, 1.4 was chosen as a representative diurnal peaking factor for both plants.

4.1.3 Peak Process Flow

A peak process flow must be developed for use in sizing the various wet stream processes. This flow establishes the maximum process capability of the wet stream treatment facilities. Flows greater than the peak process flow will cause the treatment facilities to operate beyond their intended design criteria. Sustained operation above the peak process flow may result in a violation of permit limits.

The peak process flow is most reliably established through an analysis of existing flow. This approach was not possible in the Columbus system due to the nature of the flow record. As discussed in Section 2, the flow records for the two Columbus plants provided limited information regarding the amount of sewage bypassed. As a result a reliable record of the total flow arriving is not available. Furthermore, peak wastewater flows normally include some combined sewage. A combined sewage overflow study, which will define a CSO control strategy, is currently being prepared by the city. The impact of the CSO recommendation on the wastewater treatment facilities will be evaluated at the conclusion of that study.

In the 1979 EIS, the following empirical formula was utilized to develop a peak process flow, due to the absence of a comprehensive flow record.

$$\text{Peak Process Flow} = 1.95\ (\text{Average Daily Flow})^{0.95}$$

Lacking flow information which would substantiate a peak process flow, the 1979 EIS formula provides a reasonable method for developing a peak process flow. Based on the 2008 average design flow of 154 MGD, the formula yields a peak process flow of 233 MGD. This corresponds to a process peaking factor of 1.5.

The 1.5 process peaking factor was evaluated relative to the 1986 available flow data to assess the extent of its range. The 1986 flow record includes flows treated at Jackson Pike and Southerly and also the flows which are bypassed at Southerly. The flow record does not include flows which were bypassed at Whittier Street or any other combined sewer overflows. The 1986 average flow of the two plants was 145 MGD. Applying the 1.5 process peaking factor to this average flow yields a peak process flow of 218 MGD. Comparing this flow with the 1986 record indicated that the daily flow rate of 218 MGD was exceeded only nine days during the year or approximately 2.5 percent of the time. In light of these few exceedances, the 1.5 process peaking factor established by the 1979 EIS provides a reasonable approach to establish a peak process flow.

4.1.4 Wet Weather Flow

The maximum monitored wet weather flow as determined from 1986 records and discussed in Section 3.4 is 309.52 MGD. This flow occurred on March 14. It includes 95.57 MGD for the Jackson Pike WWTP and 213.95 MGD for the Southerly WWTP. The Southerly flow can be broken down into 78.05 MGD receiving complete treatment, 30.30 MGD receiving primary treatment and chlorination, and 105.60 being bypassed directly to the Scioto River. Note that this maximum wet weather flow only includes flow that arrives at the treatment plants. Any flow being bypassed at the various points of combined sewer overflow is not included.

4.2 WASTEWATER LOADS

Monthly average influent TSS (total suspended solids) and BOD (biochemical oxygen demand) loads were determined for all weather conditions. These loads are presented in Tables 4-6 and 4-7.

The sampling point at Jackson Pike for TSS and BOD concentrations is located at the grit chambers on the O.S.I.S. Therefore, the samples do not represent the flow from the Big Run Interceptor. The O.S.I.S. carries in

TABLE 4-6. 1985 AVERAGE BOD LOADS (lb/day)

Month	Jackson Pike BOD	Southerly BOD	Total BOD
Jan.	118,466	91,187	209,653
Feb.	109,094	82,506	191,600
Mar.	104,532	82,819	187,351
Apr.	97,918	87,777	185,695
May	97,831	89,108	186,939
Jun.	109,632	85,513	195,145
Jul.	94,384	84,649	179,033
Aug.	93,591	86,073	179,664
Sep.	88,619	98,992	187,611
Oct.	104,161	105,446	209,607
Nov.	96,483	76,140	172,623
Dec.	92,466	76,992	169,458
ANNUAL	100,702	87,258	187,960

TABLE 4-7. 1985 and 1986 MONTHLY AVERAGE TSS LOADS (lb/day)

Month	Jackson Pike		Southerly		Total	
	1985 TSS	1986 TSS	1985 TSS	1986 TSS	1985 TSS	1986 TSS
Jan.	120,331	115,923	99,391	87,633	219,722	203,556
Feb.	121,223	120,583	108,739	91,508	229,962	212,091
Mar.	136,509	129,050	107,085	94,313	243,594	223,363
Apr.	110,170	124,532	106,911	92,109	217,081	216,641
May	136,038	133,613	108,516	89,700	244,554	223,313
Jun.	158,045	139,516	99,145	95,078	257,190	234,594
Jul.	153,317	113,282	105,571	93,421	258,888	206,703
Aug.	126,033	108,853	91,308	100,996	217,341	209,849
Sep.	114,192	129,688	95,424	101,437	209,616	231,125
Oct.	121,086	139,653	93,693	100,830	214,779	240,483
Nov.	148,916	112,099	99,165	88,952	248,081	201,051
Dec.	105,969	104,965	97,948	86,313	203,917	191,278
ANNUAL	129,347	122,665	101,042	93,535	230,389	216,200

approximately 65 to 70 percent of the flow at Jackson Pike. Plant staff believe that the flow arriving through the O.S.I.S. contains the majority of the industrial flow in the Jackson Pike service area. Samples taken from the O.S.I.S. have always been used to establish waste loads for the total flow to Jackson Pike. The Southerly flow is sampled between the screens and the grit chambers. Thus, the samples are representative of 100 percent of the flow entering the Southerly plant.

Only 1985 data were used to determine existing BOD loads because there were insufficient data available for 1986. There were only 304 days of reported BOD values for Jackson Pike in 1986. There were 341 days of data for Jackson Pike in 1985. Southerly reported BOD values on 362 days in 1986 and 364 days in 1985.

The 1985 annual average BOD load for Jackson Pike, as presented in Table 4-6, is 100,702 lb/day. The maximum monthly average load is 118,466 lb/day, and it occurred in January. The ratio of maximum monthly average to the annual average results in a peaking factor of 1.2.

The 1985 annual average BOD load for Southerly, as shown in Table 4-6, is 87,258 lb/day. The maximum monthly average load, which occurred in October, is 105,446 lb/day. The peaking factor, as determined by dividing the maximum monthly average by the annual average, is 1.2.

1985 and 1986 data were used to establish TSS loads for Jackson Pike and Southerly. Jackson Pike had 365 and 363 days of TSS data for 1985 and 1986, respectively. There were 364 days of TSS data reported for Southerly for both years.

The average TSS load was obtained by computing the average of the annual averages for 1985 and 1986. The Southerly 1985 and 1986 average is 97,289 lb/day; and Jackson Pike is 126,006 lb/day. Peaking factors were established for each year in the same manner as was used for BOD loads. The peaking factors for Jackson Pike are 1.2 and 1.1 for 1985 and 1986, respectively. The higher value of 1.2 was chosen as the Jackson Pike TSS peaking factor. The Southerly TSS peaking factors are 1.1 for both 1985 and 1986. Table 4-8 summarizes the 1985 and 1986 average and peak BOD and TSS loads.

TABLE 4-8. 1985 AND 1986 BOD AND TSS LOADS

	Jackson Pike	Southerly	Total
BOD LOADS			
• Average (lb/day)	100,702	87,258	187,960
(lb/capita day)	0.206	0.229	0.216
• Peak (lb/day)	118,466	105,446	223,912
• Peaking Factor	1.2	1.2	1.1
TSS LOADS			
• Average (lb/day)	126,006	97,289	223,295
(lb/capita day)	0.258	0.255	0.257
• Peak (lb/day)	151,207	107,018	251,925
• Peaking Factor	1.2	1.1	1.1
POPULATION	489,000	381,000	870,000

A summary of the 1985 population figures and historic wastewater flows and loads is presented in Table 4-9. These quantities were used as a basis for projecting flows and loads to the design year.

TABLE 4-9. 1985 FLOWS AND LOADS

	Jackson Pike	Southerly	TOTAL
Total Flow Ave. (MGD)	84	61	145
• Infiltration	40.1	22.1	62.2
• Industrial	9.0	6.9	15.9
• Commercial	4.5	3.2	7.7
• Domestic	30.4	28.8	59.2
BOD Load (lb/day)	118,500	105,400	223,900
TSS Load (lb/day)	151,200	107,000	258,200
Population	489,000	381,000	870,000

4.3 PROJECTED FLOWS AND LOADS

This next section presents flows and loads projected to the 2008 design year.

Table 4-10 presents the flows of Table 4-9 in per capita/connection form. These data further reinforce the figures presented in Table 4-9 since they represent reasonable values in agreement with the literature.

Holding infiltration and industrial flows constant and using the existing per capita commercial and domestic flows (Table 4-10) and the population projections for 1988 and 2008, wastewater flows were projected for 1988 and 2008.

TABLE 4-10. 1985 PER CAPITA/CONNECTION FLOWS

	Jackson Pike	Southerly	TOTAL
Per Capita Domestic Wastewater Flow (gpcd)	62.2	75.6	68.1
Per Capita Commercial Wastewater Flow (gpcd)	9.2	8.4	8.9
Per Capita Industrial Wastewater Flow (gpcd)	18.4	18.1	18.2
Per Capita Industrial, Commercial, and Domestic Wastewater Flow (gpcd)	89.8	102.1	95.2
Per Capita Infiltration (gpcd)	82	58	72
Per Connection Commercial Wastewater Flows* (gal/connection day)	ND	ND	816.7
Per Connection Industrial Wastewater Flows* (gal/connection day)	ND	ND	62,109
1985 Per Capita Water Pumped Industrial, Commercial, and Domestic (gpcd)	ND	ND	139.1
1985 (Industrial, Commercial, and Domestic) Water Pumped to Wastewater Discharge Factor	ND	ND	.976

* SOURCE: City of Columbus, Division of Sewerage and Drainage, December 1986

There was insufficient information available to disaggregate the existing industrial loads and the expected future industrial loads from the total. Therefore, the existing total per capita BOD and TSS loads from Table 4-8 were multiplied by the population projections and the respective peaking factors to obtain the 1988 and 2008 projected loads. In doing so, growth of industrial contributions is proportional to residential growth.

Table 4-11 presents the 1988 projected population, flows, and loads for each plant; and Table 4-12 presents the projected design average flows and loads for the 2008 design year.

TABLE 4-11. 1988 PROJECTIONS

	Jackson Pike	Southerly	TOTAL
Total Flow Ave. (MGD)	84.8	61.7	146.5
• Infiltration	40.1	22.1	62.2
• Industrial	9.0	6.9	15.9
• Commercial	4.6	3.3	7.9
• Domestic	31.1	29.4	60.5
BOD Load (lb/day)	123,400	106,900	230,300
TSS Load (lb/day)	154,500	109,100	263,600
Population	499,000	389,000	888,000

TABLE 4-12. 2008 PROJECTIONS

	Jackson Pike	Southerly	TOTAL
Total Flow Ave. (MGD)	87.9	66.0	153.9
• Infiltration	40.1	22.1	62.2
• Industrial	9.0	6.9	15.9
• Commercial	5.0	3.7	8.7
• Domestic	33.8	33.3	67.1
BOD Load (lb/day)	134,600	121,300	255,900
TSS load (lb/day)	168,600	123,800	292,400
Population	544,600	441,400	986,000

5. FACILITY PLAN METHODOLOGY

The following sections summarize the design wastewater flows and loads proposed in the facility plan and the methodology used in their development. The Revised Facility Plan Update (RFPU) and the General Engineering Report and Basis of Design (GERBOD) were used to prepare this discussion. The following sections include:

- Dry Weather Wastewater Flows
- Design Average Daily Flows
- Design Loads
- Industrial Flows and Loads
- Projected Design Flows and Loads

The facility plan developed existing dry weather wastewater flows to approximate a low groundwater condition. These flows were projected to the 2015 design year. Then average daily flows were developed to approximate average infiltration under a high groundwater condition and these flows were projected to the 2015 design year. The 2015 average daily flows approximating average infiltration under a high groundwater condition were selected as the design average flows for use in alternative development in the facility plan.

Existing waste loads were determined and projected to the 2015 design year. Two scenarios were developed for future additional flows and loads from undocumented industrial growth. However, since neither of these scenarios was included in the design average flows and loads, it appears that a decision was made not to plan for future undocumented industrial growth. The last section summarizes the facility plan's selected design wastewater flows and loads.

5.1 DRY WEATHER WASTEWATER FLOWS

The Revised Facility Plan Update developed dry weather flows to approximate low infiltration under low groundwater conditions. Monthly

Operating Reports (MORs) were used to determine dry weather wastewater flows through three different methods.

- An average daily flow was derived for the 1984 dry months (July and August).
- A 50th percentile flow was determined from 40 randomly selected dry weather days between 1982 and 1984.
- An average daily flow was derived for the dry months of 1979 through 1984.

The GERBOD states that flows of 74 MGD for Jackson Pike and 53 MGD for Southerly were determined from the first method listed above using 1984 dry months. The report states that the flows developed by the other two methods closely approximate these flows, but a direct comparison is not provided.

The 1983 population for each WWTP service area was selected as the population value to be used for calculation of gallons per capita per day (gpcd) flow factors. The 1983 Southerly population was determined to be 356,901 and the Jackson Pike population was determined to be 470,979. Calculated gpcd flow factors are 149 gpcd for Southerly and 157 gpcd for Jackson Pike which results in a system-wide average of 153 gpcd. By comparison, a system-wide average of 152 gpcd was calculated in the Original Facility Plan based upon 1975 flow data.

Utilizing population projections developed in the Revised Facility Plan Update (presented in Table 5-1) and the gpcd flow factors discussed above, dry weather flows were projected for each plant for the years 1988, 2000, and 2015. Table 5-2 presents these flows.

TABLE 5-1. FACILITY PLAN POPULATION PROJECTIONS

Service Area	Year 1988	2000	2015
Jackson Pike	487,644	531,366	573,052
Southerly	382,783	420,495	459,992
TOTAL	870,427	951,861	1,033,044

SOURCE: Revised Facility Plan Update - URS Dalton 1985

TABLE 5-2. PROJECTED DRY WEATHER FLOWS (MGD)

Service Area	Year 1988	2000	2015
Jackson Pike	77	83	90
Southerly	58	63	69
TOTAL	135	146	159

SOURCE: Revised Facility Plan Update - URS Dalton 1985

5.2 DESIGN AVERAGE DAILY FLOWS

The Revised Facility Plan Update developed design average daily flows to approximate average infiltration under high groundwater conditions. Flow values were obtained from Monthly Operating Reports (MOR). Forty-five days were randomly selected from the years 1982 through 1985 based on the following criteria:

- Weekdays only
- No significant rainfall on the sample day
- No significant rainfall for 24 hours prior to the sample day
- No reported bypassing

The 50th percentile flow values were derived from probability plots for each WWTP. The Jackson Pike flow was determined to be 84 MGD, and the Southerly flow was determined to be 59 MGD.

The WWTP service area population figures for 1984 of 475,909 for Jackson Pike and 363,097 for Southerly were used to convert the above flows to gpcd flow factors. Jackson Pike was calculated at 177 gpcd and Southerly was calculated at 162 gpcd. Table 5-3 shows the breakdown of the flow factors as presented in the RFPU.

TABLE 5-3. DESIGN AVERAGE FLOW FACTORS (gpcd)

Flow Component	Jackson Pike Service Area	Southerly Service Area	Total Service Area
Domestic	80	80	80
Industrial	15	24	19
Infiltration	82	58	72
Total	177	162	171

Source: Revised Facility Plan Update - URS Dalton 1985

Using population projections (Table 5-1) and total gpcd flow factors developed for each WWTP, design flows were projected for the years 1988, 2000, and 2015. These flows are shown in Table 5-4.

TABLE 5-4. DESIGN AVERAGE FLOWS (MGD)

	Year		
Service Area	1988	2000	2015
Jackson Pike	86	94	101
Southerly	63	68	75
TOTAL	149	162	176

SOURCE: Revised Facility Plan Update - URS Dalton 1985

5.3 DESIGN LOADS

Existing wasteloads were determined by randomly selecting 80 days from MORs for each WWTP based on the following criteria:

- 40 days during the low infiltration season - July, August, September

- 40 days during the low temperature season - December, January, February
- Years 1982, 1983, 1984
- No significant rainfall on the selected day.
- No significant rain for 24 hours prior to the selected day
- No bypassing
- Weekdays only

The parameters selected for analysis were BOD_5, TKN, phosphorus, suspended solids, and flow.

Probability plots were constructed from these calculated loads for both the low infiltration season and the low temperature season. The 80th percentile loads were chosen from the low infiltration plots. These loads were used in calculating projected loads for 1988, 2000, and 2015. Adjustments were made for the Anheuser-Busch Brewery. It was assumed that the existing loads and flow from the brewery are the following:

- BOD = 35,260 lb/day
- SS = 13,400 lb/day
- Flow = 3.13 MGD

For future projections it was assumed that the brewery would increase to its maximum monthly average BOD_5 limit of 45,000 lb/day.

Table 5-5 presents the Revised Facility Plan Update's design wasteloads for the Jackson Pike and Southerly WWTP.

TABLE 5-5. DESIGN WASTELOADS (lb/day)

	Design Year	BOD_5	Suspended Solids	TKN	Total Phosphorus
Jackson Pike					
	1988	127,150	145,780	16,700	5,459
	2000	137,060	157,130	18,000	5,884
	2015	148,620	170,390	19,520	6,380
Southerly					
	1988	117,060	180,020	14,570	4,595
	2000	123,730	116,450	15,760	4,991
	2015	131,740	126,550	17,260	5,467

SOURCE: Revised Facility Plan Update - URS Dalton 1985

5.4 INDUSTRIAL FLOWS AND LOADS

The Revised Facility Plan Update presented tables which included additional flow and loading allowances for future, undocumented industrial growth. This growth was only assumed to affect the Southerly plant. No reason was provided for this assumption. Flow projections for both dry weather and design average flow were increased by 2 MGD and 4 MGD after 1988 to account for the possibility of undocumented growth in the industrial sector. Table 5-6 presents dry weather flow projections with the additional flow allowances of 2.0 MGD and 4.0 MGD for undocumented industrial growth. Table 5-7 presents design average flow projections with the same flow allowances.

TABLE 5-6. DRY WEATHER FLOW PROJECTIONS FOR UNDOCUMENTED INDUSTRIAL GROWTH (2 MGD/4 MGD FLOW ALLOWANCES)

Service Area	Year 1988	2000	2015
Jackson Pike	77/77	83/83	90/90
Southerly	58/58	65/67	71/73
TOTAL	135/135	148/150	161/163

SOURCE: Revised Facility Plan Update - URS Dalton 1985

TABLE 5-7. DESIGN AVERAGE FLOW PROJECTIONS FOR UNDOCUMENTED INDUSTRIAL GROWTH (2 MGD/4 MGD FLOW ALLOWANCES)

Service Area	Year 1988	2000	2015
Jackson Pike	86/86	94/94	101/101
Southerly	63/63	70/72	77/79
TOTAL	149/149	164/166	178/180

SOURCE: Revised Facility Plan Update - URS Dalton 1985

The increase in industrial flow could also increase the wasteload projection. Therefore, the facility planners also revised their wasteload projections to reflect the 2/4 MGD flow increases. Since the industrial flow increase was only added to the Southerly WWTP, the increase in wasteloads will only affect the Southerly plant. Table 5-8 presents these revised wasteload projections for Southerly.

TABLE 5-8. DESIGN WASTELOAD PROJECTIONS (lb/day) ADJUSTED FOR UNDOCUMENTED INDUSTRIAL GROWTH SOUTHERLY WWTP

	Design Year	BOD_5	Suspended Solids	TKN	Total Phosphorus
2 MGD Allowance					
	1988	117,060	108,820	14,510	4,595
	2000	138,730	122,170	16,510	5,066
	2015	146,740	132,230	18,010	5,542
4 MGD Allowance	1988	117,060	108,020	14,510	4,595
	2000	163,730	131,610	17,760	5,191
	2015	171,740	141,710	19,260	5,667

SOURCE: Revised Facility Plan Update - URS Dalton 1985

The flows and loads which included an allowance for undocumented industrial growth were not used as a basis for alternative development, which assumes no industrial growth during the planning period.

5.5 PROJECTED DESIGN FLOWS AND LOADS

This section summarizes the facility plan's projected design flows and loads.

5.5.1 Design Flows

The Jackson Pike and Southerly projected 2015 design average daily flows of 101 MGD and 75 MGD, respectively, were chosen by the facility plan as the basis for development. These flows were presented in Section 5.2.

Since the Revised Facility Plan Update chose the one-plant alternative, the design flows for Jackson Pike and Southerly were combined resulting in an average daily design flow of 176 MGD to be treated at Southerly. Peak process design was then calculated as 300 MGD by multiplying the design average flow by a peaking factor of 1.7. The peak process flow of 300 MGD is used to size the wet stream treatment facilities. There is no supportable information in the facility plan on how the peaking factor was derived. There is reference to the fact that anything greater than 1.7 would adversely affect process efficiency under average flow conditions. In subsequent correspondence and a clarifying telephone conversation with the city's consultant, it was determined that 1.7 was based on a hydraulic constriction between the existing primary clarifiers and aeration basins at the Southerly WWTP. The consultant indicated that each existing train is limited to an average to peak flow ratio of 44 MGD to 75 MGD. The 44 MGD average flow is based on mass loading to the aeration basins, and the 75 MGD peak flow is based on the hydraulic capacity of the existing conduits between the primary clarifiers and the aeration tanks. In light of the fact that the CSO study is incomplete and that analyses of wet weather data was limited, the 1.7 peaking factor was considered appropriate by the city and their consultant.

An additional 130 MGD for CSO control is added on to the peak process flow of 300 MGD and this total flow of 430 MGD is considered as the peak hydraulic flow. There are conflicting statements in the facility plan regarding which treatment processes will be sized for 430 MGD. In Chapter 2, it is stated that flows between 300 MGD and 430 MGD will be processed through primary settling and chlorination. In Chapter 12, it appears that only the influent pumps and bar racks and screens are being sized for 430 MGD.

5.5.2 Design Loads

Section 5.3 presented design loads determined in the facility plan through analysis of Jackson Pike and Southerly plant records. In addition to these loads, the facility plan presents loads contributed by the additional flows conveyed to the plant during peak hydraulic flow conditions. These additional flows are considered to be diverted from Whittier Street. Table 5-9 presents the design loadings for the year 2015 including the loads from Whittier Street flows.

TABLE 5-9. DESIGN LOADINGS (lb/day)

Parameter	Southerly	Jackson Pike	Whittier St.	Total
BOD_5	131,740	148,620	10,000	290,360
TSS	126,550	170,390	20,000	316,940
TKN	17,260	19,520	1,300	38,080
P	5,467	6,380	400	12,247

SOURCE: Revised Facility Plan Update - URS Dalton 1985

Since the Revised Facility Plan Update chose the one-plant alternative, the loads listed in the Total column in the previous table were used as the basis for development of alternatives.

6. COMPARISON OF BRIEFING PAPER AND FACILITY PLAN FLOWS AND LOADS

This section summarizes the design flows and loads developed in the facility plan and those developed by this briefing paper. Table 6-1 provides a comparison between the two.

TABLE 6-1. COMPARISON OF DESIGN FLOWS AND LOADS

	Facility Plan	Briefing Paper
1988 Projected Average Flow (MGD)	149	147
Design Year	2015	2008
Design Average Flow (MGD)	176	154
Process Peaking Factor	1.7	1.5
Peak Process Flow (MGD)	300	231
Design BOD Load (lb/day)	290,360	255,900
Design TSS Load (lb/day)	316,940	292,400

The 1988 projected average flows are very close, being 149 MGD in the facility plan and 147 for this briefing paper. The projected design average flows of 176 MGD for the facility plan and 154 MGD for this briefing paper vary by 22 MGD (14 percent) due to different design years that result in a difference in population projections. The facility plan flows are based on the year 2015 and the briefing paper flows are based on a 2008 design year. For purposes of comparison, the facility plan design average flow was brought back to the year 2008. Using the 2008 population projections developed for the EIS and the gpcd flow figures used in the facility plan, the facility plan flows for 2008, presented in Table 6-2, are 96 MGD for Jackson Pike and 72 MGD for Southerly. This total flow of 168 MGD for both plants is 14 MGD (9 percent) higher than the briefing paper flow of 154 MGD.

TABLE 6-2. FACILITY PLAN POPULATION AND FLOW PROJECTIONS

	Jackson Pike	Southerly	TOTAL
Flow Values (gpcd)	177	162	171
1988			
• Population	487,644	382,783	870,427
• Flow (MGD)	86	63	149
2000			
• Population	531,366	420,495	951,861
• Flow (MGD)	94	68	162
2008			
• Population*	544,600	441,400	986,000
• Flow (MGD)**	96	72	168
2015			
• Population	573,052	459,992	1,033,044
• Flow (MGD)	101	75	176

Source: Revised Facility Plan Update - 1985

*EIS population projections.
**Developed for comparison with briefing paper 2008 design flow.

Thus, even if the design years are the same and the population projections are the same, the design flows still differ slightly. This difference is because the flow projections made in the briefing paper were developed by holding the infiltration and industrial portions of the flow constant and increasing only the commercial and domestic flows proportional to the population increase, whereas the flows in the facility plan were developed by increasing all of the flow, including infiltration and industrial, proportional to the population increase. Projected increases in infiltration do not appear justified if the population increase is located within the existing service area. The facility plan does not document why an increase in infiltration should be planned for. Projected industrial increases should be based on documented industrial growth by existing industries and/or policy decisions by the municipality to plan for future undocumented growth. Furthermore, such industrial growth should be an identifiable part of the total design loads since capital cost recovery for the added capacity must be addressed.

The projected peak process flows are 231 MGD and 300 MGD for the briefing paper and facility plan, respectively. These flows differ significantly due to differences in design average flows and different peaking factors. The reasons for the different design average flows were discussed in the previous paragraphs. The peaking factor is 1.5 for the briefing paper and 1.7 for the facility plan. The 1.5 peaking factor for the briefing papers is consistent with the peaking factor used in the original EIS. The facility plan's peaking factor of 1.7 is based on the maximum hydraulic capability of the conduits between the primary clarifiers and aeration basins in the existing trains at the Southerly WWTP.

A breakdown of the briefing paper and facility plan projected BOD and TSS loads is presented in Table 6-3. The differences in loads are partially due to differences in design years and also due to the inclusion of loads from Whittier Street. For comparison purposes, Table 6-4 presents the facility plan loads brought back to 2008 without the Whittier Street loads. These loads were decreased to the year 2008 using EIS population projections and load factors developed in Section 4.2 of this document. In comparing the briefing paper loads to the 2008 facility plan loads, it was found that the loads are within 5 percent of each other. Therefore, the 2008 facility plan loads will be used as the basis for further EIS evaluations.

TABLE 6-3. COMPARISON OF FACILITY PLAN AND BRIEFING PAPER DESIGN LOADS

Design Year	Facility Plan 2015	Briefing Paper 2008
Jackson Pike		
• BOD (lb/day)	148,620	134,600
• TSS (lb/day)	170,390	168,600
Southerly		
• BOD (lb/day)	131,740	121,300
• TSS (lb/day)	126,550	123,800
Whittier Street		
• BOD (lb/day)	10,000	--
• TSS (lb/day)	20,000	--
TOTAL		
• BOD (lb/day)	290,360	255,900
• TSS (lb/day)	319,940	292,400

TABLE 6-4. 2008 PROJECTED LOADS

	Facility Plan	EIS	Percent Difference From Facility Plan
Jackson Pike			
• BOD (lb/day)	141,600	134,600	-4.9
• TSS (lb/day)	161,600	168,600	+4.3
Southerly			
• BOD (lb/day)	126,600	121,300	-4.2
• TSS (lb/day)	121,300	123,800	+2.1
Total			
• BOD (lb/day)	268,200	255,900	-4.5
• TSS (lb/day)	282,900	292,400	+3.2

Summary

Table 6-5 summarizes the 2008 flows and loads which will be used as a basis for further EIS analysis. The 2008 average flows developed in this briefing paper will be utilized. They were developed based on 1985 and 1986 plant records, industrial flow data from the 1983 Industrial Pretreatment Report, and the facility plan infiltration values. A process peaking factor of 1.5 is applied to this average flow to obtain the peak process flow. The facility plan BOD and TSS loads brought back to 2008, without the Whittier Street loads, will be utilized as the design loads. Further documentation is required and has been requested to verify the industrial flows and infiltration value.

TABLE 6-5. 2008 PROPOSED EIS FLOWS AND LOADS

	Jackson Pike	Southerly	Total
Average Flow (MGD)	88	66	154
Peak Process Flow (MGD)	132	99	231
BOD Load (lb/day)	141,600	126,600	268,200
TSS Load (lb/day)	161,600	121,300	282,900

APPENDIX B

BRIEFING PAPER NO. 2
SOLIDS HANDLING ALTERNATIVES

BRIEFING PAPER NO. 2

SOLIDS HANDLING ALTERNATIVES

Supplemental Environmental Impact Statement
USEPA Contract No. 68-04-5035, D.O. No. 40
Columbus Ohio Wastewater Treatment Facilities

Prepared By:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TRIAD ENGINEERING INCORPORATED

SOLIDS HANDLING ALTERNATIVES

INTRODUCTION

Under the direction of USEPA, a series of briefing papers are being prepared addressing key issues in the development of the Supplemental Environmental Impact Statement for the Columbus, Ohio, Wastewater Treatment Facilities. The briefing papers form the basis of discussions between Triad Engineering and USEPA to resolve these key issues. The following paragraphs present the background of the facility planning process, a description of the briefing papers, and the purpose of this paper on solids handling alternatives.

FACILITY PLANNING PROCESS

At the time this paper was prepared (March-August 1987) the city of Columbus was proceeding to implement improvements at the Jackson Pike and Southerly Wastewater Treatment Plants to comply with more stringent effluent standards which must be met by July 1, 1988. These improvements were based on the consolidation of wastewater treatment operations at the Southerly plant. This one-plant alternative is a change from the two-plant operation proposed by the city in the 1970's and evaluated in the 1979 EIS.

The development and documentation of a wastewater treatment process and sludge management alternatives for the Columbus metropolitan area has been an extended and iterative process. The design and construction of various system components have progressed, because of the 1988 deadline, while planning issues continue to be resolved. As a result, numerous documents have been prepared which occasionally revise a previously established course of direction.

The concurrent resolution of planning issues and implementation of various project components has made preparation of the EIS more difficult because final facility plan recommendations are not available in a single document.

BRIEFING PAPERS

To facilitate preparation of the EIS, a series of briefing papers are being developed. The purpose of the briefing papers is to allow USEPA to review the work of the EIS consultant and to identify supplemental information necessary for the preparation of the EIS. Six briefing papers are being prepared as follows:

- Flows and Loads
- Sludge Management
- CSO
- Process Selection
- One Plant vs. Two Plant (Alternative Analysis)
- O&M and Capital Costs

The specific focus of each briefing paper will be different. However, the general scope of the papers will adhere to the following format:

- Existing conditions will be documented.
- Evaluations, conclusions, and recommendations of the facilities planning process will be reviewed using available documentation.
- Where appropriate, an independent evaluation of the future situation and viable alternatives will be prepared.
- The facility plan and EIS briefing paper conclusions will be compared.

The briefing paper process is intended to:

- Prompt the resolution of any data deficiencies.
- Clearly establish and define existing and future conditions.
- Identify the final recommended plan which the city desires to implement.
- Provide a data base of sufficient detail to allow preparation of the draft EIS.

SLUDGE MANAGEMENT ALTERNATIVES

This briefing paper reviews the facilities planning process and subsequent efforts by the city relative to the development and adoption of a sludge management alternative. The briefing paper is divided into four sections as follows:

Section 1 - Existing Sludge Management System.

Section 1 defines the current sludge processing and disposal practices of the Jackson Pike and Southerly plants. It establishes a foundation from which potentially viable sludge management alternatives can be identified.

Section 2 - Development of Sludge Management Alternatives

In Section 2 potentially viable sludge management alternatives are identified and developed sufficiently to allow a comparative evaluation.

Section 3 - Evaluation of Sludge Management Alternatives

Section 3 evaluates the sludge management alternatives that were developed. The alternatives are evaluated with respect to the analysis of the briefing paper and in light of the recommendations of the facilities planning process and subsequent planning and preliminary design documents.

Section 4 - Planning Issues to be Resolved

In Section 4 the issues that developed through this analysis are highlighted to facilitate discussion and resolution.

The primary sources of information utilized in preparing this briefing paper included:

- Revised Facilities Plan Update, September 30, 1985
- General Engineering Report and Basis of Design, January 1, 1986
- Preliminary Design Evaluation of Sludge Dewatering, December 12, 1986

1. EXISTING SLUDGE MANAGEMENT SYSTEMS

1.1 JACKSON PIKE

Figure 1 presents the sludge processing and disposal schematic currently in operation at Jackson Pike. The sludge processing operations include:

- Primary sludge (PS) thickening in primary clarifiers
- Centrifuge thickening of waste activated sludge (WAS)
- Thickened sludge storage and blending (i.e. PS and WAS)
- Stabilization by anaerobic digestion or thermal conditioning
- Centrifuge dewatering

Dewatered sludge is disposed of in one of the following ways:

- Dewatered sludge is incinerated and the ash product is ultimately landfilled.
- Dewatered sludge is land applied in an agricultural reuse program.

The Jackson Pike facility currently produces 230-250 wet tons per day of dewatered sludge at a cake solids concentration of about 17 percent. On a dry weight basis approximately 50 dry tons per day (dtpd) of dewatered solids are produced for ultimate disposal. Based on recent operating records, approximately 50 percent of the dewatered sludge is incinerated and 50 percent is land applied.

Table 1 identifies and describes the existing sludge management facilities at Jackson Pike. The facility has provisions for short-term storage of both PS and WAS outside of the main liquid processing stream. The centrifuges for thickening of WAS were originally installed in 1975-76 and are estimated to have a remaining useful life of approximately 10 years. Thickened sludge storage and blending is accomplished using a secondary digester. The anaerobic digestion facilities consist of eight primary digesters constructed in 1937, and eight secondary digesters constructed in

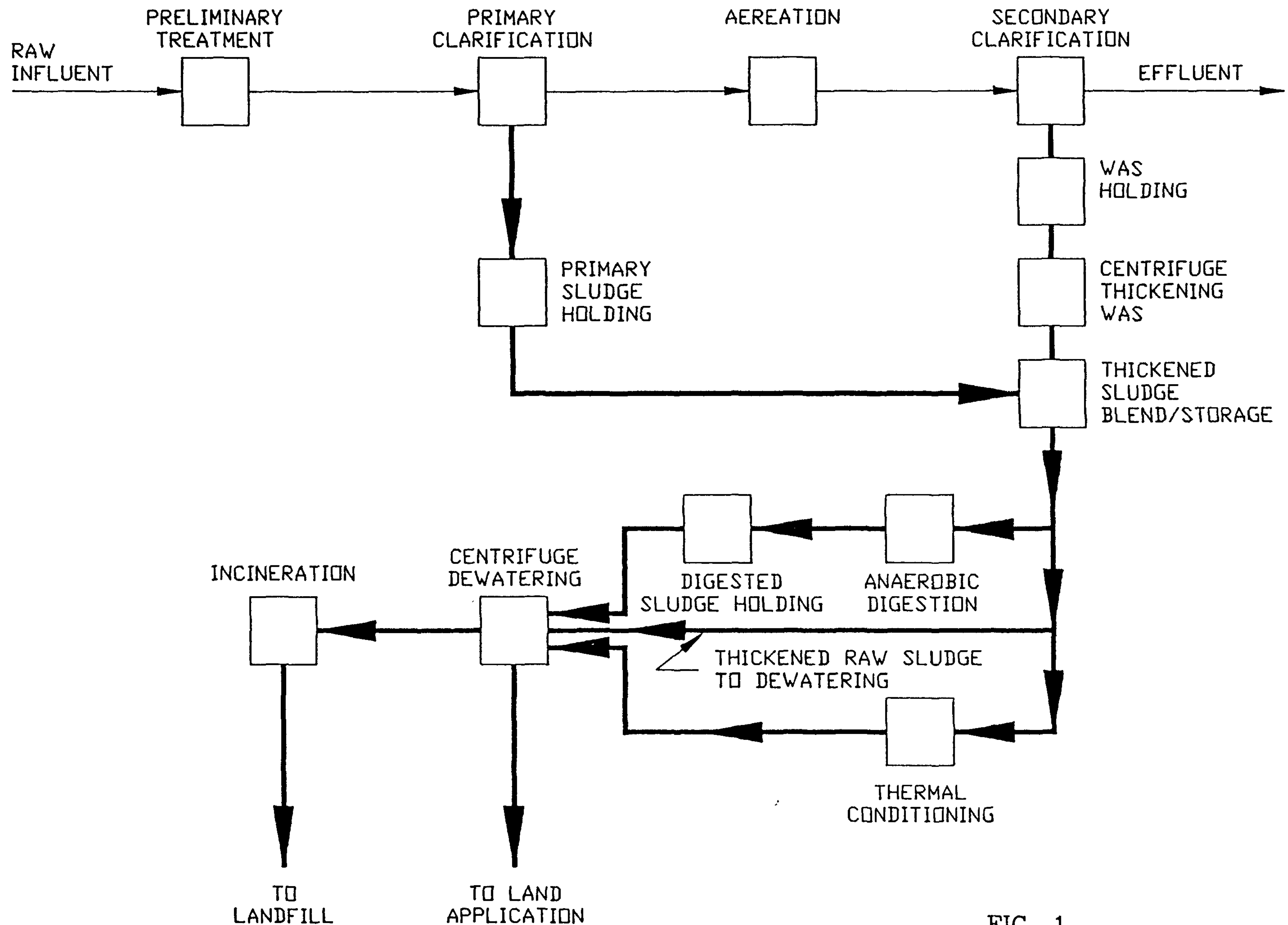


FIG. 1
JACKSON PIKE
EXISTING SLUDGE
MANAGEMENT SCHEMATIC

TABLE 1. EXISTING SLUDGE MANAGMENT FACILITIES
JACKSON PIKE WWTP; COLUMBUS, OH

Process	Facilities/Condition	Capacity
Waste Activated Sludge Holding	One 78-foot x 14-foot x 8-foot deep basin (two) standby units	0.065 MG of storage
Primary Sludge Holding	One 85-foot dia., 25.25-foot SWD	1 MG of storage
Centrifuge Thickening (WAS)	Two solid bowl centrifuges	550 gpm/unit, 400 HP/unit Feed solids 1% Thickened WAS 4%
Anaerobic Digestion	Eight primary digesters: 70-foot dia., 27.5-foot SWD Six secondary digesters: 85-foot dia., 23.5-foot SWD	Volume: 1.6×10^6 CF total 6.3 MG primary 6.0 MG secondary
Digested Sludge Holding	One 85-foot dia., 25.5-foot SWD	1.0 MG of storage
Thermal Conditioning	Two reactors installed 1972, Expanded 1978 to 4 reactors	200 gpm/unit
Centrifuge Dewatering	Six solid bowl centrifuges Installed 1976	100 gpm/unit, 100 HP/unit Feed solids 3% Dewatered cake 16-18%
Incineration	Two multiple-hearth incinerators 7-hearths, 22.25-foot diameter	170 wet tons/day Feed Solids 16-18%
Ash Lagoon	Two lagoons	Total storage capacity 48,000 cy; Cleaned as needed
Landfill	City-owned landfill	Ash landfilled on an as-needed basis through contract operation
Land Application		
Sludge Transport and Application	Contract operation	Transport 130-150 tons/day Application 70-200 tons/day Approximate unit cost of $11/wet ton
Application Sites	Required acreage 2000 Ac/yr Available acreage 10000 Ac	Application 260 days/yr Seasonal peaks dependent on weather and cropping patterns

1950. Current practice utilizes two of the secondary digesters as short-term sludge holding facilities. One digester is used as a mixing and blend tank as identified previously, the second provides for storage of digested sludge prior to dewatering. Based on information furnished by the city, the structural integrity of the digesters is adequate; however, the mechanical components have reached their useful life. The thermal conditioning units have performed better than those at Southerly and have been maintained in good operating condition, however, some process piping and mechanical rehabilitation of the system is warranted. The centrifuge dewatering equipment is less than 10 years old and has been rated as adequate for future use. The multiple hearth incinerators were rebuilt in 1978-79. The units are estimated to have 15-20 years of remaining useful service.

The existing land application program is accomplished through contract operations. A local contractor is responsible for transport and spreading of the sludge. The application program is operated approximately 260 days per year, 5-6 days per week, applying 70 to 200 wet tons per day, 17 percent solids, of dewatered cake depending on seasonal demand. In 1985, approximately 5800 dry tons of sludge were land applied, in 1986 approximately 6800 dry tons of sludge were applied. Dewatered sludge is normally removed from the Jackson Pike site on a uniform basis to either land application under favorable weather conditions or to storage sites located near the application sites. The city also has utilized the Jackson Pike ash lagoons for temporary short-term storage of dewatered cake. The city is pleased with the performance of the application program. They believe land application has been satisfactorily received by the community and that continuation of the program should be included as part of any future planning. Adequate application acreage appears available within a reasonable haul distance from the treatment facility. Short-term storage of dewatered sludge has recently been difficult and the city should address this problem if land application is part of the future sludge management alternative.

Currently, incinerator ash is slurried and pumped to ash lagoons. The lagoons are periodically dredged with the ash taken to a landfill. Plant staff have indicated that private landfill operators have declined to accept the ash. Consequently, the only repository for the ash has been the city-owned landfill.

1.2 SOUTHERLY

Figure 2 presents the sludge processing and disposal schematic currently in operation at Southerly. The sludge processing operations include:

- Primary sludge (PS) thickening in primary clarifiers
- Centrifuge thickening of waste activated sludge
- Thickened sludge blending (i.e., PS and WAS)
- Centrifuge dewatering

Dewatered sludge is disposed of in one of the following ways:

- Dewatered sludge is incinerated and the ash product is ultimately landfilled.
- Dewatered sludge is hauled to the composting facility and distributed as a soil conditioner.

The Southerly facility currently produces 350-400 wet tons per day of dewatered sludge at a cake solids concentration of about 17 percent. On a dry weight basis, approximately 64 dry tons per day (dtpd) of dewatered solids are produced for ultimate disposal. Based on recent operating records, approximately 70 percent of the dewatered sludge is incinerated and the remaining 30 percent is composted.

Table 2 identifies and describes the existing sludge management facilities at Southerly. Primary sludge is thickened to approximately 4.5 percent in the primary clarifiers. The thickening of WAS by solid bowl centrifuges was installed and operating in the latter part of 1986. The PS and WAS is directed to separate tanks in a Sludge Control Building where it is mixed prior to being pumped to the dewatering centrifuges.

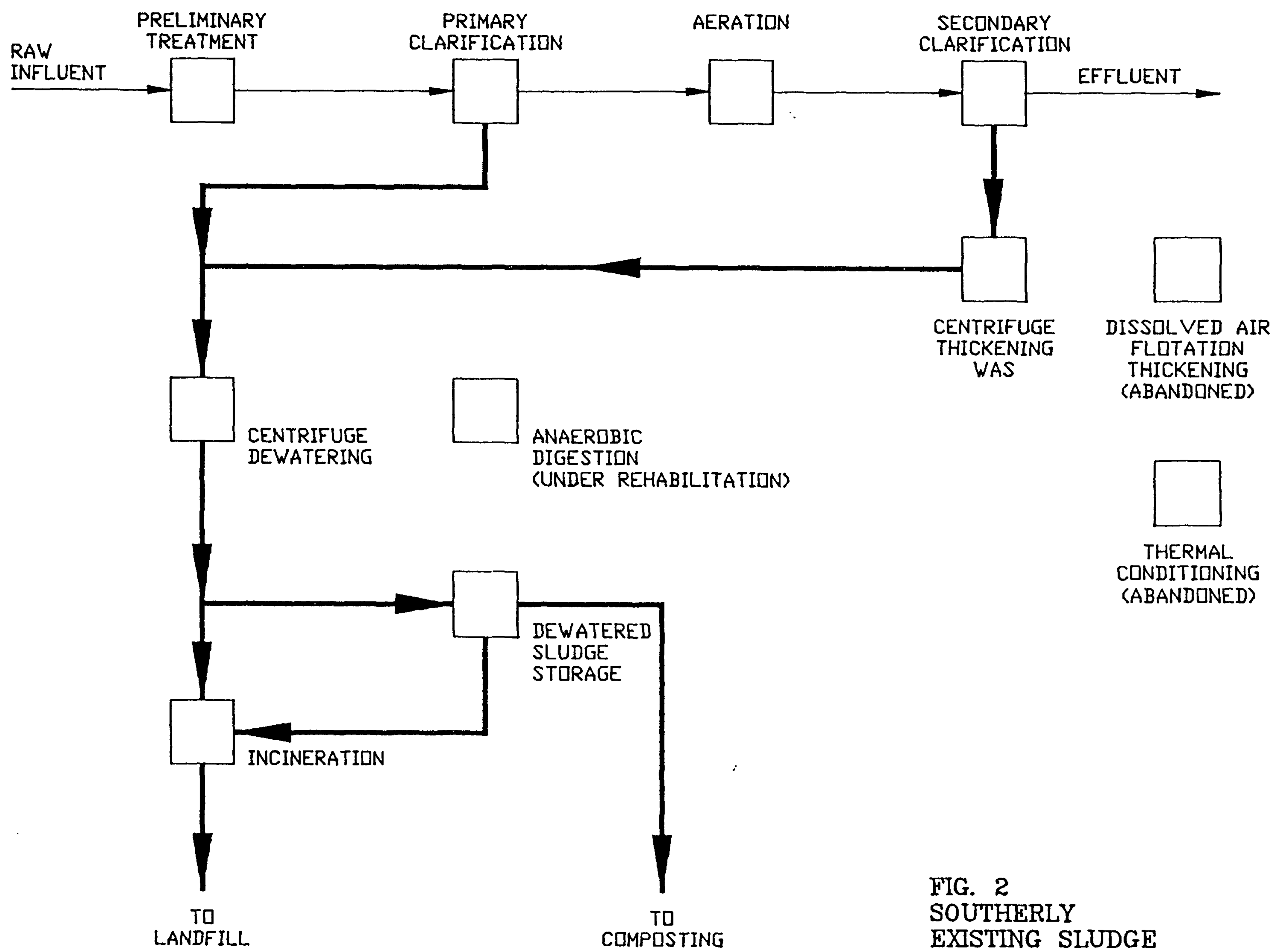


FIG. 2
SOUTHERLY
EXISTING SLUDGE
MANAGEMENT SCHEMATIC

TABLE 2. EXISTING SLUDGE MANAGMENT FACILITIES
SOUTHERLY WWTP; COLUMBUS, OH

Process	Facilities/Condition	Capacity
Dissolved Air Flotation Thickening (WAS)	Four units @ 1900 SF/unit (Abandoned 1978 used as WAS concentration tanks)	
Centrifuge Thickening (WAS)	Four solid bowl centrifuges Pre-Project 88, Contract #19 Not yet fully operational	200 gpm/unit Feed solids 1% Thickened WAS 5%
Anaerobic Digestion	Four primary digesters: 85-foot dia., 25.25-foot SWD Two secondary digesters; 85-foot dia., 25.25-foot SWD Construction date 1965	Volume of 972,000 CF total 4.8 MG primary 2.4 MG secondary
Thermal Conditioning	Three reactors Installed 1974, abandoned 1980	200 gpm/unit
Centrifuge Dewatering	Six solid bowl centrifuges Operational approx. 7 years	100 gpm/unit Feed solids 3.5% Dewatered cake 16-18%
Dewatered Sludge Storage	One storage bin.	Volume of 400 cy/300 wet tons
Transport to Composting	4-8 trucks @ 25 wet tons Hrs of operation 56 hrs/wk	Haul distance of 7 miles roundtrip
Composting	Extended aerated static pile system	120-200 wet tons/day dependent on sludge and weather
Compost Disposal	Product removed by truck	Disposal through bulk sales to public and private consumers
Incineration	Two existing multiple hearth units; Two new multiple hearth units New units in start-up	150 wet tons/day existing 260 wet tons/day new
Ash Lagoon	Two lagoons	Total storage capacity 76,000 cy; Cleaned as needed
Landfill	City-owned landfill	Ash landfilled on an as-needed basis through contract operations

The anaerobic digestion facilties have not been operational since 1978, but are currently undergoing rehabilitation. The anaerobic digestion system at Southerly consists of four primary and two secondary digesters. The thermal conditioning units have not operated at Southerly for almost 10 years. Chloride stress corrosion which led to equipment deterioration and continuous mechanical problems caused the abandonment of the thermal conditioning units.

The existing sludge dewatering facility at the Southerly plants consists of six centrifuges which produce a final cake solids of 16-20 percent. Dewatered sludge is disposed through incineration or composting. There are two eight-hearth incinerators at Southerly which are each capable of burning 150 wet tons per day at 20-percent solids. Two new incinerators are in the final stages of construction and start-up. The new incinerators will each have a disposal capacity of 260 wet tons per day based on approximately 20 percent solids in the dewatered cake.

Dewatered sludge which is not incinerated is hauled by city-owned vehicles to the composting facility where it is mixed, dried, screened, and cured as a soil conditioner. The composting facility can normally accept 30 percent of the volume of solids produced by the Southerly plant with peak capacity of 50 percent under ideal conditions. These ideal conditions relate to dry weather and cake solids concentration.

Currently, the ash is placed in on-site ash lagoons. These ash lagoons are periodically cleaned with the ash being removed to the city-owned landfill.

2. DEVELOPMENT OF SLUDGE MANAGEMENT ALTERNATIVES

Preliminary evaluations necessary to establish a foundation for the preparation of the EIS required that alternative sludge management schemes be identified and developed. The sludge management alternatives were formulated in light of several goals and objectives. These goals and objectives included the following:

- The sludge management alternatives must consist of processing and disposal options that will provide for environmentally sound processing and ultimate disposal of sludge.
- The alternative must provide a reliable means for future processing and disposal.
- The alternatives should offer some flexibility allowing the city to modify the processing and disposal methods to relieve pressures created by equipment failures or temporary loss of the ultimate disposal methods.

The alternatives developed should consider, to the extent possible, optimizing the reuse of the existing facilities thus minimizing implementation costs.

This preliminary evaluation identified alternatives for the two-plant scenario, where Jackson Pike and Southerly would be operated independently, and for the one-plant scenario, where Southerly is expanded to handle the projected flows and loads and the Jackson Pike facility in abandoned. Under the two-plant scenario, three alternative sludge management schemes were identified for Jackson Pike, and six sludge management alternatives were identified for Southerly. For the one-plant scenario (i.e., the consolidation of wastewater treatment at Southerly) the sludge management alternatives which were identified for the Southerly two-plant scenario were considered appropriate to evaluate.

The alternatives which were identified were first subjectively screened to eliminate those alternatives which did not adequately address future goals and objectives. Alternatives which advanced from the subjective evaluation were then developed in greater detail through performance of a solids balance, identification of required facilities and appropriate facilities sizes, and development of a cost estimate for each alternative. Sizing criteria used were consistent with current engineering practice. The cost estimates prepared during the facilities planning process for required facilities were reviewed in detail. For the most part, these estimates were considered reasonable and reflective of facilities planning work. The cost estimates developed in this briefing paper, revised and modified the facilities planning estimates as appropriate to account for the difference between the alternatives developed herein and the facilities plan alternatives. In areas where the facilities planning estimate was not adequately supported, this evaluation adjusted the estimates appropriately.

2.1 JACKSON PIKE SLUDGE MANAGEMENT ALTERNATIVES (TWO-PLANT SCENARIO)

Three potential sludge management alternatives were identified for the Jackson Pike WWTP. Each alternative is discussed separately in the following paragraphs.

2.1.1 Jackson Pike Sludge Management Alternative JP-A

Figure 3 presents the sludge managment schematic for alternative JP-A. The alternative would involve the following sludge processes:

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering

Dewatered digested sludge would be land applied in an agricultural reuse program.

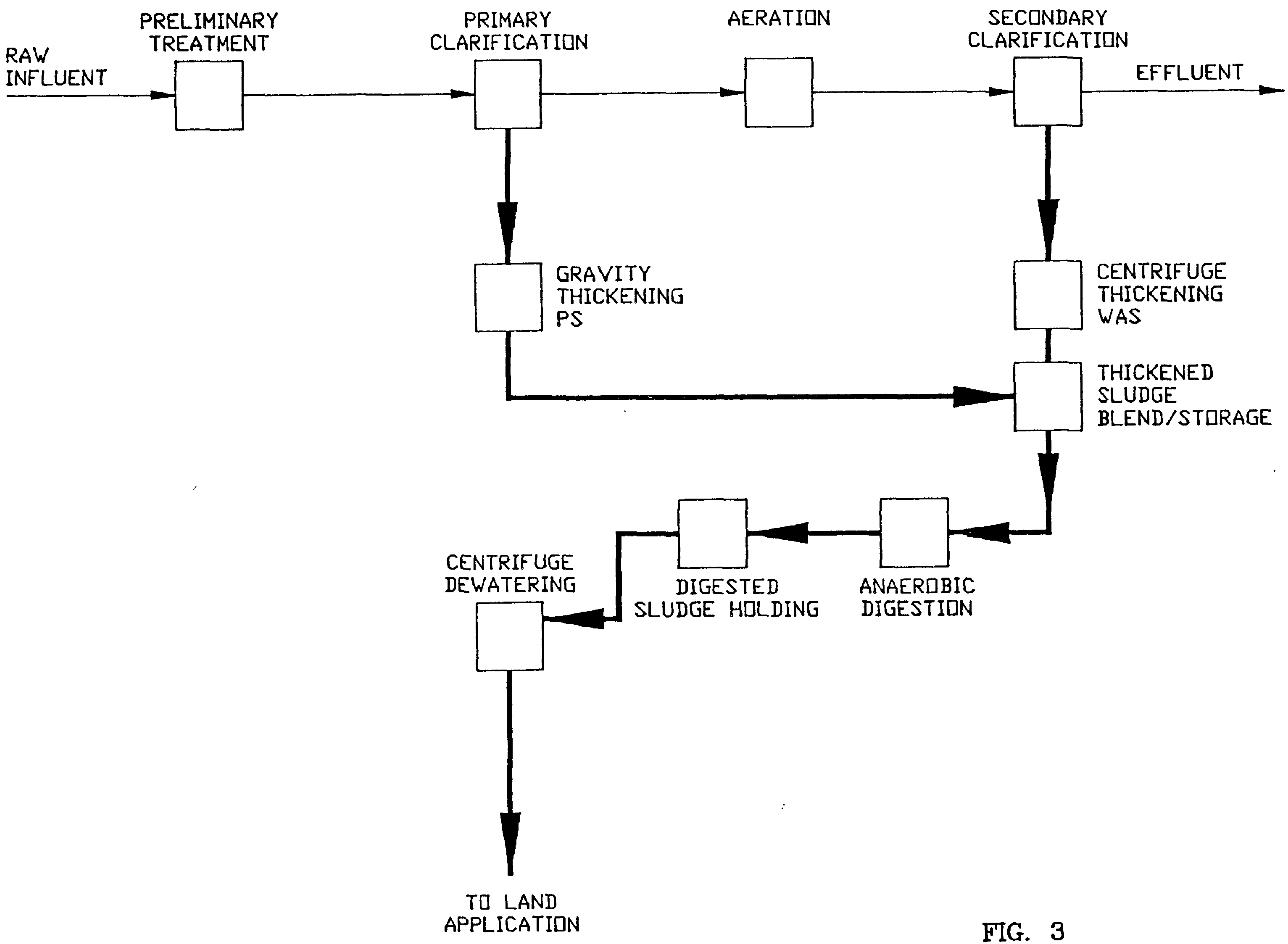


FIG. 3
JACKSON PIKE
ALTERNATIVE JP-A SLUDGE
MANAGEMENT SCHEMATIC

Based on the subjective review of this management alternative, it was eliminated from further consideration. Relying strictly on land application, for ultimate disposal of the projected sludge quantities, lacks the flexibility critical to maintaining a successful disposal program. This lack of flexibility would require an increased degree of conservatism in design and implementation to ensure plant performance during an interruption of the disposal process. Furthermore, the seasonal nature of the agricultural application program would require substantial sludge storage facilities. Normally, such storage facilities experience community relation difficulties associated with aesthetics and odors.

2.1.2 Jackson Pike Sludge Management Alternative JP-B

Figure 4 presents the sludge management schematic for alternative JP-B. This alternative would consist of the following sludge processes:

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Incineration

Dewatered sludge would be disposed of as follows:

- 50 percent of the dewatered sludge would be incinerated and the ash product landfilled.
- 50 percent of the dewatered sludge would be land applied.

The 50:50 ratio is approximately consistent with current Jackson Pike disposal practices. In this brief analysis, a comprehensive review of alternate ratios to determine an optimum was not performed. Since land application is not a limiting factor and the incinerators at Jackson Pike require some rehabilitation, a split equal to current practices appears appropriate.

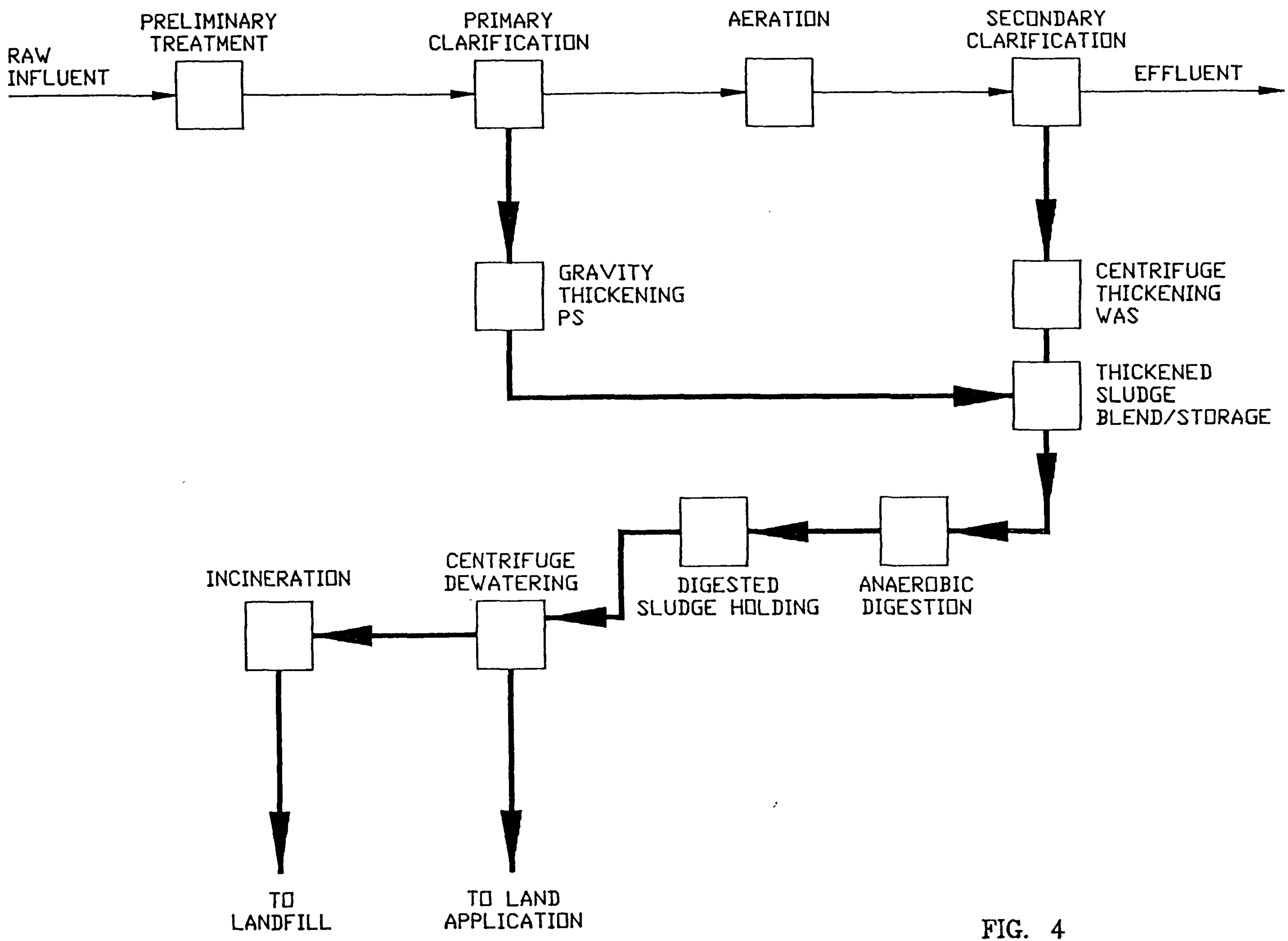


FIG. 4
JACKSON PIKE
ALTERNATIVE JP-B SLUDGE
MANAGEMENT SCHEMATIC

Subjective screening of JP-B indicated that the alternative adequately addressed the goals and objectives. Therefore, it was developed for a more detailed evaluation. Table 3 describes the facilities required and presents the estimated costs to implement JP-B.

2.1.3 Jackson Pike Sludge Management Alternative JP-C

Figure 5 presents the sludge management schematic for alternative JP-C. This alternative would consist of the following sludge processes.

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Stabilization by thermal conditioning
- Centrifuge dewatering
- Incineration

Dewatered sludge would be disposed of as follows:

- 50 percent of the dewatered sludge would be incinerated and the ash product landfilled.
- 50 percent of the dewatered sludge would be land applied.

As previously discussed, the 50:50 disposal ratio is consistent with current practice. The stabilization processes would each handle 50 percent of the thickened sludges produced under normal operating conditions. The dewatered, thermally conditioned sludge would be incinerated while the dewatered, digested sludge would be land applied.

Sludge management alternative JP-C was also determined by the subjective screening to merit more detailed consideration. Table 4 describes the facilities required and presents the estimated costs to implement JP-C.

