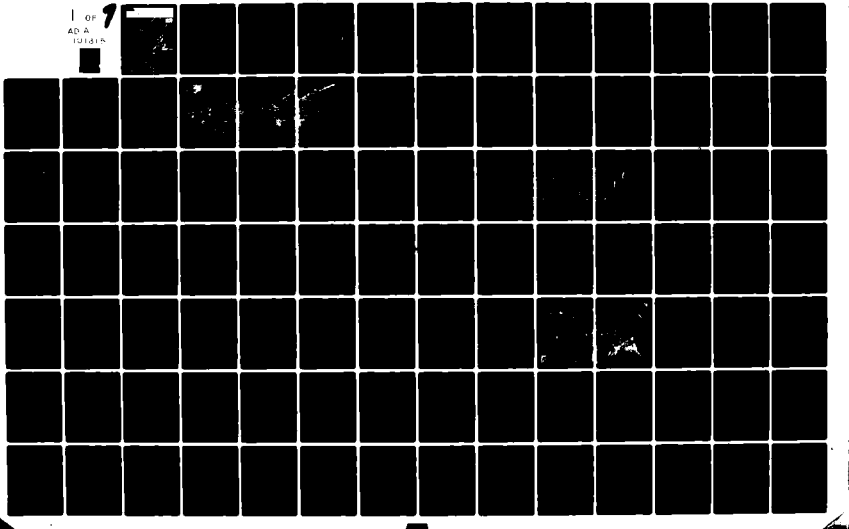
AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA. W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL



WASTEWATER MANAGEMENT STUDY

APPENDIX V LAND TREATMENT

LEVEL

1970

1985

AD A101315

ELECTE
JUL 1 0 1981
D

AUGUST 1973

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

FOR

CLEVELAND – AKRON METROPOLITAN

AND

THREE RIVERS WATERSHED AREAS

DTIC FILE COPY

81 7 10 109

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A707 315 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Wastewater Management Study for Cleveland-Akron Metropolitan and Three Rivers Watershed Areas Appendix V Land Treatment	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Enginner District, Buffalo 1776 Niagara Street Buffalo, New York 14207	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Buffalo 1776 Niagara Street Buffalo, New York 14207	12. REPORT DATE 1973
	13. NUMBER OF PAGES 310
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Distribution Unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Wastewater
Cleveland-Akron
land treatment

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This land treatment technical appendix to the Survey Scope Study provides the basic soil, geological and hydrological data for this study as a starting point for planners and engineers who may be involved in future land treatment works in northern Ohio. This appendix does not deal with the actual planning and preliminary engineering of the land treatment components of the study. It is primarily oriented toward defining the physical constraints and opportunities related to land treatment in the Lake Erie Basin or northern Ohio. The appendix discusses the conventional criteria for selecting soils cont

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

for land treatment and the rationale for a new set of criteria developed during this Survey Scope Study. The reader will learn that the soils selected for the Cleveland-Akron/Three Rivers Basin are generally far more fine grained and impermeable than previously thought to be "optimum." These tighter soils have been selelcted, and the 46,000 acres of sandy soils, which were originally at the top of the list, have been bypassed.

This appendix is intended to provide the basis for determining physical feasibility of land treatment for the Three Rivers Basin. The report does not attempt to provide final design data, but assumes that detailed studies will proceed on specific sites after the selection of general areas.

(4) CLEVELAND-AKRON METROPOLITAN
AND THREE RIVERS WATERSHED AREA,
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY,

(7)

Appendix V.
LAND TREATMENT, ~~TECHNICAL APPENDIX~~

PHASE I REPORT,

(11 Aug 72

DTIC
JUL 1 0 1981
D
C

(9) Final Rept.

(12) 584

PREPARED FOR
THE U. S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT
UNDER CONTRACT NO. (13) DACW49-72-C-0051

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO

DECEMBER 20, 1972

This document has been approved for public release and sale; its distribution is unlimited.

42

TABLE OF CONTENTS

		Page
LIST OF TABLES		vi
LIST OF FIGURES		viii
SECTION I	INTRODUCTION	1
SECTION II	INVENTORY OF SOILS FOR LAND TREATMENT AREAS	3
SECTION III	SOIL DATA SOURCES	15
	Bibliography	22
SECTION IV	GEOLOGY	26
	Physiography	27
	Stratigraphy	28
	Silurian System	30
	Lockport Group	30
	Salina Group	30
	The Bass Islands Group	32
	Devonian System	33
	The Detroit River Group	33
	The Columbus Formation	33
	The Delaware Formation	34
	The Olentangy Formation	34
	The Ohio Formation	34
	Mississippian System	35
	The Waverly Group	35
	The Bedford Formation	35
	The Berea Formation	35

TABLE OF CONTENTS (Continued)

		Page
SECTION iV	Continued	
	The Sunbury Formation	35
	The Cuyahoga Formation	36
	The Logan Formation	36
	Pennsylvanian System	36
	Economic Significance of Sedimentary Deposits	37
	Tunneling	37
	The Akron Tunnel	38
	The Cleveland-Seneca County Tunnel	40
	The Unified Effluent Transmission Tunnel	43
	Storage Reservoirs	44
	Conclusions	44
	Bibliography	48
SECTION V	GROUND WATER HYDROLOGY - Western Land Treatment Area	51
	Bedrock Aquifers	54
	Glacial Aquifers	60
	Alluvial or Stream Deposits	61
	Relationship of Potential Land Treatment Areas to the Aquifer System	63
	Summary - Western Land Treatment Areas	65
SECTION V-A	GROUND WATER HYDROLOGY - Three Rivers Watershed	68
	Glacial Aquifers	70

TABLE OF CONTENTS (Continued)

		Page
SECTION V	Continued	
	Buried River Valleys	71
	Summary - Three Rivers Watershed	72
	Bibliography	74
SECTION VI	SURFACE HYDROLOGY	76
	Introduction	76
	Climate	77
	Basin Characteristics	81
	Land Disposal Areas	82
	Normal Flow Conditions	84
	Floods	90
	Low Flow	93
	Bibliography	96
SECTION VII	SOIL SELECTION CRITERIA	98
	Introduction	98
	Soils Criteria Philosophy	98
	Initial Selection Criteria	101
	Final Selection Criteria	106
	Land Use Constraints	112
	Open Space and Greenbelt Planning	116
	Bibliography	117
SECTION VIII	SELECTION OF OPTIMUM LANDS	119
	Soils for Conventional Spray Irrigation	120

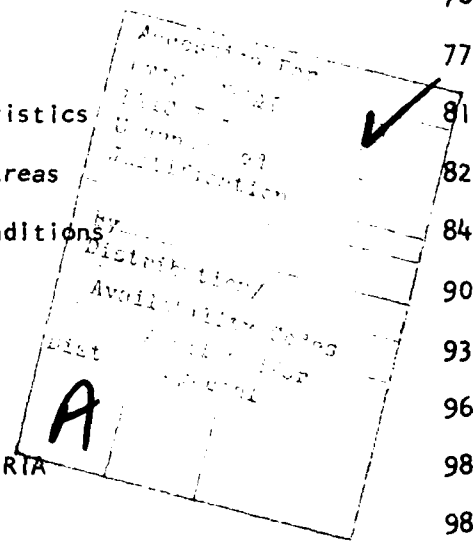


TABLE OF CONTENTS (Continued)

		Page
SECTION VIII	Continued	
	Soils for Overland Runoff/Infiltration Irrigation	122
	Soils for Low Droplet Impact Irrigation	126
	Soils for Overland Runoff Irrigation	129
	Area of Soils Available	129
	General	133
	Bibliography	137
SECTION IX	FARM MANAGEMENT OF LAND TREATMENT SITES	138
	Soil Properties	139
	Mahoning	139
	Ellsworth	139
	Chili	139
	Cardington	140
	Bennington	140
	Land Treatment Objectives	142
	Mahoning-Ellsworth Soil Management	142
	Overland Flow/Infiltration System	143
	Chili Soil Management	148
	Cardington-Bennington Soil Management	149
	Deep Plowing	158
	General	159
	Bibliography	161

TABLE OF CONTENTS (Continued)

		Page
SECTION X	RENOVATIVE CHARACTERISTICS	162
	Effluent Character	162
	Return Flow Quality	163
	Renovation	166
	Organic Removal	166
	Nutrient Uptake	169
	Nitrogen	170
	Phosphorous	172
	Potassium	175
	Total Dissolved Solids	175
	Heavy Metals	179
	Introduction	179
	Treatment Considerations	179
	Loading Limitations	181
	Applied Criteria for Classification of Soils	183
	Problems with Specific Metals	184
	Cleveland Heavy Metals	185
	Bibliography	189
SECTION XI	STRIP MINED LAND RECLAMATION	191
	Bibliography	198

LIST OF TABLES

		Page
TABLE II-1	CLASSIFICATION OF SOIL ASSOCIATIONS	5
II-2	EXPLANATION OF COLUMN HEADINGS IN TABLE II-1	10
TABLE III-1	AREAS OF VARIOUS SOIL ASSOCIATIONS AS SHOWN ON BASE MAP	20
TABLE VI-1	CLIMATIC STATIONS	78
VI-2	PRECIPITATION (INCHES)	78
VI-3	SNOWFALL (INCHES)	79
VI-4	RAINFALL DEPTH (INCHES)	80
VI-5	BASIN CHARACTERISTICS (5, 6)	82
VI-6	POTENTIAL LAND TREATMENT AREAS	83
VI-7	U. S. GEOLOGICAL SURVEY, GAGING STATIONS	86
VI-8	FLOW-DURATION	87
VI-9	IMPACT OF WASTEWATER TREATMENT ON STREAMFLOW	89
VI-10	MAJOR FLOODS, SANDUSKY RIVER NEAR FREMONT	91
VI-11	FLOOD MAGNITUDE (CFS) AND FREQUENCY	92
VI-12	LOW FLOW (2-YEAR FREQUENCY, 7-DAY DURATION) IN CFS	94
TABLE VII-1	INITIAL CRITERIA FOR SELECTION OF LANDS FOR IRRIGATION WITH SEWAGE EFFLUENT, LAKE ERIE BASIN OF OHIO	104
VII-2	SOIL PARAMETERS SUITABLE FOR CONVENTIONAL SPRAY IRRIGATION	108
VII-3	SOIL PARAMETERS SUITABLE FOR OVERLAND RUNOFF/ INFILTRATION IRRIGATION	109
VII-4	SOIL PARAMETERS RELATED TO LOW DROPLET IMPACT IRRIGATION	110

LIST OF TABLES (Continued)

		Page
TABLE VII-5	SOIL PARAMETERS SUITABLE FOR OVERLAND RUNOFF IRRIGATION	111
VII-6	SUMMARY OF AGRICULTURAL PRODUCTS	115
TABLE VIII-1	SOIL PARAMETERS, CHILI SOIL SERIES	121
VIII-2	SOIL PARAMETERS, MAHONING SOIL SERIES	124
VIII-3	SOIL PARAMETERS, ELLSWORTH SOIL SERIES	125
VIII-4	SOIL PARAMETERS, CARDINGTON SOIL SERIES	127
VIII-5	SOIL PARAMETERS, BENNINGTON SOIL SERIES	128
VIII-6	SOIL ASSOCIATION - IRRIGATION METHODS	130
TABLE IX-1	PROPERTIES OF THE THREE SELECTED SOILS	141
TABLE X-1	IRRIGATION WATER QUALITY	163
X-2	RENOVATION OF EFFLUENT WITH CARDINGTON-BENNINGTON SOILS BASED ON 75 INCHES/YEAR	164
X-3	RENOVATION OF EFFLUENT WITH MAHONING-ELLSWORTH SOILS BASED ON 90 INCHES/YEAR	164
X-4	RENOVATION OF EFFLUENT WITH MAHONING-ELLSWORTH SOILS BASED ON 150 INCHES/YEAR	165
X-5	RENOVATION OF EFFLUENT WITH CHILI SOILS BASED ON 60 INCHES/YEAR	165
X-6	DISSOLVED SOLIDS CONTENT IN LAKE ERIE TRIBUTARIES FOR 1951-1952	178
X-7	DISSOLVED SOLIDS IN SELECTED STREAMS FOR 1970	178
X-8	SOIL CONCENTRATIONS OF HEAVY METALS FROM LAND TREATMENT	188
TABLE XI-1	ACREAGE OF STRIP MINED LANDS IN OHIO	196