TABLE 3
JACKSON PIKE SLUDGE MANAGEMENT ALTERNATIVE
JP-B (Two-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping **Modify two (2)digesters; 85**-foot dia. x 10-foot SWD	**$1,967,000**
Centrifuge Thickening WAS Two (2) existing; 500 gpm One (1) new; 500 gpm	$4,500,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 23.5-foot SWD	$9,170,000
Centrifuge Dewatering Six (6) existing; 1200 lb/hr	$ 490,000
Incineration Two (2) existing, 7 hearth, 200 wet ton/day @ 20% solids	$3,600,000
Landfill Contract operations included with O&M	--
Land Application Contract operations included with O&M	--
Capital Cost	**$19,727,000**
Annual Operation and Maintenance Cost	$ 3,070,000
Present Worth (JP-B Two-Plant)	**$41,827,000**

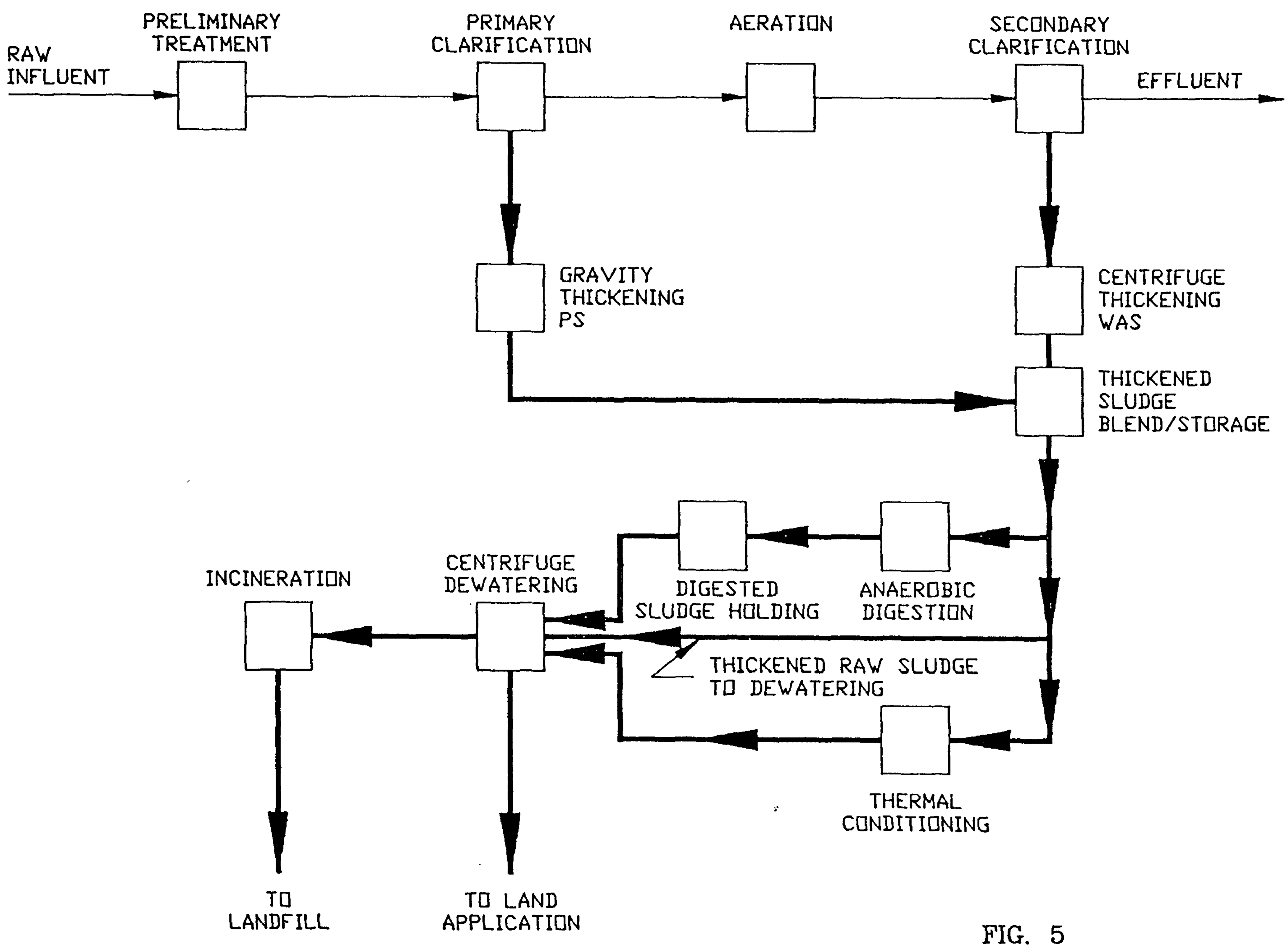


FIG. 5
JACKSON PIKE
ALTERNATIVE JP-C SLUDGE
MANAGEMENT SCHEMATIC

TABLE 4
JACKSON PIKE SLUDGE MANAGEMENT ALTERNATIVE
JP-C (Two-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping **Modify two (2) digesters**; 65-foot dia. x 10-foot SWD	**$1,967,000**
Centrifuge Thickening WAS Two (2) existing; 500 gpm One (1) new; 500 gpm	$4,500,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 23.5-foot SWD	$7,750,000
Thermal Conditioning Two (2) existing; 200 gpm	$3,000,000
Centrifuge Dewatering Six (6) existing; 1200 lb/hr	$ 490,000
Incineration Two (2) existing; 7 hearth, 200 wet ton/day @ 20% solids	$3,600,000
Landfill Contract operations included with O&M	--
Land Application Contract operations included with O&M	--
Capital Cost	**$21,307,000**
Annual Operations and Maintenance Cost	$ 3,770,000
Present Worth (JP-C Two-Plant)	**$48,597,000**

2.2 SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVES (TWO-PLANT SCENARIO)

Six potential sludge management alternatives were identified for the Southerly WWTP. Each alternative is discussed separately in the following paragraphs.

2.2.1 <u>Southerly Sludge Management Alternative SO-A</u>

Southerly sludge management alternative SO-A is graphically depicted by the schematic presented in Figure 6. Alternative SO-A would utilize the following sludge processes:

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Incineration

Dewatered digested sludge would be incinerated and landfilled.

Alternative SO-A was eliminated from further consideration for two basic reasons. First, the alternative proposes to abandon the existing compost operations. Such a move would forfeit the substantial investment the city has placed in the relatively new facilities and would substitute disposal of all of the sludge product by landfilling in lieu of the current practice which reuses a portion of the sludge as soil conditioner. Second, alternative SO-A lacks the flexibility needed to allow the city to modify disposal operations subject to equipment failures or external pressures such as public dissatisfaction or regulatory requirements.

2.2.2 <u>Southerly Sludge Management Alternative SO-B</u>

Figure 7 presents the sludge management schematic for alternative SO-B. The alternative would feature the following sludge processes:

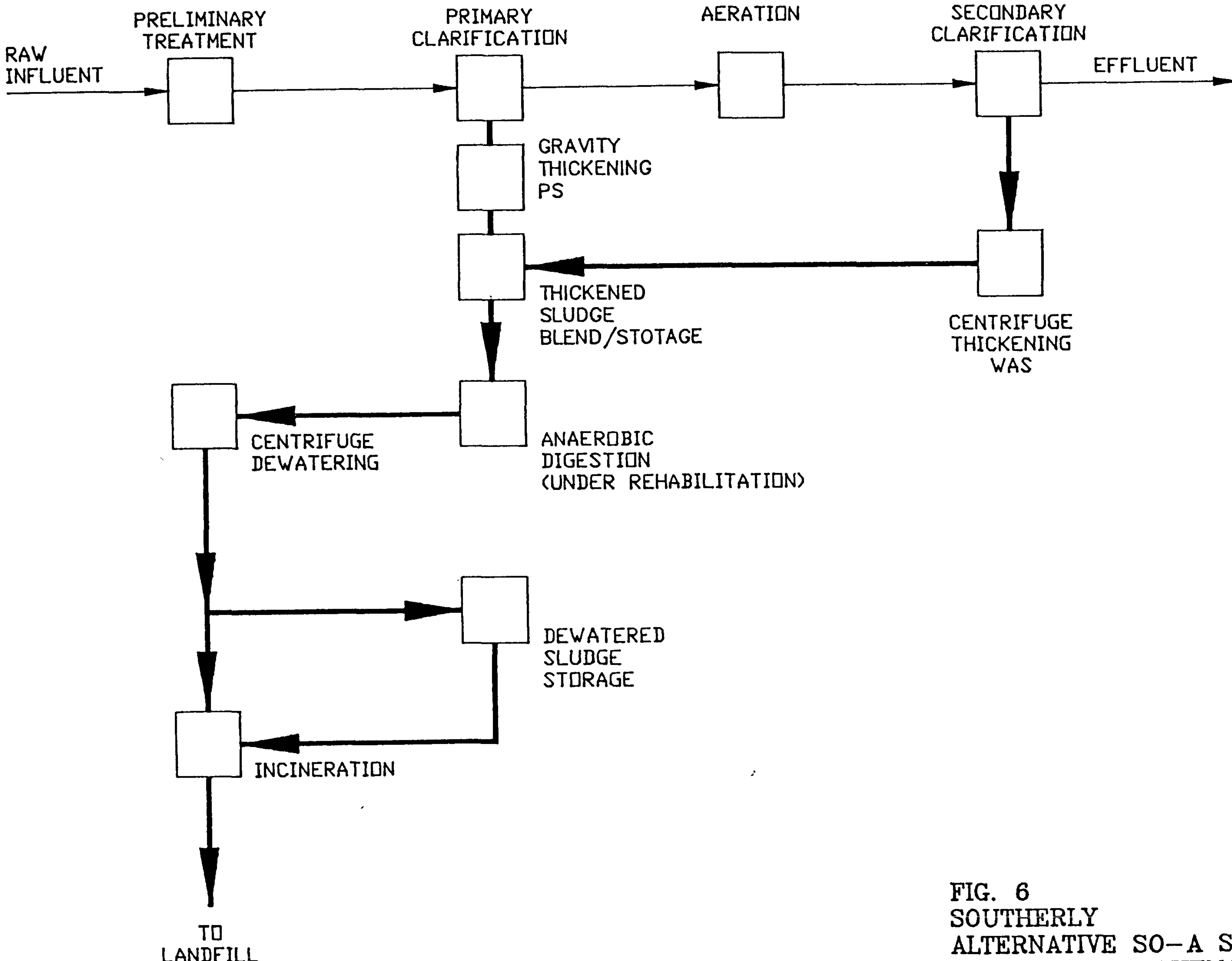


FIG. 6
SOUTHERLY
ALTERNATIVE SO-A SLUDGE
MANAGEMENT SCHEMATIC

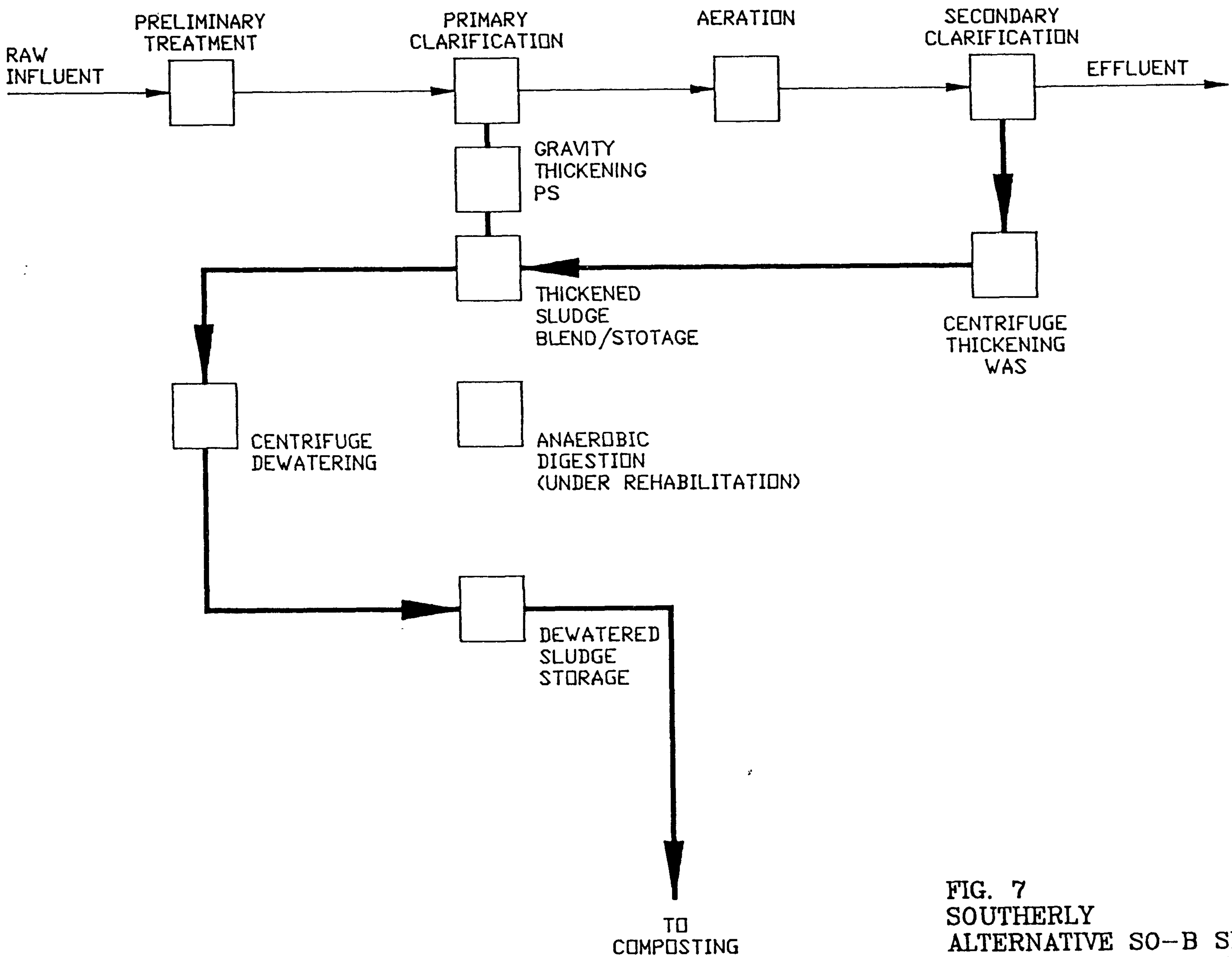


FIG. 7
SOUTHERLY
ALTERNATIVE SO–B SLUDGE
MANAGEMENT SCHEMATIC

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Centrifuge dewatering
- Composting

Ultimate sludge disposal would be accomplished through the marketing and distribution of compost as a soil conditioner.

The subjective evaluation eliminated alternative SO-B from further consideration. Flexibility to alter disposal operations was the critical factor in the evaluation. Composting the entire volume of dewatered sludge would mean a 2-3 fold increase in compost product over current conditions. If Southerly were operated in a one-plant scenario, 5-6 times the current compost product would be produced. An aggressive and successful marketing program would be mandatory to locate and maintain sufficient receptors for the compost. The long-term reliability of an alternative which relies solely on distribution of compost was not considered adequate to merit more detailed development and evaluation.

2.2.3 Southerly Sludge Management Alternative SO-C

The sludge management schematic for alternative SO-C is presented in Figure 8. Southerly sludge management alternative SO-C would consist of the following sludge processes:

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Composting
- Incineration

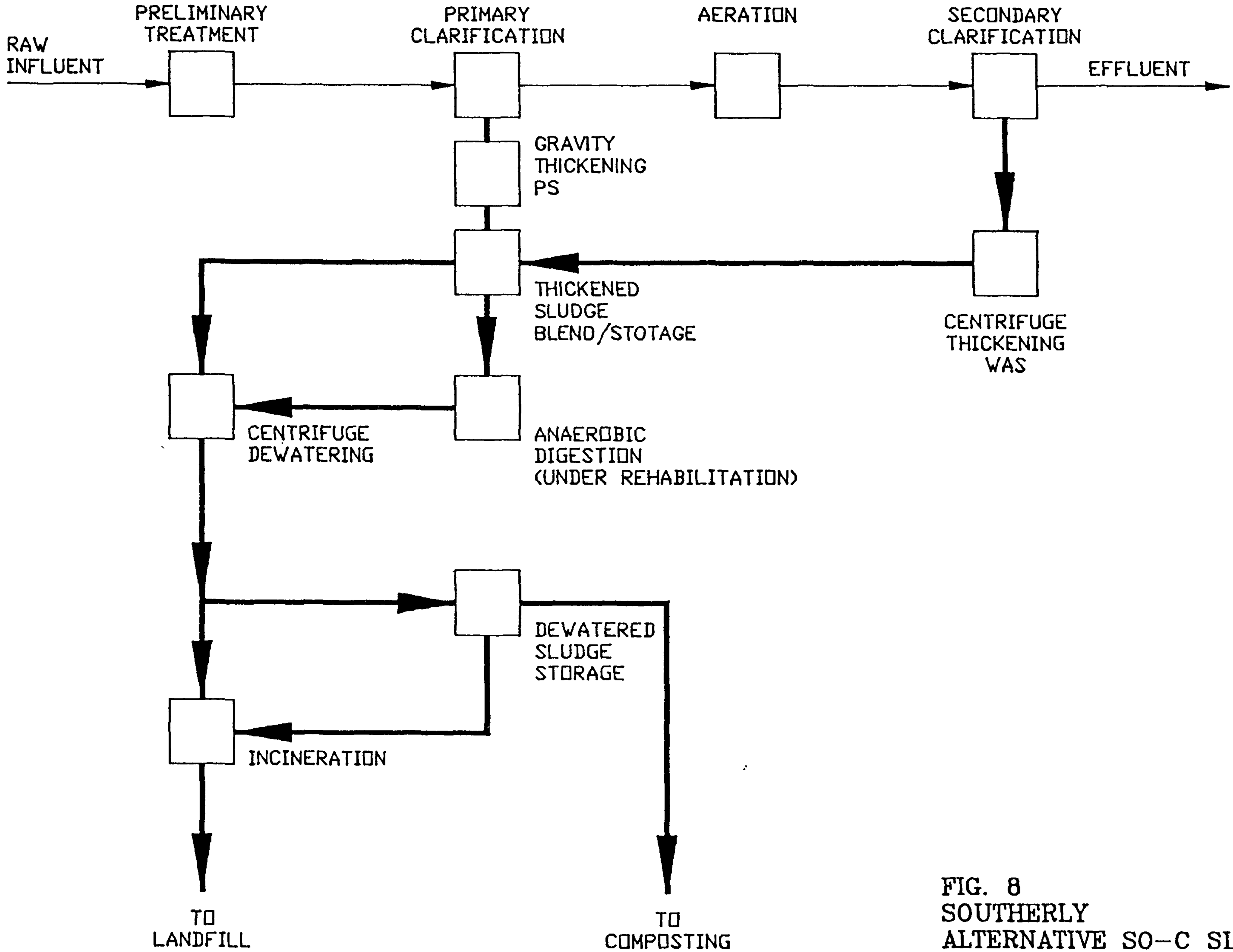


FIG. 8
SOUTHERLY
ALTERNATIVE SO-C SLUDGE
MANAGEMENT SCHEMATIC

Dewatered sludge would be disposed of as follows:

- 75 percent of the dewatered sludge would be incinerated, and the ash product would be landfilled.
- 25 percent of the dewatered sludge would be composted and the compost would be distributed as a soil conditioner.

The 75:25 ratio is approximately consistent with current Southerly disposal practices. The digestion facilities would be sized to process that portion of the sludge that would be incinerated. The portion of the sludge that would be composted would not receive stabilization prior to dewatering.

Alternative SO-C represents current practice at Southerly when the digestion facilities are operational. Therefore, subjective screening concluded that the alternative merits more detailed development and evaluation. Table 5 describes the facilities required and presents the estimated costs to implement SO-C.

2.2.4 Southerly Sludge Management Alternative SO-D

Southerly sludge management alternative SO-D is graphically depicted by the schematic presented in Figure 9. Alternative SO-D would utilize the following sludge processes.

- Gravity thickening of PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Composting
- Incineration

Ultimate disposal of the sludge would be accomplished through one of the following disposal options.

TABLE 5
SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVE
SO-C (Two-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Four (4) existing; 45-foot dia. x 17-foot SWD	$2,520,000
Centrifuge Thickening WAS Four (4) existing; 250 gpm, 1250 lb/hr One (1) new; 250 gpm, 1250 lb/hr	$2,000,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 25.25-foot SWD	$4,280,000
Centrifuge Dewatering Six (6) existing; 1000 lb/hr Two (2) new; 1000 lb/hr	$5,120,000
Dewatered Sludge Storage One (1) new; 400 cy plus material handling	$1,300,000
Composting Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Landfill Contract operations included with O&M	--
Capital Cost	$15,220,000
Annual Operation and Maintenance Cost	$ 3,260,000
Present Worth (SO-C Two-Plant)	$39,080,000

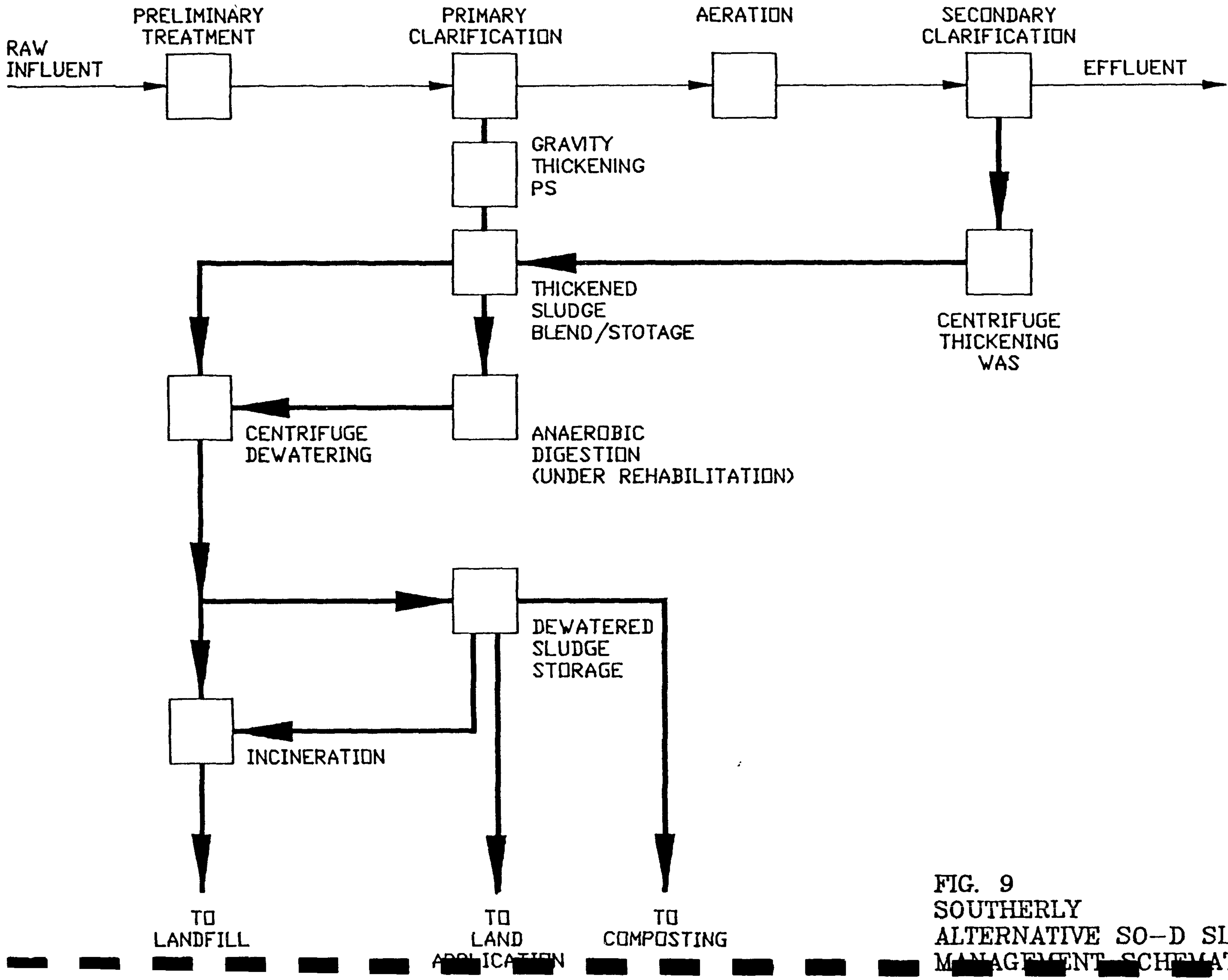


FIG. 9
SOUTHERLY
ALTERNATIVE SO-D SLUDGE
MANAGEMENT SCHEMATIC

- 25 percent of the sludge would be dewatered, composted, and distributed as a soil conditioner.
- 25 percent of the sludge would be digested, dewatered, and land applied.
- 50 percent of the sludge would be digested, dewatered, incinerated, and landfilled.

Alternative SO-D meets the goals and objectives of the subjective screening. The alternative offers continuation of the existing incineration and composting processes at Southerly and introduces land application as a disposal process. The city has indicated there is adequate acreage suitable for land application within an economically feasible distance of the plant. Alternative SO-D was advanced for further development and evaluation. Table 6 describes the required facilities and presents the estimated costs to implement SO-D.

2.2.5 Southerly Sludge Management Alternative SO-E

Figure 10 presents the sludge management schematic for Alternative SO-E. Southerly sludge management alternative SO-E would consist of the following sludge processes:

- Gravity thickening PS
- Centrifuge thickening of WAS
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Composting

Dewatered sludge would be disposed of as follows:

- 50 percent would be composted and distributed as a soil conditioner. Sludge sent to compost would not go through the digestion process.
- 50 percent would be land applied as a fertilizer to agricultural acreage within a reasonable distance from the plant.

TABLE 6
SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVE
SO-D (Two-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Four (4) existing; 45-foot dia. x 17-foot SWD	$2,520,000
Centrifuge Thickening WAS Four (4) existing; 250 gpm, 1250 lb/hr One (1) new; 250 gpm, 1250 lb/hr	$2,000,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 25.25-foot SWD	$4,280,000
Centrifuge Dewatering Six (6) existing; 1000 lb/hr Two (2) new; 1000 lb/hr	$5,120,000
Dewatered Sludge Storage One (1) new; 400 cy plus material handling	$1,300,000
Composting Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Landfill Contract operations included with O&M	--
Land Application Contract operations included with O&M	--
Capital Cost	$15,220,000
Annual Operation and Maintenance Cost	$ 3,340,000
Present Worth (SO-D Two-Plant)	$39,680,000

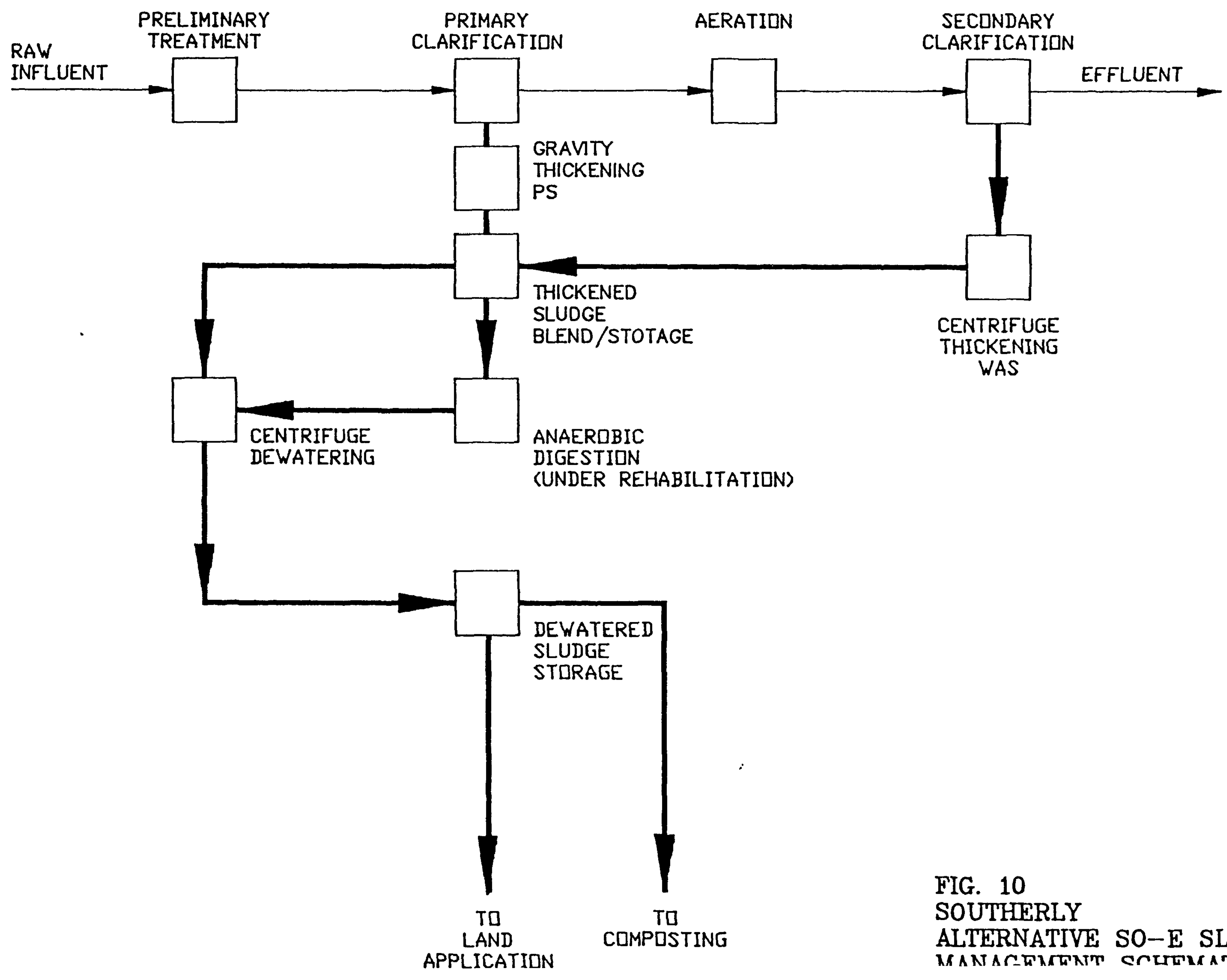


FIG. 10
SOUTHERLY
ALTERNATIVE SO–E SLUDGE
MANAGEMENT SCHEMATIC

Based on the subjective evaluation alternative SO-E was eliminated from further consideration. The reliability of utilizing only compost distribution and land application as ultimate disposal options did not appear reasonable. The plant currently practices incineration and relies heavily on incineration and landfill to dispose of sludge. Furthermore, it is critical that the plant have a disposal method that is completely within their control, i.e., not influenced by sludge quality, weather, market demand, public perception or other external pressures.

2.2.6 Southerly Sludge Management Alternative SO-F

Figure 11 presents the sludge management schematic for Alternative SO-F. Ths sludge management system would consist of the following processes:

- Gravity thickening PS
- Centrifuge thickening WAS
- Thickened sludge storage and blending
- Centrifuge dewatering
- Composting
- Incineration

Ultimate disposal of the sludge would be accomplished through one of the following disposal options.

- 50 percent would be composted and distributed as a soil conditioner.
- 50 percent would be incinerated and landfilled.

Alternative SO-F is similar to alternative SO-C with the exception that digestion is not provided. The evaluation of alternative SO-F was prompted due to the fact that digestion prior to incineration has normally not proven to be cost-effective. Although digestion diminishes the amount of solids to be handled in subsequent processes, the heat content of digested sludge is significantly reduced. Furthermore, digested sludge tends to be more

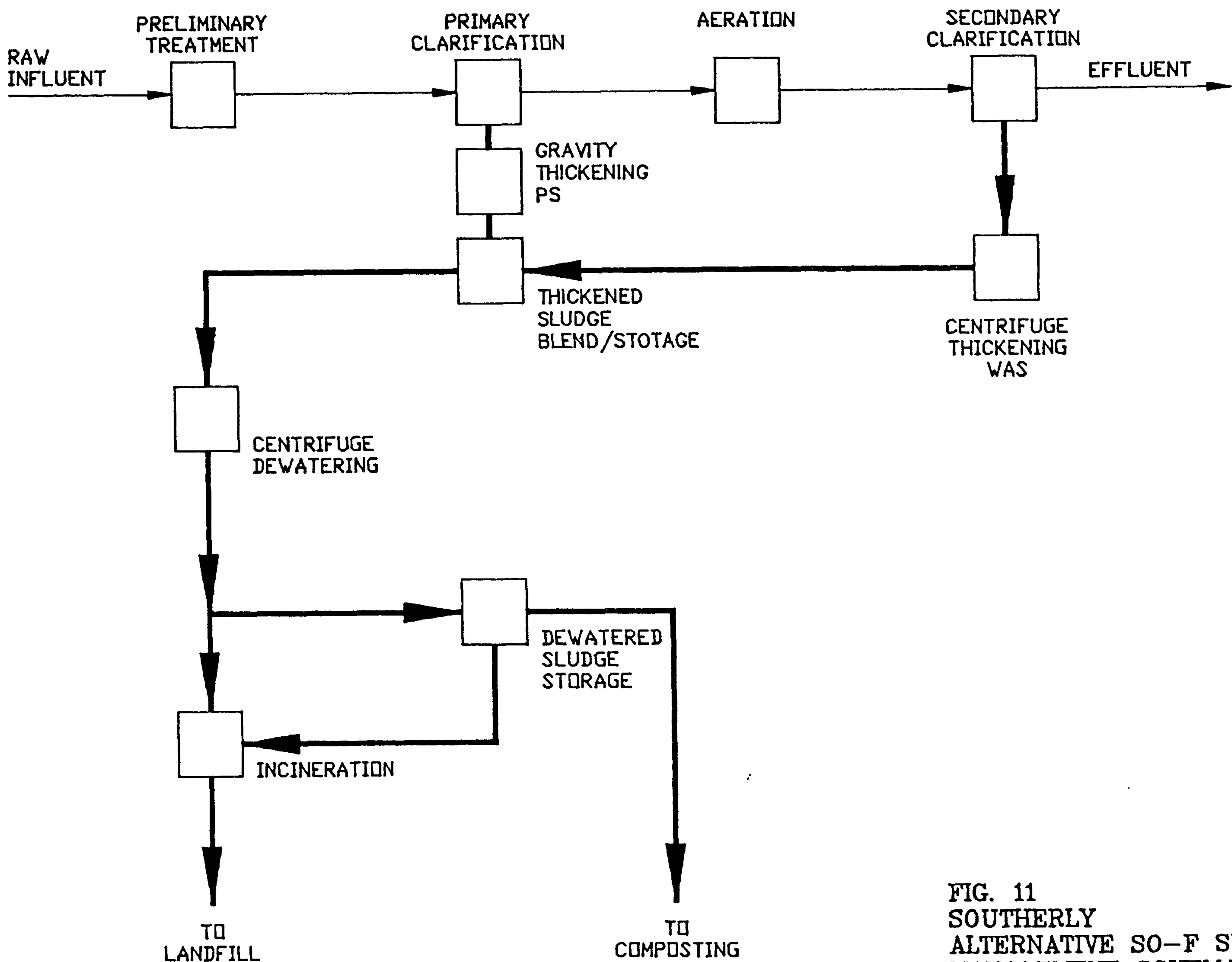


FIG. 11
SOUTHERLY
ALTERNATIVE SO-F SLUDGE
MANAGEMENT SCHEMATIC

difficult to dewater than combined raw sludges. These factors cause digested sludge to be more difficult, and consequently more expensive on a unit basis (i.e. dollars per dry ton), than raw sludges to incinerate. Since the Southerly plant has a portion of the required digestion facilities and adequate incineration facilities in place, the cost effectiveness of digestion prior to incineration is less dependent on capital cost than an evaluation where these facilities are not in place.

Table 7 describes the required facilities and presents the estimated costs to implement SO-F.

2.3 SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVES (ONE-PLANT SCENARIO)

The three sludge management alternatives that were advanced from the subjective screening phase for the Southerly two-plant scenario are considered viable for Southerly one-plant scenario. These three alternatives were previously identified as SO-C, SO-D, and SO-F. The remaining three alternatives, which were identified for the two plant scenario, are not considered viable for the one-plant scenario for the same reasons previously discussed.

The sludge management schematics for alternatives SO-C, SO-D, and SO-F have been presented in Figures 8, 9, and 11 respectively. Table 8 identifies the required facilities and presents the estimated cost to implement sludge management alternative SO-C under a one-plant scenario. Table 9 presents the facilities and estimated costs to implement SO-D under a one-plant scenario. Table 10 presents the facilities and estimated costs to implement SO-F under a one-plant scenario.

TABLE 7
SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVE
SO-F (Two-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Four (4) existing; 45-foot dia. x 17-foot SWD	$2,520,000
Centrifuge Thickening WAS Four (4) existing; 250 gpm, 1250 lb/hr One (1) new; 250 gpm, 1250 lb/hr	$2,000,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Centrifuge Dewatering Six (6) existing; 1000 lb/hr Four (4) new; 1000 lb/hr	$8,750,000
Dewatered Sludge Storage One (1) new; 400 cy plus material handling	$1,300,000
Composting Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Landfill Contract operations included with O&M	--
Capital Cost	$14,570,000
Annual Operation and Maintenance Cost	$ 3,940,000
Present Worth (SO-C Two-Plant)	$42,770,000

TABLE 8
SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVE
SO-C (One-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Four (4) existing; 45-foot dia. x 17-foot SWD Two (2) new; 85-foot dia. x 10-foot SWD	$5,070,000
Centrifuge Thickening WAS Four (4) existing; 250 gpm, 1250 lb/hr Four (4) new; 250 gpm, 1250 lb/hr	$5,600,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 25.25-foot SWD Four (4) new; 85-foot dia. x 25.25-foot SWD	$11,460,000
Centrifuge Dewatering Six (6) existing; 1000 lb/hr Nine (9) new; 1000 lb/hr	$21,040,000
Dewatered Sludge Storage	
One (1) new; 400 cy plus material handling	$1,300,000
Composting	
Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration	
Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Rehabilitate existing	$1,300,000
Landfill	
Contract operations included with O&M	--
Capital Cost	$45,770,000
Annual Operation and Maintenance Cost	$ 6,080,000
Present Worth (SO-C One-Plant)	$89,590,000

TABLE 9
SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVE
SO-D (One-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping	$5,070,000
Four (4) existing; 45-foot dia. x 17-foot SWD	
Two (2) new; 85-foot dia. x 10-foot SWD	
Centrifuge Thickening WAS	$5,600,000
Four (4) existing; 250 gpm, 1250 lb/hr	
Four (4) new; 250 gpm, 1250 lb/hr	
Thickened Sludge Storage/Blend	--
Existing Facilities Reused	
Anaerobic Digestion	$11,460,000
Six (6) existing; 85-foot dia. x 25.25 foot SWD	
Four (4) new; 85-foot dia. x 25.25 foot SWD	
Centrifuge Dewatering	$21,040,000
Six (6) existing; 1000 lb/hr	
Nine (9) new; 1000 lb/hr	
Dewatered Sludge Storage	
One (1) new; 400 cy plus material handling	$1,300,000
Composting	
Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration	
Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Rehabilitate existing	$1,300,000
Landfill	
Contract operations included with O&M	--
Land Application	
Contract operations included with O&M	--
Capital Cost	$45,770,000
Annual Operation and Maintenance Cost	$ 6,230,000
Present Worth (SO-D One-Plant)	$90,710,000

TABLE 10
SOUTHERLY SLUDGE MANAGEMENT ALTERNATIVE
SO-F (One-Plant Scenario)
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Four (4) existing; 45-foot dia. x 17-foot SWD Two (2) new; 85-foot dia. x 10-foot SWD	$5,070,000
Centrifuge Thickening WAS Four (4) existing; 250 gpm, 1250 lb/hr Four (4) new; 250 gpm, 1250 lb/hr	$5,600,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Centrifuge Dewatering Six (6) existing; 1000 lb/hr Fourteen (14) new; 1000 lb/hr	$27,430,000
Dewatered Sludge Storage	
One (1) new; 400 cy plus material handling	$1,300,000
Composting	
Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration	
Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Rehabilitate existing	$1,300,000
Landfill	
Contract operations included with O&M	--
Capital Cost	$40,700,000
Annual Operation and Maintenance Cost	$ 7,110,000
Present Worth (SO-F One-Plant)	$92,440,000

3. EVALUATION OF SLUDGE MANAGEMENT ALTERNATIVES

Sludge management alternatives were evaluated based on cost-effectiveness, dewatering, system redundancy, and ultimate disposal. Facility planning information is included for each of the criteria. The results of the evaluation are discussed in the following sections.

3.1 COST EFFECTIVENESS OF SLUDGE MANAGEMENT ALTERNATIVES

Table 11 presents the potential sludge management alternatives and the associated present worth of each. These alternatives and the present worth costs will be utilized in a subsequent briefing paper to assess the cost effectiveness of the one-plant and two-plant scenarios.

Alternative JP-B, which provides for digestion, dewatering, and a 50:50 split of the sludge to land application and incineration and landfill, is the cost-effective sludge management scheme at Jackson Pike. This alternative is approximately 16 percent less costly than JP-C which proposes to retain the thermal conditioning units for processing a portion of the sludge.

The lowest present worth of the Southerly two-plant alternatives is exhibited by SO-C. Practically speaking, however, present worth of SO-D is considered equal to that of SO-C. At this level of planning analysis the 1.5 percent present worth difference is not a significant factor in selection of an alternative. In light of this fact, SO-D is the recommended sludge management alternative for the Southerly two-plant scenario. Alternative SO-D offers more flexibility in that three disposal methods are utilized (i.e., marketing of a compost product, land application of dewatered, digested sludge, and landfilling of incinerator ash.) SO-C on the other hand utilizes only two of the disposal options, not providing for land application.

Alternative SO-F was developed to evaluate the cost effectiveness of digestion prior to incineration. SO-F proposes dewatering of raw sludge with approximately 50 percent of the dewatered cake incinerated. Alternative SO-F

TABLE 11
PRESENT WORTH COMPARISON
OF SLUDGE MANAGEMENT ALTERNATIVES

SCENARIO	ALTERNATIVE	PRESENT WORTH	RECOMMENDED ALTERNATIVES
TWO-PLANT	JP-B	$ 41,827,000	JP-B + SO-D $ 81,507,000
	JP-C	$ 48,597,000	
	SO-C	$ 39,080,000	
	SO-D	$ 39,680,000	
	SO-F	$ 42,777,000	
ONE-PLANT	SO-C	$ 89,590,000	SO-D $ 90,710,000
	SO-D	$ 90,710,000	
	SO-F	$ 92,440,000	

ALTERNATIVE PROCESS / DISPOSAL INDEX

	JP-B	JP-C	SO-C	SO-D	SO-F
DIGESTION	•	•	•	•	
THERMAL CONDITIONING		•			
DEWATERING	•	•	•	•	•
INCINERATION	•	•	•	•	•
COMPOST			•	•	•
LAND APPLICATION	•	•		•	
LANDFILL	•	•	•	•	•
REFERENCE	FIG. 4	FIG. 5	FIG. 8	FIG. 9	FIG. 11

differs from SO-C only in that the digestion provided in SO-C is not included in SO-F. From Table 11 it can be seen that alternative SO-F (i.e., incineration without digestion) exhibits a present worth approximately 9 percent higher than alternative SO-C.

Digestion prior to incineration has proven to be cost effective in this case primarily due to the sunken capital invested in the Southerly facilities. Southerly has six existing anaerobic digesters and four multiple hearth incinerators in place (i.e., two existing and two in startup). The new incinerators are equipped with a waste heat recovery system which reclaims waste heat from the incinerators to meet digestion and building heat requirements. The waste heat recovery system allows for the digester gas produced to be used as a fuel for the incinerators, thus substantially reducing the supplemental fuel requirements of the incinerators.

The existing digestion, incineration, and waste heat recovery facilities conservatively represent 20-25 million dollars of sunken capital. If these facilities were not in place, the required additional capital costs would be sufficient to show incineration of raw sludge to be more cost effective than digestion prior to incineration.

Under the one-plant scenario, sludge management alternatives SO-C and SO-D represent the lowest present worth options. Again digestion prior to incineration (SO-C) is a lower cost alternative than digestion of raw sludge (SO-F). However, the difference between SO-C and SO-F has been diminished to approximately 3 percent. This smaller difference is due to the fact that four new digesters are required in the one-plant scenario. The cost of the four new digesters weakens the impact of the sunken capital in the cost effectiveness analysis and thus lowers the present worth difference.

As with the Southerly two-plant scenario, alternative SO-D is recommended as the preferrable Southerly one-plant sludge management scheme. For the reasons previously discussed, SO-D provides the city with three reliable disposal paths and adequate flexibility.

3.2 SLUDGE DEWATERING

The RFPU evaluated the sludge dewatering component of the various alternatives in light of the existing centrifuge equipment currently in service at Southerly. The design criteria for the dewatering centrifuges was revised a number of times over the course of the planning and design. Facilities planning documents indicate the centrifuges will be rated at 120 gpm with a feed solids of 5 percent, or approximately 3000 lbs/hr. Subsequently, the GERBOD revised the design criteria for the centrifuges to 1000 lbs/hr. Based on a feed solids of 4 percent, the GERBOD assumed a dewatered cake of 20-21 percent could be produced. The GERBOD further indicated that the successful, efficient operation of the dewatering process is critical to the overall cost of sludge processing and disposal. The GERBOD noted that increasing the solids content of the dewatered cake reduces incinerator fuel consumption and subsequent handling costs, and increases the efficiency of downstream processes. The GERBOD concluded recommending that alternative dewatering equipment (specifically belt presses and diaphragm plate and frame (DPF) presses) be fully evaluated to optimize the sludge processing scheme.

As a result of the GERBOD's recommendations, pilot scale testing of dewatering equipment was conducted. The pilot testing and subsequent dewatering evaluations were documented in the Preliminary Design Evaluation of Sludge Dewatering, December 12, 1986. The evaluation acknowledges that the tests were carried out under less than optimum conditions. Tests were performed on unthickened, undigested sludge of indeterminate composition. The proportions of primary and waste activated sludge fed to the dewatering devices could only be approximated.

The dewatering evaluation selected the diaphragm plate and frame press as the optimum dewatering alternative. The evaluation recommended installation of four DPF presses in Project 88 and the future installation of an additional five DPF presses--to provide a total of nine presses. The six (6) existing dewatering centrifuges will become standby units after the Project 88 improvements and will eventually be abandoned as the treatment plant project proceeds and the remaining DPF presses are installed.

The dewatering evaluation also recommended that the diaphragm plate and frame presses be located in the existing thermal conditioning building with appropriate modifications to that structure. The estimated cost for implementing the DPF recommendation, presented in the dewatering evaluation, was approximately $22,000,000 The cost estimate previously presented in the facilities plan and utilized in the cost-effective evaluation for implementing the centrifuge dewatering alternative was approximately $12,000,000. Both of these estimates are based on the one-plant scenario.

In the evaluation of dewatering alternatives the capacity of the centrifuges was again revised. Based on the interpretation of pilot test results, the capacity of the centrifuges was established at 700-750 lb/hr. As a result, 17 centrifuges (i.e., 14 operating, 3 standby) were needed to dewater approximately 240,000 lbs/day of sludge.

Following the pilot testing, one of the existing centrifuges was modified and upgraded to allow a full-scale test. The feed sludges used were still not representative of the future anaerobically digested sludge. Review of the data from this full-scale demonstration indicates that the modified centrifuge could process in excess of 1000 lbs/hr (i.e., 1300-1700 lbs/hr) on various blend ratios of the existing sludge.

Due to the sunken investment in the six existing centrifuges, the established design capacity of modified units is important to the selection of the optimum dewatering alternative.

Based on the data contained in the Preliminary Design Evaluation of Sludge Dewatering, use of less than 1000 lbs/hr as the rated capacity of the modified centrifuge seemed unusually conservative. Consequently, an independent cost-effective evaluation of dewatering was performed using 1000 lbs/hr as the design capacity. This independent analysis was performed based on the Southerly one-plant scenario. The results of this analysis are summarized in Table 12. Since the effectiveness of the dewatering devices impact downstream processing units, the operational costs of incineration and ash disposal have been included in the cost-effective analysis. The centrifuge dewatering option at $40,800,000 exhibits a 7 percent lower present worth than the DPF option at a present worth of $43,600,000.

As a result of the higher rated capacity of the centrifuges, fewer units would be required. Fifteen units, 12 operating and 3 standby would be adequate. Assuming the thermal conditioning building was the logical location for the dewatering facility, a smaller expansion of that structure would be necessary. Fewer centrifuges and associated equipment and less building expansion result in the estimated cost of centrifuge dewatering approximately equal to that of the DPF press option (i.e., $22,000,000).

The operation and maintenance costs associated with the two dewatering alternatives are reasonably consistent with those developed in the Preliminary Design Evaluation of Sludge Dewatering. The DPF presses are approximately 45 percent more expensive to operate and maintain primarily due to higher labor costs and higher chemical costs.

The centrifuges will provide a 20 percent cake solids concentration, whereas the DPF presses will provide a 25 percent cake solids concentration. Consequently, the operating cost of incineration is approximately 80 percent higher for the centrifuge dewatered sludge. The supplemental fuel required to burn off the additional water is the major reason for this difference. From Table 12, it can be seen that operational costs for the incineration process are $500,000 higher under the centrifuge dewatering alternative. The Preliminary Design Evalution of Sludge Dewatering identified a $750,000

TABLE 12
PRESENT WORTH COMPARISON OF DEWATERING ALTERNATIVES

PROCESS	CENTRIFUGE ALTERNATIVE [a]		DPF PRESS ALTERNATIVE [b]	
	CAPITAL	O & M	CAPITAL	O & M
DEWATERING	$ 21,040,000	$ 1,300,000	$ 21,920,000	$ 1,910,000
INCINERATION	$ 0	$ 1,100,000	$ 0	$ 600,000
ASH DISPOSAL	$ 0	$ 330,000	$ 0	$ 490,000
TOTAL	$ 21,040,000	$ 2,730,000	$ 21,920,000	$ 3,000,000
PRESENT WORTH	$ 40,800,000		$ 43,600,000	

a BASED ON 15 CENTRIFUGES (12 OPERATING AND 3 STANDBY), RATED CAPACITY OF 1,000 LBS / HR / UNIT, PRODUCING CAKE SOLIDS CONCENTRATION OF 20-PERCENT.

b BASED ON 9 DPF PRESSES (7 OPERATING AND 2 STANDBY), RATED CAPACITY OF 35,000 LBS / DAY / UNIT EXCLUDING PRECOAT SOLIDS, PRODUCING CAKE SOLIDS CONCENTRATION OF 25-PERCENT.

difference in incinerator operating costs, also with the centrifuge dewatering alternative being higher.

The facilities planning documents and the Preliminary Design Evaluation of Sludge Dewatering do not address the ultimate disposal of incinerator ash. As described in Section 1 of this briefing paper, currently ash is stored in on-site ash lagoons and periodically removed to a landfill site. Due to the fact that a substantial quantity of inert solids are added to the sludge under the DPF press alternative, a larger quantity of ash is produced. Consequently, the costs associated with ash disposal will be higher for the DPF press alternative. For purposes of this analysis, an ash disposal cost of $15 per cubic yard was utilized. Based on this unit cost and the projected ash quantities, ash disposal under the DPF press alternative will be $160,000 (i.e., approximately 50 percent) more costly than ash disposal for the centrifuge dewatering alternative.

The briefing paper analysis of dewatering alternatives reached a different conclusion than the Preliminary Design Evaluation of Sludge Dewatering for several reasons. These reasons are briefly discussed below.

- Use of the higher capacity rating for the centrifuges in the briefing paper analysis, resulted in lower capital costs for the centrifuge alternative.

- Although the Preliminary Design Evaluation of Sludge Dewtering projected higher operating costs for the DPF presses than the centrifuges (i.e., approximately 15 percent higher), this difference was increased to 45 percent in the briefing paper analysis.

- The supplemental fuel required by the incineration process was higher for both alternatives in the briefing paper analysis. This is due to the fact that heat value of digested sludge was taken as 8000 BTU/lb of volatile solids. In the Preliminary Design Evaluation the heat value of digested sludge was taken as 10,000 BTU/lb of volatile solids. This difference in sludge heat value necessitated that supplemental fuel be added to the DPF press alternative in the briefing paper analysis, whereas in the Preliminary Design Evaluation the DPF press dewatered solids required no supplemental fuel.

  The two analyses also utilized different unit costs for supplemental fuel (No. 2 fuel oil). The Preliminary Design Evaluation used $1.05

per gallon. The briefing paper analysis used $0.85 per gallon based on telephone conversations with fuel suppliers. Reviewing the 1985 Operating Report for the Division of Sewerage and Drainage indicated that Southerly was purchasing fuel oil at a cost of $0.66 per gallon.

The net impact of both of these differences (i.e., heat value of digested sludge and cost of fuel oil) was that the briefing paper analysis estimated less of an economic advantage for the DPF press alternative in the incineration process.

- Lastly, the briefing paper analysis included a cost for ash disposal, whereas the preliminary design evaluation did not. Since more ash is produced with the DPF presses, this slightly favored the centrifuge alternative in this cost-effective analysis.

From the above analyses it is evident that the selection of a dewatering alternative is sensitive to the capacity criteria established for the devices being evaluated and the final sludge cake solids concentrations these units can produce. In light of this sensitivity, it appears reasonable to conduct testing programs on sludges similar to that which will be processed in the future (i.e., in this case anaerobically digested) to provide a representative picture of probable equipment performance. If such testing is not possible for whatever reason, selection of conservative design criteria appears justified for the initial project phase. However, the six existing modified centrifuges should be evaluated with anaerobically digested sludge prior to abandoning these units and implementing the final project phases.

3.3 PLANNED SYSTEM REDUNDANCY

The facilities planning documents recommended a sludge management alternative which provided redundancy in accordance with Table 13. The table is based on a Southerly one-plant scenario.

The recommended alternative calls for 22 percent of the dewatered sludge to be composted under normal conditions. The compost facility has a capacity to handle as much as 55 percent of the sludge under ideal conditions. Ideal conditions relate to total solids content of dewatered sludge, favorable weather conditions for composting, and adequate demand for the compost

TABLE 13. SLUDGE MANAGEMENT SYSTEM REDUNDANCY FOR FACILITIES PLAN RECOMMENDATION

Process/Disposal	Average Annual	Maximum Capacity
	Values as a percentage of annual sludge production	
Compost/Sales & Distribution	22	55
Digest/Land Apply	19[a]	67
Digest/Incinerate/Landfill	59[a]	80[b]
Lime Stabilization/Land Apply	--[c]	--[c]

---

[a] Digestion to handle total of sludge incinerated and land applied, i.e., approximately 80 percent of average annual sludge production.

[b] Incineration to provide complete redundancy for either composting or land application processes.

[c] Lime stabilization is proposed by the facilities plan as a backup process, however, the sizing criteria and the need for these facilities are not clear.

product. The compost facility is planned to operate in a range of 120 wet ton per day on the low side, up to more than 240 wet ton per day at maximum.

Approximately 20 percent of the average annual sludge production would be digested, dewatered, and land applied. The current appplication program has been successful, and the city anticipates that the demand for the dewatered sludge product will remain. The extent to which land application can function as a disposal option is subject to several factors including weather conditions and cropping patterns. Consequently, the amount of sludge which will be land applied is expected to vary substantially throughout the year. The program will operate from virtually no land application when factors preclude application to a maximum of 60-70 percent of the average annual sludge production (on a daily basis) being land applied during favorable application circumstances.

Approximately 60 percent of the annual sludge production would be incinerated. The planning documents indicate the incineration facility, however, would be sized to handle a maximum of as much as 80 percent of the sludge production. This additional 20-percent would function as a valuable backup for either the composting or the land application disposal option. In the event either of these options are unable to process and dispose of their planned portion of the average annual sludge production, incineration and landfilling would be available to alleviate the problem. The incineration/landfill option would be expected to routinely backup the land appplication option for reasons previously discussed. The composting option would be expected to perform more consistently than land application. If incineration were needed as a backup to composting, it should be on a scheduled basis at a time when land application could reasonably be expected to provide disposal for a minimum of 20 percent of the sludge production.

In addition to the three processing and disposal options discussed above, the facilities plan recommends that lime stabilization and land application be provided as a backup to other ultimate disposal options. Figure 5.3 of the RFPU indicates that the lime facilities would be sized only to backup the compost process, however, the details are not adequate to determine what is proposed. Furthermore, the need for this additional redundancy has not been justified. Recent correspondence with the city (i.e., May 29, 1987, URS Dalton Responses to May 12, 1987 Comments) indicates the recommendation of lime facilities has not been finalized completely and is being reevaluated due to the cost of these facilities.

In this briefing paper analysis the redundancy issue was considered relative to the existing and new incineration facilities at Southerly. The two new incinerators at Southerly will be capable of incinerating approximately 525 wet tons per day of dewatered cake at 20 percent solids. If a dewatered cake solids of 25 percent can be realized, these two units would be capable of incinerating approximately 560 wet tons per day. The two existing incinerators, which according to the planning documents will be rehabilitated under a one-plant option, are capable of incinerating 320 wet tons per day at 20 percent solids. Again, if a 25 percent cake solids concentration can be obtained, these units would be capable of 350 wet ton per day. For purposes of comparison, the total dewatered sludge cake production of Southerly under a one-plant scenario assuming all sludge was directed to incineration would be approximately 510 wet tons per day at 20 percent solids and 410 wet tons per day at 25 percent solids. With one new (larger) incinerator out of service, the remaining three incinerators can handle 15 percent more sludge at 20 percent solids than the one-plant option can produce. With a dewatered cake concentration of 25 percent solids, these three incinerators could process more than 50 percent more sludge than the one-plant option can generate.

Based on the above analysis, the incineration process offers sufficient redundancy to allow processing and disposal of all sludge produced even when the composting and land application options are inoperative and one of the larger incinerators is out of service. In light of the redundancy inherent in the incineration process, the need for greater redundancy does not appear justified.

3.4 ULTIMATE DISPOSAL PLAN

The facilities plan proposes three basic methods for ultimate use/disposal of the wastewater sludges. They are:

- Distribution and Marketing of Composted Sludge
- Land Application of Digested, Dewatered Sludge
- Landfilling of Incinerated, Dewatered Sludge

The plan, however, does not offer many details relating to the operation, costs, and planned reliability associated with these options. The following paragraphs briefly present the current understanding of the use/disposal options.

3.4.1 Distribution and Marketing of Composted Sludge

Dewatered, undigested sludge is transported by the city in trucks to the composting facility. The city operates and maintains the compost facility which most recently has been processing approximately 120 wet tons/day of dewatered sludge from Southerly. Conversations with city personnel have indicated that the composting facility costs approximately $1,200,000 per year to operate. The 1985 Operating Report published by the Division of Sewerage and Drainage shows the 1985 operating budget for the compost facility to be $2,000,000. Based on these costs and the total production of the composting facility, a unit cost of $26-40 per wet ton of sludge composted is estimated.

Currently compost is disposed of through mine reclamation projects, bulk and residential package sales, and nursery and institution use. The city has an active marketing program and anticipates that future demand will be adequate to dispose of the compost produced.

The composting facility has been cited as a source of odors by the community. The city believes that most of the odor problems can be attributed to the moisture content in the raw sludge and problems with the composting equipment. The city anticipates that future operations will increase dewatered solids concentration and reduce the potential for odors from the facility.

3.4.2 Land Application of Digested, Dewatered Sludge

The current land application program originates from the Jackson Pike plant. Currently land application is conducted on a contract basis and it is expected that this practice will continue in the future. Based on conversations with city personnel, the current cost of land appplication is approximately $12 per wet ton of sludge applied. The contractor is responsible for transport and spreading the sludge and for remote sludge storage if necessary.

Based on the earlier EIS (1979), adequate suitable acreage for sludge application is available within a reasonable distance of the plant site. The current program is subject to substantial variation in peak and off peak application rates due to weather and crop constraints. Recent discussions have indicated that remote sludge storage has become limited as farmers have decided to accept the sludge only if it is spread immediately. The ash lagoons at Jackson Pike have been utilized to provide temporary storage and relieve the pressure this situation has created.

The future land application program should be planned and administered by the city in such a way as to ensure the reliability of the agricultural use of sludge.

3.4.3 Landfilling of Incinerated Dewatered Sludge

At both Jackson Pike and Southerly, incinerator ash is temporarily stored in on-site ash lagoons. The lagoons are cleaned on an as-needed basis with the ash being transported and deposited in a landfill by a contractor. The cost of ultimate disposal of ash has not been identified. These costs vary significantly depending on local availability of landfills, transport distances, and composition of the ash. Deposit charges alone can range between $5-20 per cubic yard and may be substantially higher depending on local conditions and ash quality.

Conversations with the city have indicated that only the city-owned landfill is accepting the incinerator ash. Details relating to the projected useful life of this landfill are not contained in the facilities plan. For the EIS to review the reliability of the landfill disposal option, the city must furnish planning information documenting the steps being taken to ensure a suitable disposal site will be available.

APPENDIX C

BRIEFING PAPER NO. 3
BIOLOGICAL PROCESS SELECTION

BRIEFING PAPER NO. 3

BIOLOGICAL PROCESS SELECTION

Supplemental Environmental Impact Statement
USEPA Contract No. 68-04-5035, D.O. No. 40
Columbus Ohio Wastewater Treatment Facilities

Prepared By:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TRIAD ENGINEERING INCORPORATED

BIOLOGICAL PROCESS SELECTION

INTRODUCTION

Under the direction of USEPA, a series of briefing papers are being prepared addressing key issues in the development of the Supplemental Environmental Impact Statement for the Columbus, Ohio, Wastewater Treatment Facilities. The briefing papers form the basis of discussions between USEPA and their consultants to resolve these key issues. The following paragraphs present the background of the facility planning process, a description of the briefing papers, and the purpose of this paper on biological process selection.

FACILITY PLANNING PROCESS

At the time this paper was prepared (March-July 1987) the city of Columbus was proceeding to implement improvements at the Jackson Pike and Southerly Wastewater Treatment Plants to comply with more stringent effluent standards which must be met by July 1, 1988. These improvements were based on the consolidation of wastewater treatment operations at the Southerly plant. This one-plant alternative is a change from the two-plant operation proposed by the city in the 1970's and evaluated in the 1979 EIS.

The development and documentation of wastewater treatment process and sludge management alternatives for the Columbus metropolitan area has been an extended and iterative process. The design and construction of various system components have progressed, because of the 1988 deadline, while planning issues continue to be resolved. As a result, numerous documents have been prepared which occasionally revise a previously established course of direction.

The concurrent resolution of planning issues and implementation of various project components has made preparation of the EIS more difficult because final facility plan recommendations are not available in a single document.

BRIEFING PAPERS

To facilitate preparation of the EIS, a series of briefing papers are being developed. The purpose of the briefing papers is to allow USEPA to review the work of the EIS consultant and to identify supplemental information necessary for the preparation of the EIS. Six briefing papers are being prepared as follows:

- Flows and Loads
- Sludge Management
- Process Selection
- CSO
- One Plant vs. Two Plant (Alternative Analysis)
- O&M and Capital Costs

The specific focus of each briefing paper will be different. However, the general scope of the papers will adhere to the following format:

- Existing conditions will be documented.
- Evaluations, conclusions, and recommendations of the facilities planning process will be reviewed using available documentation.
- Where appropriate, an independent evaluation of the future situation and viable alternatives will be prepared.
- The facility plan and EIS briefing paper conclusions will be compared.