LIST OF FIGURES

		Page
FIGURE II-1	POTENTIAL LAND TREATMENT AREAS MAP	4
FIGURE II-2	STUDY LOCATION MAP SHOWING COUNTIES IN LAKE ERIE DRAINAGE BASIN INCLUDED IN SOILS INVENTORY	13
FIGURE II-3	USDA SOIL TEXTURAL CLASSIFICATION SYSTEM	14
FIGURE III-1	SCS SOIL ASSOCIATION MAP	21
FIGURE IV-1	VERTICAL SEQUENCE OF BEDROCK FORMATIONS IN NORTHERN OHIO	31
FIGURE IV-2	TYPICAL TUNNEL ROUTES (CROSS SECTION)	46
FIGURE IV-3	GEOLOGIC MAP OF WESTERN LAND TREATMENT AREAS	47
FIGURE IX-1	OVERLAND FLOW/INFILTRATION SYSTEM, MAHONING-ELLSWORTH SOILS	147
FIGURE IX-2	CENTER PIVOT RIG - REED CANARY GRASS CARDINGTON-BENNINGTON SOILS	151
FIGURE IX-3	CENTER PIVOT RIG -- FLOOD JET/GRASS STRIP CARDINGTON-BENNINGTON SOILS	152
FIGURE IX-4	CENTER PIVOT RIG - ABC METHOD (ALTERNATE BIENNIAL CROPPING METHOD) CARDINGTON-BENNINGTON SOILS	153
FIGURE IX-5	CENTER-PIVOT RIG -- 2 ROW CORN STRIPS CARDINGTON-BENNINGTON SOILS	154
FIGURE IX-6	CENTER PIVOT RIG -- SLIP PLOW/DRIP TUBE CARDINGTON-BENNINGTON SOILS	155
FIGURE IX-7	CENTER PIVOT WITH DRIP TUBE SYSTEM CARDINGTON-BENNINGTON SOILS	156
FIGURE XI-1	STRIP MINE LANDS IN OHIO - MAP	197

SECTION I

INTRODUCTION

This land treatment technical appendix to the Survey Scope Study provides the basic soil, geological, and hydrological data for this study as a starting point for planners and engineers who may be involved in future land treatment works in northern Ohio. The total volume of pertinent data available for northern Ohio is immense. A small library could be created from the publications concerning the geographic and physical characteristics of this region.

The abundance of data available to planners and engineers is a tribute to the diligence of the State of Ohio agencies, federal agencies, and others who have worked over the years to accumulate the various basic data inventories.

This appendix does not deal with the actual planning and preliminary engineering of the land treatment components of the study. It is primarily oriented toward defining the physical constraints and opportunities related to land treatment in the Lake Erie Basin of northern Ohio.

The appendix discusses the conventional criteria for selecting soils for land treatment and the rationale for a new set of criteria developed during this Survey Scope Study. The reader will learn that the soils selected for the Cleveland-Akron/Three Rivers Basin are generally far more fine grained and impermeable than previously thought to be "optimum." These tighter soils have been selected, and the 46,000 acres of sandy soils, which were originally at the top of the list, have been bypassed.

The scope of work for this Appendix of Land Treatment Technical Data is summarized as follows:

1. Inventory and identify potential land treatment areas in the Ohio portion of the Lake Erie drainage basin.

2. Classify the land treatment soils as to land treatment characteristics.

3. Present basic data in a useful form for reference purposes.

4. Provide a report on the findings with appropriate rationale given for the selection of soils and application rates. Present additional data and findings related to land treatment.

This Appendix is intended to provide the basis for determining physical feasibility of land treatment for the Three Rivers Basin. The report does not attempt to provide final design data, but assumes that detailed studies will proceed on specific sites after the selection of general areas.

SECTION II

INVENTORY OF SOILS FOR LAND TREATMENT AREAS

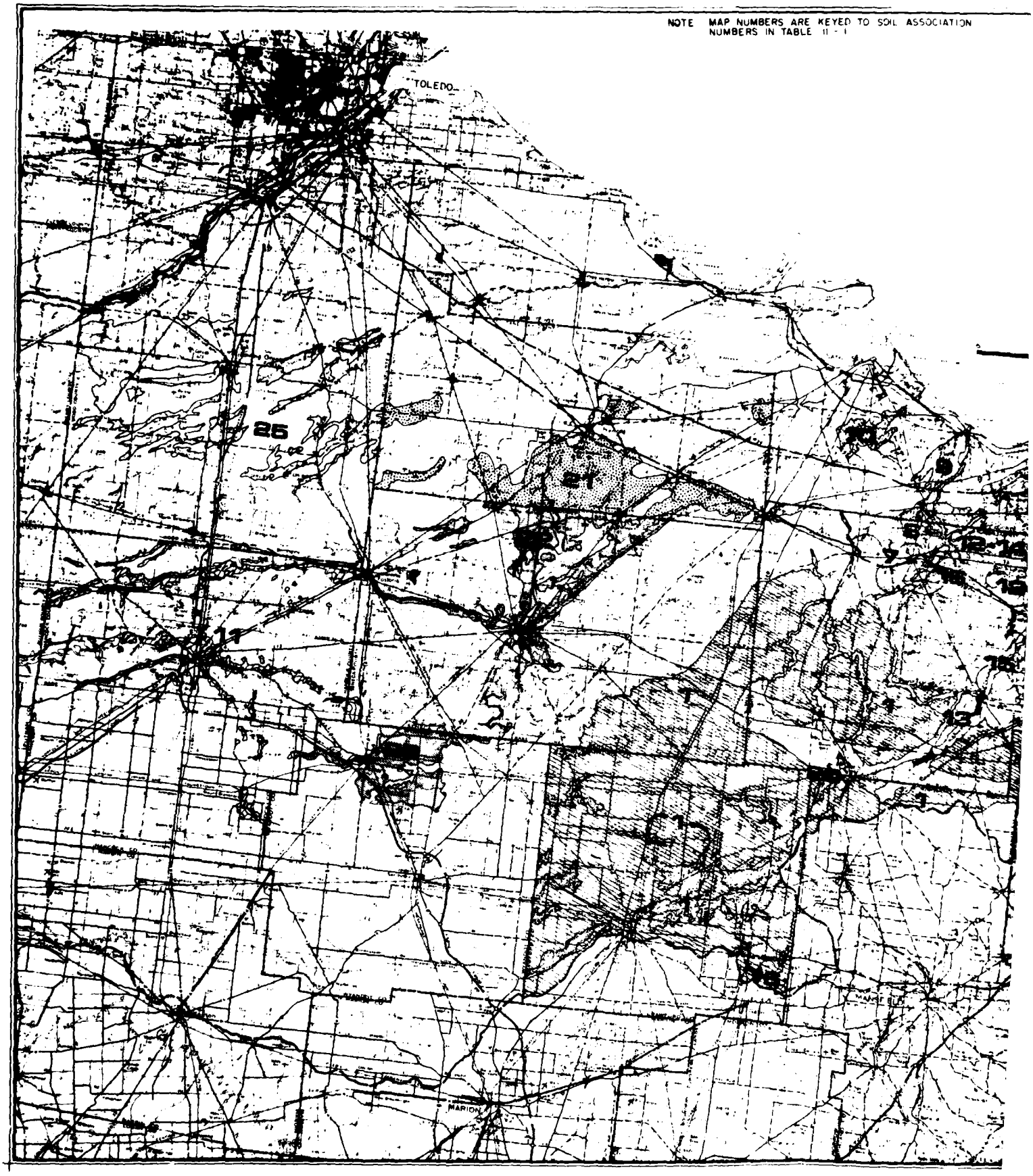
The searching out and identification of potentially suitable lands was limited to the Lake Erie Basin of northern Ohio as far west as Hancock County, and easterly to the Pennsylvania border. The 21 counties included in the review are listed below and shown on Figure II-2.

1. Ashland
2. Ashtabula
3. Crawford
4. Cuyahoga
5. Erie
6. Geauga
7. Hancock
8. Hardin
9. Huron
10. Lake
11. Lorain
12. Medina
13. Ottawa
14. Portage
15. Richland
16. Sandusky
17. Seneca
18. Summit
19. Trumbull
20. Wood
21. Wyandot

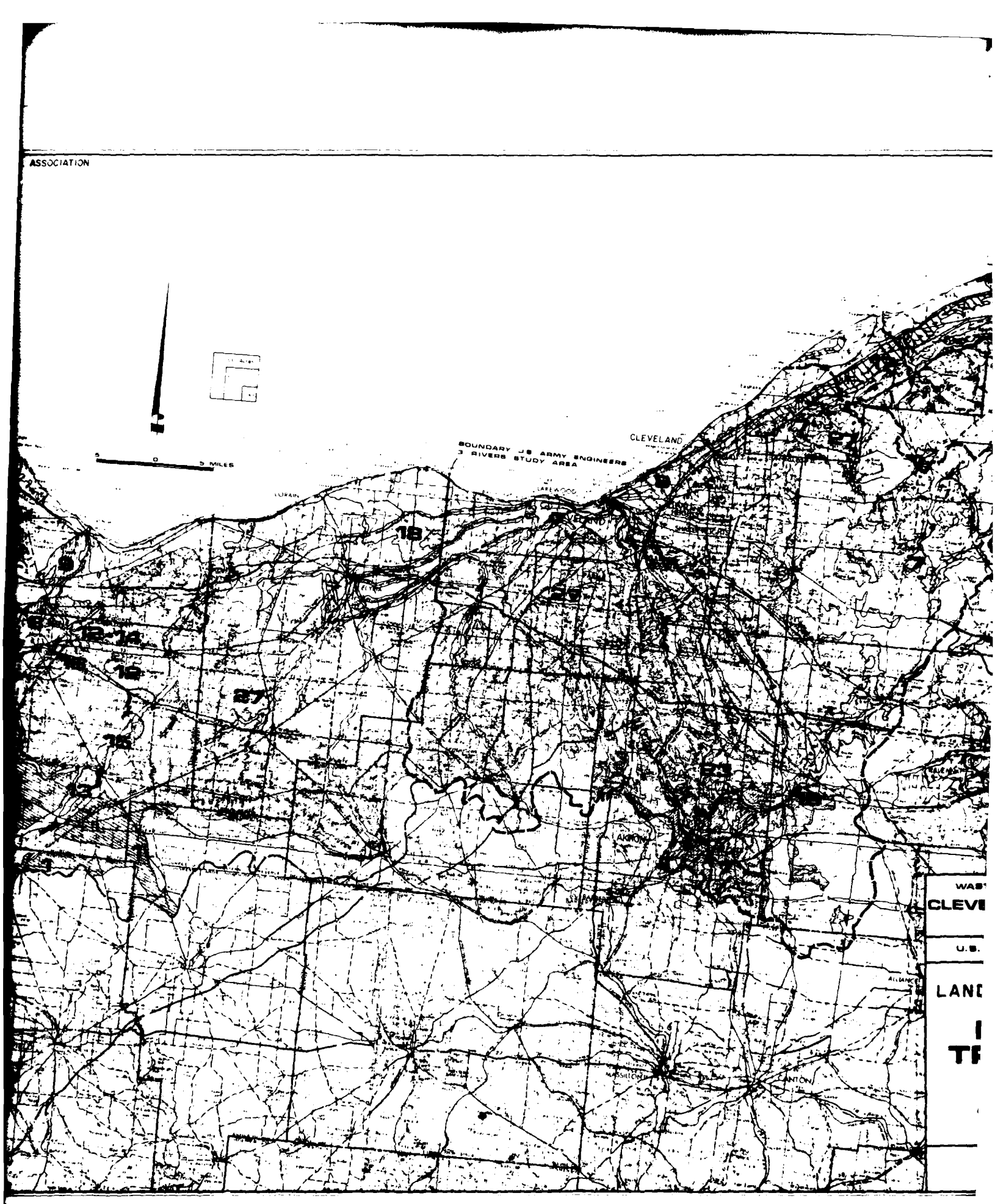
Soil classification data from published and unpublished sources, field interviews with soil and agricultural specialists in Ohio, field and office investigations by special agricultural consultants from Colorado State University, and special basic data gathered by the Columbus office of the Soil Conservation Service provided the foundation for this inventory of potential land treatment areas.

The analysis and inventory of these data resulted in the compilation of Table II-1. An explanation of column headings is presented in Table II-2. Each of the soil associations listed in Table II-1 is shown on Figure II-1, a map of the Lake Erie Basin of northern Ohio.