The briefing paper process is intended to:

- Prompt the resolution of any data deficiencies.
- Clearly establish and define existing and future conditions.
- Identify the final recommended plan which the city desires to implement.

- Provide a data base of sufficient detail to allow preparation of the draft EIS.

BIOLOGICAL PROCESS SELECTION

This Briefing Paper presents an evaluation of three different biological processes selected by the city of Columbus, for use at the Jackson Pike and Southerly Wastewater Treatment Plants (WWTP). The scope of this report is to review data made available by the city's consultant, identify issues and data gaps, aid USEPA in the decision making process, and focus on future data needs so that a complete and thorough Environmental Impact Statement may be prepared.

The biological processes to be evaluated include the semi-aerobic process (SA), conventional activated sludge process (AS), and trickling filters followed by activated sludge (TF/AS). Data provided by the city's consultant was evaluated against Ten State Standards, USEPA Design Criteria Documents, and established literature values for critical design conditions for each of the selected processes. The process evaluation includes a process description, a review of the technical criteria from each of the process trains including reliability, flexibility, performance, expandability and turndown, and environmental impacts. Capital costs are also evaluated based on the selection of system sizing and components necessary to meet Ohio EPA effluent discharge standards. The final section of the report deals with conclusions and recommendations based on data available to date.

1. TERMS AND DEFINITIONS

An evaluation of municipal biological treatment processes requires a fundamental knowledge of terminology used by design engineers. The following key words used in this briefing paper are defined to assist the reader in understanding the key issues raised during process evaluation.

Semi-Aerobic The semi-aerobic process is a modified activated sludge system which contains an initial anaerobic/anoxic conditioning stage consisting of a mixture of aerobic return activated sludge and raw primary effluent followed by aerobic treatment. This process uses an anaerobic selector zone to control bulking sludge.

Anaerobic - A biological treatment process that occurs in the absence of oxygen. This process contains bacteria that can survive only in the absence of any dissolved oxygen. These bacteria are known as obligate anaerobes. The anaerobic section of the semi-aerobic process is critical in providing a selector mechanism against those bacteria which cause bulking in a municipal waste treatment plant.

Anoxic - A condition of low dissolved oxygen (less than 0.3 mg/l) or a condition in which the only source of oxygen is mineral bound oxygen such as nitrates. Anoxic denitrification is a process by which nitric oxygen is converted biologically into nitrogen gas in the absence of dissolved oxygen. In the semi-aerobic process, the anoxic zone may change from anaerobic to anoxic depending on the level and concentration of nitrates in the wastewater.

Biological Phosphorus Removal - (Also called Bio-P Removal) A process by which phosphorus associated with biological cells, is precipitated from the wastewater and contributes to the sludge of a biological treatment system. The semi-aerobic process results in biological phosphorus removal. The city's consultant estimates that excess phosphorus removal results in approximately 4.5 milligrams additional sludge per milligram of phosphorus removed from the mixed liquor suspended solids. The mechanism which triggers removal is not well understood; however, in plants where a phosphorus effluent limitation is in effect, biological phosphorus removal is an additional benefit. Where biological phosphorus removal cannot be triggered, physical-chemical phosphorus removal must be employed. In all cases, the removal of phosphorus from the wastewater increases the sludge yield from the biological treatment train.

Bulking Sludge/Rising Sludge - A bulking sludge is one which shows poor settleability as measured by the sludge volume index (SVI Test). The cause of a bulking sludge is generally filamentous algae or bacteria. The microbe responsible for bulking at the Southerly wastewater treatment plant has been identified as the cyanobacterium Schizothrax calcicola (Phormidium). Because of its poor settling characteristics a bulking sludge will cause BOD and total suspended solids violations due to the loss of particulates over the weirs of the secondary clarifier. High SVI numbers are indicative of a bulking sludge.

A rising sludge is one in which the sludge blanket of the secondary clarifiers floats to the surface, once again causing TSS and BOD violations. Rising sludges are frequently caused by biological activity in the clarifier resulting in the release of micro gas bubbles which attach to the sludge particles. One of the most frequent causes of a rising sludge is denitrification in the secondary clarifiers. The denitrification process releases nitrogen gas and carbon dioxide which causes the sludge to float. No degree of increased clarifier sizing or decreasing the clarifier surface overflow rate will compensate for a rising sludge. The cause of the denitrification in the secondary clarifiers must be eliminated for the wastewater treatment plant to meet standards.

Carbonaceous BOD Removal - This is the biological conversion of carbonaceous organic matter in wastewater to cell tissue and various gases and by-products. In the conversion it is assumed that nitrogen present in the various compounds is converted to ammonia. High carbonaceous BOD values will result in effluent violations.

Denitrification - The biological process by which nitrate is converted into nitrogen and other gaseous end products. When denitrification occurs in the secondary clarifiers the result is a rising sludge and effluent violations.

F/M Ratio - The food to mass ratio. This is a ratio of food substrate (BOD) to biological mass (MLSS) which is used as a control parameter for determining the organic loading rate to a biological treatment system. A high F/M ratio means that oxygen uptake rates will be high, biological metabolic rates will be high, and in the absence of excess oxygen, obligate aerobic bacteria will be removed. A low F/M ratio generally results in high dissolved oxygen concentrations and may result in the selection of bulking bacteria in a municipal wastewater treatment system. In the semi-aerobic process high F/M ratios are intentionally maintained in the first bay of the aeration tank in order to **maintain anaerobic or anoxic conditions necessary to select against bulking bacteria.**

Mixed Liquor Suspended Solids - (MLSS) The mixed liquor suspended solids or mixed liquor volatile suspended solids are a measure of the amount of biomass present in the aeration system. For most conventional activated sludge systems, this concentration is approximately 1,200 to 3,000 milligrams per liter (mg/l).

Nitrification - The two-stage biological process by which ammonia or total kjeldahl (TKN) nitrogen is first converted to nitrite then to nitrate. Nitrification is the necessary first step in the nitrification/denitrification cycle. The goal is to convert ammonia into nitrates and ultimately into gaseous end products.

Over-pumping - This is the process by which the sludge inventory in the secondary clarifiers is held to a minimim in order to place the bulk of the biomass back in the aeration system. Over-pumping of the clarifier sludge is necessary when there is the potential for denitrification to occur in the secondary clarifiers or where mixed liquor suspended solids in the aeration basins must be held at a high concentration. A well-designed clarifier will permit over-pumping on a routine basis by eliminating rat-holing, the phenomenon by which water channels through the sludge blanket leaving behind the solids. Channeling is minimized by providing slow agitation and hydraulic scouring devices in the sludge pumping system. These devices are used in circular clarifiers. Rectangular clarifiers generally use a chain and flight mechanism which drags the sludge down to a sludge sump located at the discharge end of the rectangular clarifier. The chain and flight sludge mechanism is generally inefficient where over-pumping is required.

Surface Overflow Rate - (SOR) The surface overflow rate is one of the critical design parameters for sizing a clarifier. The dimensions for the surface overflow rate parameter are gallons per day square foot (gpd/d. ft^2) of clarifier surface. High surface overflow rates generally result in loss of solids from the secondary clarifiers. Ten States Standards cites a surface overflow rate of 1,200 gallons per day per square foot of clarifier surface area as a good design maximum for conventional activated sludge processes. However, due to the fact that sludges produced from nitrification processes are generally poor settling, Ten States recommends a surface overflow rate of 800 gallons per day per square foot of surface area for nitrifying sludges. For this briefing paper the general range of 700 to 1000 gallons per day per square foot was selected as a conservative design criteria.

Sludge Volume Index - (SVI) The sludge volume index is expressed as the volume in mils per gram of waste activated sludge after the mixed liquor has been allowed to settle for 30 minutes under quiescent conditions. A low SVI is indicative of a well-flocculated, poor-settling sludge. A high SVI is indicative of a bulking, dispersed poor-settling sludge. Sludges with SVIs in the range of 50 to 100 exibit excellent settling characteristics. Sludges with SVIs in the range of 100 to 150 are generally transitional sludges with fair to good settling characteristics. Sludges with SVIs in the range of 150 to 200 are characterized as bulking sludges as indicated by the poor settling characteristics in the secondary clarifier and poor dewatering characteristics in the sludge handling process.

2. BRIEFING PAPER ASSUMPTIONS

The analysis contained in this briefing paper is based on two key factors. These factors include wastewater flows and loads and NPDES permit limits for the Southerly and Jackson Pike Wastewater Treatment Plants. Alternative process trains were conservatively selected to meet applicable 1988 7-day and 30-day discharge limits.

A separate briefing paper, prepared for the EIS, documents the development of wastewater flows and loads. Table 2-1 presents the EIS flows and loads.

The average design flow for Jackson Pike will be held at 70 MGD, and the peak design flow will held at 100 MGD. This results in an additional 18 MGD at average flow and 32 MGD at peak flow being diverted to Southerly. Section 3.1.2.3 discusses the reasons for limiting the flows at Jackson Pike. Table 2-2 presents the actual flows and loadings which would be processed by each plant. These flows and loadings are used to determine facility sizes in Section 3.1.2.

Tables 2-3 and 2-4 provide a summary of the permit limitations for the Jackson Pike and Southerly WWTPs. These were taken from Ohio EPA Permit No. 4PF00000*GD (Jackson Pike) and 4PF00001*HD (Southerly). As noted on the attached tables, the effluent characteristics are segregated by time of year as well as by 30-day and 7-day limits. In addition to the concentration limits, a mass loading limit based on an effluent loading of 60 MGD from Jackson Pike and 120 MGD from Southerly are included. Table 2-5 is an estimate of the one-plant permit limitations. These are based on the assumption that the water quality impacts to the Scioto River will be the limiting factor in the event the Southerly wastewater treatment plant is expanded. Therefore, the concentration limitations were derived from those assigned to the Southerly treatment plant. Mass loading limits were derived by adding the flows of the Jackson Pike and Southerly plant together and converting them to a mass basis.

TABLE 2-1. 2008 PROJECTED FLOWS LOADS

Tributary to Jackson Pike

• BOD (lb/day)	141,600
• TSS (lb/day)	161,600
• TKN (lb/day)	18,532
• Average Flow (MGD)	88
• Peak Flow (MGD)	132

Tributary to Southerly

• BOD (lb/day)	126,600
• TSS (lb/day)	121,300
• TKN (lb/day)	16,570
• Average Flow (MGD)	66
• Peak Flow (MGD)	99

Total From Planning Area

• BOD (lb/day)	268,200
• TSS (lb/day)	282,900
• TKN (lb/day)	35,102
• Average Flow (MGD)	154
• Peak Flow (MGD)	231

TABLE 2-2. ACTUAL FLOWS AND LOADS TO BE TREATED AT EACH FACILITY

	Average	Peak
Jackson Pike		
• Flow (MGD)	70	100
• $CBOD_5$ (lb/day)	112,600	107,300
• TSS (lb/day)	128,500	122,400
• TKN (lb/day)	14,740	14,040
Southerly		
• Flow (MGD)	84	131
• $CBOD_5$ (lb/day)	155,600	160,900
• TSS (lb/day)	154,400	160,500
• TKN (lb/day)	20,360	21,060

TABLE 2-3. PERMIT LIMITATIONS - JACKSON PIKE

Effluent Characteristics	Concentration (mg/l)		Mass Loading* (lbs/d)	
	30-day	7-day	30-day	7-day
$C\text{-}BOD_5$				
(June-Oct)	8.0	12.0	3,995	5,993
(Nov-Apr)	20.0	30.0	9,988	14,980
(May)	13.0	19.5	6,492	9,737
Suspended Solids				
(June-Oct)	16.0	24.0	7,990	11,986
(Nov-Apr)	30.0	45.0	14,980	22,471
(May)	26.0	39.0	12,984	19,474
Ammonia (N)				
(June-Oct)	1.0	1.5	499	748
(Nov-Apr)	5.0	7.5	2,497	3,744
(May)	2.5	3.75	1,247	1,872

* Mass limits based on 60 MGD effluent loading

TABLE 2-4. PERMIT LIMITATIONS - SOUTHERLY

Effluent Characteristics	Concentration (mg/l)		Mass Loading* (lbs/d)	
	30-day	7-day	30-day	7-day
$C\text{-}BOD_5$				
(June-Oct)	8.0	12.0	7,990	11,985
(Nov-Apr)	25.0	40.0	24,968	39,950
(May)	13.0	19.5	12,984	19,474
Suspended Solids				
(June-Oct)	16.0	24.0	15,979	23,969
(Nov-Apr)	30.0	45.0	29,962	44,942
(May)	26.0	39.0	25,967	38,951
Ammonia (N)				
(June-Oct)	1.0	1.5	999	1,498
(Nov-Apr)	5.0	7.5	4,994	7,491
(May)	2.0	3.0	1,998	2,996

* Mass limits based on 120 MGD effluent loading

TABLE 2-5. ESTIMATED ONE PLANT PERMIT LIMITATIONS

Effluent Characteristics	Concentration (mg/l)		Mass Loading* (lbs/d)	
	30-day	7-day	30-day	7-day
$C\text{-}BOD_5$				
(June-Oct)	8.0	12.0	12,010	18,014
(Nov-Apr)	25.0	40.0	37,530	60,048
(May)	13.0	19.5	19,516	29,273
Suspended Solids				
(June-Oct)	16.0	24.0	24,019	36,028
(Nov-Apr)	30.0	45.0	45,036	67,554
(May)	26.0	39.0	39,031	58,547
Ammonia (N)				
(June-Oct)	1.0	1.5	1,501	2,252
(Nov-Apr)	5.0	7.5	7,506	11,259
(May)	2.0	3.0	3,002	4,507

* Mass limits based on 180 MGD effluent loading

1. No one-plant permit presently exists. Mass loadings were derived from 180 MGD flow and Southerly concentration limits.

For the purposes of this briefing paper, it will be assumed that a treatment train would be deficient if it would be unable to meet either the 30-day or 7-day concentration limit or the 30-day or 7-day mass loading limit. It is understood that mass limits can be modified if the new loading does not negatively impact receiving water quality. Temperature considerations as they impact such variables as nitrification rates were evaluated based on the most stringent occurrence of those temperatures. For example, **nitrification was evaluated utilizing a sewage temperature of 12°C to meet a May ammonia limit.**

3. PROCESS EVALUATION

This section describes and evaluates the biological process alternatives proposed in the facility plan. The alternatives are evaluated based on technical criteria, environmental criteria, and system costs.

3.1 PROCESS DESCRIPTION

The semi-aerobic (SA) and the trickling filter/activated sludge (TF/AS) biological processes were evaluated for these alternatives:

- Southerly Two-Plant
- Jackson Pike Two-Plant
- Southerly One-Plant

The semi-aerobic process is a modified form of the activated sludge process. The process consists of a non-aerated reaction zone ahead an aerated activated sludge zone. The non-aerated zone may be anoxic (nitrates are present), anaerobic (no nitrates or oxygen present), or a combination of both. The purpose of the anaerobic zone is to function as a selector mechanism providing an environment which discourages proliferation of filamentous organisms and thereby controls bulking sludge. The anaerobic zone may change to anoxic depending on the level and concentration of nitrates in the wastewater. Denitrification occurs in the anoxic zone. Denitrification is a process by which nitrates are converted into nitrogen gas.

The only physical differences between the semi-aerobic process and the conventional activated sludge process is the addition of an internal mixed liquor recycle loop and two baffles in the first bay of the aeration tanks. The internal recycle loop is used to bring nitrates back to the anoxic zone and thus cause denitrification to take place. The baffles are incorporated into the design to prevent backmixing from the aerated zone to the anaerobic zone.

In reviewing full-scale operational data from the Southerly plant as well as an evaluation of nitrification rates at both Southerly and Jackson Pike, it is evident that the semi-aerobic process proposed by the city is in effect similar to the conventional activated sludge process with the exception of the internal mixed liquor recycle loop and the addition of two baffles in the first bay of the aeration tanks. Given these exceptions, a conventional activated sludge system can be operated as a semi-aerobic process simply by reducing the amount of aeration provided in the first bay of the system. If one takes this reasoning one step further and adds an internal recycle pumping system (estimated cost $10,000 per aeration tank), the result is a semi-aerobic process minus two 23x15 foot concrete baffles. For this reason, it was assumed that the semi-aerobic process and the activated sludge process were in effect identical and would be evaluated on that basis.

The trickling filter/activated sludge process is comprised of roughing trickling filters followed by aeration tanks. The trickling filters are designed to remove 40 percent of the BOD_5. They function in the same manner as the anaerobic/anoxic zone of the semi-aerobic process in that they select for non-filamentous bacteria. The aeration tanks that follow the filter remove the remaining BOD_5 and provide the required nitrification. An internal recycle loop can be provided back to the trickling filters to initiate denitrification there.

Slightly reduced aeration tank capacity and aeration energy is required since the trickling filter has the ability to dampen peak biological loads and thus minimize the amount of aeration time needed to achieve complete biological oxidation.

The following sections present design criteria and recommended process sizing for each alternative.

3.1.1 Design Criteria

The biological process design criteria are listed in Table 3-1. These criteria were derived from pilot data provided by the city's consultant, the Ten States Standards (Recommended Standards for Sewage Works, 1978 Edition, Health Education Service Incorporated, Albany, New York 12224), and USEPA criteria (Innovative and Alternative Technology Manual, EPA-430/9-78-009, 1978). The range of acceptable operating conditions given in Table 3-1 defines the critical regions for the aeration, trickling filter, and final clarification processes. In the absence of more extensive full-scale piloting data, it is assumed that violation of these criteria would result in inadequate treatment of the wastewater received at Jackson Pike or Southerly which would result in effluent violations.

3.1.1.1 Aeration Basins

The aeration process listing in Table 3-1 includes evaluation criteria for the hydraulic retention time in the aeration basin, F/M ratios in the first bay as well as the overall F/M ratio of the aeration basin, design mixed liquor suspended solids concentrations, **minimum solids retention times,** and a recommended ratio of oxygen uptake rates to dissolved oxygen (OUR/DO).

A minimum hydraulic retention time in the aeration basin of 4.5 hours is limited to the final 7 bays of the plug flow reactor for the semi-aerobic process. This datum was taken from the Southerly SBR Nitrification Study conducted by the city's consultant (January 1987). The hydraulic residence time in the Project 20 full-scale semi-aerobic pilot study conducted at the Southerly waste treatment plant typically ranged from 5 to 8 hours. The use of a shorter residence time in the aeration basin for the trickling filter process is based on the fact that a roughing filter has the ability to dampen or attenuate peak biological loads, thus minimizing the amount of aeration time required to achieve complete biological oxidation.

TABLE 3-1. BIOLOGICAL PROCESS DESIGN CRITERIA

Process	Parameter	Range	Source
Aeration	Hydraulic Retention Time (HRT, hrs) Minimum	4.75-SA, AS 3-TF	SBR Report[1]
	F/M First Bay Overall	5 0.13-0.17	
	MLSS (mg/l)		
	Southerly	**3500**	
	Jackson Pike	**2500**	
	Solids Retention Time (days)		
	Southerly	**9.9**	**City of Columbus**
	Jackson Pike	**8.7**	**Comment Letter**
	OUR/D.O.	250-500	Control of Bulking Sludge[2]
Roughing Trickling Filter	Hydraulic Loading Rate (gpd/ft^2)	1400-4600	USEPA[3,4]
	Organic Loading Rate ($lb BOD/d.1000 ft^3$)	100-500	USEPA[3]
Clarifiers	Surface Overflow Rates (gpd/ft^2)	400-1000	USEPA[3]
	Solids Loading Rates ($lb/d. ft^2$)	20-50	USEPA[3]

[1]Southerly SBR Nitrification Study, Orris Albertson, URS Dalton, January 1987
[2]"The Control of Bulking Sludges", JWPCF, April 1987
[3]"Innovative and Alternative Technology Manual", EPA 430/9-78-009, 1978
[4]"Wastewater Treatment Plant Design", WPCF, 1977
[5]No MLSS are provided for the combined plant option because the nitrification studies have not been run for that wastewater blend.

The selection of an F/M ratio of 5 in the first bay of the semi-aerobic system is based on correspondence with Mr. Orris E. Albertson, Process Consultant to the city's consultant. Mr. Albertson also stated in an article published in the April 1987 Journal of the Water Pollution Control Federation that the maintenance of a high F/M ratio in the initial contact basin of a semi-aerobic system was required to maintain the anaerobic and anoxic conditions necessary to select against bulking bacteria. This high F/M ratio would be realized in both the semi-aerobic and activated sludge options. It is assumed that the trickling filter option would greatly reduce this F/M ratio due to the attenuating effect the upstream roughing filter would have on carbonaceous BOD loadings. An overall aeration basin F/M value of 0.13 to 0.17 would be consistent for a well operated nitrifying activated sludge system.

The mixed liquor suspended solids concentrations of 3,500 mg/l for the Southerly plant and 2,500 mg/l for the Jackson Pike plant were derived from SBR studies conducted by the city's consultant. It is assumed that mixed liquor concentrations of the same magnitude would be required for a conventional activated sludge system. The primary reason for the higher mixed liquor suspended solids in the Southerly aeration basin is the low nitrification rates observed at that plant. **Increasing the MLSS to 3,500 mg/l allows nitrification to proceed with fewer aeration basins than would be required at 2,500 mg/l.** The Jackson Pike WWTP experiences nitrification rates well within the range of most sewage treatment facilities.

The cause of lower nitrification rates at the Southerly plant is most likely due to toxicity of some non-conventional pollutants present in the Southerly raw wastewater. Nitrification rates for the Jackson Pike wastewater treatment system are well within the range of nitrification rates realized in North American municipal treatment facilities.

The significance of the oxygen uptake rate to dissolved oxygen ratio (OUR/DO) has been cited by Mr. Orris Albertson as necessary for the control of bulking sludge organisms in municipal treatment facilities. In his paper, Mr. Albertson indicates that "The best control of bulking sludges is provided by both reactor compartmentalization and by DO control in each of the compartments. Often in practice, either will provide the necessary SVI control; but the maximum control will be available when both a high F/M gradient is present and DO control as a function of time for each compartment is provided." Mr. Albertson further states that "Regardless of whether the initial contact zone is aerated or unaerated a sufficiently high OUR/DO ratio will ensure both SVI control and enhance phosphorus removal. The suggested minimum OUR/DO ratio is greater than 250 to 1 and preferably as high as 500 to 1." Under conditions of high F/M ratios, Mr. Albertson contends that the biological cell will uptake organic material and release soluble phosphates given that the DO gradiant across the slime layer of the cell is less than 0.5 mg per liter. Under endogenous conditions, such as occur in the final zones of the aeration basin, soluble phosphate uptake occurs as well as the release of endogenous decay products resulting in a well-flocculated mixed liquor leaving the aeration basin. It should be noted that these conditions can be achieved in a conventional activated sludge aeration basin by the use of compartmentalization and reducing the blower capacity in the initial stages of the aeration tanks. This condition is further enhanced by increasing the mixed liquor suspended solids and providing for an internal mixed liquor recycle loop.

3.1.1.2 Trickling Filters

The design criteria for roughing trickling filters which are followed by activated sludge systems is considerably higher than those for trickling filters followed by clarification. Hydraulic loading rates ranging from 1,400 to 4,600 gallons per day per square foot of surface area are considered good design criteria. Organic loading rates in the range of 100 to 500 pounds of BOD per day per 1,000 cubic feet volume would also provide adequate capacity for a roughing trickling filter. The trickling filters, when operated in this condition, act as the initial zone or anaerobic/anoxic zone of the aeration basin under the semi-aerobic or activated sludge options. The roughing trickling filters would reduce the volume of aeration basin required and effectively assist in control of sludge bulking.

3.1.1.3 Clarifiers

Given the fact that the three previously selected biological treatment processes (semi-aerobic, conventional activated sludge, and trickling filter followed by activated sludge) all can act as effective selectors against bulking organisms, it was assumed that SVIs would generally be in the range of 70 to 150. Given this SVI range, there are two critical design factors which must be considered when selecting and sizing final clarifiers. These are surface overflow rates (gallons per day per square foot surface area) and solids or floor loading rates (pounds of suspended solids per day per square foot). The city's consultant has selected conservative surface overflow rates for their final clarifiers. These are generally in the range of 470 for average flows and 800 for sustained peak flows. Mr. Richard Brenner, USEPA Cincinnati, indicated that conservative design criteria for average flow rates would be in the range of 500 to 550 with peak sustained surface overflow loading rates set at 900 to 950. For the purposes of this evaluation, a range of 400 for average flow and 1,000 for sustained peak flow will be used.

The city's consultant selected solids or floor loading rates for their clarifiers in the range of 18 to 23 pounds per day per square foot for average flows and 29 to 36 pounds per day per square foot for peak flows. A solids loading criteria of 20 to 50 pounds per day per square foot is cited in the USEPA Innovative and Alternative Technology Manual. Rectangular clarifiers should generally be sized on the lower end of this solids loading rate. Circular clarifiers with hydraulically assisted sludge removal devices can easily accommodate the higher solids loading rates without causing sludge channeling or solids entrainment. **However, as pointed out by the city's consultant, SVIs are also a limiting factor in determining an acceptable solids loading rate. Therefore, the Daigger and Roper Clarification Tank Design and Operation Diagrams will also be used in this evaluation.**

3.1.2 Recommended Sizing

Based on the previously stated process design criteria and the 2008 projected flows and loads given in Table 2-1 of this briefing paper, two biological treatment trains (i.e. semi-aerobic and trickling filter/activated sludge) were evaluated for the following alternatives:

- Southerly Two-plant
- Jackson Pike Two-plant
- Southerly One-plant

A critical assumption in this evaluation is that the projected flows and loads given in Table 2-1 will permit the plants to treat all anticipated dry weather flows plus some additional inflow and infiltration during wet weather events to a peak design flow of 100 MGD for Jackson Pike, 131 MGD for Southerly two-plant, and 231 MGD for a Southerly one-plant alternative.

BOD and total suspended solids loadings developed for this briefing paper were similar to those presented in the facility plan. Total kjeldahl nitrogen and total phosphorus loadings presented in the facility plan were used in this process evaluation (Table 2.1). It was further assumed that the increase in flow due to the application of a 1.5 peaking factor would have little or no effect on the mass daily loading of BOD, total suspended solids, or nitrogen.

Tables 3-2 through 3-7 document the results of this briefing paper analysis relative to the sizing and performance of the various biological treatment processes for Southerly and Jackson Pike. All previously stated design and loading criteria were used to derive the data presented in these tables.

3.1.2.1 Southerly Two-Plant Semi-Aerobic

Table 3-2 is a summary of the Southerly two-plant semi-aerobic or activated sludge options. The existing six aeration basins in the west train would be utilized with the addition of an internal recirculation pump and baffles for the semi-aerobic option. Four of the existing center train aeration basins would be used with the addition of two new 26 foot by 900 foot by 15 foot sidewall depth aeration basins. Given these conditions, average and peak aeration times fall well within the design parameters cited in Table 3-1. In terms of final clarification, the existing clarifiers would be replaced with six new 190-foot diameter circular clarifiers fitted with hydraulic sludge removal devices, flocculation chambers, and associated piping and an internal mixed liquor recycle system. The addition of these six 190-foot diameter units place the clarifiers well within the critically designed surface overflow rates of 400 to 800 gallons per day per square foot of surface area established by the city's consultant. The solids loading rates based on a mixed liquor suspended solids of 3500 mg per liter fall well within process evaluation criteria. Under peak hydraulic loading conditions the solids loading rates would exceed design criteria established in the facility plan. Given the fact that circular clarifiers will be used in this application, it is unlikely that a peak loading of 38 pounds per day per square foot would overload the proposed clarifiers. **The Daigger and Roper Diagram shows that the clarifiers could operate efficiently up to an SVI of 165 ml/g.**

3.1.2.2 Southerly Two-Plant Trickling Filter

The critical design data for the Southerly two-plant trickling filter option is presented in Table 3-3. Any evaluation of trickling filters at the Southerly plant requires an understanding of the existing plant layout and related logistical problems. There is inadequate space between the existing primary clarifiers and aeration basins to install the proposed 110-foot diameter trickling filters. Due to this limitation it was assumed that the trickling filters would be located in an area remote to those processes and that primary effluent would be pumped to the trickling filter and discharged from the trickling filter to the influent end of the aeration basin by gravity

TABLE 3-2. SOUTHERLY PROCESS DESCRIPTION - TWO PLANT SEMI-AEROBIC, AS

	West Train	Center Train	Total
Flow (Design)			
Average (MGD)	42	42	84
Peak (MGD)	65.5	65.5	131
Aeration			
Tankage			
New	--	2@26'x900'x15'SWD	2
Existing	6@26'x900'x15'SWD	4@26'x900'x15'SWD	10
HRT (hrs)			
Average	9.00	9.00	
Peak	5.77	5.77	
Clarification			
Tankage			
New	6@190'dia.x15'SWD		6
Existing	--	--	--
Surface Overflow Rate (gpd/ft^2)			
Average	490		
Peak	770		
Solids Loading Rate ($lb/d.\ ft^2$)			
Average	25		
Peak	38		

TABLE 3-3. SOUTHERLY PROCESS DESCRIPTION - TWO PLANT TF/AS

	West Train	Center Train	Total
Flow (Design)			
Average (MGD)	46	38	84
Peak (MGD)	71	60	131
Trickling Filters			
Filters	2@110'Øx22'ht.	2@110'Øx22'ht.	4
Hydraulic Loading Rate (gpd/ft^2)			
Average	2420	2000	
Peak	3740	3160	
Organic Loading Rate (lb.BOD/d. 1000 ft^3)			
Average	160	130	
Peak	160	130	
Aeration			
Tankage			
New	--	--	--
Existing	5	4	9
HRT (hrs)			
Average	6.85	6.63	
Peak	4.43	4.20	
Clarification			
Tankage			
New	6@190'dia.x15'SWD		6
Existing	--	--	--
Surface Overflow Rate (gpd/ft^2)			
Average	490		
Peak	770		
Solids Loading Rate (lb/d. ft^2)			
Average	25		
Peak	38		

conduits. These logistical problems while not insurmountable were taken into consideration when evaluating the overall effect of the trickling filter process as discussed in Section 4 of this briefing paper.

As indicated in Table 3-3, four 110-foot diameter by 22-foot high high-rate roughing trickling filters were sized for the Southerly two-plant option. Two trickling filters would service each of the existing treatment trains. Hydraulic loading rates of 3,740 and 3,160 gallons per day per square foot of trickling filter surface area are well within the design criteria limit of 4,600 gallons per day per square foot. The organic loading rates of 130 and 160 pounds BOD per day per 1,000 cubic feet of trickling filter volume are well within the 100 to 500 range. Following the trickling filters, five of the six existing aeration basins in the west train and four existing basins in the center train would be used for aeration capacity. Although the hydraulic retention times are considerably less than thoses cited for the semi-aerobic or activated sludge systems, it is considered adequate for aeration following roughing trickling filters.

Final clarification consists of six 190-foot diameter clarifiers with resulting surface overflow rates in the range of 490 gallons per day per square foot under average conditions and 770 gallons per day per square foot under peak conditions. Solids loading rates range from 25 pounds per day per square foot at average flow to 38 pounds per day per square foot at peak flow.

3.1.2.3 Jackson Pike Two-Plant Semi-Aerobic

Table 3-4 summarizes the design criteria for the Jackson Pike semi-aerobic and activated sludge process trains. The assumption used throughout this briefing paper is that the Jackson Pike plant is hydraulically limited to 100 MGD. This assumption is based on information from the city and their consultant. The average flow to Jackson Pike was limited to 70 MGD based on the capacity of the existing aeration tanks. Average flows in excess of 70 MGD and peak flows in excess of 100 MGD will be diverted to the Southerly WWTP.

TABLE 3-4. JACKSON PIKE PROCESS DESCRIPTION - SEMI-AEROBIC, AS

	A-Train	B-Train	Total
Flow (Design)			
Average (MGD)	42	28	70
Peak (MGD)	60	40	100
Aeration			
Tankage			
New			
Existing	6@26'x900'x15'SWD	4@26'x900'x15'SWD	10
HRT (hrs)			
Average	9.00	9.00	
Peak	6.30	6.30	
Clarification			
Tankage			
New	--	2@153'x60'x12.5'SWD	2
Existing	8@153'x60'x12.5'SWD	4@153'x60'x12.5'SWD	12
Surface Overflow Rate (gpd/ft^2)			
Average	570	510	
Peak	820	730	
Solids Loading Rate ($lbs/d. ft^2$)			
Average	20	18	
Peak	29	26	

The semi-aerobic system would utilize 6 existing aeration basins in the A train. In the B train the 4 existing aeration basins would be utilized. A flow split of 60 percent to the A Train and 40 percent to the B Train would be employed. Under both conditions, hydraulic retention times are well within the limits established in the evaluation criteria. These criteria were established during the SBR and piloting studies utilizing Jackson Pike primary effluent. As previously stated, the nitrification rates in the Jackson Pike studies have been approximately 300 percent higher than those reported for Southerly. Given these conditions, the hydraulic retention time cited in Table 3-4 is considered adequate when operating at a MLSS of 2500 mg/l.

In evaluating final clarification for Jackson Pike, the selected option includes rehabilitating the existing 12 clarifier units and adding 2 new rectangular clarifiers (153-foot by 60-foot by 12.5-foot sidewall depth) to the B-train. The addition of 2 new rectangular clarifiers would provide Jackson Pike with a combined surface overflow area of 128,000 square feet. The facility plan recommended demolishing the existing clarifiers and installing four new 200-foot diameter circular clarifiers. This would provide the facility with 126,000 square feet of final clarifier surface area. Surface overflow rates and solids loading rates would be essentially identical for the rectangular clarifiers versus the new circular clarifiers. A discussion of final clarifier utilization for both Southerly and Jackson Pike is presented in Section 4.2 of this briefing paper.

3.1.2.4 Jackson Pike Two-Plant Trickling Filter/Activated Sludge

The trickling filter/activated sludge option design criteria for the Jackson Pike WWTP is summarized in Table 3-5. The design criteria for aeration and final clarification are essentially the same as those described under the Jackson Pike semi-aerobic and activated sludge options. Two new 110-foot diameter by 22-foot high and two new 90-foot diameter by 22-foot high trickling filters would be added to the process treatment trains. Critical design conditions in terms of hydraulic loading and organic loading are well within criteria cited in Table 3-1. One limitation which impacts the selection of trickling filters for Jackson Pike is space. While the evaluation

TABLE 3-5. JACKSON PIKE PROCESS DESCRIPTION - TF/AS

	A-Train	B-Train	Total
Flow (Design)			
Average (MGD)	42	28	70
Peak (MGD)	60	40	100
Trickling Filters			
Filters	2@110'Øx22'ht.	2@90'Øx22'ht.	4
Hydraulic Loading Rate (gpd/ft^2)			
Average	2210	2200	
Peak	3160	3140	
Organic Loading Rate (lb. BOD/d.1000 ft^3)			
Average	120	120	
Peak	120	120	
Aeration			
Tankage			
New	--	--	--
Existing	6	4	10
HRT (hrs)			
Average	9.00	9.00	
Peak	6.30	6.30	
Clarification			
Tankage			
New	--	2@153'x60'x12.5'SWD	2
Existing	8@153'x60'x12.5'SWD	4@153'x60'x12.5'SWD	12
Surface Overflow Rate (gpd/ft^2)			
Average	570	510	
Peak	820	730	
Solids Loading Rate (lb/d. ft^2)			
Average	20	18	
Peak	29	26	

of critical design criteria indicate that four units would be adequate, limited available area would make siting difficult.

3.1.2.5 Southerly One-Plant Semi-Aerobic

The critical design criteria for a one-plant semi-aerobic option are presented in Table 3-6. Under the one-plant option, the existing center and west train would handle an average flow of 88 MGD with a peak flow of 132 MGD. With the increased hydraulic loading, it will be necessary to construct a new east train capable of handling an average of 66 MGD with peak sustained loads of 99 MGD. This would include use of ten existing aeration basins at the center and west trains with the construction of two new 26-foot by 900-foot by 15-foot sidewall depth basins on the center train. The new east train would contain nine 26-foot by 900-foot by 15-foot sidewall depth aeration basins.

Final clarification would include six new 200-foot diameter circular clarifiers for the center and west train and four new 205-foot diameter circular clarifiers for the east train for a combined facility clarifier surface area of 320,360 square feet. Given the amount of clarifier capacity, both the surface overflow rates and solids loading rates are within design criteria.

3.1.2.6 Southerly One-Plant Trickling Filter/Activated Sludge

The trickling filter/activated sludge option for a Southerly one-plant operation is presented in Table 3-7. The trickling filters would consist of four 115-foot diameter units for the center and west trains and two 115-foot diameter units for the east train. Under sustained peak hydraulic loading, the hydraulic loading criteria is within the 4,600 gallons per day per square foot of surface area for all trains. Organic loadings are within the range of 100 to 500 pounds of BOD per day per thousand cubic feet of reactor volume. All other aeration and clarification criteria fall within the critical design criteria for the one-plant option.

TABLE 3-6. SOUTHERLY PROCESS DESCRIPTION - ONE-PLANT SEMI-AEROBIC AND AS

	Center and West Train	East Train (New)	Total
Flow (Design)			
Average(MGD)	88	66	154
Peak(MGD)	132	99	231
Aeration			
Tankage			
New	2@26'x900'x15'SWD	9@26'x900'x15'SWD	11
Existing	10@26'x900'x15'SWD		10
HRT (hr)			
Average	8.59	8.58	
Peak	5.73	5.72	
Clarification			
Tankage			
New	6@200'Øx15'SWD	4@205'Øx15'SWD	10
Existing	--	--	
Surface Overflow Rate (gpd/ft^2)			
Average	470	500	
Peak	700	750	
Solids Loading Rate ($pounds/d.ft^2$)			
Average	23	25	
Peak	35	37	

TABLE 3-7. SOUTHERLY PROCESS DESCRIPTION - ONE-PLANT TF/AS

	West Train	Center Train	East Train	Total
Flow (Design)				
Average (MGD)	50	42	62	154
Peak (MGD)	75	63	93	231
Trickling Filter				
Filters (New)	2@115'Øx22'ht.	2@115'Øx22'ht.	2@115'Øx22'ht.	6
Hydraulic Loading Rate (gpd/ft^2)				
Average	2410	2020	2990	
Peak	3610	3030	4480	
Organic (lb.BOD/d.1000ft^3)				
Average	150	120	180	
Peak	150	120	180	
Aeration				
Tankage				
New			6@900'x26'x15'SWD	6
Existing	5@900'x26'x15'SWD	4@900'x26'x15'SWD		9
HRT (hrs)				
Average	6.29	6.00	6.10	
Peak	4.19	4.00	4.06	

	West and Center Train	East Train	Total
Clarification			
Tankage			
New	6@200'Øx15'SWD	4@200'Øx15'SWD	10
Existing			
Surface Overflow Rate (gpd/ft^2)			
Average	490	500	
Peak	730	750	
Solids Loading Rate (pounds/d.ft^2)			
Average	24	25	
Peak	36	37	

Final clarification would include six new 200-foot diameter clarifiers for the west and center trains and four new 200-foot diameter units for the east train.

3.2 TECHNICAL EVALUATION

The previously described treatment options were evaluated in terms of their reliability and flexibility. Reliability is measured in terms of potential loss of treatment system components as well as the impact of toxicity on the biological treatment process. System flexibility is discussed in terms of response to mass loadings as well as upsets within the system.

3.2.1 Reliability

A summary of system reliability for the biological process options is presented in Table 3-8. The semi-aerobic and activated sludge processes are evaluated with respect to aeration basin hydraulic retention time. Trickling filters are evaluated with respect to organic and hydraulic loading rates. Final clarification is evaluated with respect to surface overflow rates and solids loading criteria.

The analysis of system reliability considered that one of the system components was out of service. The components remaining in-service would be required to process the influent flow. Table 3-8 presents the impact on the process design criteria of processing average and peak flow through the system with one unit out of service. Under conditions where system components were separated into two parallel treatment trains, or in the case of Southerly one-plant where there are three parallel treatment trains, the worst case scenario was represented by the loss of one essential component in each of the parallel trains. The reliability evaluation may also be interpreted as a surge in hydraulic or mass loadings, where all units are operative, due to brief intervals of raw wastewater flows or loads above those projected in Table 2-1.

The system reliability data for the Jackson Pike semi-aerobic and trickling filter/activated sludge alternatives is contained in the first two columns of Table 3-8. For the aeration basin capacity, it was assumed that

TABLE 3-8. SYSTEM RELIABILITY

PARAMETER	Jackson Pike (2-Plant) SA	Jackson Pike (2-Plant) TF/AS	Southerly (2-Plant) SA	Southerly (2-Plant) TF/AS	Southerly (1-Plant) SA	Southerly (1-Plant) TF/AS
Aeration						
Hydraulic Retention Time (hrs)						
Average	**6.75**	**6.75**	**7.50**	**5.00**	7.15	4.50
Peak	4.75	4.75	4.80	3.15	4.76	3.00
Trickling Filter						
Hydraulic Loading Rate (gpd/ft^2)						
Average	--	**3150**	--	**2950**	--	2970
Peak	--	4500	--	4590	--	4450
Organic Loading Rate (lb BOD/d/1000ft^3)						
Average	--	**180**	--	**190**	--	235
Peak	--	**180**	--	**190**	--	235
Clarification						
Surface Overflow Rate (gpd/ft^2)						
Average	**610**	**610**	**590**	**590**	670	660
Peak	930	930	920	920	1000	990
Solids Loading Rate ($lb/d/ft^2$)						
Average	**22**	**22**	**29**	**29**	33	33
Peak	33	33	46	46	50	49

NOTE: This table assumes one component (aeration basin, trickling filter, or clarifier) is removed from service for repair or maintenance. The resulting impact on the process design criteria is identified.

one of the four aeration basins in the B train was removed from service for an extended period of time leaving three functional basins in the B train; and one of the six basins in the A train was removed leaving five basins available in the A train. The efficiency of either train should not be affected since the hydraulic retention times are still within design criteria listed in Table 3-1.

The impact of removing one of the 110-foot diameter trickling filters from service would cause the hydraulic loading rate to increase to 4,500 gallons per day per square foot of surface area **under peak flow conditions.** This does not exceed the design criteria of 1,400 to 4,600. The organic loading rate would increase to **180** pounds of BOD per day per 1000 cubic feet of filter. This is still within the design range of 100 to 500.

The removal of one of the clarifiers in each train would not have a significant impact on the solids overflow or solids loading design criteria.

Columns three and four of Table 3-8 show the impact of a loss of process components at Southerly under a two-plant option. Removal of one of the six aeration basins in either the west train or the center train would not cause the **minimum** hydraulic retention time to be **violated.** Removal of one of the four trickling filters would not violate either the established maximum hydraulic or organic loading rates.

Removal of one of the six circular clarifiers would not result in a violation of the established design criteria. The solids loading rates would be high (46 $lb/d/ft^2$); however, this should not be a problem for circular clarifiers **if the SVI is not excessively high.**

Columns 5 and 6 in Table 3-8 presents the system reliability evaluation for the Southerly one-plant option. One of the aeration basins in each of the three trains would be removed from service due to maintenance or mechanical failure. For the semi-aerobic and TF/AS options, this would result in hydraulic retention times in the aeration basins within specified design criteria. Removal of one of the six trickling filters would not result in violations of the established maximum hydraulic or organic loading rates.

In terms of clarifier capacity it was assumed that one of the circular clarifiers would be removed from the west and center section and one from the east section. Under these conditions, the surface overflow rate as well as the solids loading rate under peak hydraulic loadings would approach the critical limits of the design criteria; however, they would not violate them. Once again, this should not be a problem for circular clarifiers.

In summary, all of the components under each alternative would be capable of operating within the specified design criteria in the event that a unit was removed from operation.

The second measure of system reliability is its ability to respond to system upsets or toxicity problems. The semi-aerobic process provides excellent capabilities to adjust to high ammonia loadings. Ammonia concentrations will be monitored in the number 6 bay in each of the aeration basins. Once ammonia concentrations above 2 mg/l are found, **the aeration in Bay 2 will be activated as well as a general D.O. increase which will enhance the nitrification rate. If this is not adequate to reduce NH_4N to 1.0 mg/l, then the internal recycle pump will be shut down to increase the real detention time. The internal recycle pump reduces nitrification capacity due to the volume used for denitrification.**

The roughing trickling filter acts as an anaerobic/anoxic aeration bay in the semi-aerobic process. The filter reduces BOD loadings to the aeration basins and effectively aids in the control of sludge bulking. Effluent recycling from the aeration basins back to the trickling filters acts in much the same way as the internal recycle of the semi-aerobic process. Aeration basin effluent recycling would also cause denitrification to occur within the trickling filters. Denitrification is vital during the summer months to prevent a rising sludge in the final clarifiers. One significant limitation of the trickling filter in cold climates is the tendency to ice. Under these conditions, loss of bio-mass as well as reduced process efficiency reduce the effectiveness of the trickling filters.

Toxic effects will have a similar impact on the semi-aerobic and trickling filter processes due to the common bacterial organisms used in nitrification and denitrification. One source of toxicity to a nitrification system can be slug loads of ammonia or TKN. Table 3-9 is a summary of Project 20 operating data for the month of February 1987. Project 20 is not being run in a manner exactly similar to that proposed for the semi-aerobic process. Nevertheless, its performance is indicative of the ability of the semi-aerobic process to nitrify under winter conditions. The data in Table 3-9 includes primary effluent ammonia concentrations for the west and center treatment trains, final effluent ammonia concentrations for aeration basins 1 and 2 which represent the semi-aerobic process, and ammonia concentrations from the remaining aeration basins which were operated in a conventional activated sludge mode with reduced aeration in the initial bays of each basin.

The data indicate that both the semi-aerobic and activated sludge process can meet 7-day and 30-day ammonia limits under cold weather conditions. However, it should be noted that periodic peak loadings of ammonia such as occurred on February 4, February 22, and February 24, resulted in bleedthrough of high ammonia concentrations to the final effluent. Generally, it appears that ammonia concentrations in the primary effluent in excess of 25 mg/l would result in violations of the 7-day and 30-day permit if they were sustained. It is apparent from the Project 20 data that slug loads of ammonia will cause effluent violations for both the semi-aerobic and activated sludge processes. The trickling filter/activated sludge option would respond in a similar fashion allowing bleedthrough of high influent ammonia loads. The source of the high nitrogen load is most likely one or more industries within the service area. As a result it is recommended that the sources of the high ammonia loads be identified and be limited in the amount of TKN they are allowed to discharge. Without such control, it would be impossible to consistently meet the 1988 effluent limits for ammonia.

TABLE 3-9. AMMONIA BREAK-THROUGH - SOUTHERLY
(Ammonia as N, mg/l)

Date	Primary Effluent		Final Effluent	
February	West	Center	1 & 2 (Semi-Aerobic)	all others (AS)
1	17	15	1.1	2.5
2	17	14	0.7	2.5
3	18	16	0.9	3.7
4	24	24	5.3	7.4
5	20	19	1.3	3.4
8	17	15	0.1	3.1
9	18	17	0.1	2.8
10	15	15	0.1	1.4
11	15	14	0.2	0.7
12	--	--	0.1	0.1
15	17	--	0.1	--
16	16	14	0.6	1.6
17	21	21	1.2	1.5
19	20	20	4.6	5.6
22	30	30	7.3	8.7
23	19	18	8.7	10.5
24	24	25	1.8	7.1
25	15	15	0.4	2.6
			30-day 1.9	3.6
			7-day 3.5	5.4

SOURCE: Contract 20 Operational Data

The data in Table 3-10 summarizes reported pollutant concentrations in the Jackson Pike and Southerly influent and presents inhibition levels of these pollutants for various biological processes. Influent concentrations of copper and zinc at the Columbus plants may be found at levels which can inhibit the nitrification process. Copper and zinc could act as inhibitory pollutants if the influent concentrations shown in Table 3-10 are carried through the primary effluent and enter the biological treatment process. The city of Columbus must consider controlling the level of inhibitory industrial pollutants to prevent system upsets. An aggresive and well-monitored industrial pretreatment program would be necessary to ensure the nitrification process is protected from inhibitory and/or toxic effects of industrial discharges.

3.2.2 Flexibility

System flexibility is defined as the ability of the system to expand or to turn-down (respond to reduced flows or loads) its biological processes. It will be necessary for the city of Columbus to control slug loads of ammonia and TKN no matter which biological option or treatment plant option is selected. Impacts can also be manifested in terms of loss of load. At the present time, it is estimated that 35 to 45 percent of the BOD loading to the Southerly plant originates with the Anheuser-Busch Brewery. The impacts of losing this BOD loading are most directly felt in the first bay of the semi-aerobic system. Mr. Albertson has indicated that in order **to control bulking,** an OUR/DO ratio of at least 250-1 must be maintained. Under current design conditions, the OUR/DO ratio is approximately 500-1. Given the loss of all brewery waste for a sustained period, it can be assumed that a critical OUR/DO ratio can be maintained. If the brewery wastes are the primary source of the historical bulking problems at Southerly, the plant could operate in a semi-aerobic or conventional activated sludge mode with little or no problems.

The second advantage of the semi-aerobic process in terms of responding to periodic upsets is what Mr. Albertson has described as sludge memory. Most activated sludge systems which have biological phosphorus removal capabilities are able to respond in a linear fashion to organic loading upsets based on

TABLE 3-10 SUMMARY OF POLLUTANT INHIBITION LEVELS FOR BIOLOGICAL PROCESSES

Priority Pollutant	Jackson Pike Influent, ug/l	Jackson Pike Effluent, ug/l	Southerly Influent ug/l	Southerly Effluent ug/l	Activated Sludge, ug/l	Nitrification, ug/l	Anaerobic, ug/l
1 Acenapthene	—	—	—	3.7*-10.0*	—	—	—
23 Chloroform	12*	—	3.3*-10*	—	—	I 10,000	—
30 1,2-Trans Dichloroethylene	—	—	19*	—	—	—	—
38 Ethylbenzene	4*-11*	—	5.3*-13*	—	—	—	—
44 Methylene Chloride	45*	—	44*	4.3*-11.0*	—	—	—
55 Napthalene	—	—	—	47*-53*	—	—	—
65 Phenols	50*	13*	50*	3*-10*	I 200,000 U 300,000	I 4,000	—
66 BIS(2-Ethylhexyl)Phthalate	17*	—	20*	—	—	—	—
67 Butyl Benzyl Phthalate	50*	—	—	—	—	—	—
85 Tetrachloroethylene	44*	—	—	—	I 400	—	—
86 Toluene	20*-24*	—	12*	—	—	—	—
87 Trichloroethylene	150*	—	190*	—	—	—	—
118 Cadmium	4.6-15.0	1.0-1.6	1.2-7.0	0.3-1.4	I 10,000-50,000 U 60,000 T 1,000	I 7,000	I 20
119 Chromium	34.0-280.0	17.0-28.0	1.7-210.0	9.4-12.0	B 5.0-50 T 1,000 I 7,000	I 250 U 1,000	I 1,000-10,000
120 Copper	64.0-210.0	9.9-14.0	31.0-100.0	9.8-10.0	B 5-50 I 1,000 U 3,600	T 50 U 260	I 1,000-10,000
121 Cyanide	90*	23*	30*	43*	T 100 I 200 U 200,000	I 240 U 21,000	I 4,000
122 Lead	35.0-165.0	5.4-7.3	14.0-69.0	2.2-7.2	I 200	I 700	—
123 Mercury	7*	—	0.56	0.30	T 100-1,000 U 200,000	I 2,000	I 1,365,000
124 Nickel	34.0-215.0	41.0-49.0	14.0-60.0	19.0-26.0	T 1,000-2,500 I 2,000-25,000 U 25,000	T 250-500 I 500-3,000	—
128 Zinc	205.0-670.0	99.0-190.9	25.0-434.0	36.0-42.0	T 800 I 1,000	T 80-500	I 5,000-20,000

*From Priority Pollutant Scan
B - Beneficial
T - Threshold for inhibiting effects
I - Inhibiting
U - Upsets

Source: Table 8.3, Columbus Industrial Pretreatment Program, Vol. 2, January 1987
*Anaerobic from EPA 430/9-76-017a

sludge age. Assume the sludge age is maintained at 9 days for a 2-day period and the primary source of organic loading is removed from the system. The impact on the effluent would be comparable to the ratio of 2-9 or approximately 22 percent loss of system efficiency. Under these conditions, the system would recover rapidly once the source of organic loading is placed back into the system. The disadvantage of this type of activated sludge (i.e., one which demonstrates biological phosphorus removal), is that the sludge yield in terms of pounds of sludge produced per pound of BOD destroyed is quite high. This is due to the fact that the elemental phosphorus percipitated from the system contributes to the total sludge volume. **(Sentence deleted)**

3.3 ENVIRONMENTAL CRITERIA

One purpose for evaluating treatment alternatives and options is ultimately to ensure that the treatment plants meet their environmental limits. Meeting these limits is predicated on a combination of conservative design criteria, projection of hydraulic and pollutant loading rates, and pilot testing to demonstrate system strengths and weaknesses under real-world conditions. To date, pilot testing in Columbus has utilized a sequencing batch reactor (SBR), and most testing has been at the Southerly plant. In reviewing the work done to date, additional information needs to be gathered on the impacts of blending Jackson Pike and Southerly primary effluent to determine if nitrification rates can be sustained.

It will also be necessary to limit the mass loading of TKN to the Southerly waste treatment plant in order for the nitrification process to be effective. Periodic high loadings of TKN have resulted in the bleedthrough of ammonia from the primary effluent during the Project 20 pilot demonstration. Unless these loads of TKN are controlled, all three biological processes would be subject to ammonia bleedthrough resulting in violation of the permit ammonia concentration and mass-loading limits.

Meeting total suspended solids and BOD limits is primarily a function of clarifier efficiency. Soluble BOD is rapidly removed in the aeration basin. That portion of the BOD associated with the particulates in the wastewater as well as the suspended solids which escape from the clarifier, would cause BOD or suspended solids violations. Controlling suspended solids violations is based on controlling the SVI of both Jackson Pike and Southerly biological treatment systems.

All three processes have the ability to select against filamentous organisms which cause bulking. The semi-aerobic and activated sludge systems, as demonstrated by Project 20 data, could reduce SVIs and keep ammonia concentrations well within permit limits given the absence of slug primary effluent ammonia loadings. Operating data for the Southerly waste treatment plant from 1983 through 1986, indicate SVIs in the range of 75 to 181 are possible. **(Sentence deleted)**

Denitrification is equally important during the summer months. Denitrification will prevent the formation of a rising sludge in the final clarifiers. No amount of clarifier upsizing or clarifier configuration modification can prevent a violation during episodes of rising sludges. It is, therefore, necessary that the denitrifiers complete the chemical reaction, converting the nitrates into nitrogen and carbon dioxide, in the aeration basin. This is accomplished by overpumping the secondary clarifiers, maintaining a minimum sludge blanket in those clarifiers, and holding the mixed liquor suspended solids in the aeration basin to 3500 mg/l (Southerly plant). Denitrification also has the side benefit of eliminating nitrites and nitrates from the plant effluent.

At the present time there is no nitrate or nitrite standard in the Ohio EPA permit limitations written for the Jackson Pike and Southerly plants. However, removing these pollutants from the effluent wastewater would result in the removal of pollutants from the receiving waters and subsequently any groundwaters which are recharged from the surface waters. Denitrification is considered a benefit, not only in terms of removing unwanted pollutants from the surface waters and the groundwaters of the state, but also in terms of limiting the occurrence of rising sludges in the secondary clarifiers.

Another secondary benefit from the semi-aerobic process would be that it is a biological phosphorus removal system. Although phosphorus removal increases the volume of sludge to be treated by both Southerly and Jackson Pike, it also results in the removal of a nutrient pollutant from the surface water and groundwater.

A negative environmental impact of odor and pests in the form of flies is associated with the trickling filter/activated sludge option. Trickling filters have been cited in odor complaints particularly under conditions of high organic loadings such as will be employed in the roughing filters proposed for Jackson Pike and Southerly. In addition, fly larvae and flies have been known to breed on these filter media resulting in nuisance complaints. Attempts to control odors and flies by covering the trickling filters results in the installation of a drafting system to allow adequate air to pass through the filter media. This would add cost to the system and may result in reduced efficiency during the summer months.

3.4 COSTS

The biological treatment train cost components (shown in Table 3-11) include trickling filters, aeration basins, aeration system blowers, blower housing, diffusers, (and internal recycle loops in the case of semi-aerobic systems), and clarification processes. Table 3-11 provides a comparison between the costs from the Revised Facility Plan Update and the briefing paper costs.

In general, costs developed for this briefing paper are lower than those presented in the facility plan due to lower projected average and peak flows. In general, the higher facility plan costs at Southerly for the two-plant alternative are due to the fact that a new east train was required. The lower projected flows used in the briefing paper analysis did not require a new east train for the two-plant option.

TABLE 3-11 COMPARISON OF CAPITAL COSTS SEMI-AEROBIC VS. TRICKLING FILTER

(Costs in millions of dollars)

Cost Component	SOUTHERLY				JACKSON PIKE				COMBINED			
	Facility Plan		Briefing Paper		Facility Plan		Briefing Paper		Facility Plan		Briefing Paper	
	SA	TF/AS	SA	TF/AS	SA	TF/AS	SA	TF/AS	SA	TF/AS	SA	TF/AS
Trickling Filters	--	23.7	--	11.0	--	11.0	--	9.9	--	29.9	--	21.5
Aeration	34.7	21.9	12.3	7.2	23.8	23.8	22.5	22.5	63.6	47.8	46.5	30.5
Clarification	33.8	26.3	20.5	20.5	9.8	9.8	8.7	8.7	41.8	41.8	35.5	35.5
TOTAL	68.5	71.9	32.8	38.7	33.6	44.6	31.2	41.1	105.4	119.5	82.0	87.5

Note: Briefing Paper costs are consistently lower than Facility Plan costs due to lower projected flows.

Under the combined plant option, the lower costs associated with the briefing paper estimates are due to the requirement for fewer treatment facilities based on lower flows.

In most cases, the semi-aerobic option was less costly than the trickling filter/activated sludge option. This is due to the fact that a significant portion of the required aeration capacity already exists.

The briefing paper analysis also reviewed the clarifier evaluation prepared during the facility planning process. In this clarifier evaluation, it was assumed that the Southerly One-Plant Alternative would be implemented. Three clarifier configurations were developed. These included:

- Alternative 1: Construction of 12 new 200-foot diameter clarifiers,
- Alternative 2: Constructing 6 new 200-foot diameter clarifiers for the east train, using all existing clarifiers for the center train, and constructing three 200-foot diameter clarifiers for the west train.
- Alternative 3: Constructing 6 new 200-foot diameter clarifiers for the east train; using existing rectangular clarifiers and adding 2 new 175-foot diameter clarifiers for the center train; and using the existing rectangular clarifiers and adding 2 new 175-foot diameter clarifiers to the west train.

Alternative 3 was discarded as being unworkable in terms of hydraulic limitations. Alternatives 1 and 2 were evaluated with a cost of $43,194,000 for Alternative 1, and $40,126,000 for Alternative 2. The RFPU study concluded that the two alternatives exhibit similar present worth costs. Consequently, due to the advantages of circular clarifiers, it was recommended that the existing clarifiers be demolished and new 200-foot clarifiers be installed. These advantages include:

- Easier flow splitting and control of flow to each clarifier.
- Reduction in the number of telescoping sludge valves to be controlled.
- Ability to provide flocculation within the clarifier.
- Less potential risk for shortcircuiting.
- Automatic scum removal for the entire surface.
- Less complicated construction phasing.

In addition to these advantages the capability to rapidly return sludge to the aeration basin is a distinct advantage of circular clarifiers. Due to the low nitrification rates at Southerly, the briefing paper evaluation concurs with the advantages of circular clarifiers and recommends their installation at Southerly.

4. COMPARISON OF BRIEFING PAPER AND FACILITY PLAN CONCLUSIONS

4.1 PROCESS SELECTION

The briefing paper analysis concurs with the facility plan in its selection of the semi-aerobic process as the preferred biological process. The process is superior to the trickling filter/activated sludge process due to its ability to provide nutrient removal and the flexibility of process control it affords operators. As previously stated, the semi-aerobic system is essentially the same as the conventional activated sludge system and could easily be operated in the conventional activated sludge mode if necessary. Although the trickling filter/activated sludge option is considered reliable, it does exhibit the disadvantages of producing nuisance odors and pests, and requires additional space to implement.

Process selection is also predicated on the assumption that Columbus will implement and enforce a rigid industrial preteatment program which will limit the concentration of toxic pollutants and slug loads of ammonia. Pilot data have indicated that slug loads of ammonia or TKN will pass through the primary clarifiers and may result in ammonia bleedthrough from the aeration basins. These influent conditions must be controlled to ensure that any biological process will perform effectively and meet permit limitations.

4.2 CLARIFIER UTILIZATION

The briefing paper evaluation agreed with the facility plan recommendation to demolish the existing rectangular clarifiers at Southerly and replace them with new circular clarifiers. Due to the lower flows and loads utilized in the briefing paper analysis, less facilities are recommended in the briefing paper for both the Southerly one-plant and Southerly two-plant alternatives.

Contrary to the RFPU, the briefing paper recommends retaining the existing retangular clarifiers at Jackson Pike. The arguments for the selection of circular clarifiers at Southerly, primarily high mixed liquor suspended solids, the need for overpumping, and low nitrification rates do not apply to the Jackson Pike waste treatment facility. The 12 existing rectangular clarifiers at Jackson Pike should be rehabilitated, and 2 additional rectangular clarifiers should be constructed to provide adequate final effluent clarification capacity.

4.3 ONE-PLANT VS. TWO-PLANT

The decision to utilize a combined one-plant option versus a two-plant option must be based on process reliability as well as cost factors. The data presented in this briefing paper shows the biological treatment process for the two-plant option is less costly. The unknown factor at this point is the effect of nitrification rates on blending Jackson Pike and Southerly primary effluent. In the absence of this data, it is speculative to recommend a one-plant versus two-plant option based on process considerations alone.