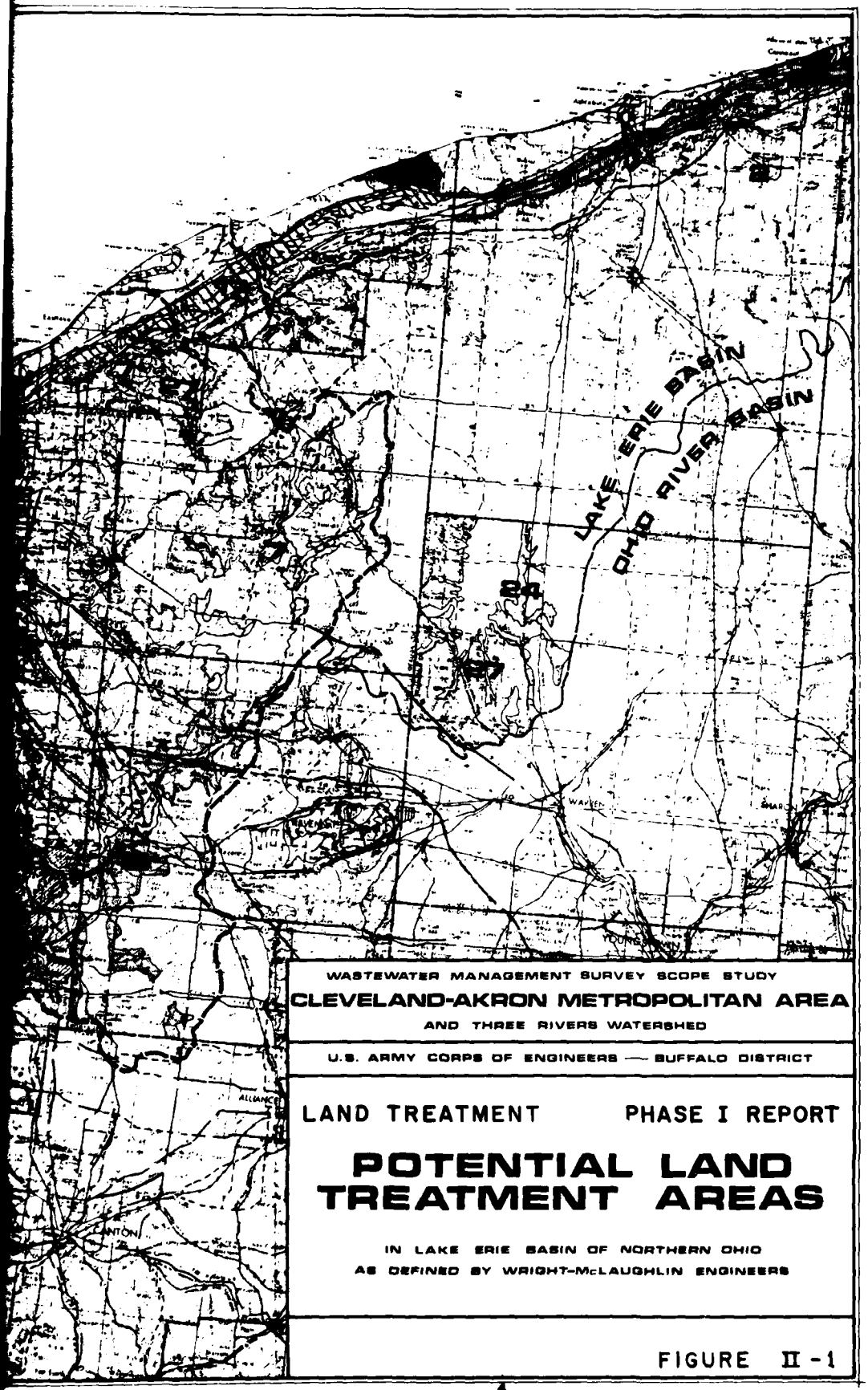
The reader is referred to Section III of this appendix for information on data sources and references.


NOTE MAP NUMBERS ARE KEYED TO SOIL ASSOCIATION NUMBERS IN TABLE II - 1
TOLEDO
25
24
MARION

ASSOCIATION



12



WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

CLEVELAND-AKRON METROPOLITAN AREA

AND THREE RIVERS WATERSHED

U.S. ARMY CORPS OF ENGINEERS — BUFFALO DISTRICT

LAND TREATMENT PHASE I REPORT

POTENTIAL LAND TREATMENT AREAS

IN LAKE ERIE BASIN OF NORTHERN OHIO
AS DEFINED BY WRIGHT-McLAUGHLIN ENGINEERS

FIGURE II-1

CLASSIFICATION OF SOIL ASSOCIATIONS SELECTED AS POTENTIAL LAND TREATMENT AREAS

TABLE B-1 Sheet 1 of 6

County	No.	Soil association or soil name	Acres (1000)	Soil layer	Depth (in.)	Texture (USDA)	Permeability (in./hr)	Available water capacity (in./in.)	pH	Shrink-swell potential	Slope (%)	Flooding frequency	Hydrologic soil group	Depth to bedrock (ft)	Depth to seasonal high water table (ft)	Sieve No. 4 (%)	Sieve No. 10 (%)	Sieve No. 200 (%)	Unified soil classification	AASHTO classification	Liquid limit	Plasticity index	Corrosivity to steel	Corrosivity to concrete	Erosion factor K	Erosion factor T	Wind erodibility group	Limitations for dwellings without basements	Limitations for small commercial buildings	Limitations for local roads and streets	Limitations for septic tank absorption fields	Limitations for sewage lagoons	Limitations for shallow excavations	Limitations for trench sanitary landfill	Limitations for area sanitary landfill	Limitations for daily cover for landfill	Suitability as source of topsoil	Suitability as source of sand	Suitability as source of gravel	Suitability as source of roadfill	Suitability as source of reclamation material	Suitability as source of agricultural drainage	Suitability as source of irrigation
ASHLAND		Cardington-		A	0- 8	sil	5.1-6.0	2.1		0- 6		0.65- 2.0	0.18-0.23	2.5	Clay till Loam	5+	1½ - 3	24.3	57.0	18.7	ML-CL,ML	A-4,A-6	95-100	85-100	70-95	Low	---	High	No Limiting Factors	Agriculture	Crops, Pasture, & 15% Wooded	Excellent	Good
				B	8-18	sicl	5.1-6.0	0.7				0.2 - 0.63	0.19-0.21					19.1	48.6	32.3	CL	A-6	95-100	85-100	70-85	Moderate	Low	High																	
				B	18-30	sicl	5.6-7.3					0.2 - 0.65	0.18-0.19					23.4	48.9	27.7	CL	A-6	95-100	85-100	70-85	Moderate	Low	High																	
				C	30-60	sl	7.4-8.0					0.2 - 0.65	0.16-0.18					24.2	51.6	24.2	CL,ML-CL	A-6	90-100	80-95	60-80	Moderate	Low	High																	
	1		9,800																																								
		Bennington		A	0- 6	sil or l	5.0-6.0	2.6	15.2	0- 6		0.63- 2.0	0.16-0.20	2.5	Clay till Loam	5+	1 - 1½	20.3	62.2	17.5	ML-CL,ML	A-4,A-6	95-100	85-100	70-95	Low	---	Moderate			Crops, Pasture, & 15% Wooded	Excellent	Good
				A	6-12	scl	5.0-6.0	0.9	15.9			0.2 - 0.63	0.15-0.18					20.7	53.9	25.4	CL	A-6	95-100	85-100	70-85	Moderate	Moderate	Moderate																	
				B	12-32	cl	5.1-7.3	0.8	22.5			0.2 - 0.63	0.15-0.18					27.6	41.1	31.5	CL	A-6	95-100	85-100	70-85	Moderate	Moderate	Moderate																	
				C	32-60	sicl	7.4-8.0					0.2 - 0.65	0.15-0.18					19.8	49.5	30.3	CL,ML,GL	A-4	90-100	80-95	60-80	Moderate	Low	Low																	
	27	Rahoning-Ellsworth	5,600	SAME AS FOR MEDINA COUNTY																																							
ASHTABULA		Chenango-			0- 7	sil	4.5-6.5	2.6		0-10	0.2-5.0	2.0 - 6.3	0.17-0.20	3.5	Sand & Gravel	5+	3+	55.6	33.4	11.0	ML	A-4	100	90-100	70-90	Low	---	High	No Limiting Factors	Soil Agriculture	Soil Wooded	Good	Good
					7-23	l	5.6-6.0	0.3				6.3 -12.0	0.12-0.15					75.0	15.6	9.4	SM	A-2,A-4	70- 95	55- 65	15-35	Low	Low	High																	
					23-61	sl	5.1-5.5	0.3				6.3 -12.0	0.09-0.07					84.4	8.2	7.4	GP,SW,SM	A-1,A-2	60- 70	30- 50	1-15	Low	Low	High																	
	2		1,600																																							
		Red Hook			0- 7	sil	6.1-6.5				0.2-5.0	5.0 -15.0		4.0	Sand & Gravel	5+	4	61.3	27.0	11.7										No Limiting Factors	Soil Urban		Good	Good
					7-46	l or sl	4.5-5.0					0.5 -15.0						84.4	15.7	9.9																							
					46+	gr						5.0 -15.0						93.2	1.5	5.3																							
		Colonie-			0-10	fs	4.5-5.0				>5.0	6.3 -12.0	0.08-0.10	2.5	Fine Sand	5+	4	91.3	6.6	2.1	SM	A-2,A-4	100	100	15-40	Low	Low	High	No Limiting Factors	Primarily Occupied By Woods	Soil Wooded	Fair	Acceptable
					10-15	fs	4.5-5.0					6.3 -12.0	0.06-0.10					95.3	9.3	5.4	SM,SP-SM	A-2,A-3	100	95-100	5-35	Low	Low	High to Mod.																	