APPENDIX D

BRIEFING PAPER NO. 4
O&M AND CAPITAL COSTS

BRIEFING PAPER NO. 4

O & M AND CAPITAL COSTS

Supplemental Environmental Impact Statement
USEPA Contract No. 68-04-5035, D.O. No. 40
Columbus Ohio Wastewater Treatment Facilities

Prepared By:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TRIAD ENGINEERING INCORPORATED

O&M AND CAPITAL COSTS

1. DEVELOPMENT OF BRIEFING PAPER COSTS

    1.1 CAPITAL COSTS
    1.2 O&M COSTS

2. FACILITY PLAN COSTS

3. COMPARISON OF BRIEFING PAPER AND FACILITY PLAN COSTS

INTRODUCTION

Under the direction of USEPA, a series of briefing papers are being prepared addressing key issues in the development of the Supplemental Environmental Impact Statement for the Columbus, Ohio, Wastewater Treatment Facilities. The briefing papers form the basis of discussions between Triad Engineering and USEPA to resolve important issues. The following paragraphs present the background of the facility planning process, a description of the briefing papers, and the purpose of this paper on costs.

FACILITY PLANNING PROCESS

At the time this paper was prepared (March-July 1987) the city of Columbus was proceeding to implement improvements at the Jackson Pike and Southerly Wastewater Treatment Plants to comply with more stringent effluent standards which must be met by July 1, 1988. These improvements were based on the consolidation of wastewater treatment operations at the Southerly plant. This one-plant alternative is a change from the two-plant operation proposed by the city in the 1970's and evaluated in the 1979 EIS.

The development and documentation of wastewater treatment process and sludge management alternatives for the Columbus metropolitan area has been an extended and iterative process. The design and construction of various system components have progressed, because of the 1988 deadline, while planning issues continue to be resolved. As a result, numerous documents have been prepared which occasionally revise a previously established course of direction.

The concurrent resolution of planning issues and implementation of various project components has made preparation of the EIS more difficult because final facility plan recommendations are not available in a single document.

BRIEFING PAPERS

To facilitate preparation of the EIS, a series of briefing papers are being developed. The purpose of the briefing papers is to allow USEPA to review the work of the EIS consultant and to identify supplemental information necessary for the preparation of the EIS. Six briefing papers are being prepared as follows:

- Flows and Loads
- Sludge Management
- CSO
- Process Selection
- One Plant vs. Two Plant (Alternative Analysis)
- O&M and Capital Costs

The specific focus of each briefing paper will be different. However, the general scope of the papers will adhere to the following format:

- Existing conditions will be documented.
- Evaluations, conclusions, and recommendations of the facilities planning process will be reviewed using available documentation.
- Where appropriate, an independent evaluation of the future situation and viable alternatives will be prepared.
- The facility plan and EIS briefing paper conclusions will be compared.

The briefing paper process is intended to:

- Prompt the resolution of any data deficiencies.
- Clearly establish and define existing and future conditions.
- Identify the final recommended plan which the city desires to implement.
- Provide a data base of sufficient detail to allow preparation of the draft EIS.

O&M AND CAPITAL COSTS

This briefing paper presents capital and operation and maintenance costs associated with the Southerly One-Plant and Jackson Pike and Southerly Two-Plant alternatives. Topics addressed include:

- Development of briefing paper capital and O&M costs
- Facility plan capital and O&M costs
- Comparison of briefing paper and facility plan costs

The briefing paper cost analysis is based on the 2008 design flows and loads which were presented in the Wastewater Flows and Loads Briefing Paper. The facility plan costs are taken from the 1985 Revised Facility Plan Update. These costs were developed for a 30-year planning period ending in 2015.

1. DEVELOPMENT OF BRIEFING PAPER COSTS

This section presents briefing paper capital and O&M costs for the Southerly One-Plant, Southerly Two-Plant, and Jackson Pike Two-Plant alternatives. Due to the differences in design flows between the facility plan and the briefing papers, an independent cost analysis was prepared based on the 2008 flows and loads developed in the Wastewater Flows and Loads Briefing Paper. Table 1-1 presents the flows and loads which were used as a basis for developing these costs. The Process Selection Briefing Paper recommended the semi-aerobic process. Therefore, O&M and capital costs were developed assuming semi-aerobic as the biological process being employed. Solids handling costs are consistent with facilities recommended in the Solids Handling Briefing Paper.

TABLE 1-1. BRIEFING PAPER FLOWS AND LOADS

	Jackson Pike	Southerly	Total
Average Flow (MGD)	70	84	154
Peak Process Flow (MGD)	100	131	231
BOD Load (lb/day)	112,600	155,600	268,200
TSS Load (lb/day)	128,500	154,400	282,900

NOTE: Average flows in excess of 70 MGD and peak process flows in excess of 100 MGD at Jackson Pike will be diverted to Southerly under the two-plant alternative.

1.1 CAPITAL COSTS

Detailed cost estimates prepared during the facilities planning process by the Turner Construction Company were utilized in preparing the construction costs for this briefing paper. These cost estimates were reviewed in detail and adjusted as appropriate to account for differences in the briefing paper design flows and unit process sizing. Table 1-2 presents the construction costs for the Southerly One-Plant, Southerly Two-Plant, and Jackson Pike Two-Plant alternatives.

TABLE 1-2. BRIEFING PAPER CAPITAL COSTS

Cost Component	Southerly (One-Plant)	Southerly (Two-Plant)	Jackson Pike (Two-Plant)
Site Work	$ 22,932,000	$ 11,448,000	$ **1,550,000**
Miscellaneous Buildings	5,232,000	4,857,000	1,857,000
Plumbing/HVAC	5,875,000	5,875,000	4,337,000
Headworks	14,300,000	--	8,271,000
Preaeration	5,905,000	1,533,000	3,750,000
Primary Settling	13,590,000	4,717,000	7,372,000
Aeration	46,533,000	12,284,000	22,502,000
Final Settling	35,462,000	20,521,000	8,691,000
Chlorination	4,000,000	2,500,000	2,000,000
Effluent Pumping	6,270,000	--	4,340,000
Outfall Line	3,000,000	--	700,000
Gravity Thickening	5,070,000	2,520,000	**1,967,000**
Digestion	11,460,000	4,280,000	9,170,000
Centrifuge Thickening	5,600,000	2,000,000	4,500,000
Centrifuge Dewatering	21,040,000	5,120,000	490,000
Dewatered Sludge Storage	1,300,000	1,300,000	--
Incineration	1,300,000	--	3,600,000
Sludge Conveyor System	--	--	5,000,000
Instrumentation & Control	10,070,000	4,799,000	6,995,000
Electrical Distribution	1,896,000	1,896,000	607,000
Jackson Pike Rehabilitation	13,564,000	--	--
Interconnector South	4,982,000	--	--
Interconnector North	5,048,000	--	5,048,000
TOTAL CONSTRUCTION COSTS	$244,429,000	$ 85,650,000	**$102,747,000**
Contingency (15%)	36,664,000	12,848,000	**15,412,000**
Land	200,000	200,000	--
Salvage Value (PW)	- 12,582,000	- 4,644,000	**- 5,137,000**
CAPITAL PRESENT WORTH	$268,711,000	$ 94,054,000	**$113,022,000**

1.2 O&M COSTS

Operation and maintenance costs were developed for each plant alternative. The costs are presented in Table 1-3. The basis of these costs are described in the following paragraphs.

TABLE 1-3. BRIEFING PAPER ANNUAL O&M COSTS ($)

	Southerly (1-Plant)	Southerly (2-Plant)	Jackson Pike (2-Plant)
Labor	4,050,000	2,850,000	2,880,000
Material & Supply	4,446,000	2,250,000	2,412,000
Chemicals	1,197,000	580,000	658,000
Energy	4,800,000	2,425,000	2,425,000
Land Application	712,000	342,000	712,000
Composting	1,314,000	1,314,000	--
Ash Disposal	330,000	60,000	170,000
TOTAL	16,849,000	9,821,000	9,257,000

NOTE: These costs are based on 2008 design flows and loads.

Labor costs for operation and maintenance were determined by evaluating information on the number of employees currently employed at the treatment facilities and their respective salaries. An average annual salary (including benefits) of $30,000 per employee was established for future cost projections. The projected number of workers for each alternative is 135 for the Southerly One-Plant, 95 for the Southerly Two-Plant, and 96 for the Jackson Pike Two-Plant.

Typically, annual material and supply costs are estimated as a percentage of total construction costs. However, in this situation, with a portion of the facilities already in place, doing so may underestimate the actual cost. Therefore, cost curves were used to determine the construction costs for each plant alternative as a new facility. One percent of this cost was estimated as the annual material and supply cost.

Chemical costs were determined for three processes: chlorination, centrifuge thickening, and centrifuge dewatering. A current chlorine cost of $200 per ton and a polymer cost of $1 per pound were used for these estimates.

Costs for electrical energy were estimated based on costs documented in the 1985 Operating Report prepared by the City of Columbus Division of Sewerage and Drainage. These costs were adjusted to account for the following:

- An increase in power costs from $0.04 to $0.05 per kilowatt-hour
- An increase in average flow from 145 MGD to 154 MGD
- Additional oxygen requirements for nitrification

Fuel cost estimates were determined based on the assumption that the future solids handling scheme would include digestion and dewatering to a minimum cake solids content of 22 percent. Under this assumption, enough sewage gas is produced to meet the fuel requirements of the incinerators and the digesters. Additional fuel cost estimates for heating and service were based on costs documented in the 1985 Operating Report prepared by the City of Columbus Division of Sewerage and Drainage. Fuel costs for heating and service were estimated as $200,000 per year for each plant under the two-plant alternative and $350,000 per year for the Southerly One-Plant Alternative. The total energy cost for the Jackson Pike WWTP and the Southerly WWTP in 1985 was $4.5 million. In comparing this cost to the 2008 projected cost of $4.7 million, it must be remembered that the following factors differ between the two costs.

- In 1985 the Southerly digesters were not operating.
- Dewatered cake solids at both plants averaged only 17 percent in 1985.
- Power costs in 1985 were $0.04 per kilowatt-hour.
- There is a 6 percent increase in average flow from 1985 to 2008.

Land application is a contract operation. Based on past contract costs from the city, it has a unit cost of $15 per wet ton.

Operation and maintenance costs for the compost facility were estimated based on historical O&M costs. A unit cost of $30 per wet ton was used. This cost includes materials, supplies, energy, and labor.

Ash disposal, which includes hauling and landfilling, was estimated at a cost of $15 per cubic yard.

The total present worth O&M cost for the combined Jackson Pike and Southerly Two-Plant option is $189,940,000. This cost is 13 percent higher than the Southerly One-Plant cost of $168,200,000.

Table 1-4 presents the present worth of the O&M costs for each plant alternative.

TABLE 1-4. BRIEFING PAPER O&M COSTS ($)

	Southerly [1-Plant]	Southerly [2-Plant]	Jackson Pike [2-Plant]
Annual O&M			
1988-1992	16,047,000	8,848,000	9,257,000
1993-1997	16,247,500	9,091,000	9,257,000
1998-2002	16,448,000	9,334,000	9,257,000
2003-2007	16,648,500	9,577,000	9,257,000
Total			
Present Worth (1988)	168,200,000	94,140,000	95,800,000

2. FACILITY PLAN COSTS

Costs were presented in the Revised Facility Plan Update (RFPU) for the Southerly One-Plant, Southerly Two-Plant, and Jackson Pike Two-Plant alternatives. These costs are for facilities which were sized based on the flows and loads presented in Table 2-1.

TABLE 2-1. FACILITY PLAN FLOWS AND LOADS

	Jackson Pike	Southerly	Whittier Street	Total
Average Flow (MGD)	101	75	--	176
Peak Process Flow (MGD)	172	128	--	300
CSO (MGD)	-	-	130	130
BOD Load (lb/day)	148,620	131,740	10,000	290,360
TSS Load (lb/day)	170,390	126,550	20,000	316,940

NOTE: Flows at Jackson Pike in excess of 100 MGD will be diverted to Southerly under the two-plant alternative. The additional flow of 130 MGD of CSO will be transported to Southerly under either alternative.

These flows and loads differ from those used in the briefing paper. Table 2-2 presents the Revised Facility Plan Update capital costs associated with these flows and Table 2-3 presents the RFPU O&M costs for the one-plant and two-plant alternatives. The O&M costs associated with wet stream treatment and solids handling were increased throughout the planning period to account for increases in flows and loads. The O&M costs for headworks, administration, Whittier Street facilities, and the Jackson Pike diversion chamber were held constant throughout the planning period.

The RFPU O&M costs also include an amount allocated to "Other Capital Costs". These costs were originally estimated with capital costs. The costs are for rehabilitation or replacement of existing equipment. Table 2-4 shows a breakdown of these costs.

TABLE 2-2. FACILITY PLAN CAPITAL COSTS

Cost Component	Southerly (One-Plant)	Southerly (Two-Plant)	Jackson Pike (Two-Plant)
Site Work	$ 24,817,490	$ 21,120,060	$ 8,056,750
Miscellaneous Buildings	6,314,840	5,856,230	3,514,900
Plumbing/HVAC	100,000	100,000	3,071,870
Headworks	26,278,310	19,536,520	10,163,620
Storm Bypass	2,316,950	2,316,950	--
Stormwater Tanks	5,506,390	5,506,390	--
Preaeration	8,802,450	6,516,490	4,148,080
Primary Settling	15,734,910	13,020,930	5,819,100
Aeration	63,605,700	34,661,730	23,856,500
Final Settling	41,812,710	33,848,295	9,832,890
Effluent Filters	50,066,830	29,682,210	25,060,510
Chlorination	6,489,190	4,367,810	3,218,280
Effluent Pumping	9,221,730	122,340	7,321,300
Outfall Line	2,491,210	--	796,280
Gravity Thickening	5,866,755	4,781,660	7,272,140
Digestion	9,833,400	5,913,650	9,377,250
Centrifuge Thickening	7,766,720	5,120,895	6,917,630
Thermal Conditioning	--	--	3,030,260
Centrifuge Dewatering	11,943,104	6,721,880	517,580
Incineration/Ash Lagoon	2,546,770	2,546,770	3,975,830
Lime Stabilization	1,200,000	1,200,000	--
Instrumentation & Control	11,439,090	8,697,710	8,331,650
Electrical Distribution	2,097,610	2,097,610	607,160
Jackson Pike Rehabilitation	15,000,000	--	--
Whittier Storm Tanks	7,465,180	7,465,180	--
Whittier to Jackson Pipe	3,782,300	3,782,300	--
Grit to Flow Diversion Pipe	4,738,940	4,738,940	--
Interconnector North	5,727,010	6,279,510	--
Interconnector South	5,509,780	5,509,780	--
Miscellaneous	--	--	5,000,000
TOTAL CONSTRUCTION COSTS	$358,475,369	$241,511,840	$149,889,580
Engineering Fees	42,592,748	26,629,941	15,962,812
Land Acquistion	200,000	200,000	--
Process License Fees	8,000,000	4,000,000	4,000,000
Salvage Value	-5,431,000	-3,774,000	-2,059,000
CAPITAL PRESENT WORTH	$403,837,117	$268,567,781	$167,793,000

TABLE 2-3. FACILITY PLAN O&M COSTS ($/YR)

	2-PLANT SOUTHERLY	2-PLANT JACKSON PIKE	2-PLANT TOTAL	1-PLANT SOUTHERLY
WETSIDE				
1988-1990	4,642,259	3,455,820	8,098,079	6,478,414
1991-1995	5,694,560	4,225,624	9,920,184	7,953,897
1996-2000	6,078,667	4,589,694	10,668,361	8,408,234
2001-2005	6,466,235	4,976,569	11,442,804	8,929,529
2006-2010	7,030,124	5,625,354	12,655,478	9,581,484
2011-2015	7,694,711	6,416,125	14,110,836	10,451,592
SOLIDS				
1988-1989	6,109,400	4,887,200	10,996,600	8,100,200
1990-1999	6,380,500	5,090,000	11,470,500	8,426,500
2000-2015	6,511,500	5,192,400	11,703,900	8,956,400
WHITTIER STREET				
1995-2015	--	47,900	47,900	47,900
JP DIVERSION CHAMBER				
1988-2015	--	136,000	136,000	136,000
HEADWORKS				
1988-1089	--	1,074,660	1,074,660	--
1990-2015	687,400	1,074,660	1,762,060	1,219,500
ADMINISTRATIVE				
1988-2015	400,000	400,000	800,000	500,000
OTHER CAPITAL				
1986-2000	915,995	366,066	1,282,061	1,141,329
TOTAL				
Present Worth (1985)	127,734,009	104,785,539	232,519,548	176,166,114

TABLE 2-4. FACILITY PLAN OTHER CAPITAL COSTS

	COST ($)
SOUTHERLY (ONE-PLANT)	
Preaeration	
• Replace Diffusers	193,000
• Replace Flushing Equipment	26,000
• Replace Blowers	88,000
• Replace Cross Collectors	111,000
Primary Settling	
• Replace Flights, Chains, and Cross Collectors	1,800,000
• Replace Skimming Equipment	90,000
• Weir Replacement	100,000
Digester Renovation	3,600,000
Centrifuges - Automatic Backdrives	300,000
HVAC Renovation	8,747,500
Jackson Pike Sewer Maintenance Yard	975,440
Incineration	1,300,000
TOTAL	17,330,940
SOUTHERLY (TWO-PLANT)	
Preaeration	
• Replace Diffusers	193,000
• Replace Flushing Equipment	26,000
• Replace Blowers	88,000
• Replace Cross Collectors	111,000
Digester Renovation	3,600,000
HVAC Renovation	8,747,500
Jackson Pike Sewer Maintenance Yard	975,440
TOTAL	13,740,940
JACKSON PIKE (TWO-PLANT)	
Miscellaneous Building Renovation	257,000
Primary Building Renovation	168,000
Primary Tanks	
• Not Filling Tanks	230,000
• Replace Flights, Chains, and Cross-Collectors	991,000
• Replace Skimming Equipment	133,000
• Replace Weirs	214,000
• Replace Sluice Gates	266,000
Aeration	
• Replace Sluice Gates	932,000
• Renovate Control Building	612,000
HVAC Renovation	1,918,000
TOTAL	5,721,000

3. COMPARISON OF BRIEFING PAPER AND FACILITY PLAN COSTS

Tables 3-1 and 3-2 present cost comparisons between the one- and two-plant alternatives for the briefing paper and facility plan, respectively. The facility plan shows the two-plant alternative being 15 percent more costly than the one-plant. However, the briefing paper shows the one-plant as **10** percent more costly than the two-plant. This difference between the facility plan and the briefing paper is primarily a result of differences in design flows. At the briefing paper's lower flows, a new east train, headworks, and expanded Interconnector Sewer are not required under a two-plant alternative. At the facility plan flows, these facilities are required under either alternative. However, they vary in size being larger for the one-plant.

A direct cost comparison between the briefing paper and facility plan costs is not possible for several reasons. There is a difference in design flows, costing methods, equipment (the facility plan's recommended CSO facilities), and planning periods.

The difference in flows between the facility plan is 22 MGD for average flow and 69 MGD for peak flow. This difference affects the costs for the two-plant alternative more than the one-plant alternative.

The method used in the facility plan for O&M costs also caused differences in the capital costs between the briefing paper and the facility plan. As discussed in Section 2, the facility plan shifted some rehabilitation costs from capital to O&M. The following processes were affected by this shift:

- HVAC renovation
- Preaeration
- Primary Settling
- Aeration
- Centrifuge Dewatering
- Incineration
- Digestion

TABLE 3-1. PRESENT WORTH OF BRIEFING PAPER CAPITAL AND O&M COSTS

	Capital	O&M	Total
One-Plant [Southerly]	268,711,000	168,200,000	436,911,000
Two-Plant [So. and JP]	**207,076,000**	189,940,000	**397,016,000**
Difference From One-Plant	**-61,635,000**	+21,740,000	**-39,895,000**
Percent Difference	**-30**	+13	**-10**

NOTE: These costs are based on a 2008 average flow of 154 MGD and a peak flow of 231 MGD. Present worth costs are in 1988 dollars.

TABLE 3-2. PRESENT WORTH OF FACILITY PLAN CAPITAL AND O&M COSTS

	Capital	O&M	Total
One-Plant [Southerly]	403,837,000	176,166,000	580,003,000
Two-Plant [So. and JP]	436,361,000	232,519,000	668,880,000
Difference From One-Plant	+32,524,000	+56,353,000	+88,877,000
Percent Difference	+8	+32	+15

NOTE: These costs are based on a 2015 average flow of 176 MGD and a peak flow of 300 MGD. Costs are included for an additional 130 MGD of CSO facilities. Present worth costs are in 1985 dollars.

A portion of the costs were for routine maintenance costs such as painting and roof repairs. These costs are covered under annual maintenance expenditures. However, some of the costs were for major equipment renovation. For example, the $6 million renovation of the existing digesters, which have not operated since 1980, was placed under the O&M costs as "Other Capital Costs". It was felt that these costs should remain in the capital costs. The city has indicated that the digesters are currently undergoing renovation. Therefore, the briefing paper capital costs include these costs. The cost of renovating the HVAC and plumbing systems was placed under O&M costs in the facility plan because the systems will be replaced as they become inoperable. The briefing paper included this cost as capital expenditures in the future brought back to a present worth amount.

An additional factor in the cost difference between the briefing paper and the facility plan costs is the recommended CSO facilities. Triad has not included costs for facilities to control CSO as the city has. Triad recommends that a CSO study be completed prior to any recommmendations on CSO facilities. The following facilities are included in the facility plan costs for CSO:

- Storm bypass
- Stormwater tanks at Southerly
- Whittier storm tanks
- OSIS Relief Sewer from Whitter Street to the flow diversion chamber.

The costs for the CSO facilities are common to both a one and two-plant alternative. Therefore, they do not have a significant impact on the comparison between the costs of one-plant vs. two-plants.

Effluent filters are no longer needed at either plant due to changes in the permit limits. Therefore, they were not included in the briefing paper costs.

The final factor which causes a difference between the briefing paper and facility plan costs is the planning period. The faciltiy plan has a 30-year planning period beginning in 1985 and ending in 2015. The briefing paper planning period extends 20 years, from 1988 to 2008. This affects the flow projections, which in turn affect the capital costs. But more importantly, it affects O&M costs. The facility plan has 30 years of annual O&M costs. These costs are presented in 1985 dollars. The briefing paper only has 20 years of O&M costs presented in 1988 dollars.

APPENDIX E

BRIEFING PAPER NO. 5
COMBINED SEWER OVERFLOWS

BRIEFING PAPER NO. 5

COMBINED SEWER OVERFLOWS

Supplemental Environmental Impact Statement
USEPA Contract No. 68–04–5035, D.O. No. 40
Columbus Ohio Wastewater Treatment Facilities

Prepared By:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TRIAD ENGINEERING INCORPORATED

COMBINED SEWER OVERFLOW

1. TERMS AND CONDITIONS

2. AVAILABLE DATA

3. CSO ANALYSIS
   3.1 Traditional Approach
   3.2 RFPU Approach: Review and Critique
   3.3 Briefing Paper Analysis

INTRODUCTION

Under the direction of USEPA, a series of briefing papers are being prepared addressing key issues in the development of the Supplemental Environmental Impact Statement for the Columbus, Ohio, Wastewater Treatment Facilities. The briefing papers form the basis of discussions between Triad Engineering and USEPA to resolve important issues. The following paragraphs present the background of the facility planning process, a description of the briefing papers, and the purpose of this paper on Combined Sewer Overflow (CSO).

FACILITY PLANNING PROCESS

At the time this paper was prepared (June-August 1987) the city of Columbus was proceeding to implement improvements at the Jackson Pike and Southerly Wastewater Treatment Plants to comply with more stringent effluent standards which must be met by July 1, 1988. These improvements were based on the consolidation of wastewater treatment operations at the Southerly plant. This one-plant alternative is a change from the two-plant operation proposed by the city in the 1970's and evaluated in the 1979 EIS.

The development and documentation of wastewater treatment process and sludge management alternatives for the Columbus metropolitan area has been an extended and iterative process. The design and construction of various system components have progressed, because of the 1988 deadline, while planning issues continue to be resolved. As a result, numerous documents have been prepared which occasionally revise a previously established course of direction.

The concurrent resolution of planning issues and implementation of various project components has made preparation of the EIS more difficult because final facility plan recommendations are not available in a single document.

BRIEFING PAPERS

To facilitate preparation of the EIS, a series of briefing papers are being developed. The purpose of the briefing papers is to allow USEPA to review the work of the EIS consultant and to identify supplemental information necessary for the preparation of the EIS. Six briefing papers are being prepared as follows:

- Flows and Loads
- Sludge Management
- Process Selection
- O&M and Capital Costs
- CSO (Combined Sewer Overflows)
- One Plant vs. Two Plant (Alternative Analysis)

The specific focus of each briefing paper will be different. However, the general scope of the papers will adhere to the following format:

- Existing conditions will be documented.
- Evaluations, conclusions, and recommendations of the facilities planning process will be reviewed using available documentation.
- Where appropriate, an independent evaluation of the future situation and viable alternatives will be prepared.
- The facility plan and EIS briefing paper conclusions will be compared.

The briefing paper process is intended to:

- Prompt the resolution of any data deficiencies.
- Clearly establish and define existing and future conditions.
- Identify the final recommended plan which the city desires to implement.
- Provide a data base of sufficient detail to allow preparation of the draft EIS.

COMBINED SEWER OVERFLOWS

This briefing paper presents an independent evaluation of the status of the Combined Sewer Overflow (CSO) problem in the city of Columbus. The Supplemental Environmental Impact Statement being prepared will address only Phases 1 and 2 of the city's facility planning process. The city has advised USEPA that these two phases do not contain provisions for CSO. Normal facility planning processes incorporate CSO into the plan prior to developing design flows for wastewater treatment facilities. However, the city of Columbus intends to conduct a detailed CSO analysis after a majority of the wastewater treatment facilities are in place.

The purpose of this briefing paper is to describe the traditional approach to the problem of CSO analysis and in this light, review and critique the approach used in the 1985 Revised Facility Plan Update (RFPU). While the lack of data does not allow a comprehensive analysis of the CSO problem, some general calculations are provided in comparison to those in the RFPU.

1. TERMS AND DEFINITIONS

The following terms and definitions are contained in Appendix A of the current USEPA Region V NPDES Permit Strategy for Combined Sewer Systems. This list is reprinted in its entirety and thus, not all of the terms are referred to in this briefing paper. These terms are used throughout the discussions in this briefing paper.

Best Management Practices (BMPS): - means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of "waters of the United States." BMPS also includes treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. (40 CFR 122.2).

Bypass: - the intentional diversion of waste streams from any portion of a treatment facility. (40 CFR 122.41(m)(4)). "Treatment Facility" means "Treatment Works" as defined below.

Combined Sewer: - a sewer that is designed as a sanitary sewer and a storm sewer. (40 CFR 35.2005(b)(11)). (This is distinguished from a sanitary sewer to which inflow sources prohibited by the sewer use ordinance have been connected).

Complete Waste Treatment System: - a complete waste treatment system consists of all the treatment works necessary to meet the requirements of title III of the Act, involving: (i) the transport of wastewater from individual homes or buildings to a plant or facility where treatment of the wastewater is accomplished; (ii) the treatment of the wastewater to remove pollutants; and (iii) the ultimate diposal, including recycling or reuse, of the treated wastewater and residues which result from the treatment process (40 CFR 35.2005(b)(12)). (the catch basins and overflow points are part of the complete waste treatment system in a combined sewer system. Also see No. 17, below.)

Dry Weather Flow: - flows that are not attributable to rainfall or snowmelt, and include infiltration.

Excessive Infiltration: - the quantity of infiltration which can be economically eliminated from a sewer system as determined in a cost-effectiveness analysis that compares the costs for correction of the infiltration conditions to the total costs for transportation and treatment of the infiltration. (40 CFR 35.2005(b)(16)).

Excessive Inflow: - the quantity of inflow which can be economically eliminated from a sewer system as determined by a cost effectiveness analysis that compares the costs for correcting the inflow conditions to the total costs for transportation and treatment of the inflow (normally determined in conjunction with the determination of excessive infiltration). (40 CFR 35.2005(b)(16)).

Infiltration: - water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinguished from, inflow. (40 CFR 35.2005(b)(20)).

Inflow: - water other than wastewater that enters a sewer system (including sewer service connections) from sources such as, but not limited to, roof leaders, cellar drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, storm waters, surface runoff, street wash waters, or drainage. Inflow does not include, and is distinguished from, infiltration (40 CFR 35.2005(b)(21)).

Nonexcessive Infiltration: - The quantity of flow which is less than 120 gallons per capita per day (domestic base flow and infiltration) or the quantity of infiltration which cannot be economically and effectively eliminated from a sewer system as determined in a cost effectiveness analysis. (40 CFR 35.2005(b)(28)).

Nonexcessive Inflow: - The maximum total flow rate during storm events which does not result in chronic operational problems related to hydraulic overloading of the treatment works or which does not result in a total flow of more than 275 gallons per capita per day (domestic base flow plus infiltration plus inflow). Chronic operational problems may include surcharging, backups, bypasses, and overflows. (40 CFR 35.2005(b)(29)).

Operational Plan: - The objective of the operational plan is to reduce the total loading of pollutants entering the receiving stream from the complete waste treatment system. This plan, tailored to the local government's complete waste treatment system, will include mechanisms and specific procedures to ensure:

a. the collection and treatment systems are operated to maximize treatment;
b. all dry weather flows are treated to the level specified in their permit;
c. storm water entry into the sewerage system is regulated;
d. the sewerage system hydraulic and storage capacity is identified and fully utilized during wet weather with eventual treatment of stored flows;
e. the greatest quantity of wet weather flows receive maximum possible treatment;
f. the sewerage system is adequately maintained to ensure optimum operational capability.

Overflow: - the uncontrolled diversion of waste streams from a combined sewer system which occurs during wet weather when flows exceed conveyance capacity.

Sanitary Sewer: - a conduit intended to carry liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions together with minor quantities of ground, storm, and surface waters that are not admitted intentionally. (40 CFR 35.2005(b)(37)).

Sewer Use Ordinance: - that ordinance or other legally binding document enacted to prohibit any new connections from inflow sources into the sewer system and require that new sanitary sewers and connections thereto are properly designed and constructed. Such ordinance shall further require that all wastewater introduced into the sewer system does not contain toxics or other pollutants in amount or concentration that endanger public safety and physical integrity of the sewer system, pump stations, or wastewater treatment facilities, cause violation of effluent limitations or water quality standards, or preclude the selection of the most cost-effective alternate for wastewater treatment and sludge disposal. (40 CFR 35.2130).

Storm Sewer: - A sewer designed to carry only storm waters, surface run-off, street wash waters, and drainage. (40 CFR 35.2005(b)(47)).

Treatment Works: - Any devices and systems for the storage, treatment, recycling, and reclamation of municipal sewage, domestic sewage, or liquid industrial wastes used to implement section 201 of the Act, or necessary to recycle or reuse water at the most economical cost over the design life of the works. These include intercepting sewers, outfall sewers, sewage collection systems, individual systems, pumping, power, and other equipment and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment and clear water facilities; and any works, including acquisition of the land that will be an integral part of the treatment process or is used for ultimate disposal of residues resulting from such treatment (including land for composting sludge, temporary storage of such compost, and land used for the storage of treated wastewater in land treatment systems before land application); or any other methods or system for preventing, abating, reducing, storing, treating, separating, or disposing of municipal waste or industrial waste, including waste in combined storm water and sanitary sewer systems. (40 CFR 35.2005(b)(48)).

2. AVAILABLE DATA

The operating records for both the Jackson Pike and Southerly Wastewater Treatment Plants include information regarding the major overflows for each sewerage system, specifically, the Whittier Street Storm Tanks for the Jackson Pike sewerage system and the bypass at the plant for the Southerly sewage system. Additional reports which were reviewed for this analysis include the following:

- Revised Facilities Plan Update (RFPU) prepared by URS Dalton September 30, 1985.
- General Engineering Report and Basis of Design (GERBOD) prepared by URS Dalton January 31, 1986.
- Combined Sewer Overflow Monitoring Report prepared by Malcolm Pirnie, Inc. January 2, 1979.
- CSO Progress Report prepared by Malcolm Pirnie, Inc. July 28, 1983.
- Central Scioto River Mainstem Comprehensive Water Quality Report prepared by Ohio EPA September 30, 1986.
- Use of Combined Sewer Overflow Analysis in the September 30, 1985, Revised Facilities Plan Update prepared by the city of Columbus March 23, 1987.

While the RFPU contains one page of conclusions reached in the CSO analysis, there is no information provided describing the analysis itself. The GERBOD provides greater detail on the analysis performed, which references data provided in the CSO Montioring Report and the CSO Progress Report. The final report cited was issued in response to questions by USEPA - Region V in regard to the CSO analysis referenced in the RFPU.

3. CSO ANALYSIS

3.1 TRADITIONAL APPROACH

The traditional approach to a combined sewer system analysis used in this briefing paper is outlined in a recent USEPA - Region V document entitled "Technical Guidance for Use in the Development of a Combined Sewer System Operational Plan" published in September 1986. The recommended tasks in the development of a stormwater management program are:

- Establishment of objectives
- Development of a data base
- Understanding the operation and response of the combined sewer system
- Identification of drainage areas
- Hydraulic analysis
- Review of meteorological data
- Monitoring of flows and collection of samples
- Selection of mathematical models
- Discussion of CSO control alternatives

The following paragraphs discuss these aspects in greater detail.

The establishment of objectives is a project specific task which leads directly into the development of a data base.

The development of a data base allows a municipality to become knowledgeable about its combined sewer system, including operation, maintenance, and response to different meteorological conditions. Data is obtained through detailed interviews with sewer, public works, and engineering personnel. The data required for such a data base includes, but is not limited to: geographical, geological, topographical, and hydrologic data; known physical condition of the sewer system, manholes, and all appurtenances; age, length, materials, sizes, slopes, and depths of sewers; maintenance practices; problems and system failures; treatment plant flow records and charts; pumping station flow records, location of overflows and associated operating experience and records; identification of sewer system problem areas; available combined sewer system maps; groundwater levels for all seasons, with correlation to rainfall; quality of local receiving waters and required effluent or water quality standards; and existing ordinances governing inflow connections to sewers and enforcement programs and policies, as well as estimates of the extent and significance of such inflow connections.

Detailed maps of the municipalities sewerage system should be up to date and the combined, sanitary and storm sewer systems should be clearly defined. The maps should show sewer sizes, slopes, direction of flow, manhole locations, and other major sewer system elements such as regulating or control structures and overflows. This information will allow a general understanding of the operation and response of the sewerage system. These maps and data will also allow the identification of drainage areas within the sewerage system and thus establish key hydraulic locations where flows can be monitored and gaged.

The hydraulic analysis proceeds from the collection of data in regard to the sewerage system itself. This analyis allows the determination of the hydraulic capacities of the sewers. The portion of the sewer system capacity available for carrying stormwater runoff is a function of the total hydraulic capacity of the sewerage system as determined by: the pipe size, slope and material of construction, the quantitiy of flows; and the level to which a particular sewer can surcharge without causing an overflow, basement flooding, or other damage. The most important parameter which may be determined in the hydraulic analysis is that of the time of concentration, which is used in the computation of the peak stormwater runoff rate. Since most rainfall events are of short duration, the peak rate of runoff is of primary importance, with the total volume secondary.

The monitoring of flows and collection of samples should proceed only after the hydraulic analysis and data collection efforts previously described have been completed. At key locations in the sewerage system and at the major overflow points, as previously determined, flows should be monitored along with collection of rainfall data. Further, it is desirable that samples be collected at the overflows at short time intervals during an overflow in order to associate pollutant concentrations with the overflow. The rain gauges should be located throughout the sewer system service area in order to characterize the rainfall in terms of duration, intensity, and volume. Thus, in the knowledge provided by the data base and hydraulic analysis that all flows are accounted for, the volume of overflow and mass loading of pollutants discharged to the receiving waters may be computed. Then the intensity duration relationships of the observed rainfalls may be compared to historical records to relate the observed overflows to a recurrence interval. Thus, statistical relationships may be developed which will relate rainfall to overflow volumes and quality.

The CSO analysis may then be taken a step further in complexity with the use of a mathematical model. Mathematical stormwater models are capable of predicting the volume of stormwater discharge and its constituent pollutants. These models typically consist of two elements - a runoff element that simulates the washoff of pollutants by rainfall on the watershed, and a transport element that simulates the movement of those pollutants in the sewer system and their eventual discharge from it. Data from flow monitoring and sampling efforts may be used to calibrate such a model after which the model is an invaluable tool in evaluating the effectiveness of various control alternatives and to identify optimum solutions.

3.2 FACILITIES PLAN APPROACH: REVIEW AND CRITIQUE

Very little of the data necessary for a traditional CSO analysis was presented in the RFPU. Existing monitoring data was utilized from two support documents: The Combined Sewer Overflow Report of January 1979, and the CSO Progress Report of 1983.

While the quality of the monitoring data used is unknown, its value is of some question due to the poorly developed data base regarding the sewerage system. No maps of the sewerage system were presented or developed, thus, the drainage areas for each overflow or each system (combined, sanitary, or storm) were not clearly defined. While the CSO Progress Report (1983) did include a discussion of computer modeling of the sewerage system with reference to the Whittier Street Storm Tanks using the SWMM model, the input data was not presented and the results were not discussed or presented. The Combined Sewer Overflow Report (1979) includes a one year record of overflow monitoring data for nineteen overflow sites, but the completeness of this record is subject to some question. Further, due to the lack of data in regard to how the sewerage system responds to wet weather conditions, whether or not all major overflows are accounted for with the monitoring data is unknown. The fact that both support documents and the RFPU overlooked the Renick Run overflow supports this contention.

The discussion of the Combined Sewer Overflow analysis in the RFPU makes four points:

1. The CSO analysis consisted of ten rainfall (overflow) events from 1979 and 1982.

2. The statistical analysis performed on these ten events showed that the 80th percentile storm could be controlled at a cost of $42 million.

3. The environmental impacts of the existing combined sewer overflows were shown to be insignificant according to documentation in the Draft OEPA Central Scioto River Water Quality Report and the city river sampling results as reported in the monthly operating reports (MORs).

4. The city would meet its NPDES permit requirements regarding the sewer system overflows and would continue to closely observe the Scioto River, the Olentangy River, and Alum Creek in order to mitigate any adverse environmental impacts due to overflows.

There is no other detail provided on the CSO analysis in the RFPU other than to make these four points. It was not until four months later that the analytical methodology for the CSO analysis was presented in the GERBOD (January 31, 1986) and later in the report titled "Use of Combined Sewer

Overflow Analysis" in the September 30, 1985, Revised Facilities Plan Update (RFPU) which was submitted to USEPA - Region V March 23, 1987, by the city.

While it was stated in the RFPU that the environmental impacts of the existing combined sewer overflows were shown to be insignificant according to documentation in the draft OEPA Central Scioto River Water Quality Report (CWQR), a review of this report did not substantiate this statement. In fact, information in the CWQR suggests that the environmental impacts of the existing CSOs are significant. On page 195 the CWQR states that "combined sewer overflows, and as previously discussed, plant bypasses also contributed significant loadings of BOD_5, NH_3-N, TSS, and other substances to the Central Scioto River Mainstem". Further, page 317 states, "Reductions in the magnitude and frequency of combined sewer overflow discharges is needed to improve aquatic community function, alleviate aesthetic problems, and reduce risks to human body contact recreation in the segment between Greenlawn Dam and the Jackson Pike WWTP".

The combined sewer overflow analysis presented in the RFPU considered only Whittier Street overflows and neglected all others including the bypass flows at Southerly. The city analyzed ten events which were selected from a larger data set of twenty-six events. The ten events selected were those that had both quality and quantity data. Data for the events not selected was not presented. Thus, due to the manner in which the ten events were selected, whether or not they can be considered representative of flows at the Whittier Street facility is questionable, and whether or not they can be considered to be representative of combined sewer overflows from the entire sewerage system is more questionable.

The statistical analysis performed for the RFPU consisted of plotting the ten events on probability paper using a simple Weibull plotting position calculation. Using this method, m is the rank of the event [highest (1) to lowest (10)] and n is the number of events (10). The plotting position thus calculated refers to the probability or return period that is associated with each of the observed events. The use of this method is illustrated in Table

1, where the calculated plotting positions and associated return period for each of the ten events analyzed are shown. Thus, for event number 1 of 10/8/77, a plotting position of 0.364 is calculated. This number refers to the fact that 36.4 percent of the observed overflow volumes are less than that of event number 1, while 63.6 percent of the observed overflow volumes are greater that that of event number 1. Thus, if the data set is established and representative, projections may be made on the overflow volumes. This method further defines the recurrence interval (in years) as the inverse of the calculated plotting position. Thus, the recurrence interval for event number 1 with a volume of 44.1 would be 1/0.364 or 2.75 years. Thus an overflow of this magnitude could be expected to occur every 2.75 years. Note, however, that the data base from which this projection is made consists of ten hand picked events from a period of time of about one year. While the objective of this method is to make such projections with a limited amount of data, the questions still remain as to how representative these ten events are and what about the other overflows in the system? The calculated probabilities of the ten events may have easily been checked using the rainfall data for each event and associating a recurrence interval with the rainfall intensity which induced the overflows based on a histrocial record of rainfall for the area. However, this check was not performed.

Thus, the 80th percentile overflow was shown to be 50 million gallons. In addition, the 80th percentile overflow at Renick Run was estimated at 12 MG by taking a simple proportion of the 80th percentile flow to the hydraulic capacity of the pipes converging at each overflow. Thus, a total volume of 62 million gallons was recommended in the RFPU for storage or treatment and the cost associated with control at this level was estimated at $42 million.

3.3 BRIEFING PAPER ANALYSIS

Lack of flow data does not allow an independent comprehensive analysis of the CSO problem. Therefore, the following analysis is presented only to provide data for comparison with the figures in the RFPU. The combined sewer overflow volumes may be estimated using a procedure outlined in

TABLE 1

Event Date	Total CSO Volume (MG)	Rank (m) Highest to lowest	Plotting Position (P) m/(n+1) n=10	Recurrence Interval (yr) (1/P)
1. 10/8/77	44.1	4	0.364	2.75
2. 10/26/77	3.1	10	0.909	1.10
3. 8/6/78	26.1	5	0.455	2.20
4. 8/19/78	10.4	8	0.727	1.38
5. 8/29/78	6.1	9	0.818	1.22
6. 8/30/78	73.3	1	0.091	10.99
7. 9/16/78	16.2	6	0.545	1.83
8. 8/4/82	44.9	3	0.273	3.66
9. 8/25/82	51.9	2	0.182	5.49
10. 9/14/82	12.8	7	0.636	1.57

reference 1. This method first estimates the percent imperviousness of the area by the following equation:

$$\text{Percent Imperviousness} = I = 9.6\ PD^{(0.573 - 0.0391 \log PD)}$$

Where PD = Population Density (Persons Per Acre)

The population density for the combined sewer area for the city of Columbus was cited as 15.78 persons per acre in reference 2. While the combined sewer service area is known to have decreased from 18.4 mi^2 to the present estimate of 11.1 mi^2 (as per city officials), the population density for this area may be assumed to have remained about the same. Therefore, 16 persons per acre will be assumed, thus:

$$I = 9.6\ (16)^{(0.573 - 0.0391 \log 16)}$$
$$= 41.3\%$$

Next the runoff coefficient (CR) weighted between pervious and impervious areas is estimated as follows:

$$CR = 0.15 + 0.75\ (I/100)$$
$$= 0.15 + 0.75\ (41.3/100) = 0.460$$

The area weighted depression storage (DS) is then estimated assuming 0.0625 inches for impervious areas and 0.25 inch for pervious areas.

$$DS = 0.25 - 0.1875\ (I/100)$$
$$= 0.25 - 0.1875\ (41.3/100) = 0.327 \text{ in.}$$

Finally, the annual runoff (AR) is estimated for the CSO area in terms of inches per year over the given area.

$$AR = (CR)\ P - 5.234\ (DS)^{0.5957}$$

Where P = Annual precipitation, in/yr = 37.01 in/yr

$$AR = (0.46)(37.01 \text{ in.}) - (5.234)(0.327 \text{ in.}^{0.5951})$$
$$= 14.33 \text{ inches per year}$$

Since the existing combined sewer service area is known to be 11.1 mi^2, the estimated annual volume of runoff from this area may be calculated as follows:

$$11.1 \text{ mi}^2 \times 14.33 \text{ in.} \times \frac{1 \text{ ft.}}{12 \text{ in.}} \times \frac{5280^2 \text{ ft.}^2}{1 \text{ mi}^2} \times \frac{7.481 \text{ Gal}}{1 \text{ ft.}^3} = 2{,}760 \times 10^6 \text{ gallons per year}$$

A summary of the 1985 and 1986 precipitation record for the city of Columbus is provided in Table 2. This table shows the number of days in which precipitation was recorded for each year broken down by depth. In order to relate the previously calculated annual volume of runoff from the combined sewer area to a rainfall day basis, an average value for 1985 and 1986 of 58 significant days of rainfall may be assumed. A "significant" rainfall may be defined as all days when greater than 0.15 inches of rainfall were recorded. This number is reasonable since the depression storage for the combined sewer area was previously calculated at 0.327 inches. Thus on a per-significant-rainfall-day basis, a daily volume of runoff from the combined sewer area may be calculated as follows:

$$2{,}760 \times 10^6 \frac{\text{Gallons}}{\text{Year}} \div \frac{58 \text{ Significant Rainfall Days}}{\text{Year}}$$

$$= 48 \times 10^6 \frac{\text{Gallons}}{\text{Signficant Rainfall Day}}$$

In addition to this flow, however, is inflow from the separate sewer area which must be estimated. Since the extent of the inflow problem in the separate sewer area is unknown, it will be assumed to be at the point of being nonexcessive (refer to Section 1: Terms and Definitions). The construction grants program defines a nonexcessive inflow value of 275 gallons per capita per day (gpcd) as the maximum allowable total daily flow during a storm. Thus, knowing that the average dry weather flow is 167 gpcd (ref. Briefing Paper No. 1), a maximum allowable inflow volume of 108 gpcd can be assumed for this area. The population for the separate sewer area may be estimated by subtracting the product of the assumed combined sewer population density (16 persons/acre) by the combined sewer area (11.1 mi^2 = 7104 acres) from the total service area population (870,000 persons). Thus the population served

TABLE 2. PRECIPITATION

		1985		1986	
	(Inches)	Days	Total Depth (In.)	Days	Total Depth (In.)
P	0.00 to 0.05	43	0.95	40	0.83
R	0.05 to 0.10	27	1.82	19	1.24
E	0.10 to 0.15	18	2.21	10	1.17
C	0.15 to 0.20	8	1.33	9	1.48
I	0.20 to 0.25	7	1.48	9	1.93
P	0.25 to 0.30	5	1.34	6	1.65
I	0.30 to 0.35	4	1.28	7	2.24
T	0.35 to 0.40	3	1.13	3	1.1
A	0.40 to 0.45	7	2.93	2	0.86
T	0.45 to 0.50	1	0.47	2	0.95
I	0.50 to 0.55	2	1.02	3	1.55
O	0.55 to 0.60	2	1.13	0	
N	0.60 to 0.65	0		1	0.63
	0.65 to 0.70	5	3.33	1	0.7
D	0.70 to 0.75	2	1.42	4	2.89
E	0.75 to 0.80	2	1.53	3	2.32
P	0.80 to 0.85	0		1	0.82
T	0.85 to 0.90	0		0	
H	0.90 to 0.95	4	3.69	3	2.75
	0.95 to 1.00	0		2	1.93
R	1.00 to 1.05	0		0	
A	1.05 to 1.10	1	1.07	0	
N	1.10 to 1.15	0		0	
G	1.15 to 1.20	0		0	
E	1.20 to 1.25	0		1	1.21
	1.25 to 1.30	0		1	1.29
	1.30 to 1.35	0		1	1.31
	1.35 to 1.40	0		0	
	1.40 to 1.45	1	1.41	1	
	1.45 to 1.50	0		0	
	1.50 to 1.55	0		0	
	1.55 to 1.60	0		0	
	1.60 to 1.65	0		0	
	1.65 to 1.70	0		1	1.69
	ALL	143	31.92	130	35.04

by the separate sewer area is about 756,336 persons. Therefore, the allowable inflow from the separate sewer area may be estimated as:

$$108 \text{ gpcd} \times 756{,}336 \text{ persons} = 82 \times 10^6 \ \frac{\text{Gallons}}{\text{Day}}$$

The 108 gpcd figure used above as the inflow from the separate sewer area may be put into perspective in the following manner. The daily volume calculated above may be expected to occur on "significant" rainfall days, as previously defined. The total "significant" rainfall average for 1985 and 1986 is shown to be 29.37 inches. Dividing this figure by the 58 significant rainfall days per year (used previously) results in an average of 0.51 inches of rainfall per significant rainfall day. This rainfall depth of 0.51 inches over the entire separate sewer area equates to a volume of 1,320 x 10^6 gallons. Thus, the calculated inflow from the separate sewer area using the 275 gpcd maximum allowable daily total flow accounts for about 6.2 percent of the total rainfall as inflow.

Therefore, the total combined sewer and inflow volume which must be dealt with for each signficant rainfall day is estimated as follows:

Combined sewer area runoff and inflow	47.7 MG
Separate sewer area inflow	81.7 MG
Total	129.4 MG

Several points should be made in regard to this figure. While the method used for the calculation of the annual runoff volume from the combined sewer area is a general one, it certainly is what would be considered a "first order approximation" using an EPA approved procedure. Secondly, since the extent of the inflow problem in the separate sewer area has not been investigated or defined, the estimate used must be assumed to be reasonable. It is important to note that this brief analysis shows that the inflow problem from the separate sewer service area on a volume basis could be greater than the runoff and inflow from the combined sewer area. Further, note that for the inflow from the separate sewer service area to be equal in volume to the runoff and inflow from the combined sewer service area that only 3.6 percent of the total significant rainfall would have to be accounted for as inflow. It must also be noted that this simple volumetric analysis only considers average conditions, i.e. 0.51 inches of rainfall per significant rainfall day. Note from the precipitation record of Table 2 that an average of 20 days each year were recorded with precipitation greater than this amount with a maximum daily total of 1.41 inches for 1985 and 1.69 inches for 1986. It must also be recognized that this analysis is only volumetric and does not account for the maximum rate of runoff or rain-induced inflow. This maximum rate would be of primary importance in the selection of control alternatives or design of facilities. This parameter, however, can only be determined through a detailed hydraulic analysis of the sewerage system.

REFERENCES

1. Heaney, J. P., et. al. Storm Water Management Model: Level 1 - Preliminary Screening Procedures. USEPA Report No. EPA-600/2-76-275. NTIS No. PB 259 916. October 1976.

2. Heaney, J. P., et. al. Nationwide Evaluation of Combined Sewer Overflows and Urban Stormwater Discharges, Volume II: Cost Assessment and Impacts. USEPA Report No. EPA-600/2-77-064. NTIS No. PB 266 005. March 1977.

APPENDIX F

BRIEFING PAPER NO. 6
ONE-PLANT VS. TWO-PLANT

BRIEFING PAPER NO. 6

ONE-PLANT VERSUS TWO-PLANTS

Supplemental Environmental Impact Statement
USEPA Contract No. 68-04-5035, D.O. No. 40
Columbus Ohio Wastewater Treatment Facilities

Prepared By:

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

TRIAD ENGINEERING INCORPORATED

ONE-PLANT VERSUS TWO-PLANTS

1. EXISTING FACILITIES
   - 1.1 Jackson Pike Wastewater Treatment Plant
     - 1.1.1 Major Interceptors
     - 1.1.2 Preliminary Treatment (O.S.I.S. Flow)
     - 1.1.3 Major Treatment Processes
   - 1.2 Southerly Wastewater Treatment Plant
     - 1.2.1 Major Interceptors
     - 1.2.2 Interconnector Pump Station
     - 1.2.3 Major Treatment Processes

2. IDENTIFICATION OF SYSTEM ALTERNATIVES
   - 2.1 No Action Alternative
   - 2.2 Upgrade the Existing Facilities
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3. DEVELOPMENT AND EVALUATION OF SYSTEM ALTERNATIVE COMPONENTS
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     - 3.1.1 One-Plant System Alternative
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   - 3.2 Wet Stream Treatment
     - 3.2.1 One-Plant System Alternative
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       - 3.2.1.2 Secondary Treatment
       - 3.2.1.3 Post Treatment
     - 3.2.2 Two-Plant System Alternative
       - 3.2.2.1 Primary Treatment
       - 3.2.2.2 Secondary Treatment
       - 3.2.2.3 Post Treatment
   - 3.3 Solids Handling and Disposal
     - 3.3.1 One-Plant System Alternative
     - 3.3.2 Two-Plant System Alternative

4. EVALUATION OF SYSTEM ALTERNATIVES

INTRODUCTION

Under the direction of USEPA, a series of briefing papers are being prepared addressing key issues in the development of the Supplemental Environmental Impact Statement for the Columbus, Ohio, Wastewater Treatment Facilities. The briefing papers form the basis of discussions between USEPA and their consultant to resolve important issues. The following paragraphs present the background of the facility planning process, a description of the briefing papers, and the purpose of this paper on one-plant versus two-plants.

FACILITY PLANNING PROCESS

At the time this paper was prepared (July-August 1987) the city of Columbus was proceeding to implement improvements at the Jackson Pike and Southerly Wastewater Treatment Plants to comply with more stringent effluent standards which must be met by July 1, 1988. These improvements were based on the consolidation of wastewater treatment operations at the Southerly plant. This one-plant alternative is a change from the two-plant operation proposed by the city in the 1970's and evaluated in the 1979 EIS.

The development and documentation of wastewater treatment process and sludge management alternatives for the Columbus metropolitan area has been an extended and iterative process. The design and construction of various system components have progressed, because of the 1988 deadline, while planning issues continue to be resolved. As a result, numerous documents have been prepared which occasionally revise a previously established course of direction.

The concurrent resolution of planning issues and implementation of various project components has made preparation of the EIS more difficult because final facility plan recommendations are not available in a single document.

BRIEFING PAPERS

To facilitate preparation of the EIS, a series of briefing papers are being developed. The purpose of the briefing papers is to allow USEPA to review the work of the EIS consultant and to identify supplemental information necessary for the preparation of the EIS. Six briefing papers are being prepared as follows:

- Flows and Loads
- Sludge Management
- CSO
- Process Selection
- One Plant vs. Two Plant (Alternative Analysis)
- O&M and Capital Costs

The specific focus of each briefing paper will be different. However, the general scope of the papers will adhere to the following format:

- Existing conditions will be documented.
- Evaluations, conclusions, and recommendations of the facilities planning process will be reviewed using available documentation.
- Where appropriate, an independent evaluation of the future situation and viable alternatives will be prepared.
- The facility plan and EIS briefing paper conclusions will be compared.

The briefing paper process is intended to:

- Prompt the resolution of any data deficiencies.
- Clearly establish and define existing and future conditions.
- Identify the final recommended plan which the city desires to implement.
- Provide a data base of sufficient detail to allow preparation of the draft EIS.

ONE-PLANT VS. TWO-PLANTS

This briefing paper evaluates the comprehensive wastewater management alternatives in light of previous biological process, solids handling, and cost analyses. The briefing paper is divided into four sections as follows:

Section 1 - Existing Facilities

This section discusses the facilities which existed at the Jackson Pike and Southerly WWTPs prior to implementing construction for Project 88.

Section 2 - System Alternatives

Section 2 provides a description of the one-plant and two-plant alternatives.

Section 3 - Development and Evaluation of System Alternative Components

Section 3 summarizes the facilities required for each process under the one-plant and two-plant alternatives. Costs are included for all facilities.

Section 4 - Evaluation of System Alternatives

This section provides a technical evaluation of the one-plant and two-plant alternatives based on present worth cost, reliability, flexibility, implementability, and operational ease.

1. EXISTING FACILITIES

This section describes the Jackson Pike and Southerly Wastewater Treatment Plants (WWTP). Figure 1-1 shows the locations of the two treatment plants and the Southwesterly Compost Facility within the planning area.

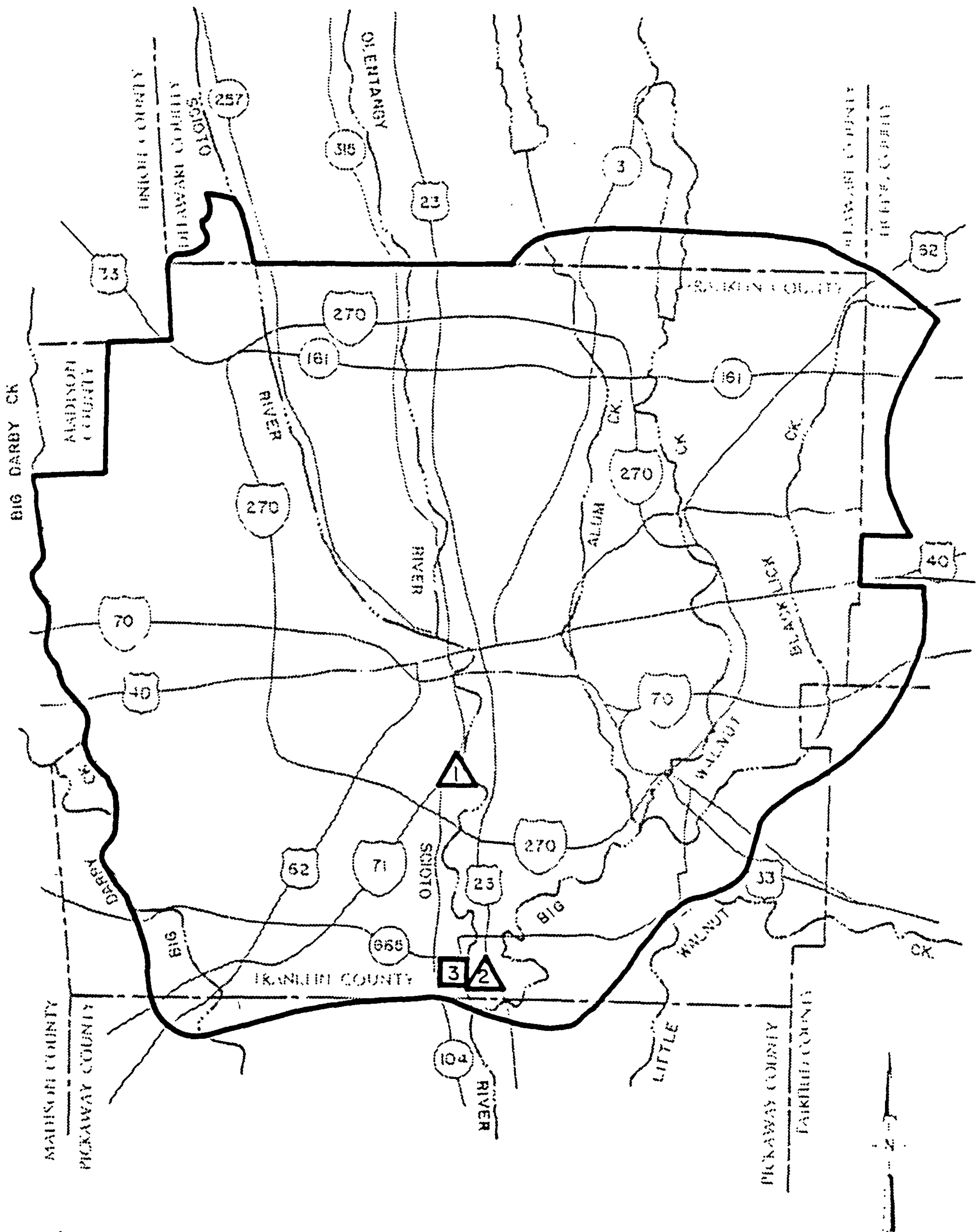
1.1 JACKSON PIKE WASTEWATER TREATMENT PLANT

The Jackson Pike WWTP began operation in 1937. The plant was modernized and expanded in capacity in the mid-fifties. Currently (prior to Project 88) there are two parallel flow trains for wet stream treatment consisting of preaeration, primary settling, aeration, and final clarification. The original train is called Plant A and the newer train is called Plant B. The two trains operate relatively independently of each other during liquid processing but share sludge handling facilities.

1.1.1 Major Interceptors

Wastewater arrives at the Jackson Pike plant via the 108-inch diameter Olentangy-Scioto Interceptor Sewer (O.S.I.S.) and the 72-inch Big Run Interceptor Sewer. The maximum hydraulic capability of the plant is 100 MGD. Current average day flows are approximately 84 MGD. The plant accepts all the flow from the Big Run Interceptor but limits its acceptance of the O.S.I.S. flow so the hydraulic capability of the plant will not be exceeded. The major diversion point for the O.S.I.S. flows is at the Whittier Street Storm Standby Tanks.