					25+	ls	6.1-6.5					6.3 -12.0	0.04-0.08					95.8	3.3	0.9	SM,SP-SM	A-1,A-3	100	95-100	5-35	Low	Low	High to Mod.																	
	3		21,500																																							
		Elnora			0-10	fsl	4.5-6.5				2.0- >5.0	6.3 -12.0+	0.08-0.10	4.5	Fine Sand	5+	1½ - 3				SM	A-2,A-4	95-100	95-100	20-40	Low	Low	High	No Limiting Factors	Soil & Urbanization		Fair	Acceptable
					10-33	fsl or fs	4.5-5.0					6.3 -12.0+	0.08-0.10								SM	A-2,A-4	95-100	95-100	20-40	Low	Low	High																	
					33-52	lfs or fs	4.5-5.0					6.3 -12.0+	0.04-0.08								SM	A-2,A-4	100	100	15-40	Low	Low	High																	
					52+	lfs or fs	5.1-5.5					6.3 -12.0+									SM	A-2,A-4	100	100	15-40	Low	Low	High																	
		Otisville-			0-6	gl	6.1-6.5				>5.0	6.3 -12.0	0.08-0.12	1.5	Sand & Gravel	5+	4+				SM	A-2	75-100	60- 85	20-35	Low	---	High	No Limiting Factors	Soil Urbanization	Soil Wooded	Fair	Acceptable
					6-18	gl	4.5-5.0					6.3 -12.0	0.03-0.06								SM,SP-SM		80-100	30- 50	5-20	Low	Low	High																	
					18+	s & g	5.1-5.5					6.3 -12.0	0.02-0.06								SM,GM,SW,SM	A-1,A-3	50-100	10-100	5-20	Low	Low	High																	
	4	Chenango	12,900	SAME AS ABOVE																																							
CRAWFORD		Cardington-		A	0- 8	sil	5.1-6.0	2.1		0- 6		0.65- 2.0	0.18-0.23	2.5	Clay till Loam	5+	1½ - 3	24.3	57.0	18.7	ML-CL,ML	A-4,A-6	95-100	85-100	70-95	Low	---	High	No Limiting Factors	Agriculture	Crops, Pasture, & 15% Wooded	Excellent	Good
				B	8-18	sicl	5.1-6.0	0.7				0.2 - 0.63	0.19-0.21					19.1	48.6	32.3	CL	A-6	95-100	85-100	70-85	Moderate	Low	High																	
				B	18-30	sicl	5.6-7.3					0.2 - 0.65	0.18-0.19					23.4	48.9	27.7	CL	A-6	95-100	85-100	70-85	Moderate	Low	High																	
				C	30-60	cl	7.4-8.0					0.2 - 0.65	0.16-0.18					24.2	51.6	24.2	CL,ML-CL	A-6	90-100	80-95	60-80	Moderate	Low	High																	
		Lobdell-		A	0- 9	sil	5.6-6.0					0.65- 2.0	0.18-0.24	>1	Silt, Loam Alluvium	5+	1½ - 3				ML, CL	A-4,A-6	90-100	80-100	70-90	Low	---	Moderate	Some Flood Hazard	Soil Rural	Soil Wooded	Good	Good
	1		203,700	C	9-60	sil	5.6-6.9					0.63- 2.0	0.15-0.18								ML, CL	A-4,A-6	90-100	80-100	70-90	Low	Moderate	High																	
		Bennington		A	0- 6	sil or l	5.0-6.0	2.6	15.2	0- 6		0.63- 2.0	0.16-0.20	2.5	Clay till Loam	5+	1 - 1½	20.3	62.2	17.5	ML-CL,ML	A-4,A-6	95-100	85-100	70-95	Low	---	Moderate			Crops, Pasture, & 15% Wooded	Excellent	Good
				A	6-12	scl	5.0-6.0	0.9	15.9			0.2 -0.65	0.15-0.18					20.7	53.9	25.4	CL	A-6	95-100	85-100	70-85	Moderate	Moderate	Moderate																	
				B	12-32	cl	5.1-7.3	0.8	22.5			0.2 -0.65	0.15-0.18					27.6	41.1	31.5	CL	A-6	95-100	85-100	70-85	Moderate	Moderate	Moderate																	
				C	32-60	sicl	7.4-8.0					0.2 -0.65	0.15-0.18					19.8	49.5	30.3	CL,ML-CL	A-6	90-100	80-95	60-80	Moderate	Low	Low																	
		Digby-		SAME AS FOR HANCOCK COUNTY																																							
	6	Honeoye-	----	SAME AS FOR RICHLAND COUNTY																																							
		Hilltgrove		A	0-10	l	6.6-7.3			0-2		0.65- 2.0	0.16-0.22	3.0	Gravelly Loam or Clay	5+													Some Ponded Depressions			Good	Good
				B	10-20	l	6.6-7.3					0.65- 2.0	0.16-0.22																														
				B	20-30	scl	6.6-7.3					0.65- 2.0	0.14-0.18																														
				B	30-38	gscl	6.6-7.3					0.65- 2.0	0.14-0.18																														
				C	38-60	gscl	6.6-7.3					0.65- 2.0	0.14-0.18																														
CUYAHOGA		Chili		A	0- 7	l	6.5-6.0	2.2	16.0	1-15		2.0 - 6.3	0.18-0.15	3.5	Gravel & Sand w/ Fines	5+	3+	23.6	60.5	15.4	ML	A-4	80- 90	70- 80	45-70	Low	---	High	Erosion on Steeper Slopes	Soil Urban & Highways		Fair	Fair
				B	7-26	scl or l	5.1-5.5	0.6	12.8			2.0 - 6.3	0.08-0.15					21.8	58.0	20.2	GM,ML	A-2,A-4	55- 85	30- 60	25-55	Low	Low	High																	
				C	26-60	s & g	5.1-5.5	0.1	8.9			>12.0	0.02-0.05					64.3	18.0	17.7	GW-GM, SW-SM, SM	A-1,A-2	30-75	20- 50	5-35	Low	Low	High																	
	8	Palmasville	13,000		0-10	sil	5.0-6.5			1-3																					Urban			Fair	Fair
					10-40	scl or sl	5.5-6.5																																			
					40-60	slc & sl																																				
		Rahoning-Ellsworth-Trumbull	179,000	SAME AS FOR MEDINA COUNTY																																							