Seven miles of 150-inch and 156-inch diameter gravity sewer currently exists between the Jackson Pike and Southerly treatment plants. It begins 3,000 feet from the Jackson Pike WWTP and connects with a pump station on the west side of the Scioto River near the Southerly WWTP. In September of 1986, USEPA provided funding for construction of the remaining 3000 feet of the sewer (Figure 1-2). This will complete the Interconnector Sewer between the two plants. Included in the north end construction will be a diversion chamber which will connect the Interconnector Sewer with the O.S.I.S. north of



JACKSON PIKE WWTP (1)

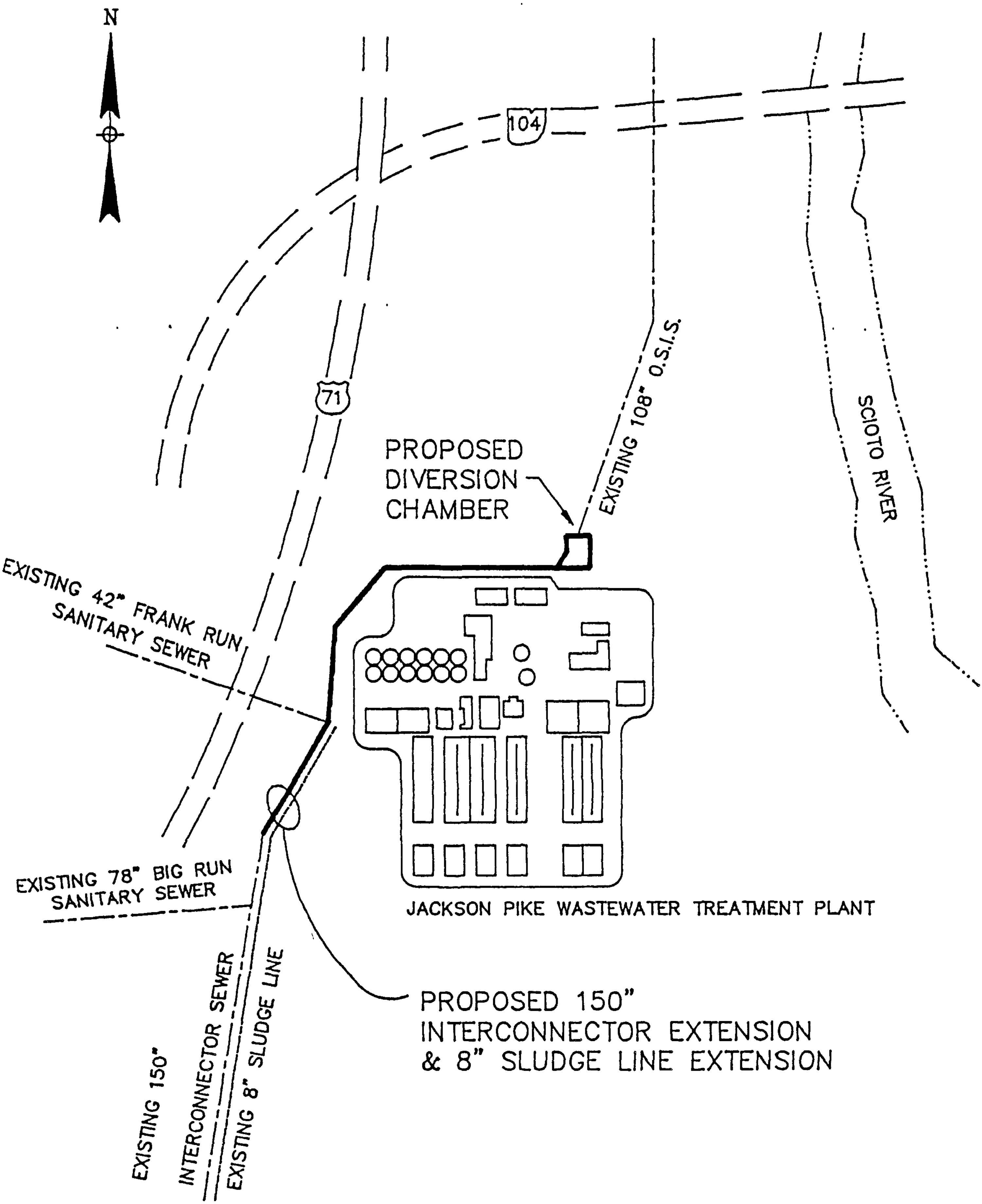
SOUTHERLY WWTP (2)

SOUTHWESTERLY COMPOST FACILITY (3)

PLANNING AREA BOUNDARY

APPROXIMATE SCALE: 1 INCH = 4.12 MILES

FIGURE 1–1
PLANNING AREA



SOURCE: REVISED FACILITY PLAN UPDATE

FIGURE 1–2
NORTH END INTERCONNECTOR

Jackson Pike. These improvements will allow the flow to Jackson Pike to be controlled by diverting excess flows to Southerly.

1.1.2 Preliminary Treatment (O.S.I.S. Flow)

Preliminary treatment is provided for flows entering Jackson Pike through the O.S.I.S. at a facility called the Sewer Maintenance Yard which is located approximately one mile north of Jackson Pike. These preliminary treatment facilities were constructed in 1948. They are rated at a capacity of 160 MGD and provide preliminary screening and grit removal for flows in the O.S.I.S. prior to their arrival at Jackson Pike.

1.1.3 Major Treatment Processes

The Jackson Pike WWTP consists of the following major treatment processes:

- Preliminary Treatment
- Primary Treatment
- Secondary Treatment
- Disinfection
- Solids Handling
- Solids Disposal

Figure 1-3 shows a flow schematic of the Jackson Pike WWTP. Table 1-1 presents the equipment sizes and the capacities for each unit process.

1.2 SOUTHERLY WASTEWATER TREATMENT PLANT

The Southerly WWTP began operation in 1967 with a single train. In the early seventies, an additional wet stream train was added. The original train is termed the Center Section. The newer train is called the West Section.

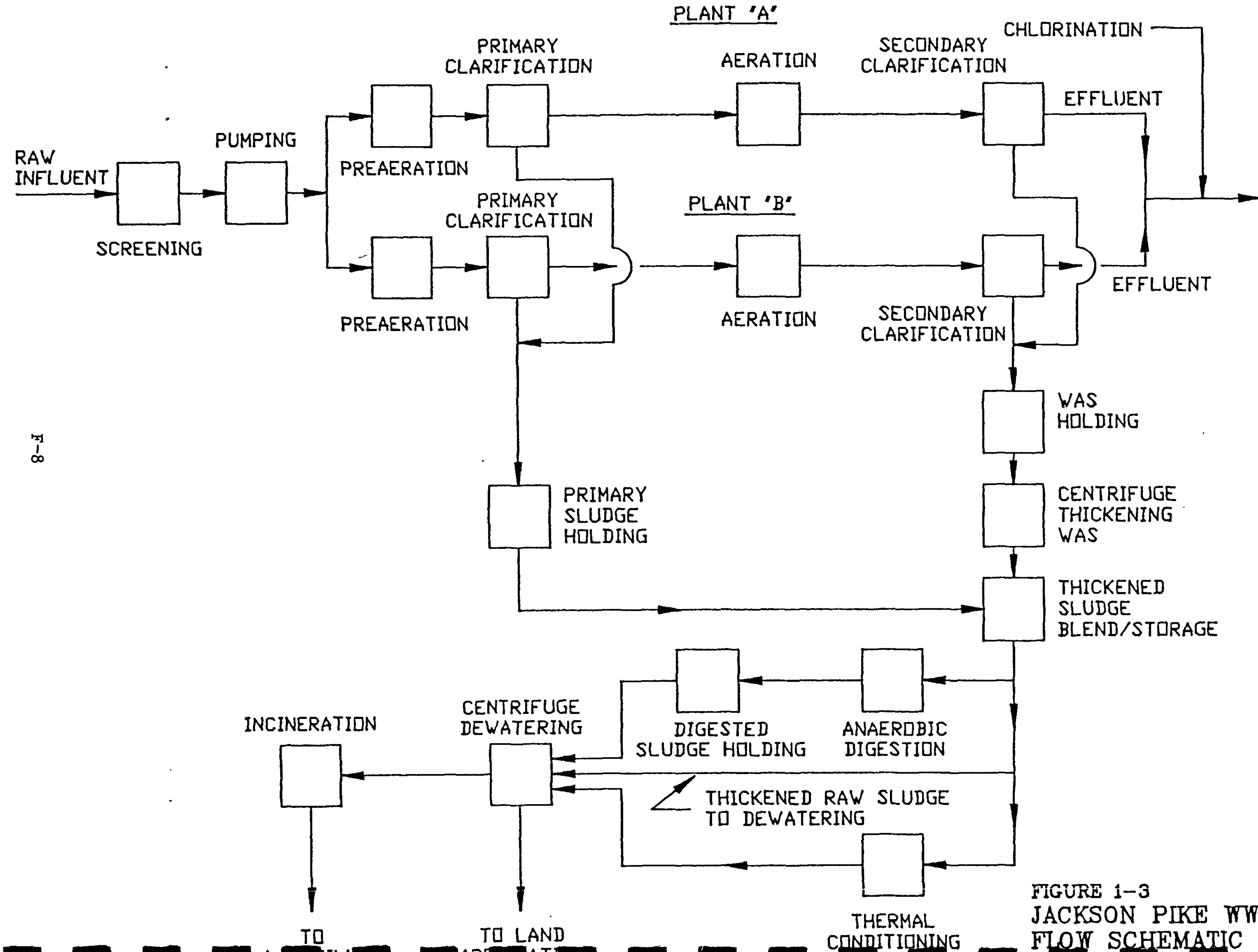


FIGURE 1-3
JACKSON PIKE WWTP
FLOW SCHEMATIC

TABLE 1-1. JACKSON PIKE EXISTING FACILITIES

Process	Facilities/Condition	
Screening	Two mechanically cleaned bar screens with 1.5-inch openings, west screen replaced in 1983	
Pumping	Two variable speed at 55 MGD (32 ft TDH) Two constant speed at 27.5 MGD (27.5 ft TDH) One constant speed at 60 MGD (30 ft TDH)	165 MGD
Preaeration	Plant A - 2 tanks at 180 ft x 26 ft x 15 ft SWD Plant B - 2 tanks at 113 ft x 26 ft x 15 ft SWD	1.05 MG total volume 0.66 MG total volume
Blowers for Preaeration and Aeration	4 at 21,000 cfm 2 at 15,000 cfm 2 at 3,000 cfm 3 at 12,500 cfm	
Primary Clarification	Plant A - 4 tanks at 150 ft x 80 ft x 10 ft SWD Plant B - 4 tanks at 150 ft x 80 ft x 10 ft SWD Twelve sludge pumps at 250 gpm each	48,000 SF total surface area 48,000 SF total surface area
Aeration	Plant A - 8 tanks at 900 ft x 26 ft x 15 ft SWD Plant B - 4 tanks at 900 ft x 26 ft x 15 ft SWD	21.0 MG total volume 10.5 MG total volume
Secondary Clarification	Plant A - 8 tanks at 153 ft x 60 ft x 12.5 ft SWD Plant B - 4 tanks at 153 ft x 60 ft x 12.5 ft SWD six return sludge pumps; one at 6,944 gpm, one at 5,555 gpm, one at 5,902 gpm, one at 3,889 gpm, and two at 3,472 gpm each	73,440 SF total surface area 36,720 SF total surface area
Chlorination	By direct injection into discharge pipeline	
Waste Activated Sludge Holding	One 78-foot x 14-foot x 8-foot deep basin (two) standby units	0.065 MG of storage

TABLE 1-1. JACKSON PIKE EXISTING FACILITIES (cont.)

Process	Facilities/Conditions	
Primary Sludge Holding	One 85-foot dia., 25.25-foot SWD	1 MG of storage
Centrifuge Thickening (WAS)	Two solid bowl centrifuges	550 gpm/unit, 400 HP/unit Feed Solids 1% Thickened WAS 4%
Anaerobic Digestion	Eight primary digesters: 70-foot dia., 27.5-foot SWD Six secondary digesters: 85-foot dia., 23.5-foot SWD	Volume: 1.6 x 10^6 CF Total 6.3 MG Primary 6.0 MG Secondary
Digested Sludge Holding	One 85-foot dia., 25.5-foot SWD	1.0 MG of storage
Thermal Conditioning	Two reactors installed 1972, Expanded 1978 to 4 reactors	200 gpm/unit
Centrifuge Dewatering	Six solid bowl centrifuges Installed 1976	100 gpm/unit, 100 HP/unit Feed solids 3% Dewatered cake 16-18%
Incineration	Two multiple-hearth incinerators 7-hearths, 22.25-foot diameter	170 wet tons/day Feed solids 16-18%
Ash Lagoon	Two lagoons	Total storage capacity 48,000 cy; Cleaned as needed
Landfill	City-owned landfill	Ash landfilled on an as-needed basis through contract operation
Land Application		
Sludge Transport and Application	Contract operation	Transport 130-150 tons/day Application 70-200 tons/day Approximate Unit Cost of $11/wet ton
Application Sites	Required acreage 2000 Ac/yr Available acreage 10000 Ac	Application 260 days/yr Seasonal peaks dependent on weather and cropping patterns

1.2.1 Major Interceptors

Southerly receives approximately 50 to 60 MGD via the Big Walnut Sanitary Outfall Sewer which serves the northeast, east, and southeast portions of Columbus and Franklin County. An additional 5 MGD of flow is carried to Southerly by the Interconnector Sewer which serves a portion of western Columbus. The Southerly WWTP only accepts the amount of flow that it can successfully treat and bypasses the remaining flow. Plant records show that bypassing occurs when treated flows are as low as 54 MGD. At other times treated flows can be as high as 90 MGD and no bypassing is reported. Excess flow can be diverted to the Scioto River through a 108-inch diameter bypass sewer at the plant's influent regulator chamber.

1.2.2 Interconnector Pump Station

The purpose of the Interconnector Pump Station is to pump flows from the Interconnector across the Scioto River to the Southerly WWTP. The Interconnector Pump Station is located on the south end of the Interconnector near Southerly (Figure 1-4). Flows from the 156-inch Interconnector Sewer enter a 58-foot wide by 25-foot long by 16-foot deep chamber to be distributed to three channels containing coarse bar racks and mechanically-cleaned bar screens. Each channel is 6 feet wide by 30 feet long by 33 feet high. Flows from the screening channels enter a 20-foot wide by 66-foot long by 23-foot high wet well and are pumped by two 20 MGD and two 30 MGD extended shaft centrifugal pumps through one 36-inch and one 48-inch force main to the Southerly headworks.

1.2.3 Major Treatment Processes

The Southerly WWTP consists of the following major treatment processes:

- Preliminary Treatment
- Primary Treatment
- Secondary Treatment
- Disinfection

- Solids Handling
- Solids Disposal

Figure 1-5 shows a flow schematic of the Southerly WWTP. Table 1-2 provides sizings and capacities of individual unit treatment processes.

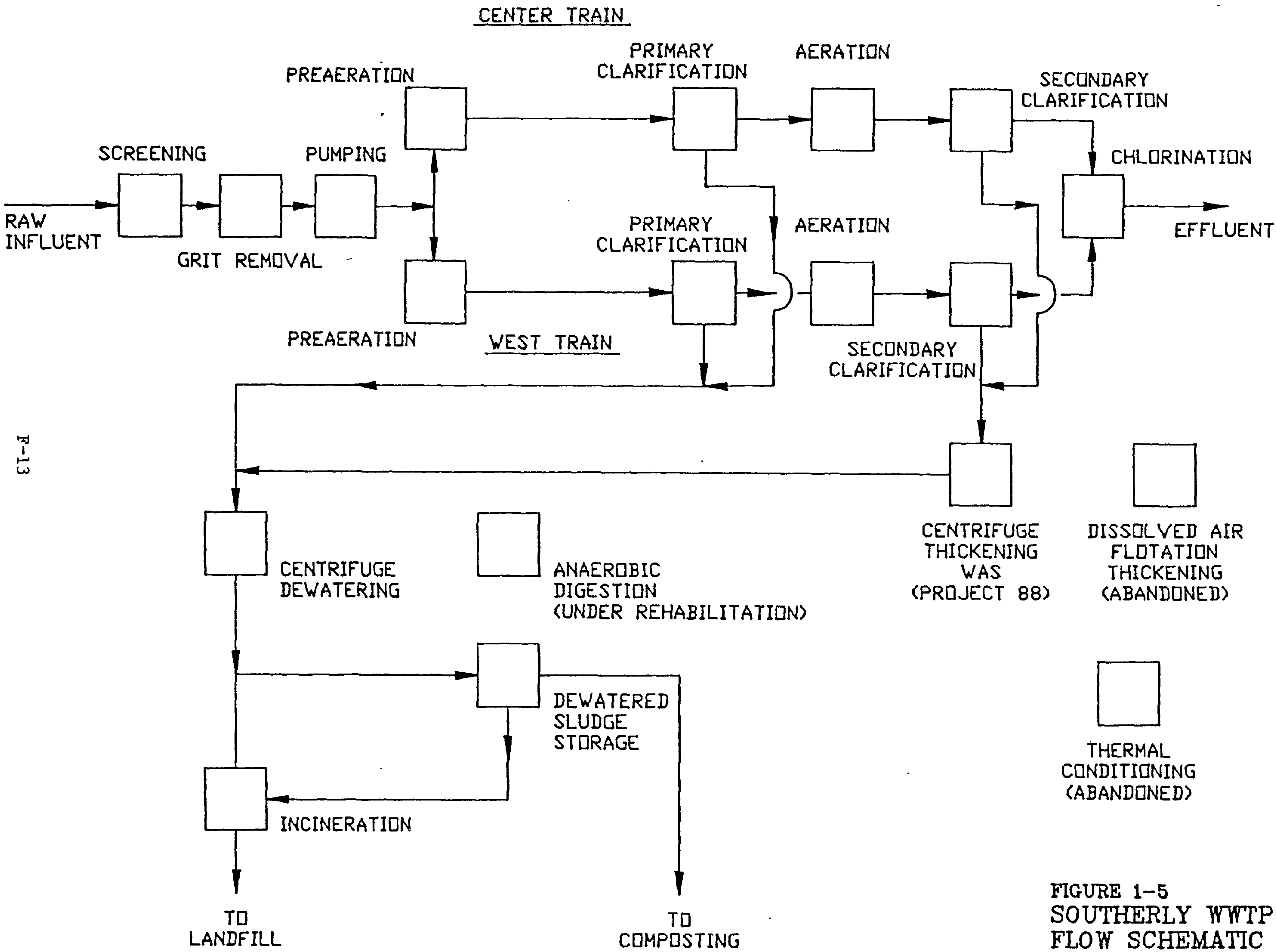


FIGURE 1-5
SOUTHERLY WWTP
FLOW SCHEMATIC

TABLE 1-2. SOUTHERLY WWTP EXISTING FACILITIES

Process	Facilities/Condition	
Screening		
	Four bar racks with 5.5-inch openings	
	Four mechanical bar screens with 1-inch openings	
Grit Removal	Two aerated grit tanks at 44.5 ft x 20 ft x 13.5 ft SWD	0.39 MG total volume
	Two aerated grit tanks at 51.2 ft x 20 ft x 13.5 ft SWD	
	Two variable speed blowers at 960 cfm each	
Pumping	Three variable speed pumps at 35 MGD (38 feet TDH)	170 MGD
	Two variable speed pumps at 65 MGD (42 feet TDH)	
	One constant speed pump at 35 MGD (38 feet TDH)	
Preaeration	Center Train - 4 tanks at 112.7 ft x 26 ft x 15.5 ft SWD	1.36 MG total volume
	West Train - 4 tanks at 112.7 ft x 26 ft x 15.5 ft SWD	1.36 MG total volume
	Three constant speed blowers at 3,400 cfm each	
Primary Clarification	Center Train - 4 tanks at 80 ft x 165 ft x 10 ft SWD	52,800 SF total surface area
	West Train - 4 tanks at 100 ft x 170 ft x 10 ft SWD	68,000 SF total surface area
	Twelve sludge pumps at 150 gpm each	
Aeration	Center Train - 4 tanks at 26 ft x 900 ft x 15 ft SWD	10.5 MG total volume
	West Train - 6 tanks at 26 ft x 900 ft x 15 ft SWD	15.8 MG total volume
	Nine blowers at 20,000 cfm each	
Secondary Clarification	Center Train - 4 tanks at 89 ft x 170 ft x 12.5 ft SWD	60,520 SF total surface area
	West Train - 4 tanks at 104 ft x 180 ft x 10.5 ft SWD	74,880 SF total surface area
	Return sludge pumps - 4 at 7,000 gpm each, 4 at 10,500 gpm each, 4 at 8,100 gpm each, 4 at 12,000 gpm each	
	Waste-activated sludge pumps - 8 at 200 gpm each	
Disinfection	Six 2,000 lb/day chlorinators	
	Six 8,000 lb/day evaporators	
	One chlorine contact basin at 260 ft x 260 ft x 7 ft SWD	
Dissolved Air Flotation Thickening (WAS)	Four units @ 1,900 SF/unit (Abandoned 1978 used as WAS concentration tanks)	

TABLE 1-2. SOUTHERLY WWTP EXISTING FACILITIES (cont.)

Process	Facilities/Condition	
Centrifuge Thickening (WAS)	Four solid bowl centrifuges Pre-Project 88, Contract #19 Not yet fully operational	200 gpm/unit Feed solids 1% Thickened WAS 5%
Anaerobic Digestion	Four primary digesters; 85-foot dia., 25.25-foot SWD Two secondary digesters; 85-foot dia., 25.25-foot SWD Construction date 1965	Volume of 972,000 CF total 4.8 MG primary 2.4 MG secondary
Thermal Conditioning	Three reactors Installed 1974, abandoned 1980	200 gpm/unit
Centrifuge Dewatering	Six solid bowl centrifuges Operational approx. 7 years	100 gpm/unit Feed solids 3.5% Dewatered cake 16-18%
Dewatered Sludge Storage	One storage bin.	Volume of 400 cy/300 wet tons
Transport to Composting	4-8 trucks @ 25 wet tons Hrs of operation 56 hrs/wk	Haul distance of 7 miles roundtrip
Composting	Extended aerated static pile system	120-200 wet tons/day dependent on sludge and weather
Compost Disposal	Product removed by truck	Disposal through bulk sales to public and private consumers
Incineration	Two existing multiple hearth units; Two new multiple hearth units under construction	150 wet tons/day existing 260 wet tons/day new
Ash Lagoon	Two lagoons	Total storage capacity of 76,000 cy; Cleaned as needed
Landfill	City-owned landfill	Ash landfilled on an as-needed basis by contract operations

2. IDENTIFICATION OF SYSTEM ALTERNATIVES

The current wastewater treatment facilities for the Columbus metropolitan area are the Jackson Pike and Southerly Wastewater Treatment Plants (WWTP) (See Figure 1-1.) Upgrading and expansion of one or both of these facilities is required to meet federal effluent limitations. Thus, the following three wastewater system alternatives have been selected to be evaluated for preferred treatment.

- No action.
- Upgrade the existing facilities.
- Eliminate Jackson Pike, upgrade and expand Southerly.

The following sections discuss these three alternatives.

2.1 NO ACTION ALTERNATIVE

The development of a no action alternative is consistent with EPA guidelines for preparing an EIS. A no-action alternative cannot be eliminated during a preliminary screening. It must be included in a detailed evaluation of alternatives. This is because it serves as a baseline when comparing and evaluating action alternatives.

The no action alternative would involve normal maintenance but no improvement to the existing facilities. Failure to rehabilitate and upgrade the existing facilities will result in permit violations. This may result in violations of water quality standards for receiving waters and possible public health problems in the Columbus metropolitan area.

New NPDES permit limits have been established for the Columbus wastewater treatment plants which they must be in compliance with by July 1, of 1988. The plants are currently operating under interim limits. The Columbus wastewater treatment plants, without improvements, cannot meet the new NPDES permit limits. The new permits are more stringent with respect to $CBOD_5$, TSS, and fecal coliform limits. The permits also include a limit for ammonia and a minimum requirement for dissolved oxygen. An inability to meet permit requirements may result in sanctions by OEPA and USEPA that could have adverse social and economic impacts in the facilities planning area.

2.2 UPGRADE THE EXISTING FACILITIES

This alternative, which is consistent with current operation, was evaluated by the city in the facility plan. This alternative will be referred to as the two-plant alternative. In this alternative, the existing treatment plant sites will be maintained. Each plant will be rehabilitated and expanded as necessary to provide advanced wastewater treatment on site for wastewater flows expected through the year 2008. Due to site limitations and existing hydraulic constraints at Jackson Pike, the city maintains that the wet stream treatment capacity cannot be expanded. However, the existing facilities can be upgraded to provide necessary treatment to meet proposed effluent requirements. Average flows in excess of 70 MGD and peak flows in excess of 100 MGD at Jackson Pike would be diverted to Southerly via the Interconnector Sewer. Figure 2-1 provides a flow schematic for the two-plant alternative.

2.3 ELIMINATE JACKSON PIKE, UPGRADE AND EXPAND SOUTHERLY

This alternative was evaluated and recommended by the City in the facility plan. Under this alternative, also called the one-plant alternative, Jackson Pike would be phased out and all flows would be diverted to Southerly via the Interconnector Sewer. Expansion and rehabilitation of the existing facilities at Southerly would be required. Figure 2-2 provides a flow schematic for the one-plant alternative.

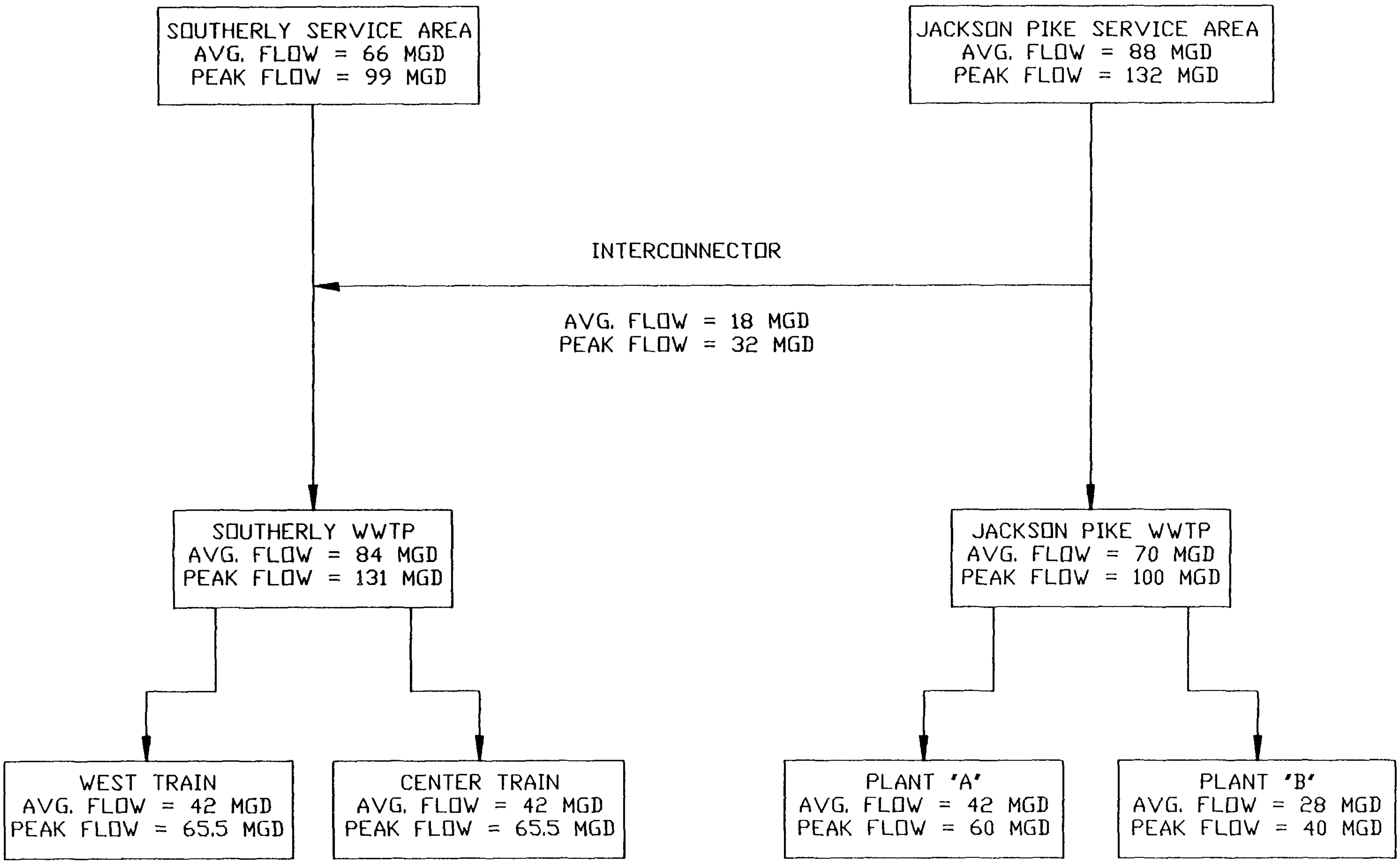


FIGURE 2-1
TWO-PLANT ATERNATIVE
FLOW SCHEMATIC

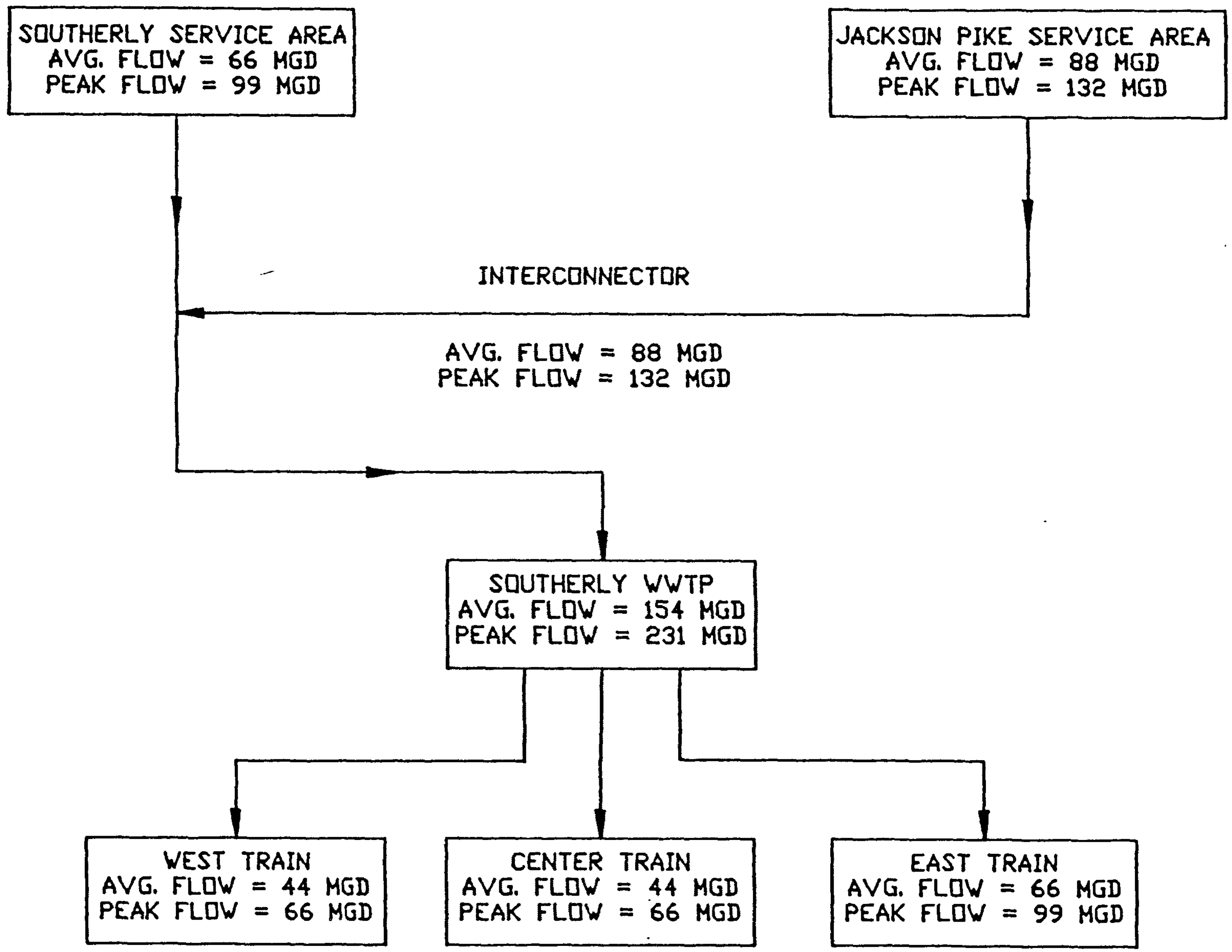


FIGURE 2-2
ONE-PLANT ALTERNATIVE
FLOW SCHEMATIC

3. DEVELOPMENT AND EVALUATION OF SYSTEM ALTERNATIVE COMPONENTS

This section presents the recommended process components and the facilities required to implement the one-plant and two-plant system alternatives. The components which will be discussed include the following:

- Interconnector/Headworks
- Wet Stream Treatment
- Solids Handling and Disposal

The Interconnector component involves options for conveyance between the two WWTPs. Included in the headworks are the coarse bar racks, mechanically cleaned bar screens, aerated grit chambers and pumps. Wet stream treatment includes primary, secondary, and post treatment. Solids components include thickening, processing, disposal, and reuse processes.

Secondary treatment and solids handling and disposal have been evaluated in previous briefing papers. Therefore, this briefing paper will summarize the recommendations of those papers.

The Interconnector, headworks, primary treatment, and post treatment are presented for the first time in this briefing paper. An evaluation of available options is contained herein. They will be discussed in greater detail than secondary treatment and solids handling and disposal.

Recommended facility sizings in this paper are based on the flows and loads developed in Briefing Paper No. 1. Costs are consistent with those costs presented in Briefing Paper No. 4.

3.1 INTERCONNECTOR/HEADWORKS

The Interconnector and headworks alternatives are being discussed together since they directly affect one another.

The 150-inch to 156-inch Interconnector Sewer runs in a north-south direction between Jackson Pike and Southerly along the west side of the Scioto River. The south end connects to the Interconnector Pump Station. The Interconnector Pump Station, with a firm capacity of 70 MGD, pumps the flow across the Scioto River to Southerly through a 48-inch force main and a 36-inch force main.

The north end of the Interconnector Sewer is incomplete. However, funding has been provided for its completion. The remaining segment will be constructed along the west and north side of Jackson Pike (Figure 1-2). A diversion chamber will be built connecting the Interconnector with the O.S.I.S. This will allow regulation of flows to Jackson Pike and diversion of flows to Southerly.

The existing Southerly headworks are rated at a capacity of 170 MGD. The headworks consist of coarse and fine screening, pumping, and aerated grit removal. The Jackson Pike headworks are rated at a capacity of 165 MGD. They consist of fine screening and pumping. Preliminary treatment is provided for flows entering Jackson Pike through the O.S.I.S. at the Sewer Maintenance Yard. These preliminary treatment facilities are rated at a capacity of 160 MGD and provide screening and grit removal for flows in the O.S.I.S. prior to their arrival at Jackson Pike.

3.1.1 One-Plant System Alternative

Under the one-plant system alternative, the Jackson Pike plant would be phased out of service and all flows tributary to Jackson Pike would be conveyed to Southerly via the Interconnector Sewer. In order to convey the Jackson Pike flows to Southerly, the south end of the Interconnector and the Southerly headworks capacity must be expanded.

The Interconnector currently conveys approximately 5 MGD to Southerly from a connection at Grove City. Under the one-plant system alternative, it would be required to convey an additional 132 MGD from Jackson Pike (Figure 2-2). This total flow exceeds the 70 MGD capacity of the existing pump station and force mains. Alternatives for expansion which were evaluated by the city include the following:

- Option A - additional pumping facilities and force mains
- Option B - extension of the 156-inch gravity Interconnector to Southerly

Option A consists of increasing the current 70 MGD capacity to 150 MGD by construction of a new pumping facility on the south side of the existing pump station, and by constructing one new 48-inch and one new 36-inch force main parallel to the existing force mains to the Southerly headworks. The pump station expansion will include the addition of three, 30 MGD submersible centrifugal pumps and motors, three mechanical bar screens, and a screenings conveyor system.

Option B consists of extending the 156-inch Interconnector Sewer to the Southerly WWTP. Four 78-inch pipes would be used for the Scioto River crossing to avoid the construction of a low head dam.

Under the one-plant alternative, the existing Southerly headworks would not be able to handle the combined peak flow of 231 MGD (i.e. 99 MGD from Southerly and 132 MGD from Jackson Pike).

The headworks options are affected by the Interconnector option selected. The potential options available are:

- Option A-1 - Expand existing headworks.
- Option B-1 - Construct separate headworks for the Interconnector flows.
- Option B-2 - Construct new headworks for all flow.

If Interconnector Alternative A is selected, the flows from the Big Walnut Interceptor and the Interconnector would arrive at the plant at the same elevation. Therefore, the existing headworks could be expanded to handle all of the flow. Expansion would include additional pumps, screens, and grit chambers. This option will be known as Option A-1.

If Interconnector Option B is selected, the gravity sewer will enter the Southerly headworks approximately eight feet lower than the Big Walnut Interceptor. This results in the need for separate headworks (Option B-1) for the gravity Interconnector or completely new headworks (Option B-2) to handle the flows from both sewers.

Option B-1 consists of utilizing the existing 170 MGD headworks at Southerly for handling the flows from the Big Walnut Interceptor and constructing new 150 MGD headworks for handling the Interconnector flows. The new Interconnector headworks will be located adjacent to the existing headworks. They will include coarse bar racks, raw pumping, followed by mechanical screening and aerated grit removal; all designed for 150 MGD. Mixing of the Interconnector and Big Walnut flows would follow aerated grit removal.

Option B-2 involves constructing completely new headworks which include a mixing chamber, coarse bar racks, pumping, and aerated grit chambers. The flows from the Big Walnut Interceptor and the Interconnector would combine in a mixing chamber and be conveyed through manually cleaned bar racks. The combined flow will then enter a wet well to be pumped to mechanical bar screens followed by aerated grit chambers. The new headworks will be designed for a peak process flow of 231 MGD. The combined costs for the Interconnector/headworks alternatives are presented in Table 3-1.

TABLE 3-1. INTERCONNECTOR/HEADWORKS ALTERNATIVE PRESENT WORTH COSTS

	Option A/A-1	Option B/B-1	Option B/B-2
Interconnector	$14,058,000	$4,432,000	$4,432,000
Headworks	$17,006,000	$25,847,000	$30,496,000
TOTAL	$31,064,000	$30,279,000	$34,928,000

Option B/B-1 exhibits the lowest present worth cost. However, practically speaking the present worth of A/A-1 is equal to B/B-1. Reliability, implementability, and ease of operation must also be considered when selecting the best alternative.

The gravity sewer options (B/B-1 and B/B-2) are more reliable than the force main option (A/A-1) because there is less chance that the gravity sewer will rupture. Also, gravity failure normally results in infiltration to the conduit; while force mains exfiltrate to the environment. In addition, the gravity sewer does not rely on the operation of a pumping facility to function properly. Therefore, it would be easier to operate and maintain. However, separate headworks are needed for option B/B-1 which would require additional operation and maintenance time.

The force mains, on the other hand, may not require as deep of an excavation as the gravity sewer; and therefore, they would be easier to implement.

Based on the cost and reliability of Option B/B-1 (gravity), it is the recommended Interconnector/headworks option for the one-plant alternative.

3.1.2 Two-Plant System Alternative

The two-plant alternative does not require any expansion of the Interconnector or any additional headworks at the Southerly WWTP. New headworks are required at the Jackson Pike WWTP. The total present worth cost of the headworks is $14,170,000.

3.2 WET STREAM TREATMENT

Briefing Paper No. 3 - Process Selection presented a detailed evaluation of secondary treatment alternatives and provided recommendations for secondary treatment facilities under each system alternative. In light of these recommendations, this section will summarize the facilities required under each system alternative for the following processes:

- Primary treatment
- Secondary treatment
- Post treatment

Secondary treatment recommendations will be consistent with the conclusion of the process selection breifing paper. Primary treatment and post treatment are being presented here for the first time.

3.2.1 One-Plant System Alternative

The one-plant alternative requires upgrading and expansion of the Southerly plant to handle all flows from the Jackson Pike and Southerly service areas. It was concluded in the process selection briefing paper that in addition to the two existing trains, one additional wet stream treatment train would be required at the Southerly WWTP. Figure 2-2 shows how the flow will be distributed between the three trains.

3.2.1.1 Primary Treatment

The Southerly WWTP currently has primary treatment consisting of preaeration and primary settling. Preaeration of wastewater prior to primary settling is done for odor control, to prevent septicity, and to improve subsequent settling. Little or no BOD reduction occurs in the preaeration tanks. However, preaeration does increase the removal of BOD and suspended solids in the primary tanks. Primary settling should remove 25 to 40 percent of the influent BOD and 50 to 70 percent of the suspended solids.

The Southerly WWTP currently has four preaeration tanks in each of the Center and West Trains. These preaeration tanks are adequate for providing treatment for the flows in these two trains under the one-plant alternative. However, an additional East Train is required under the one-plant alternative. As presented in Figure 2-2, this new East Train will provide treatment for an average flow of 66 MGD and a peak process flow of 99 MGD. Assuming a detention time of 30 minutes at average flow, four additional preaeration tanks are required in the new East Train. These new tanks are the same size as the tanks in the existing trains.

The Southerly WWTP has four primary settling tanks in each of the existing Center and West Trains. These tanks have adequate primary settling capacity for the average and peak flows allocated to these trains under the one-plant alternative. However, additional tanks are required for the new East Train. Assuming a surface loading rate of 1000 gallons per day per square foot at average flow as recommended by Ten States Standards, 66,000 square feet of surface area is required. This surface area can be provided by adding four new 150-foot diameter circular clarifiers.

3.2.1.2 Secondary Treatment

The form of secondary treatment currently provided at the Southerly WWTP is conventional single-stage activated sludge. This process includes rectangular aeration tanks followed by rectangular secondary clarifiers. The plant was designed based on NPDES permit limits of 30 mg/l for $CBOD_5$ and TSS. The $CBOD_5$ and TSS limits have become more stringent and an ammonia standard has been added to both permits. As a result of these changes, the plants are not capable of treating design flows to the more stringent permit limits.

Through the course of the facilities planning process for the Columbus wastewater treatment facilities, other alternatives to the conventional activated sludge process have been proposed. The 1979 EIS recommended a trickling filter process followed by activated sludge for the Jackson Pike plant. The Facilities Plan Update (FPU) and Revised Facilities Plan Update recommended a semi-aerobic treatment process. The Process Selection Briefing Paper evaluated the semi-aerobic, trickling filter/activated sludge, and single-stage activated sludge processes and recommended utilizing the semi-aerobic process at both plants.

The semi-aerobic process is a modified form of the activated sludge process. The process consists of a non-aerated reaction zone ahead of an aerated activated sludge zone. The non-aerated zone may be anoxic (nitrates are present), anaerobic (no oxygen or nitrates present), or a combination of both. The purpose of the anaerobic zone is to control bulking sludge. The anaerobic zone may change to anoxic depending on the level and concentration of nitrates in the wastewater. In the anoxic zone denitrification occurs. Denitrification is a process by which nitrates are converted into nitrogen gas.

The only physical differences between the semi-aerobic process and the conventional activated sludge process is an internal mixed liquor recycle loop and the addition of baffles to compartmentalize the aeration tanks. The baffles are incorporated into the design to prevent back-mixing from the aerated zone to the anaerobic zone. The internal recycle loop is used to bring nitrates back to the anoxic zone and thus cause denitrification to occur.

Under the one-plant scenario, the Southerly WWTP would be upgraded to handle all flows from the Columbus service area. The Southerly WWTP currently has a West Train and a Center Train. The West Train has six aeration tanks which are capable of treating an average design flow of 44 MGD. The Center Train has four aeration tanks which are capable of treating an average design flow of 29 MGD. These flows are based on the design parameters of the semi-aerobic process.

The 2008 average design flow for the one-plant alternative is 154 MGD. This will require an additional aeration basin capacity of 81 MGD. This can be provided by adding two tanks to the existing Center Train and by constructing a new East Train consisting of nine aeration basins. Figure 2-2 shows how the flow is allocated to each train.

The existing aeration basins will require some modifications to allow them to be operated in the semi-aerobic mode. Two baffles must be installed in the first bay of each of the ten existing tanks and an internal mixed liquor recycle loop must also be added to each tank.

The existing rectangular clarifiers will be replaced by six new circular clarifiers. New circular clarifiers were recommended for the Southerly WWTP due to the high mixed liquor concentration which must be maintained for nitrification and the difficulty associated with settling a nitrified sludge.

In addition to the six new secondary clarifiers for the existing Center and West Trains, four new circular clarifiers are required for secondary settling in the new East Train.

3.2.1.3 Post Treatment

The current post treatment provided at the Southerly WWTP is chlorination. The Southerly WWTP has an earthen contact basin with internal baffles. This basin was designed as a temporary structure until a decision on tertiary treatment could be finalized. Since new regulations require disinfection, Southerly needs permanent facilities.

Southerly would require two new chlorine contact tanks sized at 81 feet by 200 feet by 10 feet side water depth. Dechlorination is also required to limit the chlorine residual in the effluent. Post aeration will take place in the final pass of the tanks to maintain a dissolved oxygen in the effluent of 7.0 mg/l.

Table 3-4 summarizes the wet stream facilities required under the one-plant alternative and the associated costs.

TABLE 3-4
WET STREAM TREATMENT
(Southerly One-Plant)
Facilities and Estimated Costs

PREAERATION	$ 5,905,000
Eight existing tanks; 112.7 ft x 26 ft x 15.5 ft SWD	
Four new tanks; 112.7 ft x 25.5 ft x 15.5 ft SWD	
PRIMARY SETTLING	13,590,000
Four existing tanks; 80 ft x 165 ft x 10 ft SWD	
Four existing tanks; 100 ft x 170 ft x 10 ft SWD	
Four new tanks; 150 ft dia. x 15 ft SWD	
AERATION	46,533,000
Ten existing tanks; 26 ft x 900 ft x 15 ft SWD	
Eleven new tanks; 26 ft x 900 ft x 15 ft SWD	
FINAL SETTLING	35,462,000
Demolish existing tanks	
Ten new tanks; 200 ft dia. x 15 ft SWD	
CHLORINATION/DECHLORINATION/POST AERATION	3,000,000
Two new tanks; 81 ft x 200 ft x 10 ft SWD including mixers, chlorinators, evaporators, and sulfonators. Post Aeration takes place in the final pass of the chlorine contact tanks.	
TOTAL CAPITAL COSTS	$104,490,000
ANNUAL O&M COSTS	5,224,000
TOTAL PRESENT WORTH	$144,504,000

3.2.2 Two-Plant System Alternative

The two plant alternative requires upgrading of both plants and minor expansion of the Southerly plant. No additional wet stream treatment trains are required at either plant. Flows are distributed to each of the plants as shown in Figure 2-1.

3.2.2.1 Primary Treatment

Under the two-plant alternative, the Southerly WWTP has adequate primary settling and preaeration capacity. However, upgrading of the existing facilities is required.

The Jackson Pike WWTP currently has two preaeration tanks in each of the two trains, Plant A and Plant B. The two tanks in Plant A provide 1.05 MG of total volume. The two tanks in Plant B provide 0.66 MG of total volume. These tanks are capable of treating an average flow of 70 MGD.

The Jackson Pike WWTP has four primary settling tanks in each existing train, Plant A and Plant B. These tanks are also adequate to treat an average flow of 70 MGD.

3.2.2.2 Secondary Treatment

The semi-aerobic process is recommended at both plants under the two-plant alternative.

Under the two-plant option the Southerly WWTP will be required to treat an average flow of 84 MGD and a peak process flow of 131 MGD. These flows include 18 MGD under average conditions and 32 MGD under peak conditions being diverted from Jackson Pike. The Jackson Pike WWTP is limited to an average flow of 70 MGD and a peak process flow of 100 MGD.

In accordance with the evaluation presented in the Process Selection Briefing Paper, only two additional aeration basins are required in the Center Train at Southerly under the two-plant alternative. Then each train would have six basins and could treat an average flow of 42 MGD and a peak process flow of 65.5 MGD (see Figure 2-1).

The existing rectangular clarifiers should be demolished and replaced with six new circular clarifiers.

The Jackson Pike WWTP is hydraulically limited to a peak process flow of 100 MGD. Any peak flows in excess of this flow would be diverted to the Southerly WWTP under a two-plant alternative. An average flow of 88 MGD was projected for the 2008 design year. However, in evaluating the existing facilities, the aeration facilities were found to be limited to 70 MGD average flow.

At an average flow of 70 MGD and a peak process flow of 100 MGD, the existing aeration facilties at Jackson Pike have adequate capacity. However, extensive rehabilitation and the addition of baffles and an internal mixed liquor recycle system would be required to operate in the semi-aerobic mode.

The final clarifiers, on the other hand, are not sufficient to treat a peak process flow of 100 MGD. Two additional rectangular clarifiers would be necessary.

3.2.2.3 Post Treatment

Under the two-plant alternative, the Jackson Pike and Southerly WWTPs would require new chlorine contact tanks. As discussed in the previous section, Southerly has a temporary contact basin. Jackson Pike performs disinfection by injection of chlorine into the discharge pipeline. Under the two-plant alternative, Southerly would need two new tanks sized at 150 feet by 64 feet by 10 feet side water depth. Jackson Pike would need two new tanks sized at 100 feet by 70 feet by 10 feet side water depth. Dechlorination would also be employed. Post aeration would take place in the final pass of the tanks.

Tables 3-5 and 3-6 present a summary of the required wet stream treatment facilities and the associated costs for the Southerly WWTP and the Jackson Pike WWTP, respectively.

3.3 SOLIDS HANDLING AND DISPOSAL

This section summarizes the recommended solids handling and disposal components for the one-plant system alternative and the two-plant system alternative. These recommendations were identified in the solids handling briefing paper after a thorough evaluation of solids management options for each plant.

3.3.1 One-Plant System Alternative

The solids handling and disposal scheme identified for Southerly under the one-plant system alternative is shown in Figure 3-1. This handling and disposal scheme includes the following sludge processes:

- Gravity thickening of primary sludge
- Centrifuge thickening of waste-activated sludge
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Composting
- Incineration
- Land Application

Dewatered sludge would be disposed of as follows:

- 25 percent would be composted and distributed as a soil conditioner. Sludge sent to compost would not go through the digestion process.
- 25 percent would be land applied as a fertilizer to agricultural acreage within a reasonable distance from the plant.
- 50 percent would be incinerated, and the ash product would be landfilled.

TABLE 3-5
WET STREAM TREATMENT
(Southerly Two-Plant)
Facilities and Estimated Costs

PREAERATION Eight existing tanks; 112.7 ft x 26 ft x 15.5 ft SWD	$ 1,533,000
PRIMARY SETTLING Four existing tanks; 80 ft x 165 ft x 10 ft SWD Four existing tanks; 100 ft x 170 ft x 10 ft SWD	4,717,000
AERATION Ten existing tanks; 26 ft x 900 ft x 15 ft SWD Two new tanks; 26 ft x 900 ft x 15 ft SWD	12,284,000
FINAL SETTLING Demolish existing tanks Six new tanks; 190 ft dia. x 15 ft SWD	20,521,000
CHLORINATION/DECHLORINATION/POST AERATION Two new tanks; 150 ft x 64 ft x 10 ft SWD including mixers, chlorinators, evaporators, and sulfonators. Post aeration takes place in the final pass of the chlorine contact tanks.	1,800,000
TOTAL CAPITAL COSTS	$40,855,000
ANNUAL O&M COSTS	2,382,000
TOTAL PRESENT WORTH	$61,562,000

TABLE 3-6
WET STREAM TREATMENT
(Jackson Pike Two-Plant)
Facilities and Estimated Costs

PREAERATION	$ 3,750,000
Two existing tanks; 180 ft x 26 ft x 15 ft SWD	
Two existing tanks; 113 ft x 26 ft x 15 ft SWD	
Building renovation	
PRIMARY SETTLING	7,372,000
Eight existing tanks; 150 ft x 80 ft x 10 ft SWD	
Control building renovation	
AERATION	22,502,000
Twelve existing tanks; 900 ft x 26 ft x 15 ft SWD	
Control building renovation	
FINAL SETTLING	8,691,000
Twelve existing tanks; 153 ft x 60 ft x 12.5 ft SWD	
Two new tanks; 153 ft x 60 ft x 12.5 ft SWD	
CHLORINATION/DECHLORINATION/POST AERATION	1,300,000
Two new tanks; 100 ft x 70 ft x 10 ft SWD including mixers, chlorinators, evaporators, and sulfonators. Post aeration takes place in the final pass of the chlorine contact tanks.	
TOTAL CAPITAL COSTS	$43,615,000
ANNUAL O&M COSTS	2,648,000
TOTAL PRESENT WORTH	$66,722,000

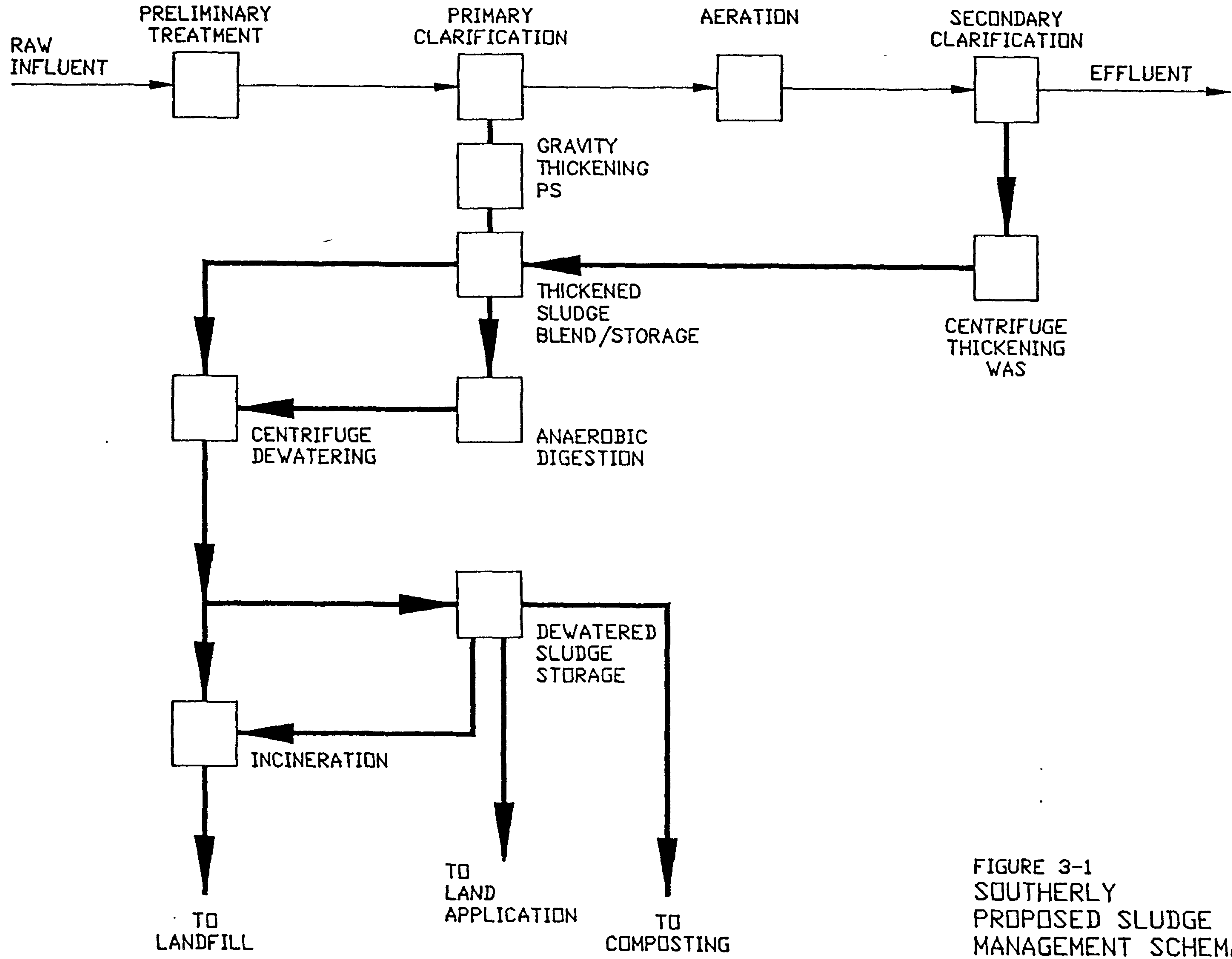


FIGURE 3-1
SOUTHERLY
PROPOSED SLUDGE
MANAGEMENT SCHEMATIC

This alternative provides a great deal of flexibility for disposal. It offers continuation of the existing incineration and composting processes at Southerly and introduces land application as a disposal process. Table 3-7 presents the required sizing and associated costs of the sludge management facilities for the one-plant system alternative.

3.3.2 Two Plant System Alternative

The recommended solids handling and disposal scheme for Southerly under a two-plant system alternative is the same as that for a one-plant system alternative. This scheme was previously described in Figure 3-1. Table 3-8 presents the sizing and costs of the required sludge management facilities for Southerly under a two-plant system alternative.

The recommended solids handling and disposal scheme for Jackson Pike under a two-plant alternative is presented in Figure 3-2. This alternative includes the following sludge processes:

- Gravity thickening of primary sludge
- Centrifuge thickening of waste-activated sludge
- Thickened sludge storage and blending
- Stabilization by anaerobic digestion
- Centrifuge dewatering
- Incineration
- Land Application

Dewatered sludge would be disposed of as follows:

- 50 percent would be incinerated and the ash product landfilled
- 50 percent would be land appplied as a fertilizer to agricultural acreage within a reasonable distance from the plant.

TABLE 3-7
SOUTHERLY SLUDGE MANAGEMENT COMPONENTS
One-Plant System Alternative
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping	$5,070,000
Four (4) existing; 45-foot dia. x 17-foot SWD	
Two (2) new; 85-foot dia. x 10-foot SWD	
Centrifuge Thickening WAS	5,600,000
Four (4) existing; 250 gpm, 1250 lb/hr	
Four (4) new; 250 gpm, 1250 lb/hr	
Thickened Sludge Storage/Blend	--
Existing Facilities Reused	
Anaerobic Digestion	11,460,000
Six (6) existing; 85-foot dia. x 25.25-foot SWD	
Four (4) new; 85-foot dia. x 25.25-foot SWD	
Centrifuge Dewatering	21,040,000
Six (6) existing; 1000 lb/hr	
Nine (9) new; 1000 lb/hr	
Dewatered Sludge Storage	
One (1) new; 400 cy plus material handling	1,300,000
Composting	
Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration	
Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Rehabilitate existing	1,300,000
Landfill	
Contract operations included with O&M	--
Land Application	--
Contract operations included with O&M	
Capital Cost	$45,770,000
Annual Operation and Maintenance Cost	6,230,000
Present Worth (One-Plant)	$90,710,000

TABLE 3-8
SOUTHERLY SLUDGE MANAGEMENT COMPONENTS
Two-Plant System Alternative
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Four (4) existing; 45-foot dia. x 17-foot SWD	$2,520,000
Centrifuge Thickening WAS Four (4) existing; 250 gpm, 1250 lb/hr One (1) new; 250 gpm, 1250 lb/hr	2,000,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 25.25-foot SWD	4,280,000
Centrifuge Dewatering Six (6) existing; 1000 lb/hr Two (2) new; 1000 lb/hr	5,120,000
Dewatered Sludge Storage One (1) new; 400 cy plus material handling	1,300,000
Composting Existing Facilities; 120 wet ton/day @ 20% solids	--
Incineration Two (2) new; 8 hearth, 260 wet ton/day @ 20% solids	--
Landfill Contract operations included with O&M	--
Land Application Contract operations included with O&M	--
Capital Cost	$15,220,000
Annual Operation and Maintenance Cost	3,340,000
Present Worth (Two-Plant)	$39,680,000

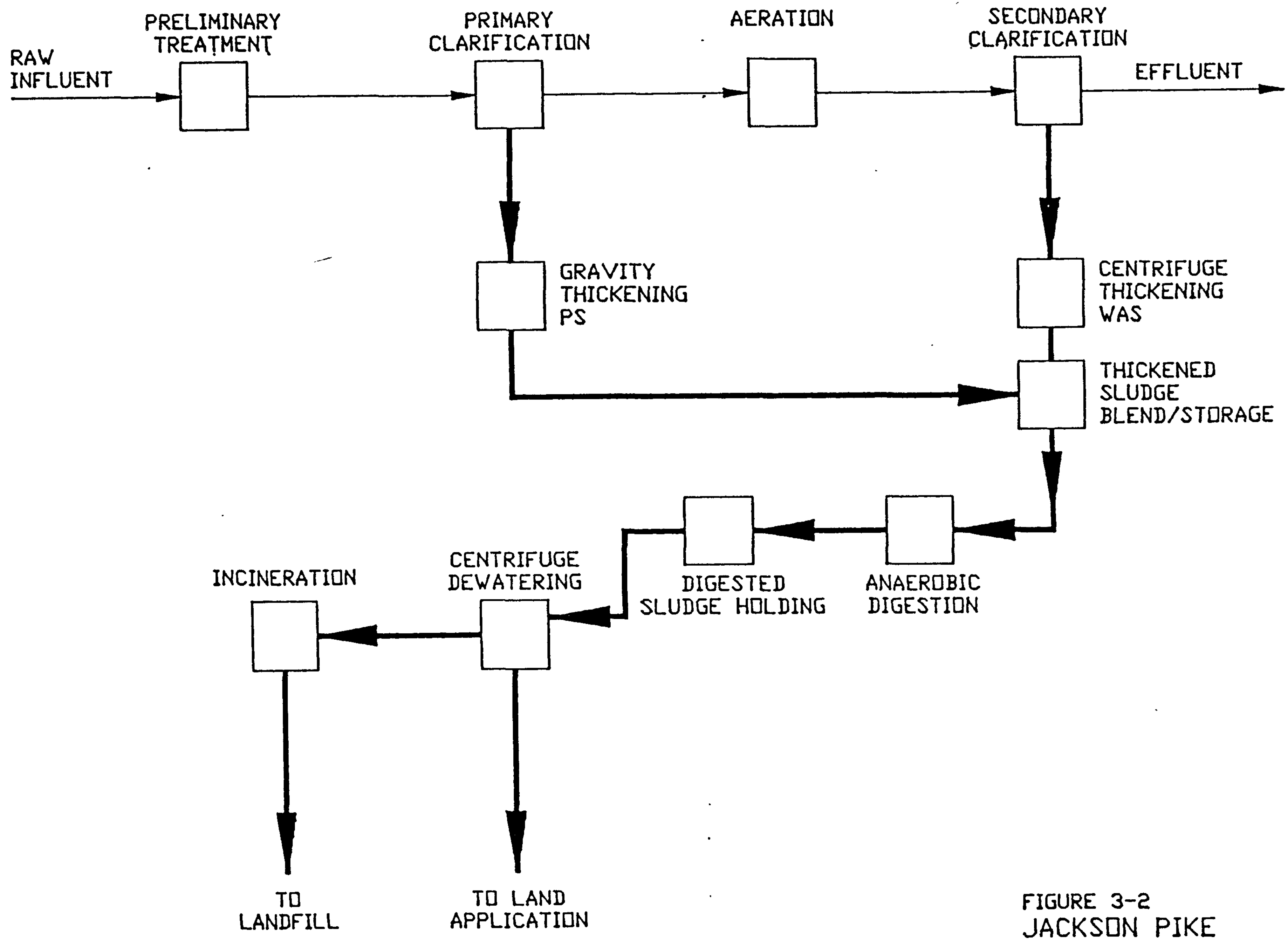


FIGURE 3-2
JACKSON PIKE
PROPOSED SLUDGE
MANAGEMENT SCHEMATIC

The difference between this alternative and the alternative recommended for Southerly is that the Jackson Pike alternative does not include composting. The recommended 50:50 disposal ratio between land application and incineration is approximately consistent with current Jackson Pike disposal practices. Table 3-9 provides a list of the required facilities for Jackson Pike and their associated costs.

TABLE 3-9
JACKSON PIKE SLUDGE MANAGEMENT COMPONENTS
Two-Plant System Alternative
Facilities and Estimated Costs

Gravity Thickening PS plus Dilution Water Pumping Modify two (2) digesters; 85-foot dia. x 10-foot SWD	**$1,967,000**
Centrifuge Thickening WAS Two (2) existing; 500 gpm One (1) new; 500 gpm	4,500,000
Thickened Sludge Storage/Blend Existing Facilities Reused	--
Anaerobic Digestion Six (6) existing; 85-foot dia. x 23.5-foot SWD	9,170,000
Centrifuge Dewatering Six (6) existing; 1200 lb/hr	490,000
Incineration Two (2) existing, 7 hearth, 200 wet ton/day @ 20% solids	3,600,000
Landfill Contract operations included with O&M	--
Land Application Contract operations included with O&M	--
Capital Cost	**$19,727,000**
Annual Operation and Maintenance Cost	3,070,000
Present Worth (Two-Plant)	**$45,827,000**

4. EVALUATION OF SYSTEM ALTERNATIVES

This section evaluates the one-plant and two-plant system alternatives based on cost, reliability, fexibility, implementability, and operational ease.

Table 4-1 presents the capital, annual O&M, and total present worth costs for the one-plant and two-plant system alternatives.

TABLE 4-1. SYSTEM ALTERNATIVE COSTS

	Capital	Annual O&M	Total Present Worth
One-Plant [Southerly]	268,711,000	16,849,000	436,911,000
Two-Plant [So. and Jackson Pike]	**207,076,000**	19,078,000	**397,016,000**
Difference from One-Plant	**-61,635,000**	+2,229,000	**-39,895,000**
Percent Difference	**-30**	+13	**-10**

Details on the development of the costs in Table 4-1 are presented in Briefing Paper No. 4 - Capital and O&M Costs.

The two-plant system alternative exhibits a total present worth cost approximately **10** percent lower than the one-plant alternative.

Both the one-plant and two-plant alternatives are equal with respect to their reliability in meeting final effluent limits. However, the two-plant would be more reliable with respect to shock loads. Under the one-plant alternative, a plant upset at Southerly could result in a significant loss of biological treatment capacity and may cause a serious water quality problem. However, if the shock and/or toxic load can only reach one of the two plants, the impact may not be as severe.

The two-plant alternative is judged more flexible than the one-plant alternative. With both facilities operational, the city would have more flexibility to adapt to increased future flow, to meet more stringent effluent limits, and to address combined sewer overflows. The two-plant alternative would leave more land available at Southerly for expansion. The two-plant alternative would improve and upgrade Jackson Pike to provide a solid 100 MGD treatment capacity. The two-plant alternative would allow for future expansion of the Interconnector system to divert more flow to Southerly while optimizing the use of the Jackson Pike facility.

The two-plant alternative would be easier to implement since the majority of the facilities already exist. Most of the construction would consist of rehabilitation of existing facilities. No expansion of the conveyance system between the plants is required under this alternative.

The one-plant alternative would be easier to operate and maintain since all facilities would be consolidated at one location.

A recommendation on a system alternative cannot be made based solely on this technical evaluation. Environmental impacts must be considered prior to making a recommendation.

APPENDIX G

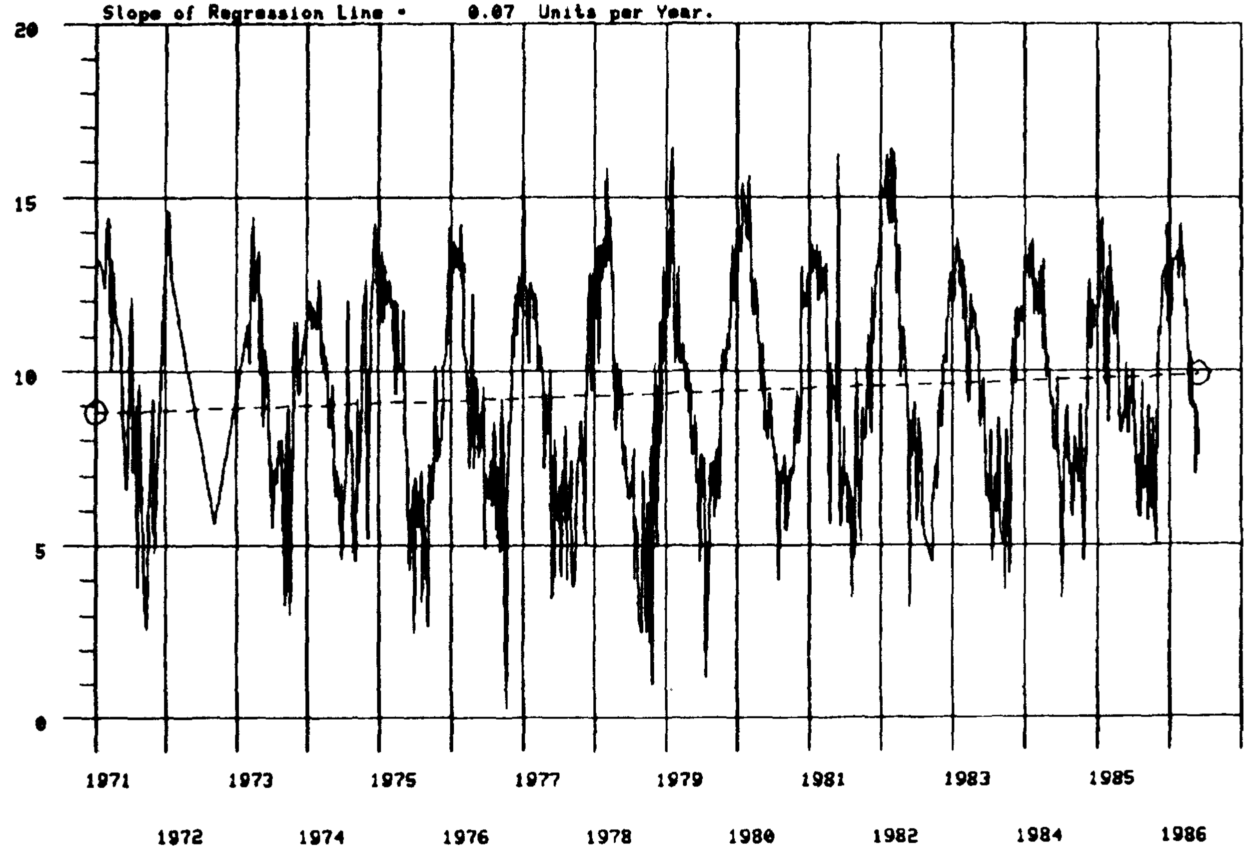
GRAPHS OF STORET DATA
FOR DO, BOD, AND AMMONIA
FROM 1971-1986 AT SIX
STATIONS ON THE SCIOTO RIVER
BETWEEN JACKSON PIKE WWTP
AND CIRCLEVILLE, OHIO

STORET System

```
39 55 00.0 083 00 35.0  2
SCIOTO R. AT COLUMBUS - FRANK RD.  (RM 127.74)
39049 OHIO               FRANKLIN
OHIO RIVER                051091
SCIOTO RIVER
21OHIO    05060001                /TYPA/AMBNT/STREAM
                   DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 127.74
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
299	DO	PROBE	MG/L	724	9.4	16.4	0.3	71/01/04	86/05/27

Slope of Regression Line = 0.07 Units per Year.



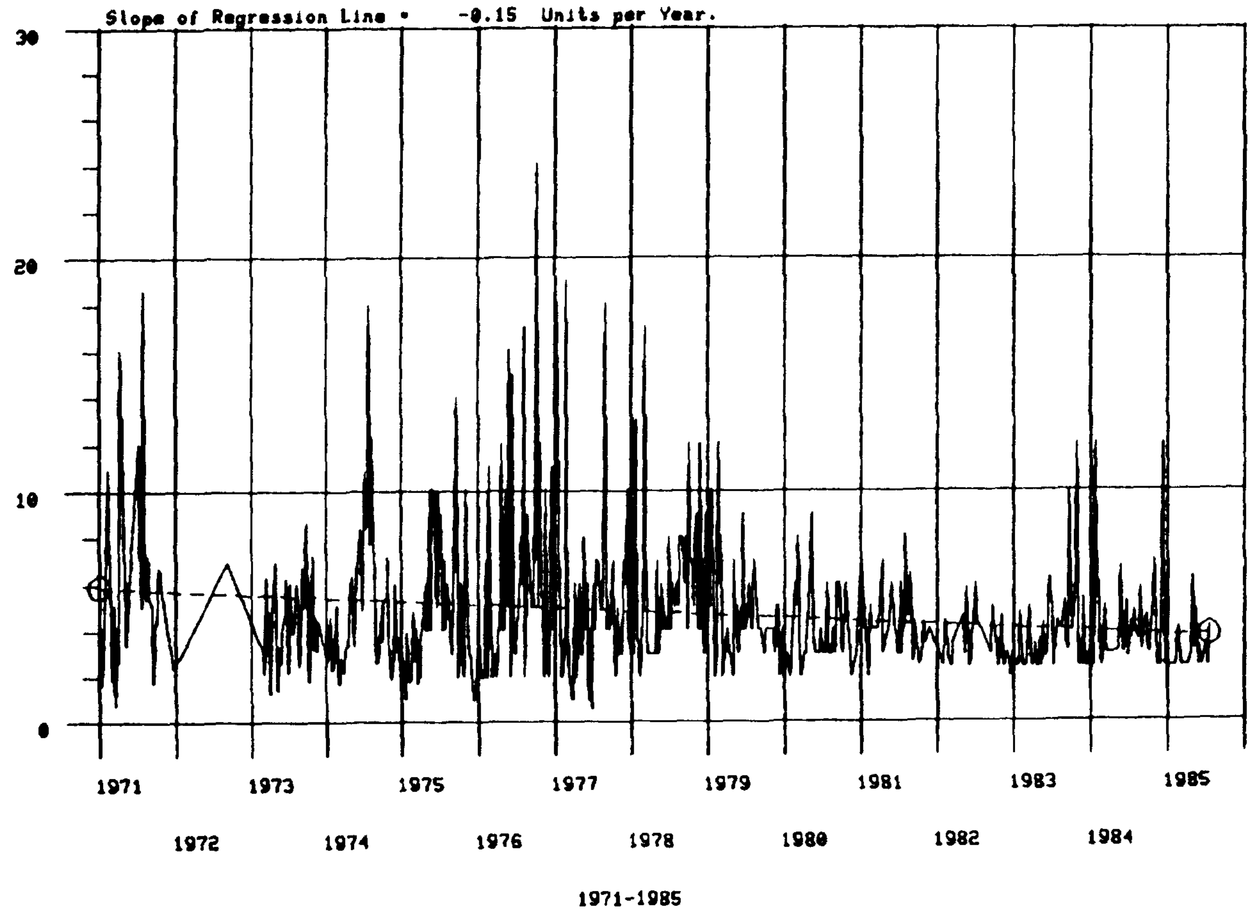
1971-1986

Station 600870
RM 127.74

STORET System

```
39 55 00.0 083 00 35.0  2
SCIOTO R. AT COLUMBUS - FRANK RD.  (RM 127.74)
39049 OHIO              FRANKLIN
OHIO RIVER                051091
SCIOTO RIVER
21OHIO    05060001                  /TYPA/AMBNT/STREAM
                   DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 127.74
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
310	BOD	5 DAY	MG/L	596	4.7	24.0	0.6	71/01/04	85/07/19

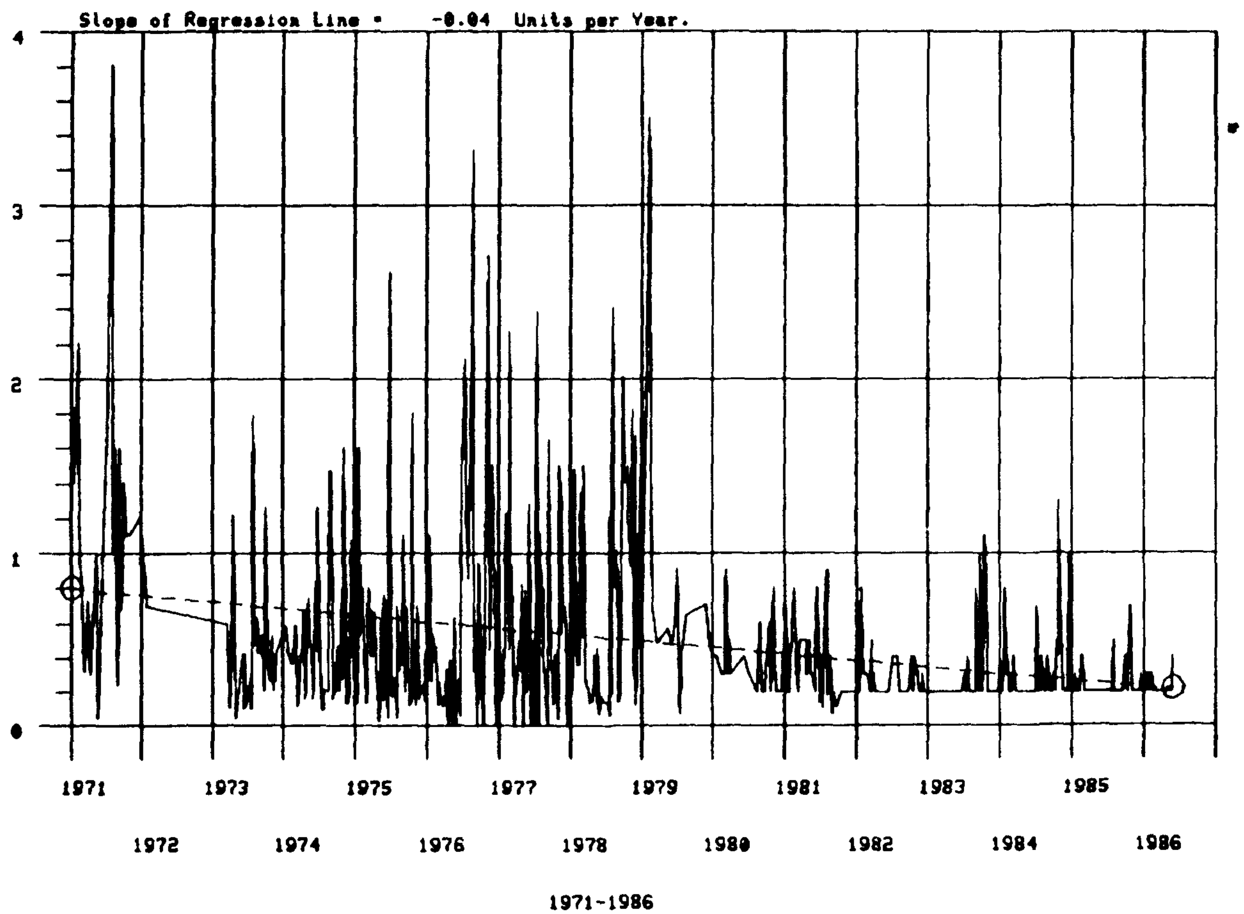


Station 600870
RM 127.74

STORET System

```
39 55 00.0 083 00 35.0  2
SCIOTO R. AT COLUMBUS - FRANK RD.  (RM 127.74)
39049 OHIO              FRANKLIN
OHIO RIVER                051091
SCIOTO RIVER
21OHIO    05060001                     /TYPA/AMBNT/STREAM
                   DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 127.74
```

PARAMETER		NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
610 NH3+NH4- N TOTAL	MG/L	605	0.482	3.800	0.000	71/01/04	86/05/27

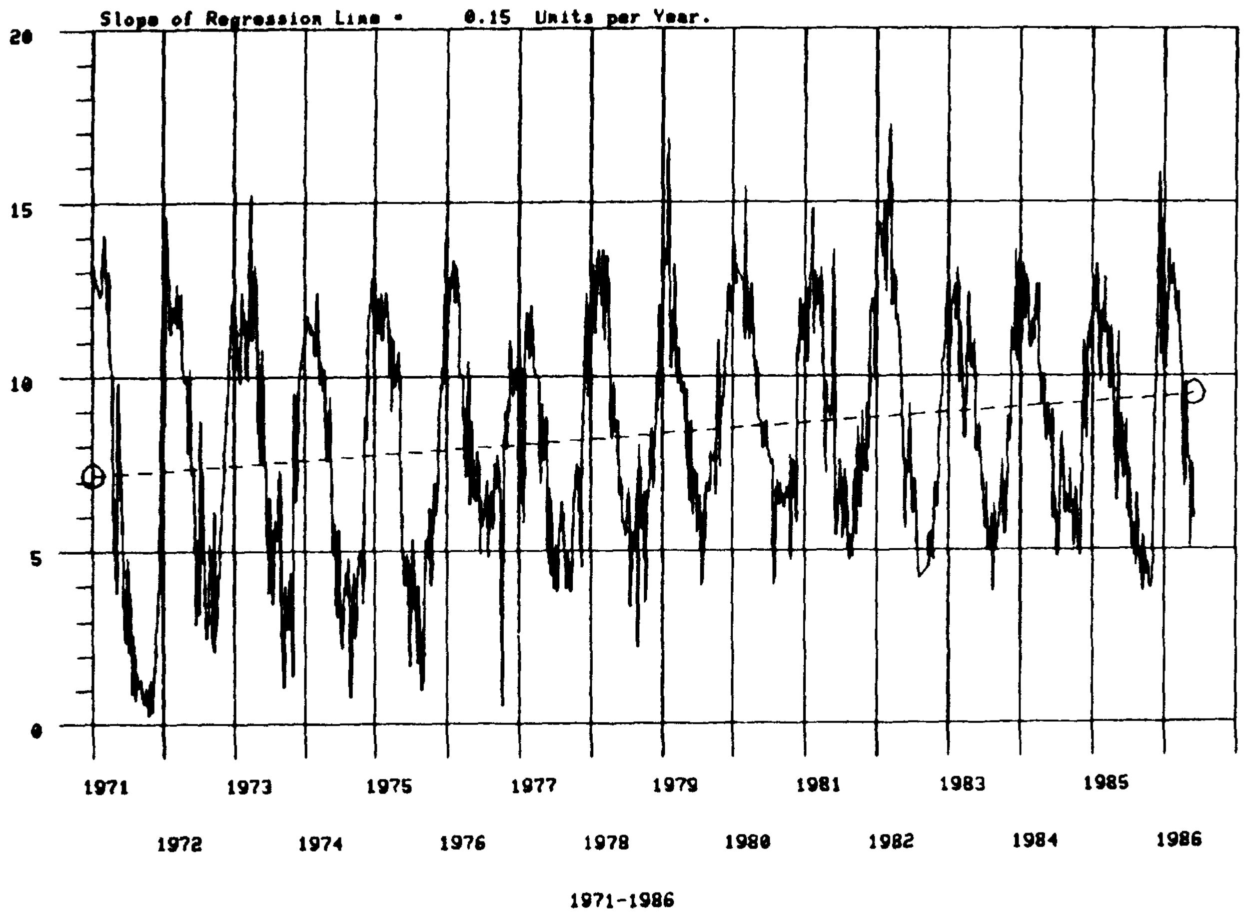


Station 600870
RM 127.74

STORET System

```
39 52 51.0 083 01 07.0  2
SCIOTO R. AT COLUMBUS - I-270 S.   (RM 124.40)
39049 OHIO                FRANKLIN
OHIO RIVER                 051091
SCIOTO RIVER
21OHIO    05060001                  /TYPA/AMBNT/STREAM
                     DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 124.40
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
299	DO	PROBE	MG/L	785	8.4	17.2	0.3	71/01/04	86/05/27



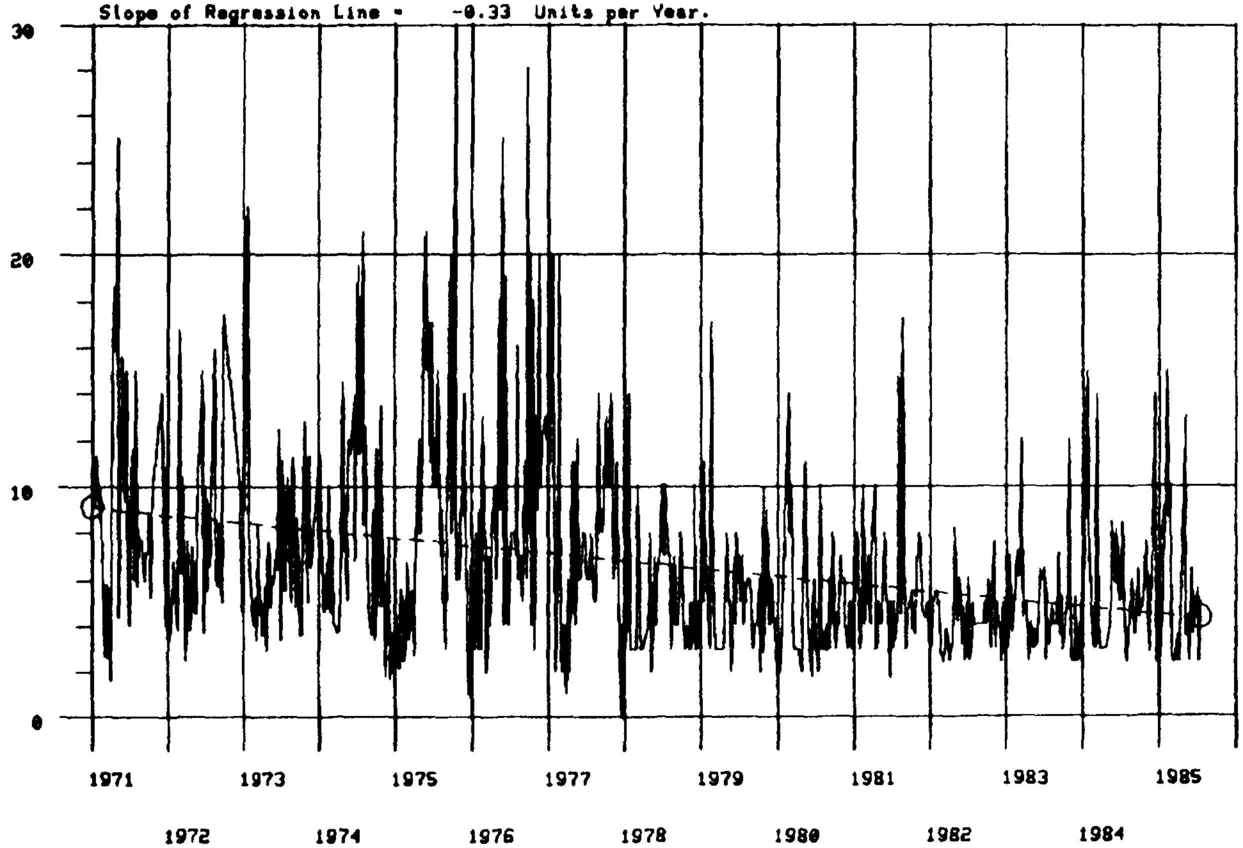
Station 600880
RM 124.4

STORET System

```
39 52 51.0 083 01 07.0  2
SCIOTO R. AT COLUMBUS - I-270 S.  (RM 124.40)
39049 OHIO             FRANKLIN
OHIO RIVER               051091
SCIOTO RIVER
21OHIO   05060001                /TYPA/AMBNT/STREAM
                   DEPTH    0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 124.40
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
310	BOD	5 DAY	MG/L	683	6.7	30.0	0.0	71/01/04	85/07/19

Slope of Regression Line = -0.33 Units per Year.



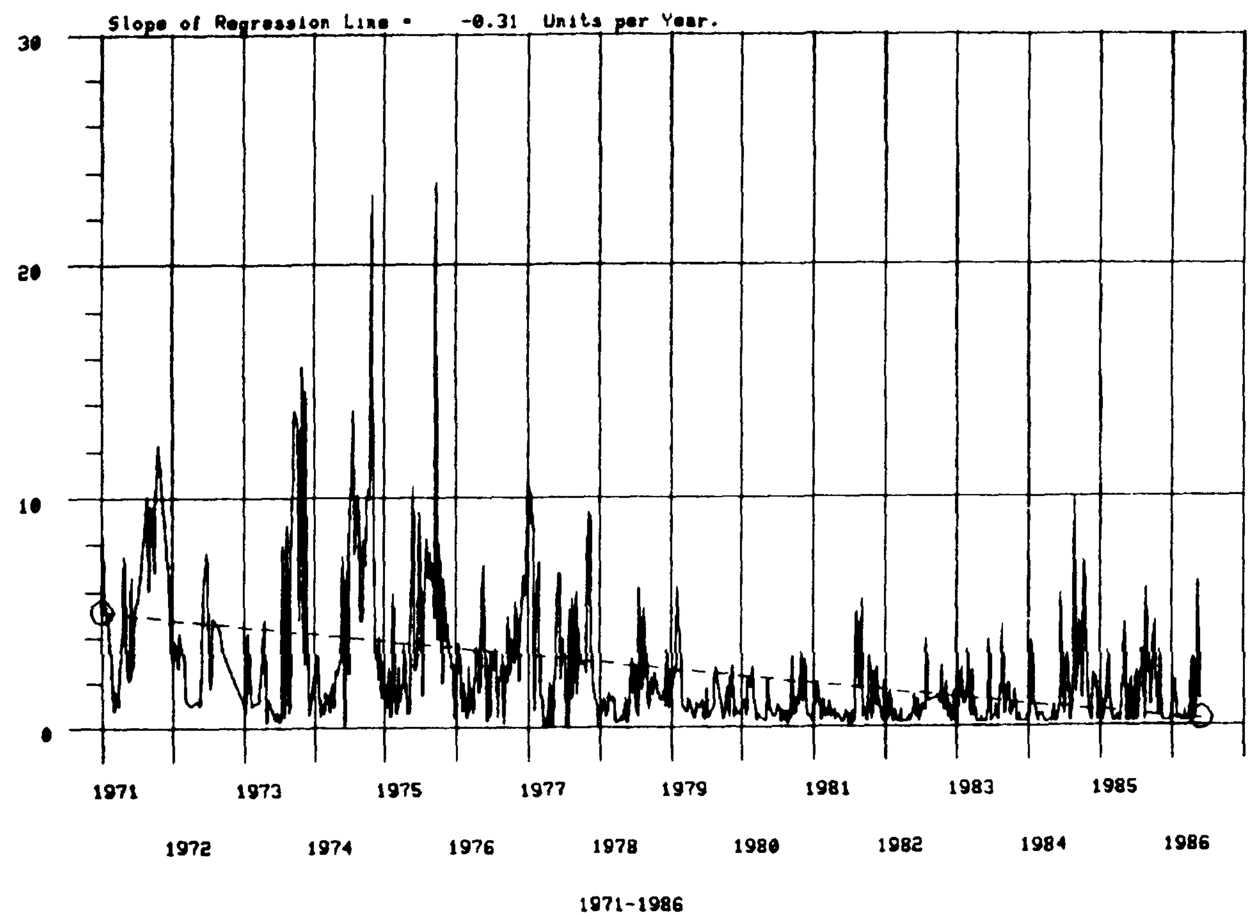
1971-1985

Station 600880
RM 124.4

STORET System

```
39 52 51.0 083 01 07.0  2
SCIOTO R. AT COLUMBUS - I-270 S.  (RM 124.40)
39049 OHIO              FRANKLIN
OHIO RIVER                051091
SCIOTO RIVER
21OHIO   05060001                /TYPA/AMBNT/STREAM
                   DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 124.40
```

PARAMETER		NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
610 NH3+NH4- N TOTAL	MG/L	718	2.481	23.500	0.000	71/01/04	86/05/27

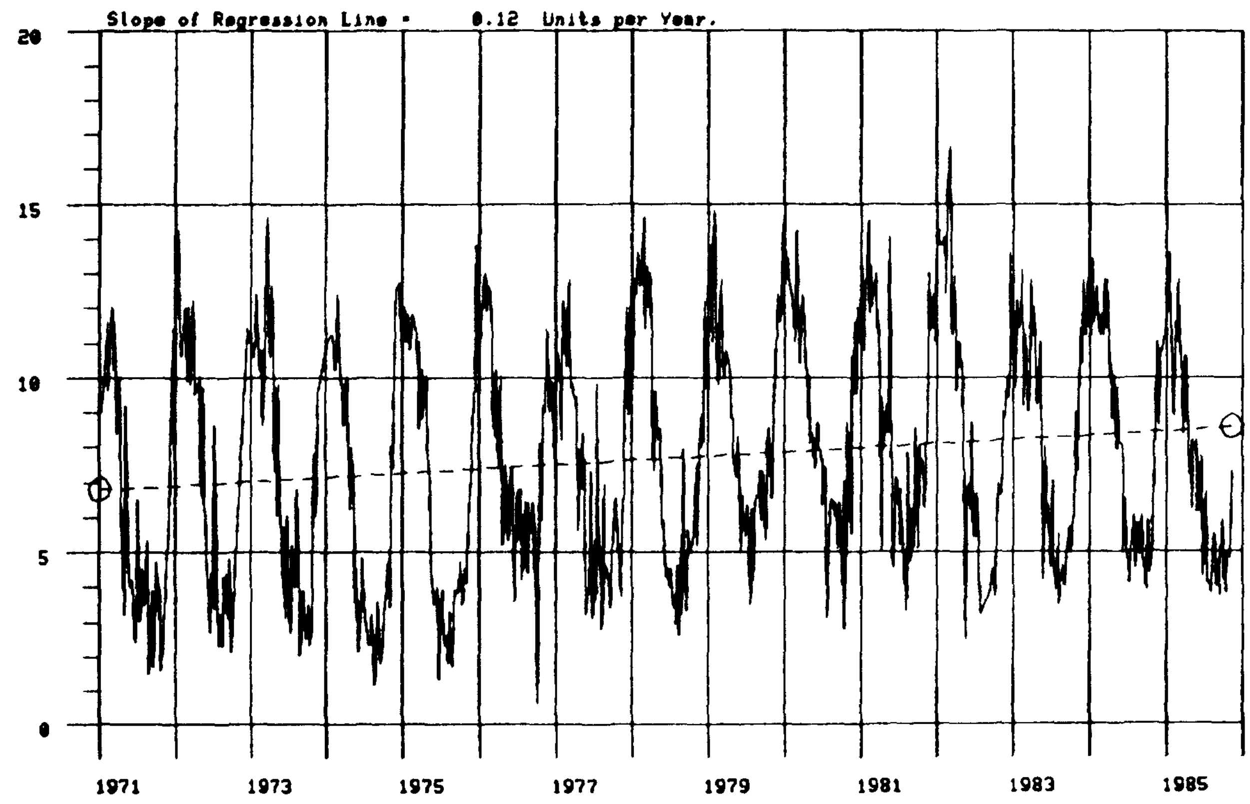


Station 600880
RM 124.4

STORET System

```
39 49 57.0 083 00 30.0  2
SCIOTO R. AT SHADEVILLE - S.R. 665  (RM 119.90)
39049 OHIO              FRANKLIN
OHIO RIVER                051091
SCIOTO RIVER
210HIO    05060001                    /TYPA/AMBNT/STREAM
                    DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 119.90
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
299	DO	PROBE	MG/L	773	7.7	16.6	0.6	71/01/04	85/11/07



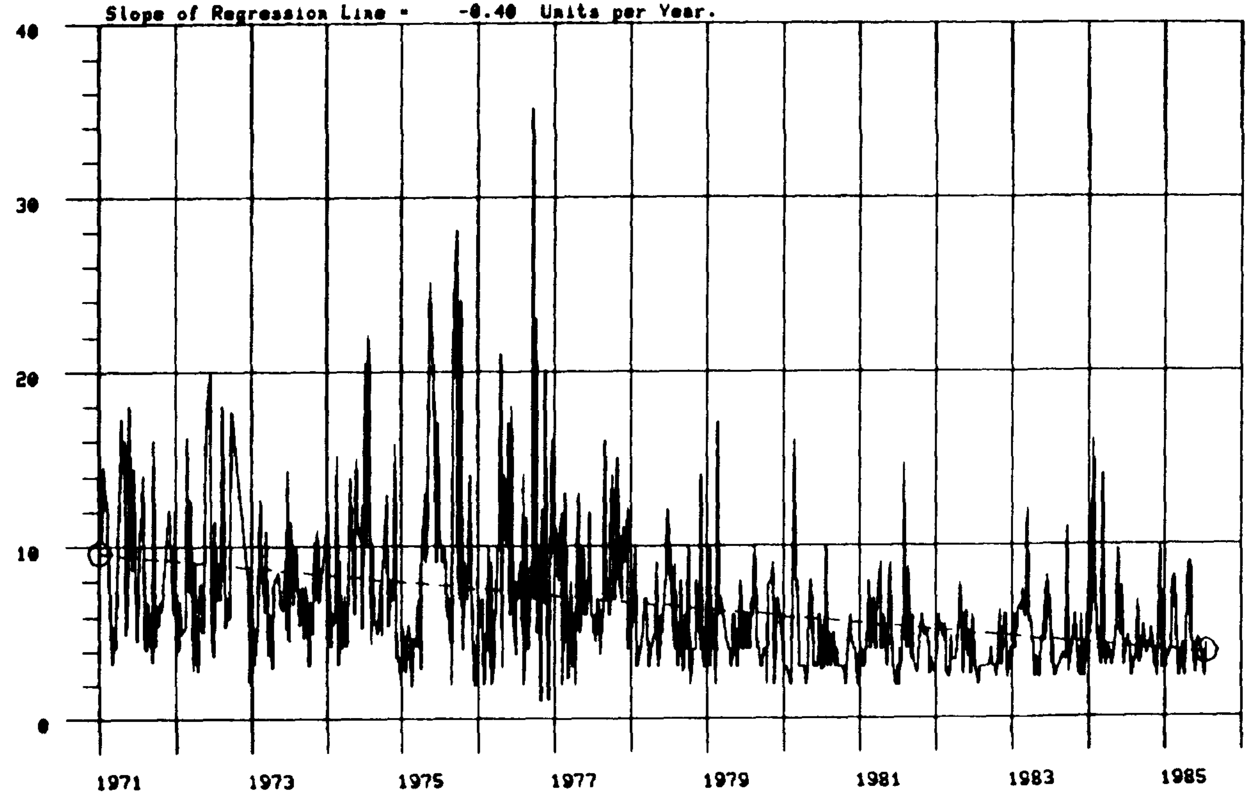
Station 600810
RM 119.9

STORET System

```
39 49 57.0 083 00 30.0  2
SCIOTO R. AT SHADEVILLE - S.R. 665  (RM 119.90)
39049 OHIO              FRANKLIN
OHIO RIVER               051091
SCIOTO RIVER
21OHIO   05060001                    /TYPA/AMBNT/STREAM
                   DEPTH    0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 119.90
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
310	BOD	5 DAY	MG/L	705	6.6	35.0	1.0	71/01/04	85/07/19

Slope of Regression Line = -0.40 Units per Year.



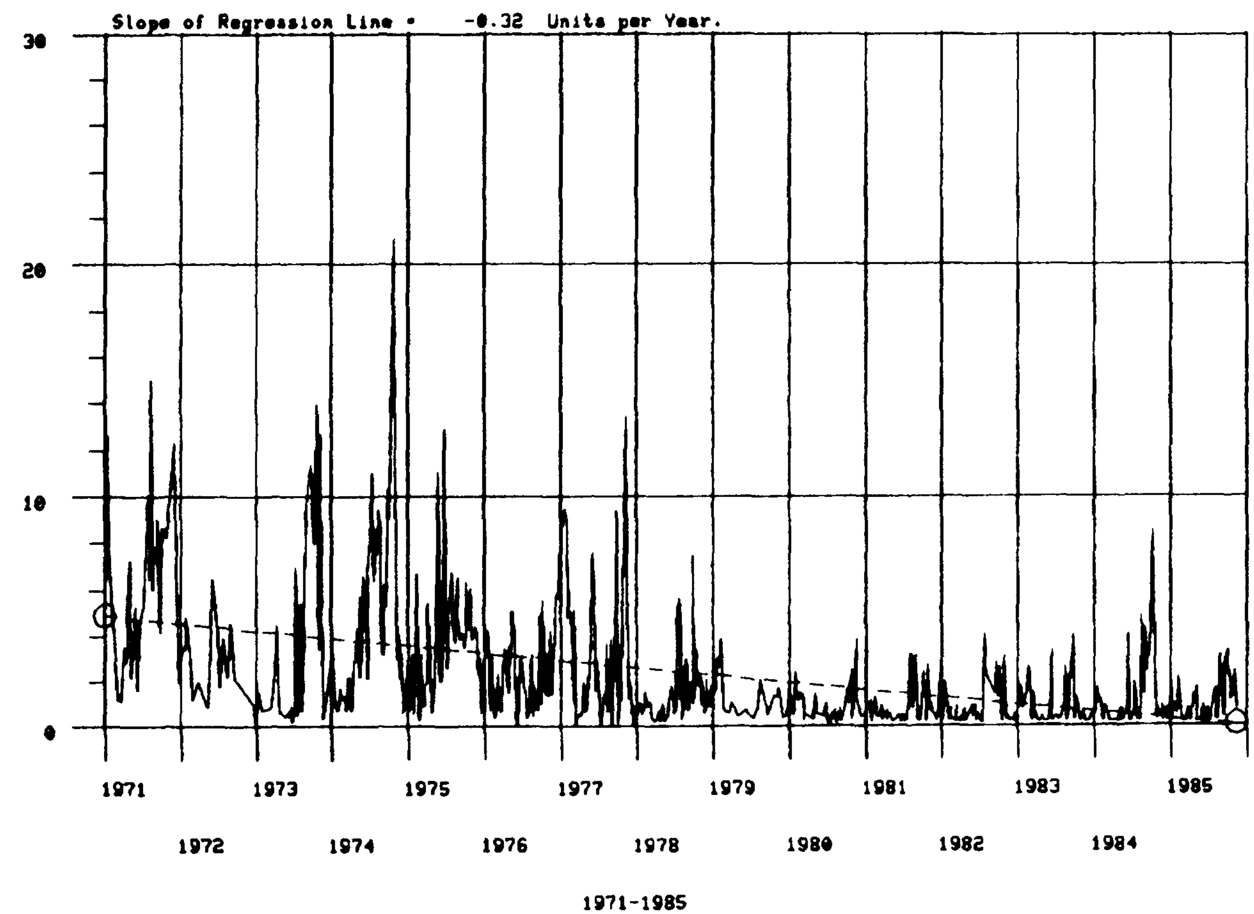
1971-1985

Station 600810
RM 119.9

STORET System

```
39 49 57.0 083 00 30.0  2
SCIOTO R. AT SHADEVILLE - S.R. 665  (RM 119.90)
39049 OHIO              FRANKLIN
OHIO RIVER                051091
SCIOTO RIVER
21OHIO    05060001                /TYPA/AMBNT/STREAM
                   DEPTH      0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 119.90
```

PARAMETER		NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
610 NH3+NH4- N TOTAL	MG/L	687	2.293	21.070	0.000	71/01/04	85/11/07



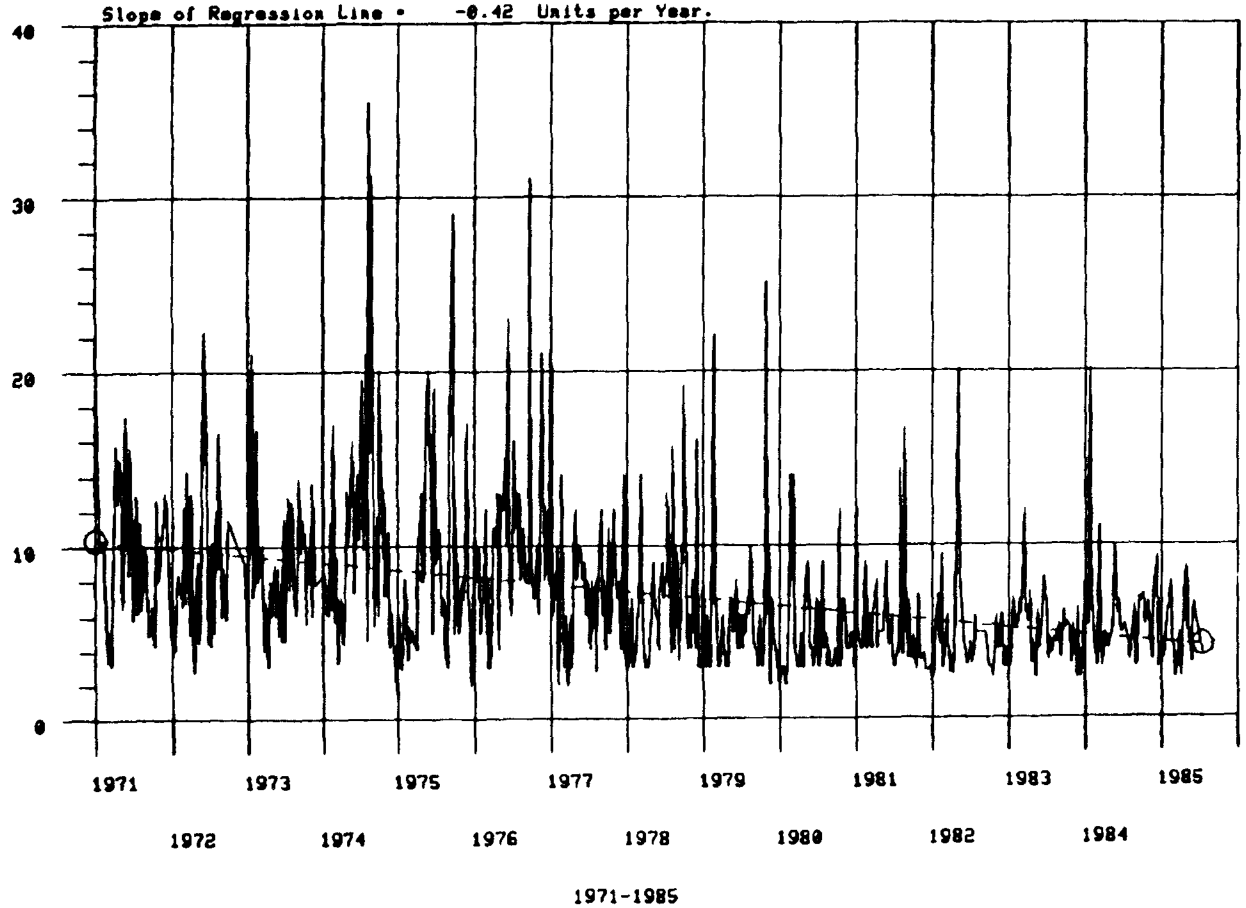
Station 600810
RM 119.9

STORET System

```
39 46 27.0 083 00 27.0  2
SCIOTO R. NR COMMERCIAL POINT - S.R. 762
39129 OHIO              PICKAWAY
OHIC RIVER               051091
SCIOTO RIVER
21OHIO   05060001                /TYPA/AMBNT/STREAM
                  DEPTH    0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 115.31
```

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
310	BOD	5 DAY	MG/L	717	7.2	35.4	1.4	71/01/04	85/07/19

Slope of Regression Line = -0.42 Units per Year.

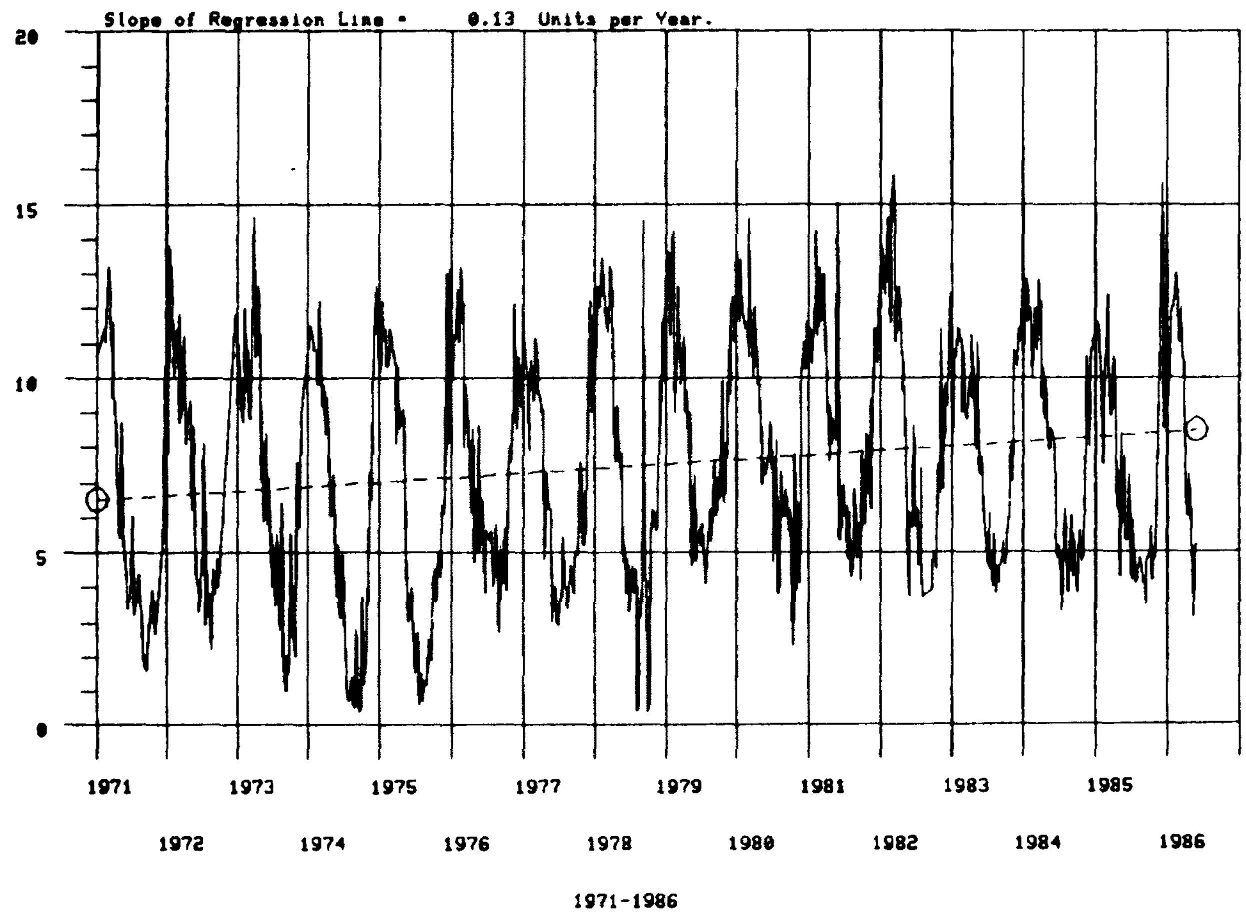


Station 600900
RM 115.31

STORET System

39 46 27.0 083 00 27.0 2
SCIOTO R. NR COMMERCIAL POINT - S.R. 762
39129 OHIO PICKAWAY
OHIO RIVER 051091
SCIOTO RIVER
21OHIO 05060001 /TYPA/AMBNT/STREAM
DEPTH 0
INDEX 1021500 007720 13190
MILES 953.80 624.93 115.31

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
299	DO	PROBE	MG/L	795	7.5	15.8	0.4	71/01/04	86/05/27

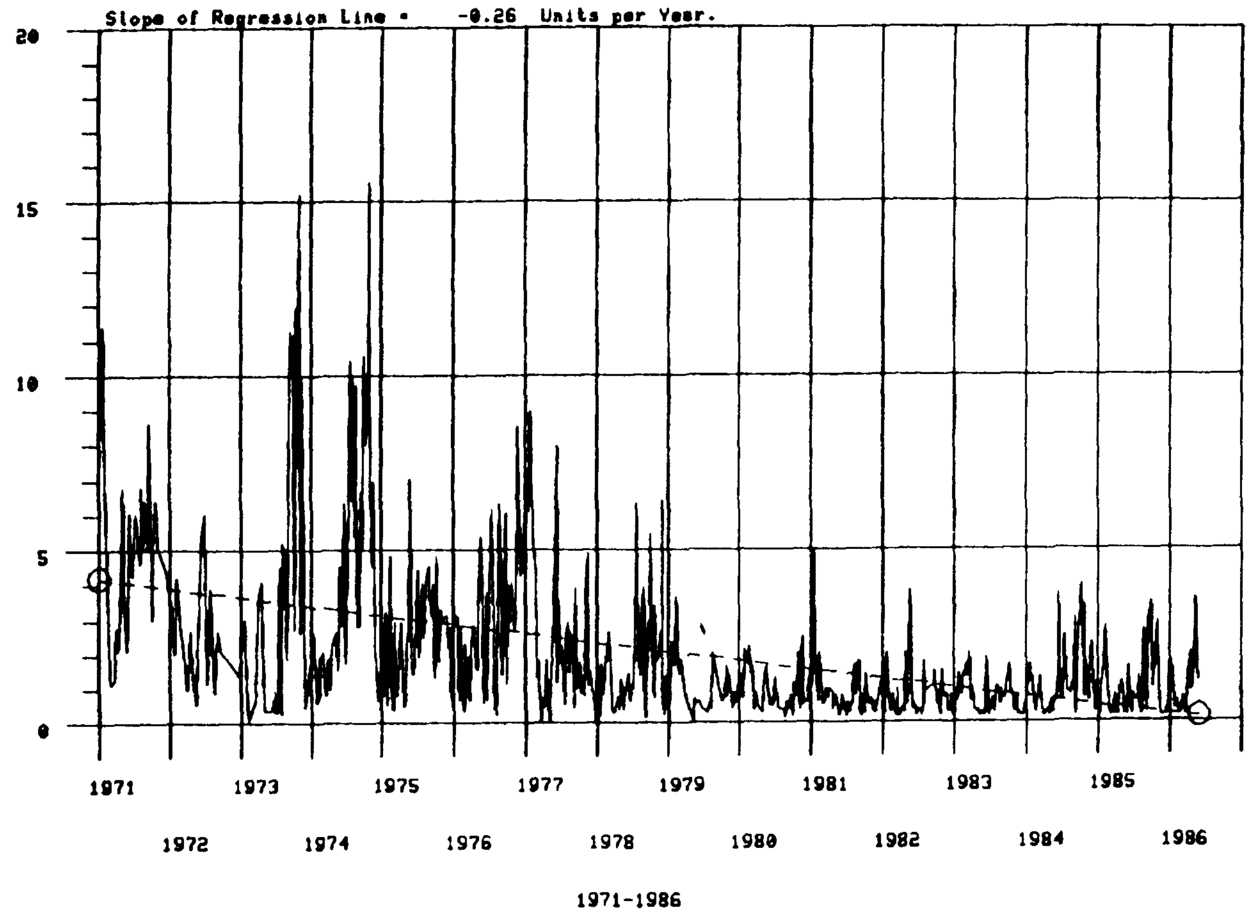


Station 600900
RM 115.31

STORET System

```
39 46 27.0 083 00 27.0  2
SCIOTO R. NR COMMERCIAL POINT - S.R. 762
39129 OHIO             PICKAWAY
OHIO RIVER               051091
SCIOTO RIVER
21OHIO   05060001               /TYPA/AMBNT/STREAM
                   DEPTH     0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 115.31
```

PARAMETER		NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
610 NH3+NH4- N TOTAL	MG/L	716	1.993	15.470	0.000	71/01/04	86/05/27



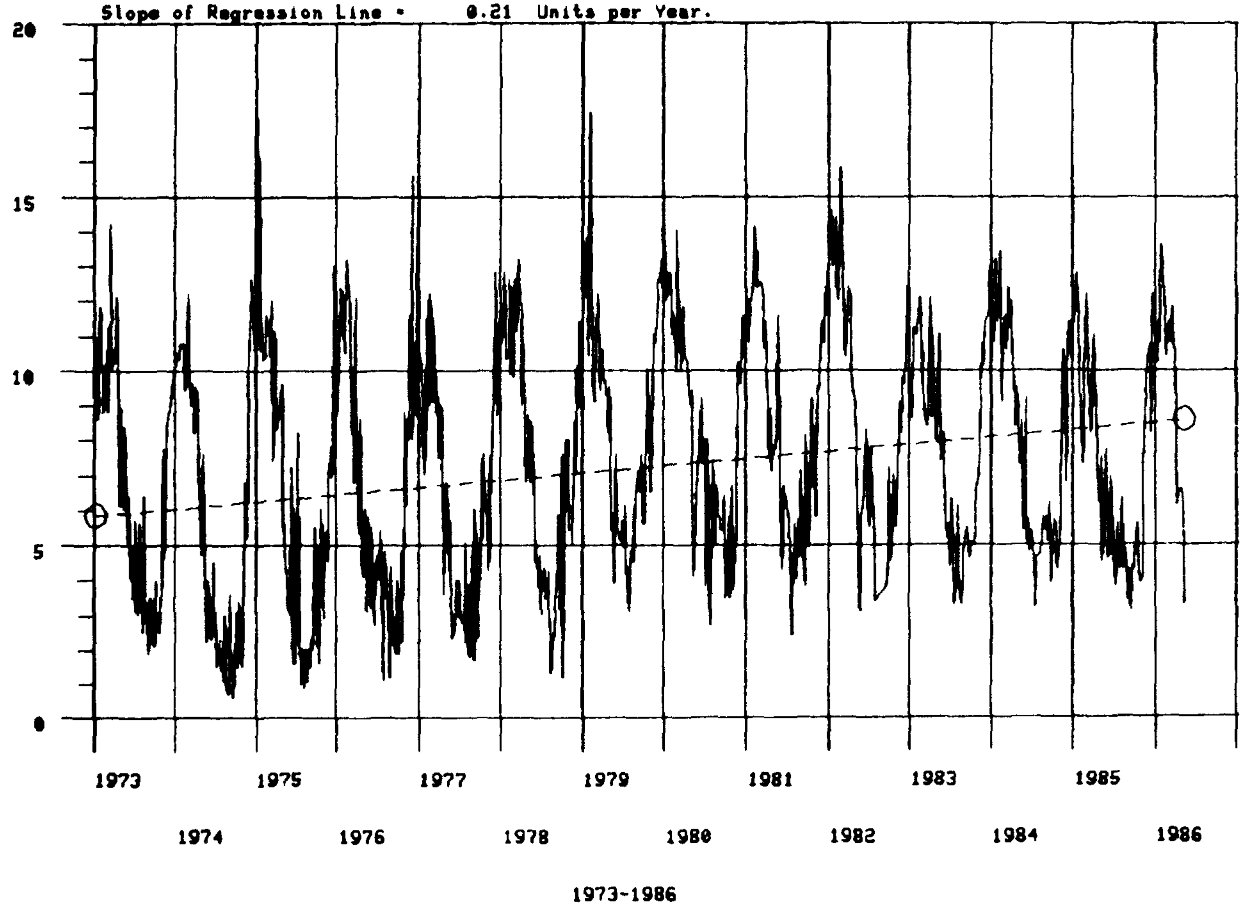
Station 600900
RM 115.31

STORET System

```
39 43 10.0 083 00 45.0  2
SCIOTO R. NR SOUTH BLOOMFIELD - S.R. 316
39129 OHIO              PICKAWAY
OHIO RIVER                051091
SCIOTO RIVER
21OHIO   05060001                   /TYPA/AMBNT/STREAM
                   DEPTH    0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 109.37

          PARAMETER                            NOBS      AVE       MAX       MIN  BEG-DATE  END-DATE
    299     DO      PROBE       MG/L           894       7.0       17.4      0.6  73/01/04  86/05/09
```

Slope of Regression Line = 0.21 Units per Year.



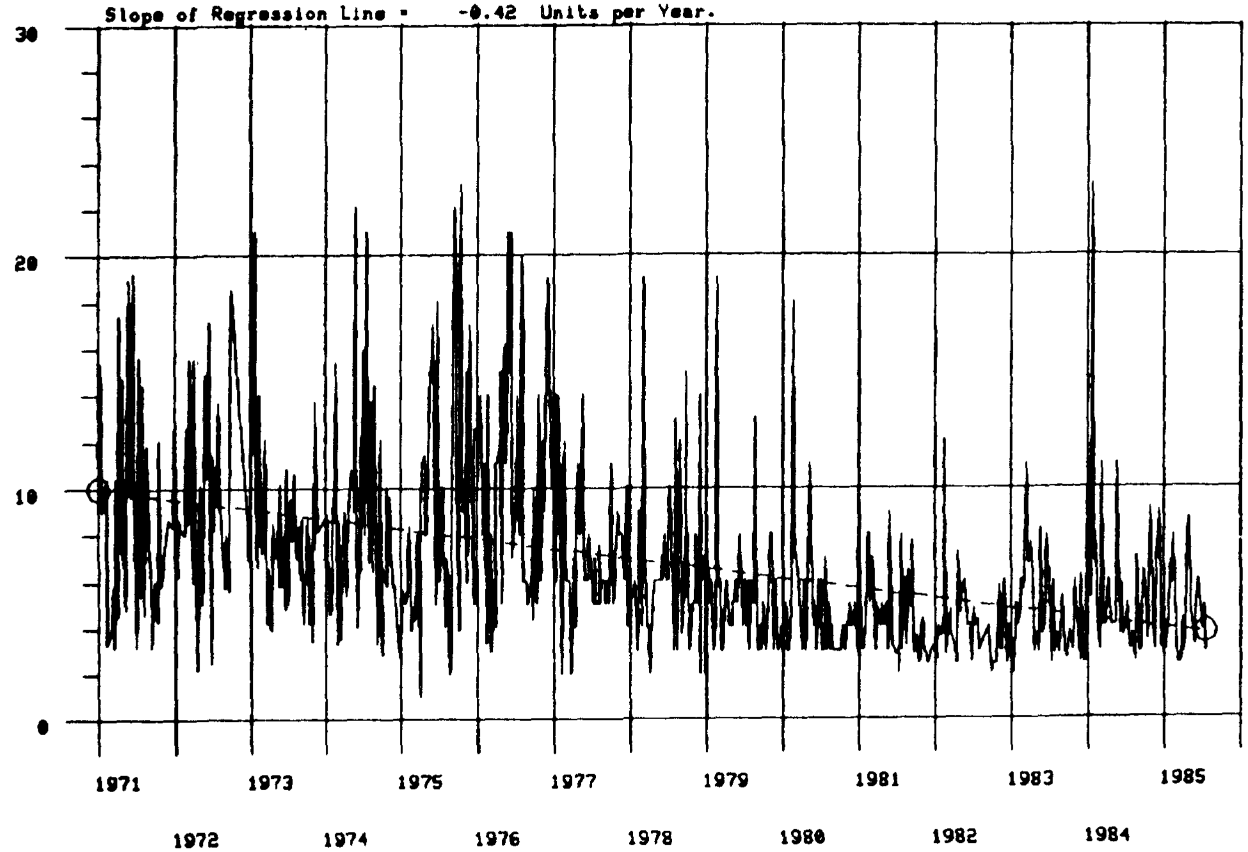
Station 600910
RM 109.37

STORET System

39 43 10.0 083 00 45.0 2
SCIOTO R. NR SOUTH BLOOMFIELD - S.R. 316
39129 OHIO PICKAWAY
OHIO RIVER 051091
SCIOTO RIVER
21OHIO 05060001 /TYPA/AMBNT/STREAM
DEPTH 0
INDEX 1021500 007720 13190
MILES 953.80 624.93 109.37

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
310	BOD	5 DAY	MG/L	702	6.8	23.0	1.0	71/01/04	85/07/19

Slope of Regression Line = -0.42 Units per Year.



1971-1985

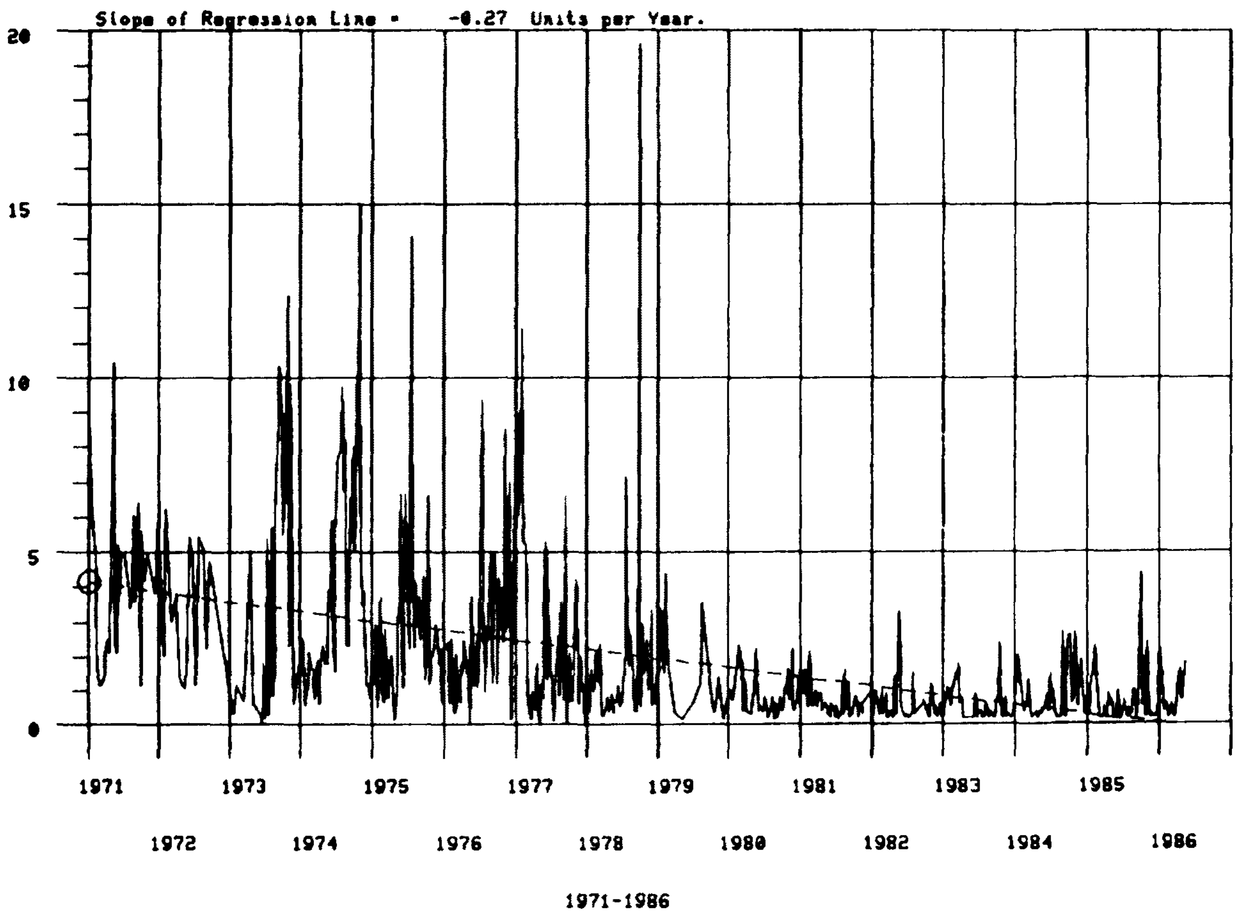
Station 600910
RM 109.37

STORET System

39 43 10.0 083 00 45.0 2
SCIOTO R. NR SOUTH BLOOMFIELD - S.R. 316
39129 OHIO PICKAWAY
OHIO RIVER 051091
SCIOTO RIVER
21OHIO 05060001 /TYPA/AMBNT/STREAM

		DEPTH	0
INDEX	1021500	007720	13190
MILES	953.80	624.93	109.37

PARAMETER		NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
610 NH3+NH4- N TOTAL	MG/L	685	1.886	19.600	0.000	71/01/04	86/05/09



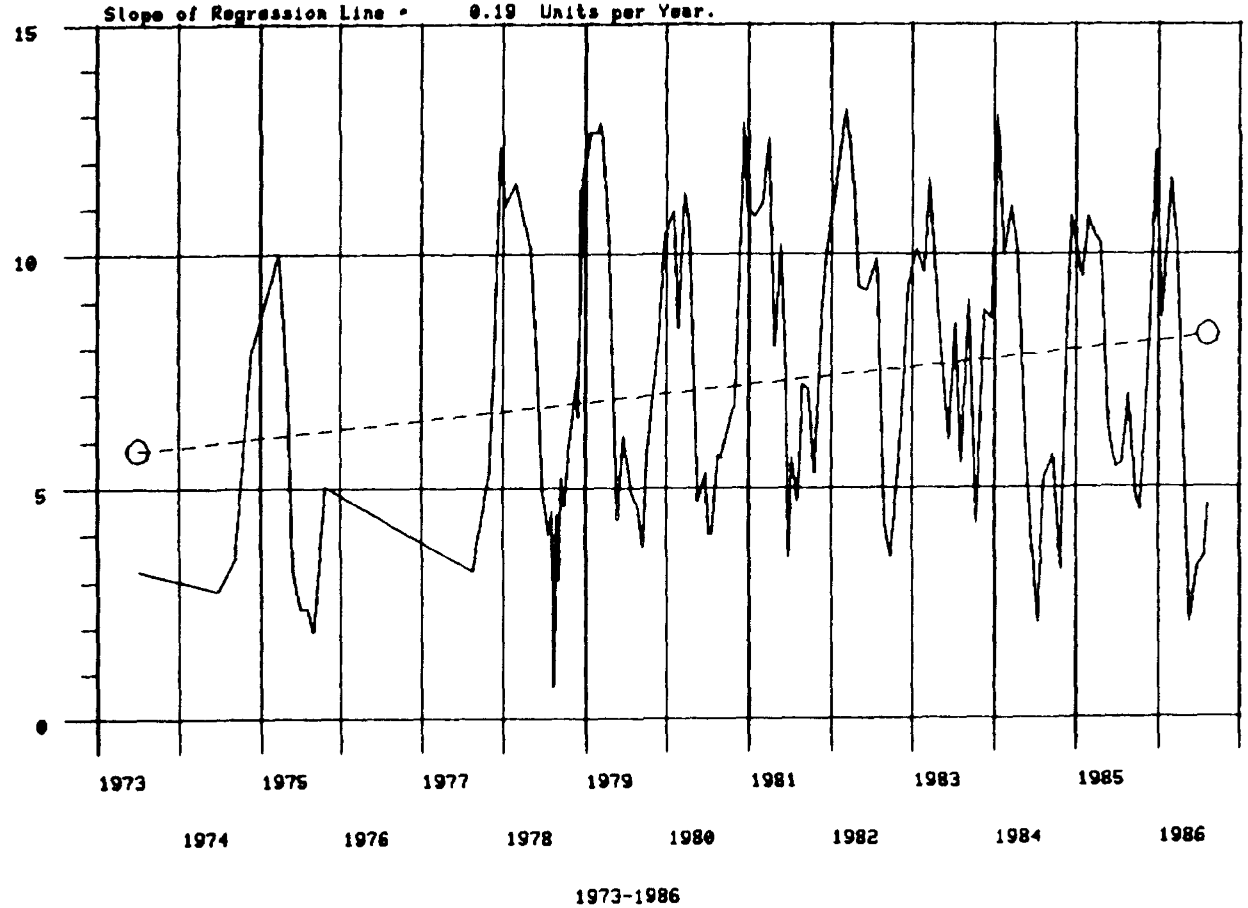
Station 600910
RM 109.37

STORET System

39 37 58.0 082 57 45.0 2
SCIOTO R. UPST CIRCLEVILLE - FLORENCE CHAPEL RD.
39129 OHIO PICKAWAY
OHIO RIVER 051000
SCIOTO RIVER
21OHIO 05060001 /TYPA/AMBNT/STREAM
780210 DEPTH 0
INDEX 1021500 007720 13190
MILES 953.80 624.93 102.14

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
299	DO	PROBE	MG/L	140	7.2	13.1	0.7	73/06/28	86/08/04

Slope of Regression Line = 0.19 Units per Year.



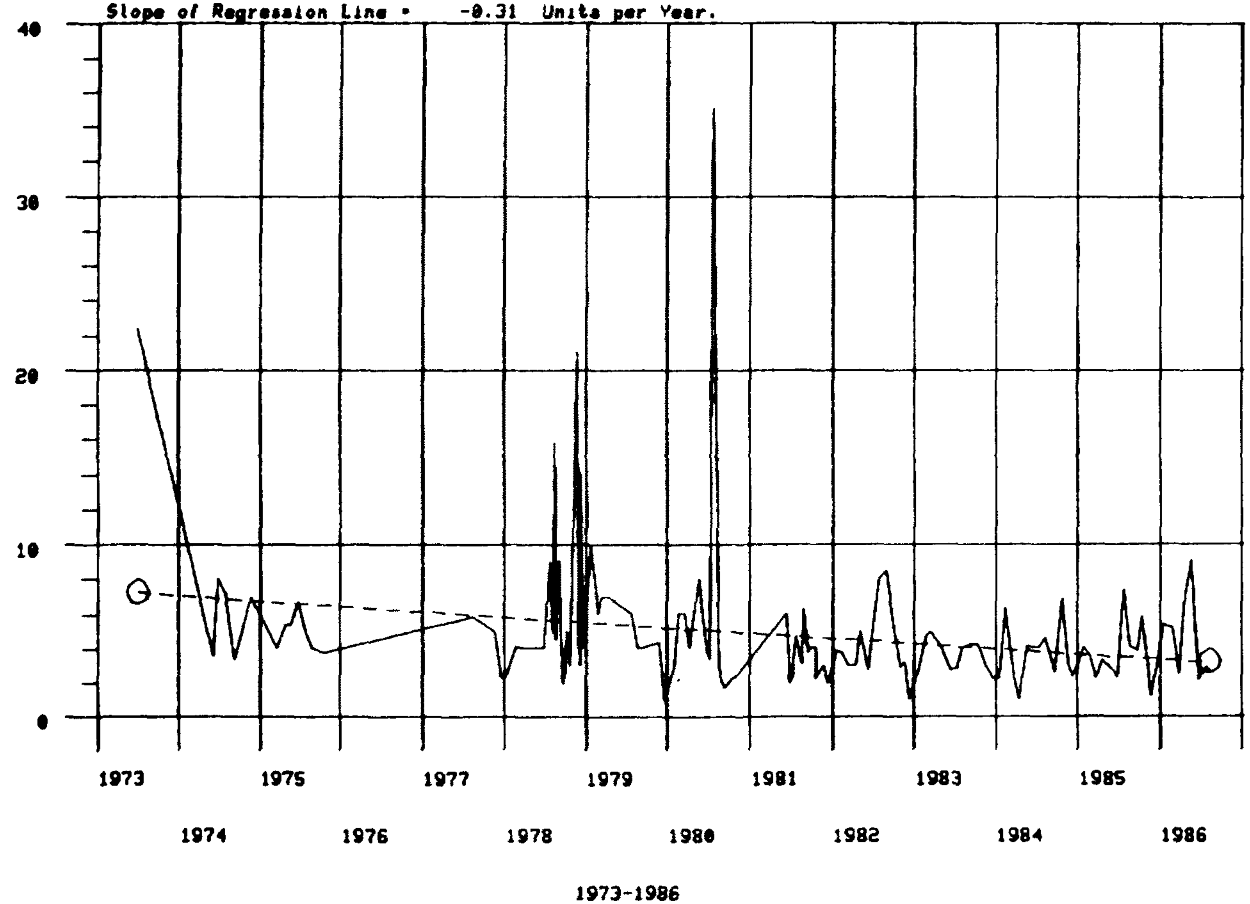
Station 600340
RM 102.14

STORET System

39 37 58.0 082 57 45.0 2
SCIOTO R. UPST CIRCLEVILLE - FLORENCE CHAPEL RD.
39129 OHIO PICKAWAY
OHIO RIVER 051000
SCIOTO RIVER
21OHIO 05060001 /TYPA/AMBNT/STREAM
780210 DEPTH 0
INDEX 1021500 007720 13190
MILES 953.80 624.93 102.14

	PARAMETER			NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
310	BOD	5 DAY	MG/L	135	4.9	35.0	0.9	73/06/28	86/08/04

Slope of Regression Line = -0.31 Units per Year.

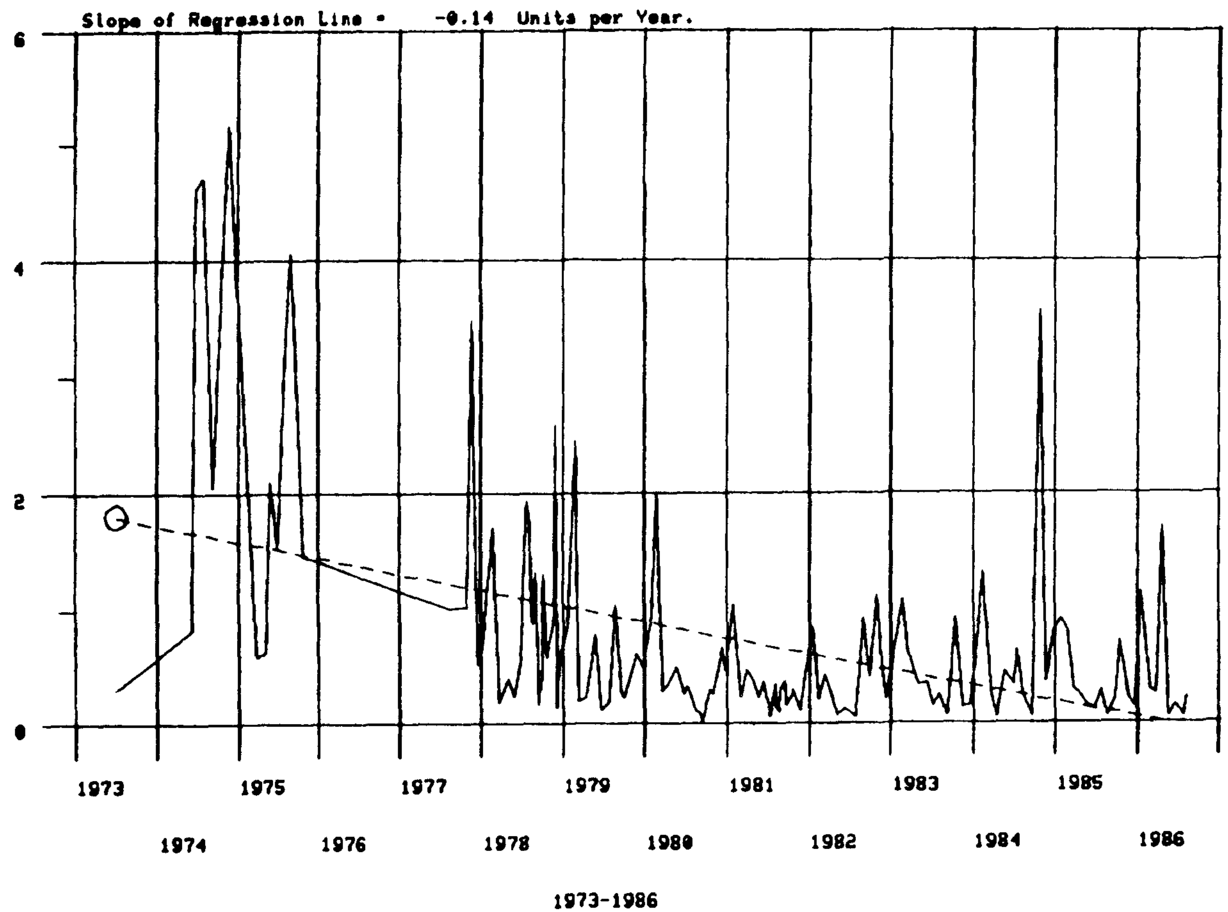


Station 600340
RM 102.14

STORET System

```
39 37 58.0 082 57 45.0  2
SCIOTO R. UPST CIRCLEVILLE - FLORENCE CHAPEL RD.
39129 OHIO             PICKAWAY
OHIO RIVER               051000
SCIOTO RIVER
21OHIO    05060001                /TYPA/AMBNT/STREAM
        780210      DEPTH    0
 INDEX 1021500  007720  13190
 MILES  953.80  624.93 102.14
```

PARAMETER		NOBS	AVE	MAX	MIN	BEG-DATE	END-DATE
610 NH3+NH4- N TOTAL	MG/L	146	0.733	5.160	0.020	73/06/28	86/08/04



Station 600340
RM 102.14

APPENDIX H

TABLES OF ENDANGERED SPECIES

TABLE H-1. ENDANGERED FAUNA SPECIES KNOWN TO OCCUR IN THE COLUMBUS FACILITIES PLANNING AREA, OHIO[a]

Species	State Endangered	Federally Endangered	Remarks
Indiana bat (*Myotis sodalis*)	x	x	Habitat requirements are not fully known.
Peregrin falcon (*Falco peregrinus*)	x	x	Occurs as an uncommon migrant.
Bald eagle (*Haliaeetus leucocephalus*)	x	x	Occurs as an uncommon migrant.
Kirtland's warbler (*Dendroica kirtlandii*)	x	x	Occurs as an uncommon migrant.
Upland sandpiper (*Bartramia longicauda*)	x		May occur in suitable, grassy habitat anywhere in the country. Recent records exist for Bolton Field and Rickenbacker Air Base.
Common tern (*Sterna Hirundo*)	x		Occurs as an uncommon migrant.
Four-toed salamander (*Hemidactyliumd scutatum*)	x		Requires a bog-like habitat. A recent record exists for the northeastern corner of the country.
Northern brook lamprey (*Icthyomyzon fossor*)	x		Rare occurrence in Big Walnut Creek and Big Run (tributary of Olentangy River).
Paddlefish (*Polyodon spathula*)	x		One specimen observed in Scioto River below Greenlawn Dam in 1976.
Blacknose shiner (*Notropis heterolepis*)	x		Population in Rocky Fork Creek (tributary of Big Walnut Creek, northeast Franklin County).
River redhorse (*Moxostoma carinatum*)	x		Known population in Scioto River and tributaries.

TABLE H-1. ENDANGERED FAUNA SPECIES KNOWN TO OCCUR IN THE COLUMBUS FACILITIES PLANNING AREA, OHIO[a] (Continued)

Species	State Endangered	Federally Endangered	Remarks
Slenderhead darter (Percina phoxocephala)	x		Known population in Big Walnut and Big Darby Creeks.
Spotted darter (Etheostoma Maculatum)	x		Small population in Olentangy River and Big Walnut Creeks.
Lake Chubsucker (Erimyzon succtta)[b]			
Shortnose gar (Lepisosteus platostomius)[b]			
Mooneye (Hiodon tergisus)[c]			
Tippecanoe darter (Ethestoma tippecanoe)[d]	x		Collected just downstream of FPA at Circleville.
Scioto madtom (Noturus trautmani)[d,e]	x	x	Found only in Big Darby
Piping plover (charadrius melodus)[f]		x	Last seen at the Jackson Pike Wastewater Treatment plant in the 1940's.

[a]Source: Ohio Department of Natural Resources 1986, unless otherwise noted.

[b]Source: OEPA 1986a.

[c]Source: Yoder 1987; Ohio Department of Natural Resources 1986.

[d]Source: Cavender 1986.

[e]Source: Multerer 1986.

[f]Source: Huff 1988

TABLE H-2. LIST OF STATE AND FEDERALLY ENDANGERED PLANT SPECIES IN OHIO

Selaginella rupestris, Rock Spikemoss
Isoetes engelmannii, Appalachian Quillwort
Botrychium lanceolatum, Triangle Grape-fern
Ophioglossum engelmannii, Limestone Adder's-tongue
Trichomanes boschianum, Appalachian Filmy Fern
Polypodium polypodioides, Little Gray Polypody
Dryopteris clintoniana, (D. cristata var. clintoniana) Clinton's Wood Fern
Sparganium androcladum, Keeled Bur-reed
Sparganium chlorocarpum, Small Bur-reed
Potamogeton filiformis, Filiform Pondweed
Potamogeton gramineus, Grass-like Pondweed
Potamogeton hillii, Hill's Pondweed
Potamogeton praelongus, White-stem Pondweed
Potamogeton robbinsii, Robbin's Pondweed
Potamogeton tennesseensis, Tennessee Pondweed
Scheuchzeria palustris, Scheuchzeria
Sagittaria graminea, Grass-leaf Arrowhead
Cinna latifolia, Northern Wood-reed
Danthonia compressa, Flattened Wild Oat Grass
Digitaria filiformis, Slender Finger-grass
Glyceria acutiflora, Sharp-glumed Manna-grass
Koeleria macrantha (K. cristata), Junegrass
Melica nitens, Three-flowered Melic
Muhlenbergia cuspidata, Plains Muhlenbergia
Oryzopsis asperifolia, Large-leaved Mountain-rice
Panicum bicknellii, Bicknell's Panic-grass
Panicum boreale, Northern Panic-grass
Panicum leibergii, Leiberg's Panic-grass
Panicum villosissimum, Villous Panic-grass
Panicum yadkinense, Spotted Panic-grass
Poa wolfii, Wolf's Bluegrass
Schizachne purpurascens, False Melic
Carex aquatilis, Leafy Tussock Sedge
Carex arctata, Drooping Wood Sedge
Carex argyrantha, Silvery Sedge
Carex atherodes, Wheat Sedge
Carex bebbii, Bebb's Sedge
Carex cryptolepis (C. flava var. fertilis), Little Yellow Sedge
Carex debilis var. debilis, Weak Sedge
Carex decomposita, Cypress-knee Sedge
Carex folliculata, Long Sedge
Carex garberi, Garber's Sedge
Carex gravida, Heavy Sedge
Carex haydenii, Hayden's Sedge
Carex louisianica, Louisiana Sedge
Carex nigromarginata, Black-margined Sedge
Carex ormostachya, Stiff Broad-leaved Sedge
Carex pallescens, Pale Sedge
Carex sprengelii, Sprengel's Sedge
Carex striatula, Lined Sedge
Cyperus acuminatus, Pale Umbrella-sedge

TABLE H-2. LIST OF STATE AND FEDERALLY ENDANGERED PLANT SPECIES IN OHIO (Continued)

Cyperus dipsaciformis, Teasel-sedge
Rhynchospora globularis, Grass-like Beak-rush
Scirpus expansus, Woodland Bulrush
Scirpus smithii, Smith's Bulrush
Scirpus subterminalis, Swaying Rush
Wolffiella floridana, Wolffiella
Juncus interior, Inland Rush
Clintonia borealis, Bluehead-lily
Lilium philadelphicum, Wood-lily
Melanthium virginicum, Bunchflower
Nothoscordum bivalve, False Garlic
Smilax pulverulenta, Downy Carrion-flower
Streptopus roseus, Rose Twisted-stalk
Iris brevicaulis, Leafy Blue Flag
Iris verna, Dwarf Iris
Sisyrinchium atlanticum, Atlantic Blue-Eyed-grass
Sisyrinchium montanum, Northern Blue-eyed-grass
Arethusa bulbosa, Dragon's-mouth
Coeloglossum viride (Habenaria viridis), Long-bracted Orchid
Corallorhiza trifida, Early Coral-root
Corallorhiza wisteriana, Spring Coral-root
Cypripedium calceolus var. parviflorum, Small Yellow Lady's-slipper
Cypripedium candidum, White Lady's-slipper
Hexalectris spicata, Crested Coral-root
Platanthera blephariglottis (Habenaria blephariglottis), White Fringed Orchid
Spiranthes romanzoffiana, Hooded Ladies'-tresses
Populus balsamifera, Balsam Poplar
Populus heterophylla, Swamp Cottonwood
Salix caroliniana, Carolina Willow
Salix pedicellaris, Bog Willow
Myrica pensylvanica, Bayberry
Ulmus thomasii, Rock Elm
Urtica chamaedryoides, Spring Nettle
Polygonum cilinode, Mountain Bindweed
Polygonum ramosissimum, Bushy Knotweed
Chenopodium leptophyllum (sensu Fernald 1950), Slender Goosefoot
Froelichia floridana, Cottonweed
Arenaria patula, Spreading Sandwort
Silene caroliniana var. wherryi, Wherry's Catchfly
Nuphar variegatum, Bullhead Lily
Aconitum noveboracense, Northern Monkshood
Aconitum uncinatum, Southern Monkshood
Actaea rubra, Red Baneberry
Ranunculus pusillus, Low spearwort
Trollius laxus, Spreading Globe-flower
Magnolia macrophylla, Bigleaf Magnolia
Magnolia tripetala, Umbrella Magnolia
Arabis divaricarpa, Limestone Rock-cress

TABLE H-2. LIST OF STATE AND FEDERALLY ENDANGERED PLANT SPECIES IN OHIO (Continued)

Arabis drummondii, Drummond's Rock-cress
Arabis patens, Spreading Rock-cress
Draba brachycarpa, Little Whitlow-grass
Draba cuneifolia, Wedge-leaf Whitlow-grass
Draba reptans, Carolina Whitlow-grass
Erysimum arkansanum (E. capitatum), Western Wall-flower
Drosera intermedia, Spathulate-leaved Sundew
Ribes missouriense, Missouri Gooseberry
Ribes rotundifolium, Appalachian Gooseberry
Ribes triste, Swamp Red Currant
Amelanchier sanguinea, Rock Serviceberry
Dalibarda repens, Robin-run-away
Potentilla arguta, Tall Cinquefoil
Prunus nigra, Canada Plum
Pyrus decora (Sorbus decora), Western Mountain-ash
Rubus setosus, Small Bristleberry
Astragalus neglectus, Cooper's Milk-vetch
Baptisia australis, Blue False Indigo
Desmodium illinoense, Prairie Tick-trefoil
Desmodium sessilifolium, Sessile Tick-trefoil
Galactia volubilis, Milk-pea
Lathyrus venosus, Wild Pea
Oxalis montana (O. acetosella), White Wood-sorrel
Geranium bicknellii, Bicknell's Crane's-bill
Polygala cruciata, Cross-leaved Milkwort
Polygala curtissii, Curtiss' Milkwort
Euphorbia serpens, Roundleaf Spurge
Phyllanthus caroliniensis, Carolina Leaf-flower
Paxistima canbyi, Cliff-green
Acer pensylvanicum, Striped Maple
Caenothus herbaceus (C. ovatus), Prairie Redroot
Hypericum denticulatum, Coppery St. John's-wort
Hudsonia tomentosa, Beach-heather
Viola missouriensis, Missouri Violet
Viola nephrophylla, Northern Bog Violet
Viola primulifolia, Primrose-leaved Violet
Viola tripartita var. glaberrima (forma glaberrima), Wedge-leaf Violet
Viola walteri, Walter's Violet
Arlia hispida, Bristly Sarsaparilla
Hydrocotyle umbellata, Navelwort
Ledum groenlandicum, Labrador-tea
Rhododendron calendulaceum, Flame Azalea
Vaccinium myrtilloides, Velvet-leaf Blueberry
Vaccinium oxycoccos, Small Cranberry
Hottonia inflata, Featherfoil
Halesia carolina, Silverbell
Styrax americanus, Snowbell
Gentiana puberulenta (G. puberula), Prairie Gentian
Gentiana saponaria, Soapwort Gentian
Cuscuta compacta, Sessile Dodder
Cynoglossum virginianum var. boreale (C. boreale), Northern Wild Comfrey

TABLE H-2. LIST OF STATE AND FEDERALLY ENDANGERED PLANT SPECIES IN OHIO (Continued)

Collinsonia verticillata (Micheliella verticillata), Early Stoneroot
Monarda punctata, Dotted Horsemint
Trichostema dichotomum var. lineare (T. setaceum), Narrow-leaved Bluecurls
Agalinis auriculata (Gerardia auriculata; Tomanthera auriculata), Ear-leaf Foxglove
Agalinis purpurea var. parviflora (A. paupercula var. pauperula and var. borealis; Gerardia paupercula var. paupercula and var. borealis), Small Purple Foxglove
Agalinis skinneriana (Gerardia skinneriana), Skinner's Foxglove
Aureolaria pedicularia var. ambigens (Gerardia pedicularia var. ambigens), Prairie Fern-leaf False Foxglove
Orobanche ludoviciana, Louisiana Broom-rape
Utricularia cornuta, Horned Bladderwort
Plantago cordata, Heart-leaf Plantain
Galium labradoricum, Bog Bedstraw
Galium palustre, Marsh Bedstraw
Symphoricarpos albus var. albus, Snowberry
Cirsium carolinianum, Carolina Thistle
Eupatorium hyssopifolium, Hyssop Thoroughwort
Heterotheca graminifolia (Chrysopsis graminifolia), Silkgrass
Hieracium canadense, Canada Hawkweed
Hieracium longipilum, Long-bearded Hawkweed
Hymenoxys acaulis (Actinea herbacea), Lakeside Daisy
Prenanthes aspera, Rough Rattlesnake-root
Silphium laciniatum, Compass-plant
Solidago odora, Sweet Goldenrod
Verbesina occidentalis, Yellow Crownbeard

TABLE H-3. ENDANGERED UNIONID MOLLUSCS KNOWN TO HAVE INHABITED THE SCIOTO RIVER SYSTEM

Scientific Name	Common Name
Simpsonaias ambigua	Simpson's Shell
Quadrula cylindrica	Cob Shell
Quadrula metaneura	Knobbed Rock Shell
Quadrula nodulata	Winged Pimpleback
Fusconaia maculata	Long-solid
Plethobasus cyphyus	Common Bullhead
Pleurobema clava	Club Shell
Pleurobema cordatum	Ohio Pigtoe
Cyprogenia stegaria	Ohio Fan Shell
Potamilus laevissimus	Fragile Heel-Splitter
Lampsilis teres	Yellow Sand Shell
Lampsilis orbiculata	Pink Mucket Pearly Mussel
Lampsilis ovata	Ridged Pocketbook

Table H-4. Rare or endangered fish species collected during the 1979-1981 sampling period and/or listed as occurring in the central Scioto River mainstem study area by the Ohio Department of Natural Resources, Heritage Program. (Source: Ohio EPA 1986a).

Species	ODNR Status	ODNR Locations, Year	Ohio EPA collections, dates
Lake chubsucker	Endangered	Circleville Canal off Rd 100 (1974, 1981)	Not collected
Bluebreast darter	Threatened	1) Scioto R at mouth of Deer Cr. (1961) 2) Scioto R near Circleville (1962) 3) Scioto R. below Big Darby confluence (1963)	Not collected
Goldeye	Undetermined	1) Scioto R. at Greenlawn Ave. (1959) 2) Scioto R. dst. Big Darby Cr. confluence (1962)	RM 74.1 (1981)
Silver lamprey	Endangered	Scioto R at Chillicothe (1964)	Not collected (only below Chillicothe, 1979)
Shortnose gar	Endangered	Scioto R. dst. Chillicothe 1973	RM 118.8 (1981)
River redhorse	Endangered	1) Scioto R. ust. Big Darby Cr. (1962) 2) Scioto R. dst. Dublin Rd. WTP dam (1979)	RM 70.7 (1980) RM 78.3 (1979) RM 102.0 (1979) RM 102.0 (1981) RM 104.8 (1979) RM 134.8 (1981) RM 138.6 (1981)
Shorthead redhorse	Undetermined	1) *M. breviceps* - Scioto R. at Chillicothe (1964)	RM 138.6-70.7 (72 fish; 1979-1981) Olentangy R. (1980) Big Walnut Cr. (1980,1981)
Paddlefish	Endangered	Scioto R. dst. Greenlawn dam (1976)	Not collected

APPENDIX I

SITES AND STRUCTURES IN THE COLUMBUS AREA LISTED ON THE NATIONAL REGISTER OF HISTORIC PLACES

APPENDIX I

The following sites/structures are listed on the National Register of Historic Places.

<u>Delaware County</u>

Ashley, Building at 500 East High Street (Eastlake Houses of Ashley Thematic Resources) (11-25-80)

Building at 505 East High Street (Eastlake Houses of Ashley Thematic Resources) (11-25-80)

Building at 101 North Franklin Street (Eastlake Houses of Ashley Thematic Resources) (11-25-80)

Building at 223 West High Street (Eastlake Houses of Ashley Thematic Resources) (11-25-80)

Ashley vicinity, Sharp, Samuel, House (Sharp's Run), 7436 Horseshoe Rd. (07-29-82)

Delaware. Delaware County Courthouse. N. Sandusky St. and Central Ave. (5-22-73) PH0034681

Delaware Public Library, 100 N. Sandusky St. (01-11-83)

Elliott Hall, Sturges Library, and Merrick Hall. Ohio Wesleyan University Campus (4-23-73) PH0094480

Monnett Hall, Ohio Wesleyan University Campus at Elizabeth and Winter Sts. (6-23-75).

Sandusky Street Historic District. 44 S. to 92 N. Sandusky, 47 E. to 31 W.

St. Mary's Church and Rectory, 82 E. William St. (5-23-80)

Van Deman, Henry, House, 6 Darlington Rd. (05-31-84)

Delaware vicinity. Greenwood Farms. S. of Delaware off U.S. 42 (4-17-79); 79/07/23 079 0001773

Limestone Vale, 3490 Olentangy River Rd. (10-2-78)

Ufferman Site, N. of Delaware (7-24-74) PH0034711

Warren Tavern Complex. U.S. 36 (08/30/83)

Galena vicinity. Curtiss, Marcus, Inn E. of Galena at 3860 Sunbury Rd. (12-12-76)

Keeler, Diadatus. House, SE of Galena at 4567 Red Bank Rd. (2-2-79) 80/01/10079 0006789

Spruce Run Earthworks. About 3 mi. S. of Galena, (7-16-73) PH0034703

Harlem vicinity. Cook, John, Farm, E. of Harlem at Miller Paul Rd. and Gorsuch Rd. (4-11-77)

Olive Green vicinity. Chambers Road Covered Bridge, 1.5 mi. NE of Olive Green (11-21-74) PH0085049

Sunbury Tavern (Hopkins House), NW corner OH 37 and Galena Rd. (2-24-75)

Sunbury Township Hall, Town Sq. (2-20-75)

Sunbury vicinity, Center Inn, SE of Sunbury on OH 37 (01/11/83)

Westerville vicinity, Sharp, Stephen, House, N. of Westerville on Africa Rd. (09/30/82)

Winter, and 9 E. to 17 W. William (12-17-82)

Worthington vicinity. Highbank Park Works. E. bank of Olentangy River (2-15-74) PH0112895

Fairfield County

Amanda, Barr House, 350 W. Main St. (11-26-80)

Amanda vicinity. Allen, Lyman, House and Barn, NW of Amanda on OH 188 (11-18-76)

Baltimore vicinity. Bright, John, Covered Bridge, 2.5 mi. SW of Baltimore over Poplar Creek (5-28-75)

Miller Farm, S of Baltimore on Pleasantville Rd. (5-22-75)

Musser, Henry, House, SE of Baltimore at 7079 Millersport Rd. (5-5-78)

Pugh-Kittle House, 2140 Bickel Church Rd. (06-16-83)

Canal Winchester. Loucks Covered Bridge, SE of Canal Winchester on SR 207 (Diley Rd.) (10-8-76)

Carroll vicinity. Ety Enclosure, NE of Carroll (7-12-74) PH0034801

Ety Habitation Site, NE of Carroll (7-24-74) PH0034819

Carroll vicinity. John Bright, No. 1 Iron Bridge, 2 mi. (3.2 km) NE of Carroll on Havensport Rd. (9-20-78)

Lancaster. Bush, Samuel, House, 1934 Cold Spring Dr. (10-1-74) PH0034762

Lancaster Historic District, Roughly bounded by 5th Ave., Penn Central

Lancaster West Main Street Historic District, W. Main St. from Columbus to Broad St. (2-2-79); 80/01/10079 0006790

Medill, William, House, 319 N. High St. (3-30-78)

Sherman, John, Birthplace, 137 E. Main St. (10-15-66) PH0034845 NHL.

Square 13 Historic District, Roughly area along Broad and High Sts. between Mulberry and Chestnut Sts. (7-24-72) PH0034851 HABS;G

St. Peter's Evangelical Lutheran Church, Broad and Mulberry Sts. (4-16-79); 79/07/23 079 0001775

Lancaster, Tallmadge-Mithoff House, 720 Lincoln Ave. (5-6-76)

Lancaster vicinity. Chestnut Ridge Farm, 3375 Cincinnati-Zanesville Rd., SW. (7-24-72) PH0034771

Concord Hall, 1445 Cincinnati-Zanesville Rd., SW. (U.S. 22) (10-25-72) PH0034789

Reber, Valentine, House, W. of Lancaster at 8325 Lancaster-Circleville Rd. (OH 188) (7-30-75)

Willow Lane Farm (Nathaniel Wilson House), SW of Lancaster on U.S. 22 (10-26-72) PH0034878

Lithopolis vicinity. Old Maid's Orchard Mound, E. of Lithopolis (7-15-74) PH0034843

Lockville. Lockville Canal Locks, Off Pickerington-Lockville Rd. (9-10-74) PH0085006

Pickerington vicinity, Dovel, J.H., Farm, 660 N. Hill Rd. (03-15-82)

Hizey Covered Bridge, E. of Pickerington on SR 235 (10-8-76)

Stemen Road Covered Bridge, NE of Pickerington over Sycamore Creek, (4-20-79); 79/07/23 079 0001776

RR tracks, OH 33 and Tennant St. (08-11-83)

Rushville, Rushville Historic District, Bremen Ave., Main and Market Sts. (11-24-80)

Rushville vicinity. Winegardner Village (7-30-74) PH0034886

Rock Mill. Rock Mill Covered Bridge, SR 41 (4-26-76)

Royalton. Royalton House, Amanda Northern Rd. (7-30-75)

Sugar Grove vicinity. Crawfis Institute, Crawfis and Old Sugar Grove Rds. (11-29-79); 80/01/10079 0006402

West Rushville, Ijams, Joseph, House, Broad and Main Sts. (06/16/83)

Franklin County

Bexley, Duncan, Robert P., House, 333 N. Parkview Ave. (08-23-84)

Jeffrey, Malcomn, House 358 N. Parkview (05-08-83)

Canal Winchester, Canal Winchester Methodist Church, S. Columbus and High Sts. (03-15-82)

Canal Winchester vicinity. Bergstresser Covered Bridge, W. of OH 674 over Walnut Creek (5-3-74) PH0070181

Central College Multiple Resource Area. This area includes: Westerville vicinity, Central College Presbyterian Church, Sunbury Rd.; Fairchild Building.

Central College vicinity. Squire's Glen Farm, 6770 Sunbury Rd. (8-13-74) PH0070432

Columbus, American Insurance Union Citadel, 50 W. Broad St. (3-21-75)

Camp Chase Site, 2900 Sullivant Ave. (4-11-73) PH0112909

Broad Street United Methodist Church, 501 E. Broad St. (11-26-80)

Columbia Building, 161-167 N. High St., (08-12-83)

Capital University Historic District, E. Main St. and College Ave. (12-17-82)

Columbus Country Club Mound, 4831 E. Broad St., (2-15-74) PH0070211

Columbus Near East Side District, Roughly bounded by Parsons Ave., Broad and Main Sts., and the railroad tracks (5-19-78)

Columbus Savings and Trust Building (Atlat Building), 8 E. Long St. (9-15-77)

Columbus Transfer Company Warehouse, 55 Nationwide Blvd. (02-24-83)

Drake, Elam, House, 2738 Ole Country Lane (4-6-78)

East Town Street Historic District, Roughly bounded by Grant and Franklin Aves., Lester Dr. and E. Rich St. (7-30-76)

Felton School, Leonard Ave. and N. Monroe St. (05-31-84)

Fort Hayes, Cleveland Ave. and I-71 (1-26-70) PH0070238

Franklin Park Conservatory, 1547 E. Broad St. (1-18-74) PH0070246

Franklinton Post Office (David Deardurf House), 72 S. Gift St. (3-20-73) PH0070254

German Village, Roughly bounded by Livingston Ave., Pear Alley, Nursery Lane, Blackberry Alley, and Lathrop St. (12-30-74) PH0044148

Great Southern Hotel and Theatre, S. High and E. Main Sts. (12-02-82)

Hamilton Park Historic District, Broad and Long Sts. (07-28-83)

Hanna House, 1021 E. Broad St. (4-19-79); 79/07/23 079 0001778

Harrison, Gen. William Henry, Headquarters (Jacob Oberdier House), 570 W. Broad St. (12-15-72) PH0070271

Hayes and Orton Halls, Ohio State University, The Oval (7-16-70)

Higgins, H.A., Building (Flatiron Building), 129 E. Naghten St. (8-27-79); 79-11-30 079 0005031

Holy Cross Church, Rectory and School, 212 S. 5th St. (4-26-79) 79/07/23 079 001779

Huntington, Franz, House, 81 N. Drexel Ave. (5-29-80)

Indianola Junior High School, 420 E. 19th Ave. (6-30-80)

Jaeger Machine Company Office Building, 550 W. Spring St. (06-16-83)

Jefferson Avenue Historic District, Roughly bounded by I-71, E. Broad, 11th, and Long Sts. (12-02-82)

Jones, W.H., Mansion, 731 E. Broad St. (10-2-78)

Krumm House, 975-979 S. High St. (09-30-82)

Long and Third Commercial Building, 103-113 E. Long St. (07-01-82)

Near Northside Historic District, Off OH 315 (6-4-80)

North Market Historic District, Roughly bounded by W. Goodale, Park, High, Front, and Vine Sts. (12-30-82)

Ohio Asylum for the Blind, 240 Parsons Ave. (7-26-73) PH0070351

Ohio National Bank, 167 S. High St. (11-26-80)

Ohio Stadium, 404 W. 17th Ave. (3-22-74) PH0070360

Ohio State Arsenal, 139 W. Main St. (7-18-74) PH0070378

Ohio Statehouse, SE corner of High and Broad Sts. (7-31-72) PH0070386 G. Ogers, Isaiah Saiah Rogers.

Ohio Theatre, 39 E. State St. (4-11-73) PH0070394 NHL; G.

Old Governor's Mansion (Ohio Archives Building, Charles H. Lindenberg House), 1234 E. Broad St. (6-5-72) PH0070408

Old Ohio Union, 154 W. 12th Ave. (4-20-79); 79/07/23 079 0001780

Old Port Columbus Airport Control Tower, 420 E. 5th Ave. (7-26-79); 79-11-13 079 0004392

Orton Memorial Laboratory, 1445 Summit St. (11-25-83)

Pierce, Elijah, Properties, 435 E. Long St. and 142-44 N. Everett Alley (08-03-83)

Pythian Temple and James Pythian Theater, 861-867 Mt. Vernon Ave. (11-25-83)

Rankin Building, 22 W. Gay St. (03-10-82)

Rickenbacker, Capt. Edward V., House, 1334 E. Livingston Ave. (5-11-76) NHL.

Schlee-Kemmler Building, 328 S. High St. (12-02-82)

Second Presbyterian Church, 132 S. Third St. (01-11-83)

Seneca Hotel, 361 E. Broad St. (12-29-83)

Sessions Village, Both sides of Sessions Dr. (2/20/75)

Smith, Benjamin, House, 181 E. Broad St. (6/4/73) PH0070424

South High Street Commercial Grouping, Bounded by Pearl, Mound, Main, and High Sts. (12/29/83)

Sullivant, Lucas, Building, 714 W. Gay St. (3/20/73) PH0070441

Thurber, James, House, 77 Jefferson Ave. (11/8/79); 80/01/10079 0006403

Toledo and Ohio Central Railroad Station, 379 W. Broad St. (6/18/73) PH0070475 HAER; G.

Trinity Episcopal Church, 125 E. Broad St. (11/13/76)

U.S. Post Office and Courthouse (Old, Old Post Office), 121 E. State St. (4/11/73)

Valley Dale Ballroom, 1590 Sunbury Rd. (12/17/82)

Welsh Presbyterian Church, 315 E. Long St. (11/24/80)

Wyandotte Building, 21 W. Broad St. (2/23/72) PH0070491 HABS

York Lodge No. 583, 1276 N. High St. (07/19/84)

Columbus Vicinity

Agler-la Follette House, 2621 Sunbury Rd. (12/14/78)

Davis, Samuel, House, 4264 Dublin Rd. (2/15/74) PH0070220

Hartman Stock Farm Historic District, S. of Columbus on U.S. 23 (10/9/74) PH084999

Jackson Fort (12/10/74) PH0085251

McDannald Homestead, NE of Columbus at 5847 Sunbury Rd. (2/17/78)

Noble, Jonathan, House, 5030 Westerville Rd. (SR 3) (12/3/75)

Dublin vicinity. Davis, Anson, House, 4900 Hayden Run Rd. (7/7/75)

Holder-Wright Works (2/15/74) PH0070319

Sells, Benjamin, House, S. of Dublin at 4586 Hayden Run Rd. (7/30/75)

Gahanna, Shepard Street School (Gahanna Nursing Home), 106 Short St. (11/29/79); 80/01/10079 0006404

Grove City, Gantz Homestead, 2233 Gantz Rd. (6/20/79); (10/23/79) 079 0002507

Groveport, Groveport Log Houses, Wirt Rd. (5/6/76)

Groveport Town Hall Historic Group, 628, 632 Main and Main and Front Sts. (7/31/78)

Hilliard vicinity. Wesley Chapel, SE of Hilliard at 3299 Dublin Rd. (2/27/79); 79/07/13 079 0000620

Lockbourne vicinity, Herr, Christian S., House, N. of Lockbourne at 1451 Rathmell Rd. (03/05/82)

Marble Cliff, Miller, J.F., House, 1600 Roxbury Rd. (05/31/84)

Riverlea, Russell, Mark, House 5805 N. High St. (12/12/76)

Sunbury Rd.; Presbyterian Parsonage, 6972 Sunbury Rd.; Washburn, Rev. Ebenezer, House, 7121 Sunbury Rd. (11/25/80)

Washington Township. Washington Township Multiple Resource Area. This area includes various properties at various locations. Details available upon request. (4/11/79); 79/07/16 079 0001090

Westerville, Alkire House, 269 N. State St. (3/30/78)

Hanby, Benjamin, House, 160 W. Main St. (11/10/70) PH0094501

Hart, Gideon, House, 7328 Hempstead Rd. (8/14/73) PH0070289

Otterbein Mausoleum, W. Walnut St. (11/29/79); 80/01/10079 0006405

Towers Hall, Otterbein College, Main and Grove Sts., Otterbein College campus (3/4/71) PH0070459

Westerville High School, Vine Street School, 44 N. Vine St. (5/29/75)

Westerville vicinity. Everal, John W., Farm Buildings, 7610 Cleveland Ave. (9/18/75)

Osborn, Charles S., 5785 Cooper Rd. (3/28/77)

Worthington, Johnson, Orange, House, 956 High St. (4/3/73) PH0070335

New England Lodge, 634 N. High St. (3/20/73) PH0070343

Snow, John, House, 41 W. New England Ave. (7/26/73) PH0071251

Worthington Manufacturing Company Boardinghouse, 25 Fox Lane (6/19/73) PH0112917

Worthington Multiple Resource Area. This area includes: Adams, Demas, House, 721 High St.; Bishop-Noble House, 48 W. South St.; Brown, Sidney, House, 12 E. Strafford Ave.; Fay, Cyrus, House, 64 W. Granville Rd.; Gardner House, 80 W. Granville Rd.; Johnson, Orange, House, 956 High St. (previously listed in the National Register 4-3-73); Kilbourne House, 679-681 High St.; Ladd-Mattoon House, 73 E. North St.; New England Lodge, 634 High St. (previously listed in the National Register 3-20-73); Old Worthington Inn, New England and High Sts.; President's House, 38 Short St.; Ripley House, 623 High St.; St. John's Episcopal Church, 700 High St.; Scott, Travis, House, 72 E. Granville Rd.; Sharon Township Town Hall, Granville Rd. and Hartford St.; Skeele, Capt. J.S., House, 700 Hartford St.; Snow, John, House, 41 W. New England Ave. (previously listed in the National Register 7-26-73); Topping, J.R., House, 92 E. Granville Rd.; Park, Jonathan, House, 91 E. Granville Rd.; Wilcox, Hiram, House 196 E. Granville Rd.; Worthington Historical Society Museum, 50 W. New England Ave.; Worthington Manufacturing Company Boarding House, 25 Fox Lane (previously listed in the National Register 6-19-73); Worthington United Presbyterian Church, High St. and W. Granville Rd.; Worthington Village Green, Village Green; Wright, Horace, House, 137 E. Granville Rd.; Wright, Potter, House, 174 E. New England Ave. (4/17/80)

Licking County

Brownsville vicinity. Flint Ridge (11/10/70) PH0070904

Croton vicinity. Belle Hall Covered Bridge, E. of Croton on Dutch Cross Rd. (10/22/76)

Granville, Avery-Hunter House, 221 E. Broadway (12/27/79)

Buxton Inn, 313 E. Broadway (12/26/72) PH0070874

Granville Multiple Resource Area (Partial Inventory). This area includes: Granville, Granville Historic District, OH 37; Bancroft, A.A., House, N. Pearl St. and Washington Dr.; Carpenter, Wallace W., House (The Castle) 323 Summit St.; Dustin Cabin, 597 N. Pearl St.; Rogers House, 304 N. Pearl St.; Rose, Capt. Levi, House 631 N. Pearl St. (11/28/80)

St. Lukes Episcopal Church, 111 E. Broadway St. (4/26/76)

Granville vicinity, Bryn Mawr (Fassett's Folly), 3758 Lancaster Rd., SW (03/29/83)

McClune's Villa, 537 Jones Rd. (04/22/82)

Stanbery, Edwin, Office, 1 mi (1.6 km) E. of Granville (11/30/78)

Heath, Ohio Canal Groundbreaking Site, OH 79 (5/24/73) PH0070963

Johnstown, Monroe Township Hall-Opera House, 1 S. Main St. (7/6/81)

Johnstown vicinity. Lynnwood Farm, S. of Johnstown at 4986 Caswell Rd. (6/22/79); (10/23/79) 079 0002509

Newark. Chapel Hill Cemetery Buildings, Cedar St., Chapel Hill Cemetery (4/13/77)

Courthouse Center, 35-37 S. Park Pl. and jct. of S. Park and S. 2nd St. (11/29/79); 80/01/10079 0006411

Home Building Association Bank, 6 W. Main St. (7/2/73) PH0070912

Hull Place, 686 W. Main St. (12/21/79)

Licking County Courthouse, Courthouse Sq. (3/20/73) PH0070921

McNamar-McLure-Miller, Residence, 124 W. Main St. (06/17/82)

Newark Earthworks, Mound Builders State Memorial (10/15/66) PH0070955 NHL.

Oakwood, 64-70 Penney Ave. (5/29/80)

Pennsylvania Railway Station, 25 E. Walnut St. (11/29/79); 80/01/10079 0006412

Rhoads, Peter F., House, 74 Granville St. (11/28/80)

Sherwood-Davidson and Buckingham Houses, W. Main and 6th Sts. (11/10/77)

Shield's Block, 23-29 S. Park Pl. (11/29/78)

Upham-Wright House, 342 Granville St. (6/22/79); (10/23/79) 079 0002510

West Side Planning Mill, 197 Maholm St. (01/21/83)

Williams, Elias, House (Bolton House), 565 Granville St. (4/16/79); 79/07/23 079 0001786

Newark vicinity. Upland Farm, N. of Newark off OH 657, (12/1/78)

Pataskala, Bethel Baptist Church (Pataskala MRA), Vine and Cedar Sts. (09/22/83)

Casterton House (Pataskata MRA), 105 Broadway (09/22/83)

Elliot House (Pataskala MRA), 301 S. Main St. (11/14/83)

Kauber, Warren F., Funeral Home (Pataskala MRA), 289 S. Main St. (09/22/83)

Mead House (Wind Flower House) (Pataskala MRA), 245 S. Main St. (09/22/83)

Pataskala Banking Company (Pataskala MRA), 354 S. Main St. (09/22/83)

Pataskala Elementary School (Pataskala MRA), 396 S. High St. (09/22/83)

Pataskala Jail (Pataskala MRA), Main St. (09/22/83)

Pataskala Presbyterian Church (Pataskala MRA), Atkinson and Main Sts. (11/14/83)

Pataskala Town Hall (Pataskala MRA), 430 Main St. (09/22/83)

Pataskala United Methodist Church (Pataskala MRA), 458 S. Main St. (09/22/83)

Madison County

Lafayette. Red Brick Tavern, 1700 Cumberland Rd. (9/5/75)

London. Madison County Courthouse, Public Sq. (3/14/73) PH0094552

Swetland House, 147 E. High St. (01/11/83)

Mount Sterling. Mount Sterling Historic District, Both sides of London St. (10/1/74) PH0060801

Plain City vicinity. Cary Village Site, SE of Plain City (5/13/75)

Somerford vicinity. Wilson, Valentine, House, About 1 mi. N. or Somerford off I-70 (5/22/73) PH0060828

Pickaway County

Ashville, Ashville Depot, Madison and Cromley Sts. (2/25/80)

Circleville. Anderson, William Marshall, House, 131 W. Union St. (11/29/79); 80/01/10079 0006419

Circleville Historic District, Main and Court Sts. (5/16/78)

Memorial Hall, 165 E. Main St. (11/21/80)

Morris House, 149 W. Union St. (8/3/79); 79-11-13 079 0004400

Circleville vicinity, Horsey-Barthelmas Farm, W. of Circleville on OH 104 (7-24-80)

Lawndale Farm Complex, 26476 Gay Dreisbach Rd. (04/19/84)

Mount Oval (Tolbert House), Off U.S. 23 (7/25/74) PH0071293

Peters, Stevenson, House, OH 188 (02/09/84)

Redlands, 1960 N. Court St. (05/14/82)

Kingston vicinity. Bellevue, N. of Kingston on OH 159 (3/17/76)

Marcy vicinity. Fridley-Oman Farm, W. of Marcy in Slate Run Metropolitan Park (12/6/75)

South Bloomfield vicinity, Renick Farm, N. of Bloomfield on U.S. 23 (03/05/82)

Williamsport vicinity. Bazore Mill, S. of Williamsport on OH 138 at Deer Creek (12/19/78)

Williamsport vicinity. Shack, The, NW of Williamsport (5/23/74) PH0071307

The following properties have been determined to be eligible for inclusion in the National Register.

Fairfield County

Lancaster, U.S. Post Office--Lancaster (10/28/83)

Richland, R.F., Baker Bridge, Thornville Rd. and Little Rush Creek; 78/11/13 078 0055084

Franklin County

Columbus, Barber Shop, 82-86 E. Town St. (1204.3)

Beggs Building, 21 E. State St.

Bldg. at 736-40 East Long Street (02/17/84)

Central National Bank Building, 152-166 S. High St. (1204.3)

Hartman Theater Building, 73-87 E. State St. (1204.3)

LaSalle Wine Store, 242-244 S. High St. (1204.3)

Owen, Jim, Real Estate, 232 S. High St. (1204.3)

Trailways, 246-254 S. High St. (1204.3)

1000-02 S. High Street (63.3)

17-19 E. Stewart Avenue (63.3)

21-33 E. Stewart Avenue (63.3)

99 S. High Street (63.3)

<u>Licking County</u>

Health. Digiondomenico Site (Ohio LIC 343-0.00).; 78/11/15 078 0050632

<u>Pickaway County</u>

Darby township, Orient Bridge, OH 762 over Big Darby Creek (63.3)

The following sites/structures are pending inclusion to the National Register.

<u>Franklin County</u>

Broad Street Apartments, East Broad Street MRA, 880--886 E. Broad St., 86003404 11/04/86

Broad Street Christian Church, East Broad Street MRA, 1051 E. Broad St., 86003448, 11/04/86

Cambridge Arms, East Broad Street MRA, 926 E. Broad St., 86003412, 11/04/86

Central Assurance Company, East Broad Street MRA, 741 E. Broad St. 86003421, 11/04/86

East Broad Street Commercial Building, East Broad Street MRA, 747, 749, 751 E. Broad St., 86003424, 11/04/86

East Broad Street Historic District, East Broad Street MRA, Along E. Broad St. between Monypenny and Ohio Aves. 86003393, 11/04/86

East Broad Street Presbyterian Church, East Broad Street MRA, 760 E. Broad St., 86003397, 11/04/86

Garfield--Broad Apartments, East Broad Street MRA, 775 E. Broad St., 86003427, 11/04/86

Heyne--Zimmerman House, East Broad Street MRA, 973 E. Broad St., 86003450, 11/04/86

Hickok, Frank, House, East Broad Street MRA, 955 & 957 E. Broad St., 86003444, 11/04/86

House at 753 East Broad Street, East Broad Street MRA,, 753 E. Broad Street, 86003425, 11/04/86

Jacobs, Felix A., House, 1421 Hamlet St., 86003434, 11/04/86

Johnson--Campbell House, East Broad Street MRA, 1203 E. Broad St., 86003414, 11/04/86

Joseph--Cherrington House, East Broad Street MRA, 785 E. Broad St., 86003429, 11/04/86

Kauffman, Linus E., House, East Broad Street MRA, 906 E. Broad St., 86003410, 11/04/86

Kaufman, Frank J., House, East Broad Street MRA, 1231 E. Broad St., 86003420, 11/04/86

Levy, Soloman, House, East Broad Street MRA, 929 E. Broad St., 86003427, 11/04/86

Lovejoy, Carrie, House, East Broad Street MRA, 807 E. Broad St., 86003435, 11/04/86

Morris, C.F., House, East Broad Street MRA, 875 E. Broad St., 86003398, 11/04/86

Frentiss, Frank, House, East Broad Street MRA, 706 E. Broad St., 86003396, 11/04/86

Prentiss--Tulford House, East Broad Street MRA, 1074 E. Broad St., 8603413, 11/04/86

Saint Paul's Episcopal Church, East Broad Street MRA, 787 E. Broad St., 86003430, 11/04/86

Schueller, Erwin W., House, East Broad Street MRA, 904 E. Broad St., 86003406, 11/04/86

Scofield--Saner House, East Broad Street MRA, 1031 E. Broad St., 86003447, 11/04/86

Sharp--Page House, East Broad Street MRA, 935 E. Broad St.

86003445

86003449

ARCHAEOLOGICAL SITES

Delaware County

Powell vicinity. Highbanks Metropolitan Park Mounds I and II, E. of Powell on U.S. 23 (3/19/75)

Fairfield County

Canal Winchester vicinity. Schaer, Theodore B., Mound, SE of Canal Winchester (6/20/75)

Carroll vicinity, Coon Hunters Mound (5/2/74) PH0034797

Pinkerington vicinity. Fortner Mounds I, II. NE of Pinkerington (7/12/74) PH0034827

Tarlton vicinity. Tarlton Cross Mound, N. of Tarlton (11/10/70) PH0034860

Franklin County

Columbus. Campbell Mound (11/10/70) PH0094498

COE Mound, W. of High St. (7/18/74) PH0070203

Columbus vicinity. Hartley Mound, N. of Columbus (7/15/74) PH0070297

Galloway vicinity. Galbreath, John Mound, W. of Galloway (7/15/74) PH0070262

Georgesville vicinity. Cannon, Tom, Mound (5/2/74) PH0070190

Worthington vicinity. Jeffers, H.P., Mound (5/2/74) PH0070327

Licking County

Granville vicinity. Alligator Effigy Mound (11/5/71) PH0070891

Homer. Dixon Mound (Williams Mound) (6/4/73) PH0070882

Reynoldsburg vicinity. ETNA Township Mounds I and II, E. of Reynoldsburg off I-70 (9/5/75)

Utica vicinity. McDaniel Mound (5/2/74) PH0070939

Melick Mound, S. of North Fork of Licking River (3/27/74) PH0070947

Madison County

West Jefferson vicinity. Skunk Hill Mounds (7/30/74) PH0060810

Pickaway County

Circleville vicinity. Arledge Mounds I and II (7/30/74) PH0071285

Luthor List Mound (10/16/74) PH0034291

Fox vicinity. Clemmons, W.C., Mound (5/2/74) PH0071315

Tarlton vicinity. Horn Mound (8/7/74) PH0034304

Williamsport vicinity. Tick Ridge Mound District, NW of Williamsport (6/11/75)

APPENDIX J

ARCHAEOLOGIC BACKGROUND

APPENDIX J
ARCHAEOLOGIC BACKGROUND

The earliest evidence of human culture within the Scioto Drainage system is evidenced by the Fluted Point Complex of the Palaeo-Indian Tradition, which has been dated to between 18,000 and 10,000 years B.C. This component, the Fluted Point Complex, is represented primarily by the surface recovery of isolated Fluted Points (projectile points) and other characteristic artifacts of this manifestation.

The Fluted Point Complex is followed by the Plano Complex of the Palaeo-Indian Tradition, dating between 10,000 and 6,000 years B.C. The Plano Complex is documented in the Scioto Valley by a series of isolated surface finds of characteristic projectile point types including Lanceolate Points, Sawmill Stemmed Lanceolate Points, and Stringtown Spurred-Stemmed Lanceolate Points.

The known distribution of Plano Complex workshop sites centers in Coshocton County in proximity to the outcrops of Upper Mercer Flint with a secondary center in Licking County adjacent to the heavily utilized Flint Ridge Flint. These raw materials were used in the manufacture of the vast majority of Lanceolate-style projectile points. The distribution of excavated sites and surface finds in this region would be along major stream valleys.

The Archaic Developmental Stage spans the time interval from ca. 8,000 to 1,500 years B.C. In part, the Plano Complex and the earliest manifestations of the Archaic stage overlap in time.

The Archaic Development Stage is evidenced by two cultural traditions throughout the Scioto Drainage system: the Appalachian Archaic Tradition (8,000 to 3,500 years B.C.) and the Laurentian Archaic Tradition (3,500 to 1,500 years B.C.).

The Kirk Phase of the Appalachian Archaic Tradition has been dated to between 8,000 and 7,000 years B.C., while the St. Albans Phase dates to between 7,000 and 6,100 years B.C. The majority of sites are situated within the low terraces of the major stream valleys--in environmental zones that have been reconstructed as bottomland hardwood forests.

The distribution of Kirk and St. Albans Phase components is rather well known for the Scioto Drainage south of Circleville. Stray surface finds of Kirk Corner-Notched and St. Albans Bifurcated-Base projectile points were recovered along both the east and west banks of the Scioto River in southern Franklin County. However, it was not possible to define either clusters of artifact occurrence or to define sites on the basis of this analysis. The only evidence for Archaic Stage (6,000 and 3,500 years B.C.) occupation of the Scioto Drainage has come from the surface recovery of several well-defined projectile point types, either as isolated surface occurrences or from occurrences in multicomponent surface manifestations.

The Laurentian Tradition represents the most recent of the Archaic Development Stage manifestations within Ohio. The various components of the tradition have been radiocarbon dated to between ca. 3,500 years B.C. and prior to 1,500 years B.C. In this region, one phase of the tradition has been defined: the Dunlap Phase of the Laurentian Tradition within the central and lower Scioto Valley. Sites occur as both open sites and within rock shelters in the eastern portion of Ohio. The majority of open sites are situated in close proximity to the then-contemporary shorelines of water sources (lakes, bogs, swamps, and streams).

The Glacial Kame Manifestation represents a poorly understood series of archaeological remains that are contemporaneous with the terminal portion of the Laurentian Tradition. The manifestation is known primarily from the discovery of human burials that occur deep within shaft graves excavated into glacial kames, usually elevated over adjacent stream valleys. Sites of the Glacial Kame Manifestation do occur in both Pickaway and Franklin Counties.

The Scioto Tradition spans the time interval from 1,500 years B.C. to ca. 900 years A.D. Three phases of the Scioto Tradition have been defined. The three major manifestations include the following:

a. Adena Phase (Early Woodlands), dating from 1,500 years B.C. to 1 A.D./B.C.

   This phase represents the earliest manifestation of the Scioto Tradition within the Scioto Drainage. The majority of manifestations have been dated to between 1,500 years B.C. and 1 A.D./B.C., although components predating 1,500 years B.C. are known from both the Hocking River and Ohio River Valleys. Only four Adena Phase burial mounds are known from Franklin and Pickaway Counties.

The Adena Phase mortuary ceremonial manifestation is evidenced by one site occurring within a 10-kilometer radius of the Southerly WWTP. Typical burial mounds of the Adena Phase represent small structures covering less than 20 inhumations located on high terraces and/or bluffs overlooking major stream valleys. The settlement pattern of the Adena Phase, known for limited information, consists of small villages or hamlets (2 to 10 structures) scattered along the low terraces and flood plain of the stream valleys. One large habitation site--the Dominion Land Company Site in Franklin County--has been reported.

b. Hopewellian Phase (Middle Woodland), dating from 150 years B.C. to 650 years A.D.

This phase of the Scioto Tradition has been dated to between 150 B.C. and 650 A.D. The greatest concentration of sites occurs in the Scioto River Valley between Circleville and Portsmouth. The concentration of Hopewellian earthworks occurs in the Scioto Valley and its tributaries south of Columbus.

Within the central and lower Scioto Valley, Hopewellian hamlets appear to be composed of two to four structures (houses) situated on rises of the flood plain and first terrace of the Scioto River and the major tributary stream.

Four Hopewellian Phase sites are known to be in the vicinity of the Southerly WWTP project area.

c. Chesser Phase, Peters Phase, Cole Complex (Late Woodland), dating from 650 to between 900 and 1,000 years A.D.

The subsequent portion of the Scioto Tradition consists of a series of regionally defined phases: the Peters Phase in the Hocking Valley, the Chesser Phase in the lower Scioto Valley, the Cole Complex in the upper Scioto Valley, and the Licklighter Phase in the Miami Valley. These various Late Woodland phases occupy a time interval that has been radiocarbon dated to between 650 and 950 to 1,000 years A.D.

The Cole Phase (also known as Cole Complex) has been defined by Baby, Potter, and their co-workers for the upper portion of the Scioto Valley (Circleville to Columbus) and for the Darby Creek, Upper Scioto, and Olentangy Drainages.

The terminal portion of the pre-European culture history of the Scioto Drainage is dominated by the Fort Ancient or Mississippian Tradition.

Fort Ancient Tradition settlement patterns consist of large nucleated villages, frequently oriented around vacant plazas or areas containing platform or "temple" mounds and frequently defined by palisades. Villages are most frequently located in close proximity to major streams and on rises within the flood plain, or on first terraces of the stream valleys; frequently in close proximity to the richest of the available soils.

A total of seven Late Woodland Mississippian manifestations are known to occur in the vicinity of the Columbus Southerly project area. Nearly all adjacent manifestations are known only from the results of the phase II survey.

The terminal portion of the prehistoric sequence within the Scioto Valley--the time interval from 1650 to 1680 until Anglo-European settlement during the 1780s and 1790s--is poorly known from both the archaeological and historical literature. Only one site has been excavated from this time interval--the Morrison Site from the Scioto Valley south of Chillicothe.

In summary, the Scioto Drainage system has been used by a succession of prehistoric cultures and prehistoric populations for over 18,000 years. Many of these cultural manifestations are well represented within the region.

A phase I and phase II survey of the Southerly WWTP in 1985 revealed four prehistoric sites.

APPENDIX K
POPULATION PROJECTIONS AND METHODS

APPENDIX K
POPULATION PROJECTIONS AND METHODS

Introduction

This appendix presents past population trends of the overall planning area as well as the proposed interceptor areas. The overall service area covers most of Franklin County, including all of the City of Columbus as well as small portions of Delaware, Fairfield, and Licking Counties. This review outlines baseline data used in evaluating population projections and for estimating the relative attractiveness for development of various communities within the planning area.

Most of the available population projections have not been prepared for small areas and the detailed information required for accurate small area projections is not available. The 1980 census provides the baseline for the trend analysis used to prepare all of the regional population projections. Because growth between 1970 and 1980 was less than expected and the growth between 1980 and 1985 was greater than expected, the Ohio Department of Economic Development, which prepares the State population estimates at the Ohio Data Users Center (ODUC), has revised its official estimates three times since the 1980 U.S. Census. The most recent estimate was published and verified in September of 1985. Both the Mid-Ohio Regional Planning Commission (MORPC) and Ohio Environmental Protection Agency (OEPA) prepare population estimates for small areas; that is counties, cities, and unincorporated areas. These two agencies have not revised their population estimates to reflect the most recent ODUC projections. Therefore, these small area projections do not reflect the most recent State-approved projections. The Revised Facility Plan Update (RFPU) considers these revisions, but does not reflect the region's most recent growth trends.

Revised Facilities Plan Update Projections

Population levels were forecast for the year 2015 in the RFPU. Besides the year 2015 population, used for planning purposes, the population in 1988 also was evaluated by this RFPU because the Clean Water Act Amendments mandate compliance by all wastewater treatment facilities with NPDES permit limits by

July 1, 1988. The following sources of population data and existing projections were reviewed prior to development of RFPU projections:

- o Environmental Impact Statement (EIS) for Wastewater Treatment Facilities for the Columbus Metropolitan Area (US EPA 1979);
- o Design Finalization Overview Team Report (AWARE 1984);
- o Facilities Plan Update Report (Malcolm Pirnie 1984);
- o Growth Potential Report (City of Columbus 1984);
- o Ohio Department of Development, Data Users Center, State and County Projections (June 1982);
- o Ohio Department of Development, Data Users Center, Draft Final Population Projections (August 1985);
- o Traffic Zone Projections - 1980 and 2010 (Mid-Ohio Regional Planning Commission 1983);
- o Franklin County projections developed by the Design Parameters Team as a check against other projections;
- o Miscellaneous Facilities Plan and Facilities Plan Segment documents pertaining to sewer service areas;
- o Ohio Environmental Protection Agency, Office of the Planning Coordinator, Water Quality Management Plan Projections (1977, 1982).

As the preceding list indicates, numerous sources using various methodologies were used to make population projections in the RFPU and the Consolidated Environmental Information Document (EID). For the purpose of this EIS, the population projections prepared by the Ohio Data Users Center (a division of the Ohio Department of Development) and the OEPA were reviewed and adjusted to reflect the overall service area for 1988, 2000, and 2008.

Ohio Data Users Center Projections

The ODUC prepares the official population projections for the State of Ohio. ODUC bases its recent projections on the 1980 U.S. Census, and historic trends for migration, births, and deaths. The projections reviewed in this EIS were revised in September 1985. These projections were prepared on the county and state level, for the years 1980 through 2010. A preliminary accuracy check recently was conducted by ODUC for their Franklin County forecasts. During this check, the population estimates were well within the accepted statistical confidence level with an error rate of less than 2 percent.

Table K-1 shows ODUC's population projections for the State of Ohio and the four counties in the service area for 1980 through 2010. This table shows that the State of Ohio will decrease over the 30-year period while the population in Franklin County as well as the other counties in the service area will increase.

ODUC is responsible for certifying population projections prepared within the State. In 1982, after several public hearings, ODUC certified OEPA's Planning and Engineering Data Management System for Ohio (PEMSO) population projections. The OEPA prepared its projections for selected service areas on the township, village, and county levels. These projections were prepared before the 1980 U.S. Census was released, and therefore are based on the 1970 U.S. Census and the growth trends exhibited in the area prior to 1980. Although the methodology employed to make these projections is sound, the growth between 1970 and 1980 was less than expected. And the growth between 1980 and 1984 was larger than expected.

TABLE K-1. POPULATION PROJECTIONS FOR THE STATE OF OHIO AND THE COUNTIES IN THE COLUMBUS SERVICE AREA

	1980	1990	2000	2010
Ohio	10,797,630	10,681,863	10,583,083	10,398,338
Delaware	53,840	61,709	71,381	81,164
Fairfield	93,678	98,655	104,033	107,577
Franklin	869,132	924,592	975,013	1,026,008
Licking	120,981	127,390	132,154	136,765

Source: (ODUC, 1985).

Table K-2 lists the service area population by county as a percent of the total county population for the same time period. This table indicates that most of Franklin County's population (over 99%) will be located in the service area. Less than 1 percent of Fairfield's population and an average of 3 percent of Delaware and Licking Counties will be included in the service area.

Ohio Environmental Protection Agency Projections

Table K-3 compares OEPA's projections with ODUC's by county for 1980, 1985, and 2000. This table indicates that ODUC currently assumes a slightly higher growth rate for Franklin County than OEPA used in its earlier forecasts. ODUC'S projections are based on the 1980 U.S. Census and show a higher 1980 population in Franklin County than OEPA. In fact, OEPA's earlier forecasts underestimate the 1980 Franklin County population by 56,000 persons. OEPA uses higher growth rates for Fairfield, Delaware, and Licking Counties than ODUC. This results in higher overall population estimates by OEPA for these counties.

OEPA acknowledges that its 1982 PEMSO estimates may not reflect an accurate picture of the service area population and has attempted to modify or revise these estimates. However, since the 1982 estimates are the only numbers that have been certified by the State, OEPA cannot release the revised version of these estimates. The growth rates used for Franklin County are similar for both OEPA and ODUC; this analysis will assume that if OEPA's 1980 population is adjusted to reflect the 1980 U.S. Census, then the two projections will be more closely aligned. This adjustment, referred to hereafter as OEPA (adj.), is reflected in Table K-2 as part of the comparison for Franklin County. Since Fairfield, Delaware, and Licking Counties combined comprise 1 percent of the total service area population in 1980 and 2 percent of the total service area population in 2015, no adjustments were made for these counties.

TABLE K-2. OHIO EPA-PEMSO PROJECTIONS FOR THE COLUMBUS SERVICE AREAS

Service Area by County	Baseline 1970/77	1980 Projected	1985	1990	1995	2000
Columbus						
Franklin	787,062	789,089	802,857	820,946	834,634	869,006
Delaware	1,149	1,616	1,928	2,276	2,663	3,131
Licking	845	1,020	1,120	1,218	1,305	1,375
Subarea Total	789,056	791,725	805,905	824,440	838,602	873,512
Canal Winchester						
Franklin	3,420	4,016	4,801	5,898	7,353	8,384
Fairfield	9	8	8	8	8	8
Subarea Total	3,429	4,024	4,809	5,906	7,361	8,392

OEPA notes that the 1980 population for Canal Winchester was 37 in Fairfield and 2,712 in Franklin

Service Area by County	Baseline 1970/77	1980 Projected	1985	1990	1995	2000
Backlick Creek						
Franklin	12,137	17,246	19,210	22,891	23,746	25,426
Fairfield	526	587	634	684	735	786
Licking	1,643	2,233	2,602	3,007	3,421	3,831
Subarea Total	14,306	20,066	22,446	26,582	27,902	30,043
Service Area Total	794,128	815,815	833,160	856,928	873,865	911,947

Source: Ohio Environmental Protection Agency Computer Print Out 1982
PEMSO: Planning & Engineering Data Management System for OHIO

TABLE K-3. COMPARISON OF POPULATION PROJECTIONS BY COUNTY FOR THE COLUMBUS, OHIO AREA

County Source	1980	1985	2000	2015*
Franklin				
ODUC	869,132	898,345	975,013	1,048,000
OEPA	812,670	829,523	906,903	974,900
OEPA (adj.)**	869,132	887,400	971,700	1,044,600
Fairfield				
ODUC	93,678	96,120	104,033	109,000
OEPA	82,401	87,972	106,180	128,500
Delaware				
ODUC	53,840	57,693	71,381	86,500
OEPA	54,779	62,320	87,810	123,500
Licking				
ODUC	120,981	124,394	132,154	138,000
OEPA	125,943	137,648	162,791	187,000

*This estimate is a simple extrapolation of OEPA and ODUC projections based on previous growth rates and rounded to 500.

**OEPA figures were increased to reflect the 1980 U.S. Census (see text for complete explanation).

Comparisons

Using the proportions shown in Table K-4 ODUC's county-wide population estimates were adjusted to reflect the OEPA estimate of the service area populations. Table K-5 compares OEPA's PEMSO estimate with ODUC's estimates adjusted to reflect the service area boundaries, and with the OEPA (adjusted) estimates. A straightline extrapolation was used to estimate the 1988 and 2008 populations. When this table is compared with Table K-6 RFPU population projections, it shows that ODUC and OEPA (adjusted) estimates are higher than the RFPU. The difference between the two projections is less than 2 percent which is within an acceptable range for statistical error. This sets the service area population at a high of 1,020,000 and a low of 950,400 in 2008. This figure is at most 23,000 individuals greater than the revised service area projections shown in Table K-6. These population figures will serve as a baseline for estimating the growth that would be likely to occur without the construction of the interceptors.

Revision of RFPU Projections

The RFPU used the Mid-Ohio Regional Planning Commission's (MORPC) traffic zone population projections as the initial data base for developing the overall and subservice area population projections. MORPC's traffic zone system is based on a network of roadway intersections developed in the 1960's and was updated between 1974 and 1980. This network is based on land use and traffic patterns and is able to predict population projections, changes in land use and transportation needs. These projections are a disaggregation of the ODUC projections for Franklin County. As a result of ODUC's 1985 revisions, MORPC is revising its projections. MORPC will increase its 2010 population projection from 941,341 to 1,027,341 (1,026,000 is the ODUC estimate) for Franklin County. This increases the forecast population in Franklin County by 86,000 individuals by 2010.

TABLE K-4. POPULATION DISTRIBUTION BY COUNTY FOR THE COLUMBUS SERVICE AREA

County/Service Area	1980	1985	2000
Franklin			
Total Population	812,670	829,523	906,903
Service Area Population	810,351	826,868	902,816
% of total	99.7%	99.7%	99.5%
Fairfield			
Total Population	82,401	87,972	106,180
Service Area Population	595	642	796
% of Total	.7%	.7%	.7%
Delaware			
Total Population	54,779	62,320	87,810
Service Area Population	1,616	1,928	3,131
% of Total	3.0%	3.1%	3.6%
Licking			
Total Population	125,943	137,648	162,791
Service Area Population	3,253	3,722	5,206
% of Total	2.6%	2.7%	3.2%

Source: OEPA, PEMSO Projections, February 1982.

TABLE K-5. COMPARISON OF POPULATION PROJECTIONS BY COUNTY FOR THE COLUMBUS SERVICE AREA

Source	1988	2000	2008	Increase Between 2000-2008
ODUC	925,900	982,600	1,018,000	35,400
OEPA	848,600	911,947	950,347	38,400
OEPA (adj.)	902,200	976,130	1,052,900	41,000

Source: Interpolation of Tables K-1, K-2, K-3, K-4.

TABLE K-6. REVISED FACILITY PLAN UPDATE POPULATION FORECASTS

Service Area	Service Population 1980	1988	2000	2015
Jackson Pike (1980 Bdry.)	467,153	487,644	500,294	511,035
Southerly (1980 Bdry.)	324,336	336,633	360,834	372,344
West Scioto (a)	(b)	(b)	31,072	42,564
Big Run	(b)	(b)	(b)	(b)
Darby Creek	(b)	(b)	(b)	(b)
Grove City	15,941	16,601	17,490	22,571
Minerva Park	(b)	2,063	2,187	2,265
Sunbury-Galena	(c)	(c)	(c)	(c)
Big Walnut	(b)	(b)	(b)	(b)
Blacklick	(b)	21,904	31,034	35,091
Groveport	(b)	3,436	3,499	3,542
Rickenbacker AFB	(b)	2,146	2,146	2,146
Rocky Fork	(b)	(b)	3,305	3,601
TOTAL	807,430	870,427	951,861	995,159

NOTES:

(a) A significant portion of the Upper Scioto West Interceptor presently is served by temporary pump stations and force mains that discharge to the Upper Scioto East Interceptor. This service area population is included in the 1980 and 1988 service population of Jackson Pike. By the year 2000, this service population is deducted from the Jackson Pike service area and allocated to the West Scioto service area, reflecting construction of the Upper Scioto West Interceptor Sewer.

(b) Area not served during projection period.

(c) Area excluded from analysis. No service planned.

Source: URS Dalton 1986.

APPENDIX L

DRAFT
CRITIQUE OF
WATER QUALITY MODELING ISSUES
FOR THE COLUMBUS, OHIO
SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Draft

Critique of Water Quality Modeling Issues for the Columbus, Ohio Supplemental Environmental Impact Statement

August 31, 1987

Submitted To:
U.S. Environmental Protection Agency, Region V
230 South Dearborn Street
Chicago, Illinois 60604

Submitted By:
Science Applications International Corporation
8400 Westpark Drive
McLean, Virginia 22102

EPA Contract No. 68-04-5035; D.O. #040
SAIC Project No. 2-813-06-193-40

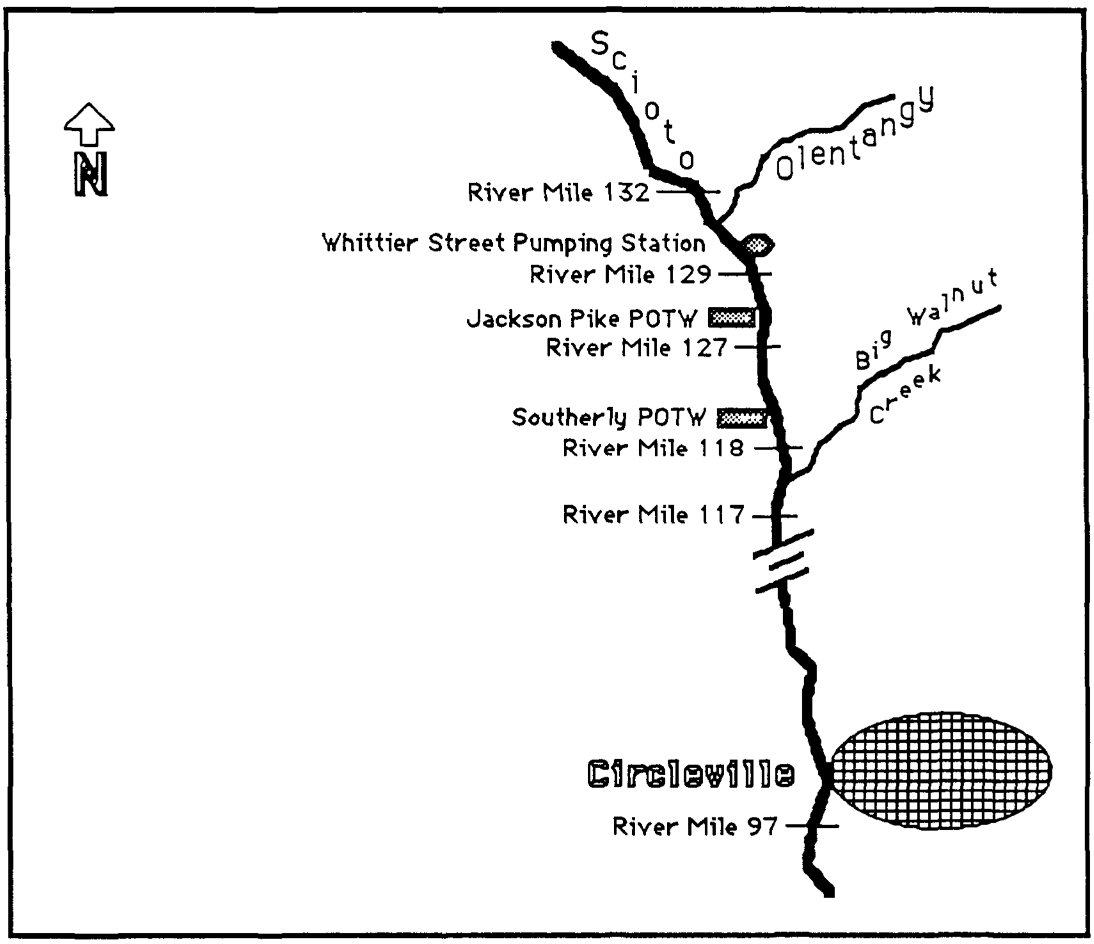
1. Introduction

The Columbus Supplemental EIS (SEIS) is being prepared to evaluate the current facilities planning information for the City of Columbus. Key provisions of the current facilities plan for Columbus include:

- o Upgrading and expansion of the Southerly wastewater treatment plant (WWTP)
- o Phase-out and ultimate abandonment of the Jackson Pike WWTP, and
- o Re-routing of Jackson Pike flows to the Southerly WWTP.

Future facilities planning activities will address the issue of CSO control at the Whittier Street storm tanks overflow. The two wastewater treatment plants operated by the City of Columbus (Jackson Pike and Southerly) are projected to discharge almost180 mgd of treated effluent to the Scioto River by the year 2008.

A simplified graphic of the locations of point source discharges and riverine features in the Columbus area is provided below.



Facilities planning activities for the City of Columbus, including future (but as yet unspecified) modifications for CSO control at Whittier Street, involve decisions which will directly impact water quality in the Scioto River. These decisions include:

- o Locations of effluent discharge outfalls
- o Quantity of treated effluent released from each outfall, and
- o Extent of wastewater treatment prior to discharge.

Due to the Federal government's participation in the proposed project (through the USEPA §201 grant), and the potential for the proposed project to result in significant impacts on the environment, an environmental review is required. This review is necessitated in the USEPA procedures for implementation of NEPA.

Results of current and future facilities planning activities will directly affect the three major point sources (Whittier Street, Jackson Pike and Southerly) which presently influence water quality in a 30 mile stretch of the Scioto River, in the Columbus area. Because of this direct relationship between facilities planning decisions and the quality of the aquatic environment, it is essential that these aspects of project impacts be carefully considered in the SEIS.

The most common approach to evaluating the water quality impacts related to a WWTP effluent discharge is through application of a water quality model. The USEPA relies on models to determine the need for upgrading wastewater treatment plants beyond secondary, and whether Federal grant monies may be used for such purposes. As an evaluative tool, the model provides a mathematical simulation of the naturally-occuring physical/chemical processes which biodegrade, or assimilate, wastes in the receiving water. Through such mathematical representations, models assist managers in determining whether proposed improvements in wastewater treatment processes will provide significant benefits to the water quality of the receiving waters.

Typically, initial model development is followed by a process of model calibration and verification, with site specific field data, to ensure that the model is faithfully characterizing and reflecting natural conditions. At this point, individual variables (such as effluent quantity, quality or total wasteload) can be selectively modified to predict and evaluate the impacts (positive or negative) on water quality in the receiving water. Permitted effluent limits can then be established for the discharger. Such limits reflect a quantification of the total excess wasteload assimilative capacity of the receiving water which is allocated to the subject discharger (generally, the total available assimilative capacity is not allocated to a single discharger).

As an aid to the establishment of wasteload allocations (WLA) and related permit discharge limits, a water quality model was initially developed for the Scioto River, in the Columbus vicinity, by the Ohio EPA (OEPA), using QUAL2 (a commonly used, reliable framework). Based on this model, the OEPA proposed permit limits for the Jackson Pike and Southerly POTWs, in the Comprehensive Water Quality Report (CWQR).

The original QUAL2 model was later updated, by a consultant to the City (URS Dalton), and transformed to a QUAL2E format, which is operable with PC hardware. The updated model was then used to derive alternate wasteload allocations and discharge limits, which were proposed by the City to OEPA. These alternate allocations and limits were accepted by OEPA and sent to USEPA in an amended CWQR. To date, the amended CWQR has not been approved by the USEPA, however the discharge limits have been approved. The discharge limits in the amended CWQR are the basis for the current facilities planning efforts and a key component in the SEIS evaluations.

Therefore, in order to determine if the proposed project will significantly impact the quality of the natural environment, it is necessary to determine the accuracy of the wasteload allocations and resultant discharge limits. This determination is made through examination of the reasonableness of variables and assumptions on which the model was constructed, and through assessment of the reliability of these variables and assumptions to represent natural conditions.

Preliminary evaluations conducted as part of the SEIS have questioned a variety of the variables and assumptions used in the QUAL2E model and resultant discharge limits. Although these questions are currently unresolved, they include technical input variables to which the model is especially sensitive. Collectively, these questions seriously undermine the reliability of the current model.

In the following sections, the questioned model input variables and assumptions are identified and discussed.

2. Technical Issues

This section includes an identification of specific model input variables and assumptions whose reliability is considered questionable, as a result of preliminary SEIS review efforts.

2.1 Existing Modeling.

Two attempts were made at developing a water quality model for the Scioto River near Columbus, Ohio. The first model was developed by the OEPA using the computer program QUAL2 (SEMCOG). This model was calibrated with water quality data collected during a July, 1982 "intensive survey", and verified with similar data collected in August, 1981. The second modeling effort was conducted by the City of Columbus and its consultant, URS-Dalton. An updated version of QUAL2, QUAL2E (enhanced), was used in the second effort.

The major difference between the two efforts, other than the computer program employed, was that URS incorporated a term to account for the production of oxygen by the benthic (attached) algae that staff members observed growing in the river during a field reconnaisance survey in September, 1985. The OEPA had not included the effects of benthic algae or phytoplankton in its earlier (QUAL2) model of the Scioto.

Two major problems are associated with the existing water quality modeling. The first problem is that steady state modeling frameworks (ie; QUAL2 and QUAL2E) were applied to stream conditions that were essentially not at steady state. The second major problem stems from the use of a benthic photosynthesis oxygen production term. In constructing both models, rate constants were derived through analysis of field data on physical/chemical parameters in the river. However, comparison of the field data and the resulting calibration and verification plots has indicated that acceptable fits to DO data were not obtained in either study.

Other problems include inappropriate or incomplete consideration of ammonia data, other nitrogen species, phytoplankton, and cross-sectional profiles.

2.2 Steady State Modeling Framework.

Modeling frameworks such as QUAL2 and QUAL2E are normally applied to situations in which none of the state variables (the concentrations of DO and other water quality constituents) or "forcing functions" (effluent and boundary BOD, nitrogen loadings, etc.) vary at any given location with respect to time, i.e., when the system is at "steady state". However, it is often acceptable to apply steady state models to certain non-steady state situations. For example, steady state models are often used to model estuaries. However, the model is constructed with data gathered at high or low slack tides, and is therefore tidally-averaged. In this way, any error introduced by using a steady state framework to model a dynamic, periodically varying estuary is reduced.

Similarly, in streams, when a state variable such as DO varies at specific locations due to such dynamic processes as photosynthesis, error is introduced into the output of a steady state model. If such time variation in the inputs or state variables occurs, and steady state models are the only practical tools available, care must be taken to consider the effects of any time variable factors in order to minimize the model error resulting from the use of the steady state framework. As in the preceding estuarine example, error minimization is usually accomplished by time-averaging the data over the period of concern (e.g., periods of darkness, periods of light).

Non-steady state conditions occurred in the Scioto River near Columbus during the July, 1982 intensive survey. Streamflows were observed to decline steadily during this survey, reflecting the effects of a moderate rainfall event which had occurred just prior to the start of sampling. Therefore, background BOD and NOD loadings, and velocities and depths throughout the system, were also declining. More significantly, a diurnal DO variation of greater than 2 mg/L was measured at several of the sampling stations (as indicated in Figure 6-7 of the Central Scioto River Mainstem CWQR). At several of the most downstream stations sampled, supersaturated DO conditions occurred during the early evening hours. Thus, true steady state conditions were not realized in the Scioto during the July intensive survey.

Steady state model error due to non-steady state effects, such as variable waste loading, can be reduced by considering individual "plugs", or parcels, of water. In plug flow sampling, unique parcels of water are followed and sampled as they move downstream, at intervals according to the expected time of travel (determined from dye studies conducted concurrently, or at similar streamflow). Each plug is then treated as a separate water quality sampling run, from which a predicted profile can be generated using the corresponding inputs. However, no data have been collected from the Scioto River from which such a plug flow model can be developed.

No steady state model, no matter how carefully developed, will allow an accurate prediction of the DO time series as impacted by photosynthesis. QUAL2E may be run in the dynamic mode, which will allow the development of a model to predict the time-variable effects of phytoplankton (but not periphyton algae) on the instream DO and nutrient profiles. While inputs and forcing functions (i.e. effluent and background streamflows, BOD and NOD loadings, and DO concentrations) must remain constant, the variation in stream DO concentrations due to diurnal variation in algal photosynthesis can be simulated. However, QUAL2E does not have the capability to properly simulate benthic photosynthesis which, apparently, may be quite significant in the Scioto River. To successfully accomplish the simulation of benthic or planktonic algae over time, detailed knowledge of the algae nutrient uptake kinetics and light-growth relationships are required. This knowledge is preferably gained from site-specific studies which, in the present case, are lacking for the intensive survey periods. In an attempt to compensate for these deficiencies, literature information would have to be used as initial values for most of the parameters.

In both existing versions of the model, all of the observed DO data points for the four-day survey were used in calibrating the model. However, these DO values were taken from samples collected in both the morning and afternoon hours. Simultaneously calibrating to both morning and afternoon DO observations resulted in the underprediction of the afternoon, and overprediction of the morning, DO profiles. Only 11 of 50 observations were from the morning, and none were from before 9:30 am. Since most of the DO values used for calibration were from the afternoon hours, when DO will be at its highest level of the day, the resulting predicted DO profile was skewed towards a higher level than it probably should have been. This procedure disregards the night and early morning hours, when DO is usually at its lowest level. (Note that the DO concentration measured at river mile 118.5 at 9:30 am on July 21, 1982 was 3.9 mg/l, which was the lowest value observed during the entire survey.) In the URS model (QUAL2E), inclusion of the benthic photosynthesis term resulted in an even higher mean DO profile than the OEPA model (QUAL2), based on the same sampling data.

As an alternative, it might be appropriate to segregate the water quality data with respect to the date and time sampled, i.e. to "time-average" the data. The use of a steady state model could then be better justified, perhaps by calibrating separately to morning (low DO) and afternoon (high DO) observations, or by assigning weights to each observation so that a more realistic picture of daily average water quality values could be obtained. Actual mean parameter values (e.g., Kd, Kn, etc.) could be better estimated in this way, and more accurate predicted profiles could subsequently be generated.

2.3 Benthic Photosythesis Term in QUAL2E.

The QUAL2E model is an improvement over the earlier QUAL2 model in that it recognizes the need to include the effects of algal periphyton on DO in the Scioto River. It is apparent from the URS data that, at times, these attached algae can significantly impact the observed DO profile in the river. However, the URS model incorporates a negative sediment oxygen demand (ie; benthic oxygen production). There are numerous pitfalls associated with the use of a negative sediment oxygen demand (SOD) term in the URS model.

URS' experiment was conducted over a two day period beginning September 25, 1985. During this period, it was generally sunny, but periods of clouds and rain occurred on the 26th. During the periods of cloud cover on the 26th, a net consumption of oxygen was measured in the DO chambers, which would be expected. During the sunny periods, a net production of oxygen was observed. By plotting the change in DO in the chambers and bottles over time, URS derived slopes, in mg/L/min, of the oxygen depletion curves. It is not stated whether these slopes represent averages over the entire experimental period, or instantaneous maxima. However, only the results of the experiments on September 25, when a net production of oxygen was occurring, were used to calculate the "overall" net 24 hour SOD of -1.74 $g/m^2/day$ (the negative sign implies a net production of oxygen).

The applicability of this SOD rate to a model calibrated with data collected three years prior to these experiments must also be questioned. Stream conditions, such as substrate composition and nutrient availability to adequately support benthic algae growth, can change in three years, especially in a relatively small, wastewater-dominated stream such as the Scioto. Also, the sunlight conditions that greatly influence the rate of oxygen production were much different during the July 1982 study period. URS reports that sky cover ranged from 0% to 100% during the survey period. However their SOD rate was derived from an experiment conducted only during bright sunshine. In addition, the experiments were conducted at only one station, located between the Jackson Pike and Southerly discharges. This rate was applied to all of reaches in the model, except in those reaches where the predicted DO greatly exceeded observed values. In those cases, the SOD term was arbitrarily removed in order to "fit" the observed DO data.

Finally, there is also the difficulty in determining a "design condition" SOD rate for use in a WLA model. No precedent or EPA guidance exists in applying a net benthic oxygen production term for use in a WLA model. Before using a term in the model which has little or no literature justification, and which appears to have been used mainly to better fit the data representing higher DO concentrations, additional data collection should be required to support its use.

2.4 Other Significant Problems.

In addition to the major technical problems discussed in the preceding sections, several additional problems are noted. These additional problems are discussed in the following.

2.4.1 Phytoplankton Influence on DO Profile.

Neither model accounted for the influence of phytoplankton on the DO profile of the river. This is especially apparent in the lower reaches of the Scioto (below river mile 109) where significant populations of phytoplankton apparently caused supersaturated DO conditions. In addition, elevated ultimate CBOD values were also observed beginning at river mile (RM) 109. Chlorophyll a samples taken in September, 1982 during a diurnal DO study conducted by OEPA indicate that this section of the river is probably impacted by an active phytoplankton population. (In bottle BOD tests, the presence of algae in the samples can increase the measured ultimate BOD considerably over that which is traceable directly to wastewaters.) However, the OEPA CWQR mentions that "algal simulations were not performed. With the information available, the QUAL-II model could not be accurately calibrated to the Scioto River."

URS attempted to incorporate the effects of phytoplankton in their WLA analysis, and a sensitivity analysis of the effects of phytoplankton on the DO profile under design wasteflow conditions was conducted. The analysis showed that an increase in DO of only 0.14 mg/L would be expected if the phytoplankton population were to increase from 0 to 100 ug/L. This contradicts the July and September, 1982 data presented by OEPA, where significant increases in afternoon DO were observed at the most downstream stations, correlated with high chlorophyll a levels. URS provides no information in the report concerning values for algal kinetics or cell stoichiometry parameters used in the sensitivity analysis.

2.4.2 Nitrogen Species.

The QUAL2E model does not appear to be successfully calibrated for NH3-N and NO2+NO3-N, and organic N was not modeled. Figures 6-5 and 6-6 of the CWQR appear to indicate an erroneous value for the nitrification rate coefficient. Observations for both ammonia and nitrite-nitrate nitrogen are generally underpredicted. This carries over, although to a somewhat lesser extent, to the verification profiles for these variables given in Figures 6-9 and 6-10 of the CWQR. This could stem from not accounting for the effects of algal uptake on nutrients in the model.

Organic nitrogen was not considered in either model. Organic N can hydrolyze to produce ammonia, which can then be taken up by algae or oxidized by nitrifying bacteria. Inclusion of all of the nitrogen species, as well as the effect of algal uptake, may result in a closer correspondence between observed and predicted values.

2.4.3 Cross Sectional Profiles.

Cross sectional profiles provided by the OEPA do not indicate significant variation in cross sectional area or depth. OEPA established 25 reaches based on times-of-travel, river cross sections and flows observed during studies conducted in 1980-1981. Each of these reaches is characterized by a unique power function for flow vs. velocity and flow vs. depth. However, none of the information required to assess the flow-velocity or flow-depth power equations presented in Table 6-2 (flows, times-of-travel, depths for each reach) is given in the report.

Flow vs. velocity and flow vs. depth relationships affect the model's internal calculation of reaeration, and the rate of transport of pollutants through the system. Therefore, it is critical to properly define these relationships to correctly predict the DO response to changes in flow, especially when determining the WLA. However, predicted stream depths developed in the QUAL2E model do not appear to correlate with actual field data. For example, if a flow of 150 cfs is used, the depth equations for reaches 2 and 4 yield depths of 2.8 and 1.8 feet, while the equation for reach 3 yields 0.7 feet. In contrast, based on observation of the profiles submitted by OEPA, there do not appear to be any locations that were sampled that have a mean depth of less than two feet.

Since the shapes of the cross sectional profiles appear to be relatively uniform, it may be more appropriate to divide the study area into fewer physical reaches, so that less variation in depths is obtained. It is accepted modeling practice not to divide a stream system into any more reaches than is necessary, especially if a general physical uniformity throughout the stream is observed.

3. Conclusions and Recommendations.

Based on the reviews conducted to date, it does not appear that an accurate and reliable predictive model for use in assessing current and future environmental conditions has been developed. This is most likely due to limitations in the available data, and to the inability of QUAL2E to simulate diurnal DO variations in the steady state mode. Specific conclusions and recommendations concerning the existing water quality models are listed below.

3.1 Algal Effects on DO.

The contribution of dissolved oxygen by algae to the stream DO balance is not usually accounted for in determining assimilative capacity. However, an attempt should be made to factor the effects of algae on DO into the modeling for the Scioto River, using the September, 1982 diurnal DO data. Any assumptions on daytime oxygen production by algae must be balanced against the catastrophic effects that nighttime respiration of these cells can have on DO, and subsequently on stream biota.

A diurnal DO study was conducted in September, 1982. Some extremely low DO values were observed, and most values recorded were below the 5 mg/L DO standard. However, the number of samples and their times of collection were not reported in the Draft CWQR. The appropriate data for developing an accurate and reliable model of algae in the Scioto for the July, 1982 survey are apparently not available. Thus, it may be difficult to improve on either modeling effort for that period, given the existing data set. However, it may be possible to use the diurnal data collected during September, 1982 to formulate a model of the river which includes the effects of algae on DO. This data set should be analyzed for its potential use in model development.

3.2 Benthic Algae/SOD.

The effects of benthic algae on SOD should not be incorporated into the WLA model until a more complete set of data is available. More studies similar to the URS SOD study should be conducted before a term describing the benthic production of oxygen is incorporated into the model. Due to the existence of the Whittier St. CSO and periodic bypasses of the Southerly WWTP, organic solids introduced into the river during storm events may settle out in the study area and result, at times, in a benthic oxygen demand that exceeds the production of oxygen by benthic algae. This needs to be considered in establishing a steady state net SOD term for use in the model.

3.3 Non-steady State Modeling.

The feasibility of using a non-steady state modeling framework should be explored. USEPA has developed WASP, a multi-purpose dynamic modeling framework that can be used to simulate the effects of phytoplankton on nutrients and DO in streams as well as other types of water bodies. The available body of data should be examined carefully to determine whether WASP, or any other similar framework, may be a more appropriate tool for modeling the Scioto River than QUAL2E.

Although WASP is more flexible than QUAL2E, it is also more complicated and, therefore, more costly to develop and utilize.

3.4 Additional Data.

The feasibility of collecting an additional set of data should be examined. The shortcomings of the available data upon which to build a valid water quality model for the Scioto River have been described by the OEPA and URS. The basic problem is that water quality samples were collected without regard to plug flow in the system. Due to the time variability of DO in the Scioto during low flows, the assumption of steady state (which is crucial to the successful utilization of QUAL2E as the modeling framework) is invalidated.

Also, the depth and velocity vs. flow relationships were developed for flows that may be exceeded as a result of plant expansion in the future. New information collected at higher flows in the Scioto would decrease the uncertainty in the results produced by these equations.

3.5 Evaluation of Alternatives.

Because the existing models were developed under a two-discharge scenario, these models should not be used to evaluate the one-plant alternative without further data collection and modeling analysis. It is likely that, under a one-plant scenario, the water quality impacts of the Southerly plant will extend even farther downstream during 7Q10 flow events than presently occurs.

The existing models extend downstream only to RM 103, near Circleville. Beyond RM 103, there is no information - physical, hydrologic or chemical - on which to base model development. Furthermore, there are other large industrial discharges below RM 100 whose effluent limits may be impaired by the downstream relocation of the DO sag likely to occur due to the combination of flows in a one-plant scenario. This data deficiency needs to be corrected before a reliable model of this section of the river can be constructed.

APPENDIX M

U.S. ENVIRONMENTAL PROTECTION AGENCY, WATER QUALITY BRANCH, MEMORANDUM ON COLUMBUS WATER QUALITY MODEL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE: SEP 30 1987

SUBJECT: Columbus, Ohio Water Quality Modeling

FROM: Kenneth A. Fenner, Chief
Water Quality Branch

TO: Todd A. Cayer, Chief
Municipal Facilities Branch

In response to your memorandum of September 9, 1987, regarding the water quality modeling for Columbus, Ohio, my staff has reviewed the EIS consultant's (SAIC) critique of the modeling work performed by OEPA and later work completed by URS-Dalton for the City of Columbus.

As you may know, the original OEPA two-plant modeling analysis for Jackson Pike and Southerly was reviewed by the Eastern District Office, the Planning and Standards Section and our Permits Section. These offices found the original QUAL II analysis to be sound.

OEPA effort resulted in the following limits:

Plant	River Mile	Flow	$CBOD_5$	NH_3-N
Jackson Pike	127	110 MGD	5.2 mg/l	1.3 mg/l
Southerly	118	85 MGD	5.0 mg/l	1.5 mg/l

Subsequently, the City of Columbus employed URS-Dalton to model the Scioto River as a means of confirming the State's analysis and for exploring a one-plant alternative. URS-Dalton employed lower flow discharge projections, and concluded that the following limits would achieve dissolved oxygen and ammonia water quality standards:

Plant	Time	Flow	$CBOD_5$	NH_3-N
Jackson Pike	Pre-1992	60 MGD	8.0 mg/l	1.0 mg/l
Southerly	Pre-1992	90 MGD	8.0 mg/l	1.0 mg/l
Jackson Pike	1992-	Decommissioned		
Southerly	1992-2015	156 MGD	8.0 mg/l	1.0 mg/l

As you can see, the results are comparable, with a decrease in ammonia that allows slightly higher $CBOD_5$ values. We would also point out that these limits approach those achievable with available technology.

In terms of the critique by SAIC, we agree that model calibration and verification would be improved with further work on stream hydraulics and algal kinetics. However, we can make this same statement regarding virtually any other water quality model in Region V and perhaps the rest of the Country. Furthermore, it does not always follow that a better calibration of existing conditions would necessarily improve the prediction of future conditions. This is because future conditions will be dramatically different due largely to changes in hydraulics and the control of both point and nonpoint sources of pollution. For these reasons, professional judgment is an overriding factor in developing and applying a water quality model. The current model may have an error margin of ±1.0 mg/l of dissolved oxygen. Given the complexity of the Scioto River in this area, we are not convinced that future modeling work will either significantly reduce this error or significantly revise the current effluent limitations.

We agree with the Environmental Review Branch that further modeling of the one-plant vs. two-plant alternative seems counterproductive. This is because reasonable estimates of the one vs. two-plant approach are available to your staff. We have endorsed the two-plant analysis developed by URS-Dalton which is the basis for the current permit limits at each facility.

We also agree that OEPA may be able to provide additional professional judgment if that is deemed necessary for the purpose of the EIS.

APPENDIX N

THE INFRASTRUCTURE PROJECT 1985-1986
FINAL REPORT: EXECUTIVE SUMMARY

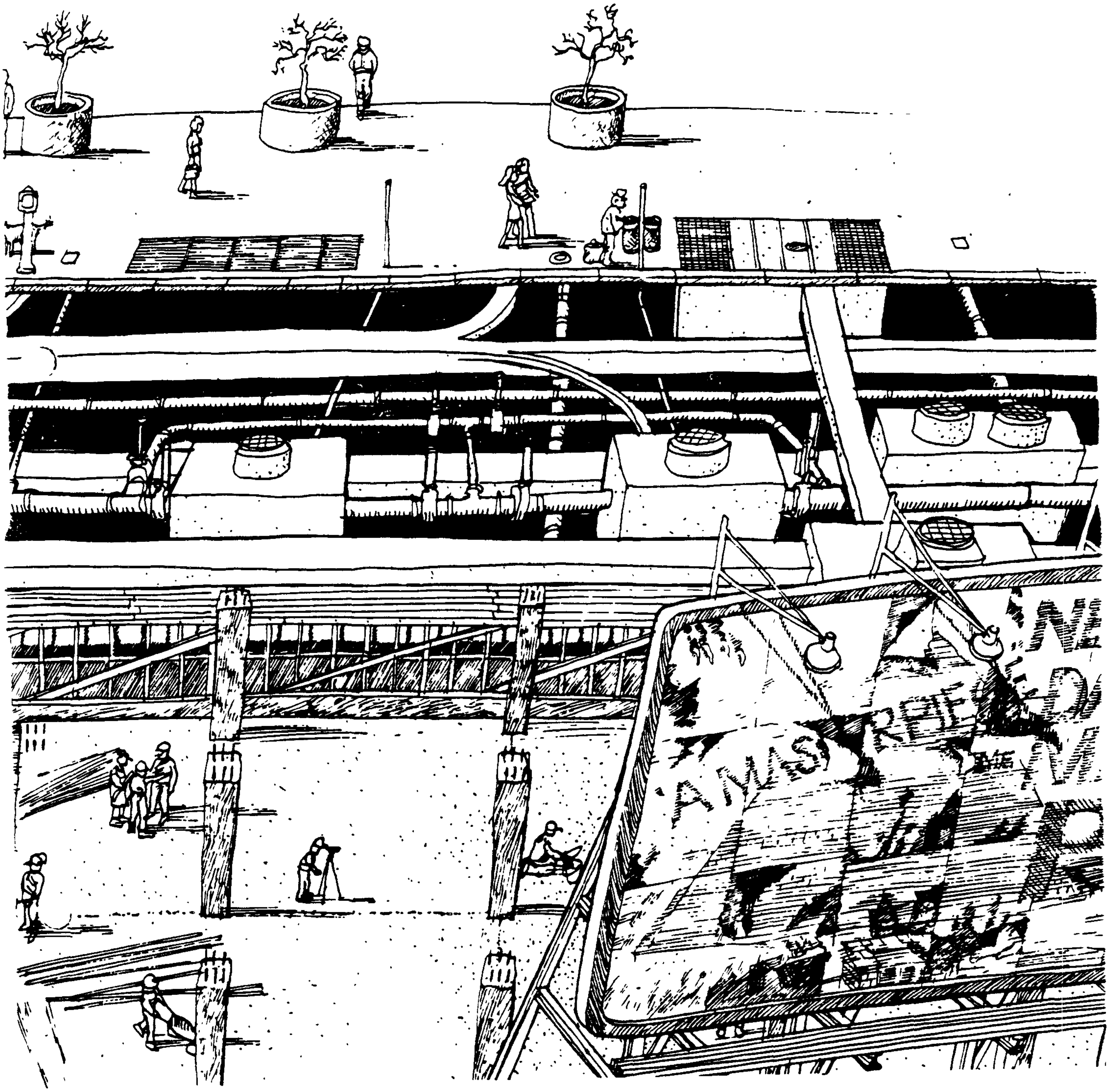
DEVELOPMENT COMMITTEE FOR GREATER COLUMBUS

THE INFRASTRUCTURE PROJECT

1985-1986

FINAL REPORT

5 DECEMBER 1986



"While the space directly beneath a building contains the systems required to support its structure, the area under the surface of the streets and sidewalks is filled with the systems essential to support its occupants. The basic systems, which we call utilities, include water, sewage removal and drainage, electricity, steam, gas, and telephone communication."

"The nation's infrastructure: The physical framework that supports & sustains virtually all economic activity."

Definition by the National Council on Public Works Improvement.

CONTENTS

Extracts from the "GREATER COLUMBUS INFRASTRUCTURE INVESTMENT REQUIREMENTS AND FINANCING STRATEGY: THE NEXT FIVE YEARS" (the Final Report of the DCGC 1985-1986 Infrastructure Project)

NOTE: The Final Report of the DCGC 1985-1986 Infrastructure Project will be distributed to all agencies which were participants in the Project.

EXECUTIVE SUMMARY

The Development Committee for Greater Columbus undertook a major study to assess the area's infrastructure condition and to develop strategies for keeping its capital facilities well managed and maintained. This report represents the final product of two earlier reports written by The Urban Institute in February and September 1986. The first report, Greater Columbus Infrastructure Investment Requirements (Feb. 1986), evaluates capital facility performance and determines capital investment requirements and funding availability over the next five years for area roads, bridges, water, and sewer systems. The second report, Financing Greater Columbus's Infrastructure (Sep. 1986), provides a detailed analysis of the area's options for financing its capital program. The present report represents a final statement of this Greater Columbus Investment Strategy.

GREATER COLUMBUS'S CAPITAL PLANT

- Two indicators of performance -- a street maintenance effectiveness index and resurfacing cycles -- suggest that several jurisdictions are falling behind in **road** repair. The City of Columbus, in particular, falls below a sample of other large cities in road performance, reflecting a fluctuating program of maintenance and repair.

- Jurisdictions with high ratings generally show short resurfacing cycles and more systematic programs of street resurfacing.

- Based on several performance measures, **bridges** in the county are generally in good condition. Only 6 percent are structurally deficient, the potentially most serious bridge problem. The older structures that fall largely under county responsibility, are in the poorest condition.

- Area **water supply** is adequate to the year 2000, provided additional sources are identified beginning in 1991.

- Area water distribution systems show low main breaks relative to other cities. The level of unaccounted-for-water, at 20 percent, is higher than average, but it is not out of line with older cities.

- The major performance problem facing the Greater Columbus area in **sanitary sewers** is the need to upgrade the City of Columbus' sewage treatment plants to meet EPA requirements.

- Condition of area collection systems appears to be adequate. The City of Columbus and its suburbs fare well relative to other cities with respect to the number of main breaks and sewer line back-ups.

- As a relatively new area of infrastructure concern, information is not readily available on the performance of area **storm sewer** facilities.

GREATER COLUMBUS'S CAPITAL INVESTMENT PATTERNS

- The majority of area improvements are slated for expansion (46 percent) and upgrading (43 percent) of capital facilities. Only 11 percent of total investment dollars are targeted for rehabilitation of existing facilities. The City of Columbus, in particular, should consider a more balanced division of resources to insure that existing facilities will be kept in good repair.

- Approximately half of projected investment requirements over the next five years can be met from available federal, state, and local resources.

- The City of Columbus is responsible for nearly half of the funding shortfall, not surprising in view of the city's major role as provider of area highway services, water supply, and sewage treatment. Nearly two-thirds of suburban investment projects, however, are also unfunded.

- The area shows large projected investments of $454 million over the next five years for **roads**, but only 18 percent is slated for rehabilitation.

- Planned investment requirements for **bridges** over the next five years are small relative to other infrastructure areas. The majority are for rehabilitation and upgrading.

- The City of Columbus system accounts for 90 percent of total planned **water** investments. The majority of city investments are for supply improvements and system upgrading. The majority of suburban needs are for rehabilitation and upgrading.

- Planned **sanitary sewer** investments over the next five years represent the second largest spending area. The majority of improvements are for upgrading, to meet Environmental Protection Agency requirements, and for expansion. Only a small fraction of planned spending is for rehabilitation.

- Planned **storm sewer** investments over the next five years are the smallest of all of the infrastructure areas. However, since several studies are only now underway that could lead to a higher needs estimate.

THE COST OF RENEWING GREATER COLUMBUS'S CAPITAL FACILITIES: REASSESSING THE AREA'S NEEDS

The Development Committee for Greater Columbus (DCGC) and the Mid-Ohio Regional Planning Commission (MORPC) with guidance and input from local area officials prioritized an initial list of capital projects according to several criteria such as funding availability, health and safety standards, and impact on the local community. The effort produced a list of priority projects and an estimate of the funding shortfall expected for 1987-1991.

- o Investment requirements across all infrastructure areas and jurisdictions were reduced from $1.05 billion (1986-1990) to $946 million (1987-91). The funding shortfall declined by 9 percent, from $500 million to $457 million.

- o Funding shortfall as a percentage of total planned capital investment is 48 percent.

- o Sanitary sewer projects represent 39 percent of the total investment; storm sewers 2 percent. Capital spending for water systems are 8 percent of the total. Road and bridge improvement expenditures comprise 47 percent and 5 percent of total investments, respectively.

- o Sanitary sewers comprise about 35 percent of the total shortfall. Road funding shortfalls account for 54 percent.

  Funding shortfalls in the water area amount to 2 percent; bridges 7 percent of the total shortfall.

- o The shortfall as a percent of total investment requirements in each infrastructure area is greatest in bridges, at 67%, followed by: roads, 56%; sanitary sewers, 44%; storm sewers, 31%; and water, at 11%.

- o The City of Columbus comprises the bulk of total area shortfalls in roads, bridges, and sanitary sewers. The growth suburbs account for most of area shortfalls in water systems and storm sewers.

FINANCING CAPITAL REQUIREMENTS

- o Proposed financing mechanisms to support infrastructure requirements should be consistent with accepted public finance practice: large scale investments should be debt-financed; debt issuance should be by jurisdictions with the greatest overall responsibility for area infrastructure; improvements should be paid for by those who directly benefit from the improvements.

- The bulk of area road and bridge requirements could be supported with modest increases in user charges: $10 increases in license tag fees; a 2¢ per gallon local fuel tax; an extension of the county sales tax to gasoline.

- Other road and bridge funds required could be raised through developer contributions, so that the increased capacity needed to service growth is supported by those who create added demand.

- The Columbus area appears to have a strong claim on increased ODOT discretionary funds, which historically represent a smaller share than total road mileage responsibility.

- Most jurisdictions with water and sewer funding shortfalls could support the required investment with increases over current rates. The remaining jurisdictions likely will have to partially support investment requirements through general fund support.

- The creation of a storm-water management district represents the best avenue for handling the area's flood and drainage investment requirements.

- Institution of a comprehensive, automated, infrastructure mapping and information system, including inventory, condition, and investment data across jurisdictions and sectors, would encourage better infrastructure management, and ensure reduced long-range capital requirements through improved maintainance programming for existing infrastructure.

VI. NEXT STEPS: IMPLEMENTATION

The development of a comprehensive analysis of Greater Columbus's infrastructure and financing opportunities represents the first step in a capital stock investment and management strategy. The main objective lies ahead: translating this strategy into concrete action. This will require a coordinated effort to educate the public as to its importance, secure authorization from the General Assembly for key steps in the financing plan, cement local cooperation regarding the choice and financing of capital priorities, and ensure the collection and automated storage of the information needed to wisely choose among capital projects, and between capital and maintenance expenditures.

Taxpayer/Voter Approval

The financing plan contemplated in this report places on local highway and utility service users the responsibility for financing improvements to these same services. In the area of roads and bridges, increased fees and charges can support general obligation borrowing by the County to support area-wide investment. This requires authorization of general obligation bond issues by the Franklin County Commissioners, and approval by county voters.

The rate increases required to fund utility system investments do not require general voter approval. However, city councils will have to support increases of the needed magnitudes to cover borrowing requirements, or authorize the expenditure of general fund revenues to meet extraordinary investment costs. In contrast to the multi-jurisdictional approach needed to address area road and bridge investment, increased funding for water and sewer investment is a decision for each system, in each community.

State Legislative Change

The first action required of the state is to modify the current limitation on the county vehicle license fee. Instead of the current $5 ceiling, counties should be allowed to increase the license fee, either by a designated amount or according to locally perceived needs.

State action also will be required to permit local imposition of fuel taxes. Since the 2¢ increase in the gasoline tax is the major source of planned new revenues to support road and bridge investment, this approach should have a local priority. In addition, the decline in fuel prices offers a window of opportunity to impose an additional fee at a time when the impact on consumers will be minimal. Similarly, State approval will be required to permit extension of the county sales tax to gasoline. As this would not represent an increase in the tax, but an increase in the taxing base, resistance to this approach should be somewhat muted.

Local Government Cooperation

Area governments already have demonstrated willingness to cooperate in a coordinated infrastructure renewal effort by participating in the DCGC's Greater Columbus Community Capital Investment Strategy effort. However, many specific project priorities remain to be negotiated, a process requiring continuing good will and cooperation among all governments in the County.

A cooperative agreement will have to be negotiated between the City of Columbus and Franklin County to determine the specific road and bridge projects to be financed from a County bond issue, and the sequencing of repair work. In addition, suburban jurisdictions will have to reach their own accomodation with the County in slating local road projects for renewal. The DCGC has a vital role to play in sustaining the areawide cooperation that has developed during this first project effort.

The creation of a storm-water management district represents the best way to finance areawide flood and drainage improvements. The structure of such a district remains to be worked out among the prospective participants, for example, the rights and terms of entry and withdrawal, the allocation of investment, and the type and level of service charges. Though difficult, this process will result in a secure mechanism for storm-water funding.

Improved Coordination and Management of Capital and Maintenance Spending

The overall Community Capital Investment Strategy effort till now has focused primarily on capital investment needs and funding requirements. The immediate thrust of this effort is to remedy any investment backlogs, and ensure that the facilities needed to accomodate new population and economic growth are in place. However, the Columbus area faces a unique opportunity to reduce long-run capital investment requirements. The complex interrelationship between ongoing maintenance spending and capital improvements requirements is long-recognized but not always considered as a basis for action. By acting now to improve local infrastructure management, area jurisdictions can ensure that the existing, and planned, capital stock is adequately maintained, thus forestalling more costly future investments in infrastructure renewal. The creation of a comprehensive, multi-jurisdictional, automated geographic information and mapping system would be an important, indeed critical, step in improved capital planning.

Such a system would store and display inventory and condition information, and combine water and sewer distribution system information, street and bridge information, including traffic data, zoning and land use data, demographic and economic information, and virtually any other information to allow an assessment of service demand for any infrastructure link. With the addition of maintenance and repair history data, area infrastructure managers can plan for cost-effective maintenance investment, to ensure the longest useful life of any capital asset. In addition, capital investments across sectors can be coordinated to ensure cost-effective repair and minimal disruption; for example, through the sequencing of street repairs and water line replacement.

The cost recovery period of an investment in infrastructure management systems can be quite short. The City of San Jose estimated their system investment at $3.3 million, with annual operating costs of $705,000. The annual benefits expected were $995,000 for avoidance of higher future replacement costs; $1,020,000 for increased maintenance productivity; and $75,000 for reduced costs of tort settlements and insurance. The initial capital investment would be repaid in 2.5 years.

INFRASTRUCTURE MAPPING & INFORMATION SYSTEM

A timely recommendation by the Urban Institute is for the "institution of a comprehensive, automated infrastructure mapping and information system..." The recommendation is considered timely due to a great amount of interest locally and activity nationally in such systems. Variously known as a "Geographic Information System" (GIS in Chattanooga, Tennessee), a "Mapping and Geographic Infrastructure System" (IMAGIS in Indianapolis), "Mapping Oriented Information System" (MOIS at American Electric Power), "Automated Mapping/Facilities Management" (AM/FM for the U.S. Air Force, Consolidated Gas Transmission Corporation of Clarksburg, West Virginia,...and others), or some combination, such as AM/FM-GIS, in Seattle, the systems are basically similar. For sake of simplicity, here and until a better acronym is devised - we will refer to the system as AM/FM.

An important part of the DCGC Infrastructure Project has been gathering information concerning AM/FM. We have found a wealth of experiences available for reference as the Greater Columbus community investigates developing an AM/FM system.

Many agencies admit to having come to a realization that they are having difficulties and high costs in their mapping and information systems.

These were well summarized by Peoples Natural Gas Company of Pittsburgh as due to:

> "redundancy of data due to decentralized divisions; update delays to complete a record; difficulties in researching data due to the independent maintenance of varying documents; inadequacies for special applications such as network analysis; and expensive maintenance costs since the effort was very labor intensive."

They continue by stating:

> "The Peoples Natural Gas Company feels that a corporate Facilities Information Management System with computer graphics has enormous potential. Considering the changing needs of the gas industry for extensive record keeping, mapping and design, we must pursue means to improve the effort."

Statements repeated often by utility companies and metropolitan areas are that the high costs of AM/FM systems can be made acceptable by forming coalitions and thereby sharing the system and costs. Repeatedly, the experienced voices in this new industry of AM/FM urge adequate planning and project definition as being crucial to the success of an AM/FM project.

Some experiences have been of starting over, or regrouping, as stated in the following concerning Seattle:

> "The City of Seattle Joint Automated Mapping Project began as individual efforts by four separate City agencies. The City's Budget Office, recognizing their commonality, initiated this joint project. The City is currently conducting a unique pilot project intended to develop cost estimates of conversion of the City's land and utility facilities data base and to provide a better understanding of AM/FM-GIS system capabilities and related implementation procedures and processes. The pilot project was developed by the City participating agencies jointly following an evolutionary process. The process of development of a request for proposal for a consultant to complete the pilot began with an agreement on goals and objectives, included identification of candidate applications and development of a pilot project approach, and concluded with a memo of agreement, or charter, between the agencies assuring commitment of adequate resources (dollar and personnel) to the pilot. Key to the success of this process and to the success of the project itself, is the ability of project management to (1) maintain management commitment to the project, (2) continue an open communicative, synergistic decision process, and (3) assure sufficient resources in the leadership role. With these factors, the cooperative, i.e., joint, nature of the project can be maintained through the pilot and into an implementation decision process. In summary, management commitment, an open process, and leadership support have forged a team effort from the initial set of individual agency, or turf, interests."

In conclusion, we will report a statement from the Coachella Valley Water District (California) Deputy Chief Engineer:

> "CAD is here to stay - AM/FM is on the way!
>
> When? How soon? No one has the answer today. The only statement that can be made to a certainty is that AM/FM is as inevitable to the District and to all similar public agencies as data processing was 15 or 20 years ago."

APPENDIX O

SEIS DISTRIBUTION LIST TO
PUBLIC GROUPS AND OFFICES

Federal Agencies

U.S. Department of Agriculture
U.S. Department of Commerce
U.S. Department of Defense,
  Army Corps of Engineers
U.S. Department of Housing and Urban Development
U.S. Department of Health and Human Services,
  Public Health Service
U.S. Department of the Interior,
  Fish and Wildlife Service
  National Park Service
U.S. Department of Labor
U.S. Department of Transportation,
  Coast Guard
  Federal Highway Administration
Ohio Congressional Delegation,
  U.S. Senators
  U.S. Representatives

State of Ohio

Building Industry Association of Ohio
Office of the Governor
Ohio Office of Management and Budget
State Clearinghouse
Ohio Environmental Protection Agency
Ohio Department of Natural Resources
Ohio Department of Public Health
Ohio Department of Transportation
Ohio Department of Justice
Ohio Department of Economic and Commercial Development
Ohio Department of Energy
Ohio Water Development Authority
Ohio Department of Agriculture
Ohio Federation of Soil and Water Conservation Districts
Ohio Historic Preservation Office
Ohio Attorney General
Ohio Department of Parks and Recreation
Ohio Utilities Company

Local

Capital Square Commission
City of Bexley
City of Gahanna
City of Grandview
City of Grove City
City of Hilliard
City of Reynoldsburg
City of Upper Arlington
City of Worthington
Clinton Area Commission
Columbus Dispatch
Columbus Health Department
Columbus Industrial Association
Delaware County Regional Planning Commission
Fairfield County Regional Planning Commission
Franklin County Farm Bureau
German Village Commission
Greater Hilltop Area Commission
Hamilton Township
Italian Village Commission
Logan-Union-Champaign Regional Planning Commission
Madison County Regional Planning Commission
Mid-Ohio Health Planning Federation
Mid-Ohio Regional Planning Commission
Near East Area Commission
Northeast Area Commission
Pickaway County Regional Planning Commission
Public Library of Columbus and Franklin County
Rickenbacher Air Force Base
South Linden Area Commission
University Area Commission
Village of Brice
Village of Canal Winchester
Village of Dublin
Village of Galena
Village of Harrisburg
Village of Johnstown
Village of New Albany
Village of New Rome
Village of Obetz
Village of Orient
Village of Pataskala
Village of Plain City
Village of Riverlea
Village of Urbancrest
Village of Valleyview
Village of West Jefferson

Public Interest Groups

American Association of University Women Great Lakes Basin
  Task Force
Archaeological Society of Ohio
Audubon Society of Ohio
Citizens for a Better Environment
Citizens Advisory Council
Citizens for Good Planning
Columbus Board of Realtors
Environmental Clearinghouse, Inc.
Environmental Defense Fund
Franklin County Health Department
F.U.T.U.R.E.
Future Farmers of America
Greater Cleveland Growth Association
Izaak Walton League
League of Ohio Sportsmen
League of Women Voters of Ohio
Natural Wildlife Federation
Nature Conservancy of Ohio
Ohio Academy of Sciences
Ohio Air Quality Development Authority
Ohio Biological Survey
Ohio Chamber of Commerce
Ohio Conservation Foundation
Ohio Conservation Fund
Ohio Electric Utility Institute
Ohio Environmental Council
Ohio Environmental Health Association
Ohio League of Conservation Voters
Ohio Natural Areas Council
Ohio State University
Ohio Natural Heritage Program
Ohio Sierra Club
Ohio Soil and Water Conservation Commission
Ohio Water Pollution Control Conference
Ohio Water Resources Center
Sciota Bass Anglers
Water Pollution Control Federation
Water Resources Council
Wildlife Legislative Fund

Interested Citizens

Complete list available upon request.