CLASSIFICATION OF SOIL ASSOCIATIONS SELECTED AS POTENTIAL LAND TREATMENT AREAS

TABLE II – 1 Sheet 2 of 5

(1)	(2)	(3)	(4a)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)
COUNTY	SOIL ASSOCIATION MAP NO. / NAME	GROSS AREA (ACRES)	DEPTH (HORIZ. / INCHES)	TEXTURE DOMINANT USDA	REACTION pH	EXISTING ORGANIC MATTER (%)	C.E.C. (MEQ. / 100 GM)	SLOPE (%)	HYDRAULIC CAPACITY INFILTRATION (IN/HR)	HYDRAULIC CAPACITY PERMEABILITY (IN/HR)	AVAILABLE MOISTURE (IN/IN of SOIL)	SUBSTRATUM DEPTH (FT.)	SUBSTRATUM MATERIAL	ROCK DEPTH (FT.)	PRESENT SEASONAL HIGH WATER TABLE (FT.)	PARTICLE DISTRIBUTION % SAND	% SILT	% CLAY	CLASSIFICATION UNIFIED	CLASSIFICATION AASHO	PERCENT PASSING SIEVE No. 4 (4.7mm)	No. 10 (2.0mm)	No. 200 (0.074mm)	SHRINK SWELL POTENTIAL	CORROSIVITY GALVANIZED STEEL	CORROSIVITY CONCRETE	TERRAIN CHARACTER	LAND USE CURRENT	VEGETAL COVER	ORGANIC REMOVAL	HEAVY METAL STORAGE CAPACITY
ERIE																															
	Sisson-		A 0-10	sil, sicl, or fsl	6.6-7.3	1.6	8.9	2-10		0.63- 2.0	0.15-0.20	3.0	Lacustrine Silt & Fine Sand	5+	2½ - 4	61.6	28.8	9.6	ML, CL	A-4,A-6	100	100	70- 90	Low	Low	Low	Erosion on steep areas	70% Rural	15% Wooded	Fair	Fair
			B & C 10-60	scl	6.6-7.3	0.4	11.8			0.63-12.0	0.15-0.20					39.8	36.2	24.0	ML, CL	A-4,A-6	100	100	70- 90	Low	Low	Low					
			C 60-80	sil or fs	7.4-8.4						0.13-0.16					51.2	40.1	8.6	ML	A-4	100	100	90-100	Low	Low	Low					
	9	8,600																													
	Tuscola		A 0-10	fsl, sil, or l	5.6-6.5			0- 6		0.63-12.0	0.06-0.23	3.5	Lacustrine Silt	5+	2½ - 4	73.7	21.7	4.6	ML	A-4	100	100	40- 55	Low	Low	Moderate				Good	Good
			B 10-32	scl	5.6-6.5					0.63- 2.0	0.14-0.18					21.1	22.0	6.9	ML	A-4	100	100	40- 55	Low	Low	Moderate					
			C 32-42	sil	6.1-7.3					0.63- 2.0	0.18-0.23					30.1	40.7	29.5	SM-ML	A-4	100	100	40- 55	Low	Low	Low					
			C 42-60	sil or fs	7.4-8.4					2.0 -12.0	0.04-0.23					16.0	57.8	26.2	ML	A-4	100	100	50- 95	Low	Low	Low					
	Arkport-		A 0-11	lfs	6.6-7.4	1.4	8.0	0-18		6.3 -12.0	0.08-0.12	2.5	Loamy Sand	5+	1½ - 3	85.7	8.8	5.5	SM	A-2	100	95-100	5- 35	Low	Low	Moderate		60% Urbanized		Fair	Acceptable
			B & C 11-60	lfs	6.6-7.4	0.3	5.0			2.0 -12.0+	0.06-0.08					91.1	5.4	3.5	SM	A-2,A-4	100	90-100	30- 45	Low	Low	Moderate					
	10	11,200																													
	Galen		A 0-10	sil or fsl	6.6-7.4			0- 6		0.0 -12.0	0.06-0.16	2.5	Fine Sand	5+	2 - 3				SM	A-2	100	90-100	10- 25	Low	Low	Moderate		Urbanized	15% Wooded	Fair	Acceptable
			A 10-20	lfs	6.6-7.4					6.3 -12.0	0.06-0.08								SM	A-2	100	90-100	10- 25	Low	Low	Moderate					
			A & B 20-44	fs	6.6-7.4					6.3 -12.0	0.04								SM	A-2,A-4	95-100	90-100	30- 50	Low	Low	Low					
			A & B 44-60	fs						6.3 -12.0	0.04								SM	A-2,A-4	95-100	90-100	30- 50	Low	Low	Low					
	27 Mahoning-Rogart-Haskin-Jimtown	29,000	SAME AS FOR MEDINA COUNTY SAME AS FOR HURON COUNTY SAME AS FOR LORAIN COUNTY SAME AS FOR LORAIN COUNTY																								Flat	90% Rural	20% Wooded	Excellent Fair Excellent Good	Good Acceptable Good Good
GEAUGA	7 Chili	13,100	SAME AS FOR CUYAHOGA COUNTY																								Some Steep Terrain	60% Rural	25% Wooded	Fair	Fair
	27 Mahoning-Ellsworth	43,900	SAME AS FOR MEDINA COUNTY																								Few Limiting Factors	30% Urban	60% Wooded	Excellent	Good
HANCOCK	Belmore-		SAME AS FOR RICHLAND COUNTY																											Good	Fair
	Digby-		A 0- 9	l or scl	5.6-6.0			0- 2		0.63- 2.0	0.20-0.18	2.5	Gravel & Sand; Clay poss. bel. 42"	5+	< 1½	55.8	28.6	14.6	ML	A-4	90- 95	80- 90	65- 75	Low	---	Low				Good	Fair
			B 9-25	scl	6.6-7.4					0.63- 6.3	0.10-0.18					55.1	29.0	15.9	CL, SC	A-6	85- 95	80- 90	35- 55	Moderate	High	Low		60% Occupied by Highways or Urbanization			
			B & C 25-60	sl	7.4-8.4					2.0 - 6.3	0.14-0.18								SM	A-2	70- 85	50- 65	15- 25	Low	High	Low	Flat to Slightly Sloped				
	11	21,800	A 0- 9	fsl	6.1-6.5			0- 2	0.2→5.0	5.0 - >15.0		3.5	Lacustrine Clay or Clay till	5+		92.5	6.4	1.1											10% Wooded	Fair	Fair
	Sawark-		A & B 9-37	ls or sl	5.6-6.5											95.0	2.8	2.2													
			C 37+													23.9	47.4	28.7													
	Ottokee		A 0- 9	lfs	6.1-6.5			0- 5	> 15.0	6.3 -12.0	0.05-0.09	5.0	Fine Sand	5+	1½ - 3	95.3	0.6	4.1	SM	A-2	100	100	15- 30	Low	Low	Low				Fair	Acceptable
			A 9-16	lfs	6.1-6.5					6.3 -12.0	0.05-0.09								SM	A-2	100	100	15- 30	Low	Low	Low					
			A & B 16-60	lfs or s	7.4-7.8					6.3 -12.0	0.05-0.09								SM	A-2	100	100	20- 35	Low	Low	Low					
HARDIN	---0---																														
HURON																															
	Bennington-		A 0- 6	sil or l	5.0-6.0	2.6	15.2	0- 6		0.63- 2.0	0.16- &.20	2.5	Clay till Loam	5+	½ - 1½	20.3	62.2	17.5	ML-CL, ML	A-4, A-6	95-100	85-100	70-95	Low	---	Moderate	No limitations	85% Rural	10% Wood	Excellent	Good
			A 6-12	scl	5.0-6.0	0.9	15.9			0.2 - 0.63	0.15-0.18					20.7	53.9	25.4	CL	A-6	95-100	85-100	70-85	Moderate	Moderate	Moderate					
			B 12-32	cl	5.1-7.3	0.8	22.5			0.2 - 0.63	0.15-0.18					27.4	44.1	31.5	CL	A-6	95-100	85-100	70-85	Moderate	Moderate	Moderate					
			C 32-60	sicl	7.4-8.0					0.2 - 0.63	0.15-0.18					19.8	49.9	30.3	CL, ML-CL	A-6	90-100	80- 95	60-80	Moderate	Low	Low					
	1	79,200																													
	Cardington		A 0- 8	sil	5.1-6.0	2.1		0- 6		0.63- 2.0	0.18-0.23	2.5	Clay till Loam	5+	1½ - 3	26.3	57.0	18.7	ML-CL, ML	A-4, A-6	95-100	85-100	70-95	Low	---	High	No limitations	85% Rural	10% Wood	Excellent	Good
			B 8-18	sicl	5.1-6.0	0.7				0.2 - 0.63	0.19-0.21					19.1	48.6	32.3	CL	A-6	95-100	85-100	70-85	Moderate	Low	High					
			B 18-30	sicl	5.6-7.3					0.2 - 0.63	0.18-0.19					23.4	48.9	27.7	CL	A-6	95-100	85-100	70-85	Moderate	Low	High					
			C 30-60	cl	7.4-8.0					0.2 - 0.63	0.16-0.18					24.2	51.6	24.2	CL, ML-CL	A-6	90-100	80- 95	60-80	Moderate	Low	High					
	12 Berrien	1,100	SAME AS FOR LAKE COUNTY																								No Limitations	85% Rural	10% Wood	Fair	Acceptable
	13 Rogart	1,300	A 0- 7	sl	5.5-6.0			0- 2		0.63- 2.0	0.17-0.20		Gravel & Sand	5+	3 - 4	45.7	42.9	11.4	ML, SM, GM	A-4	75- 85	70- 80	36- 65	Low	Moderate	Moderate	No Limitations	85% Rural	10% Wooded	Fair	Acceptable
			A & B 7-22	sl	5.5-6.0					0.63- 2.0	0.16-0.18					49.8	36.4	13.8	SM or SC	A-2,A-4	75- 85	70- 80	36- 65	Low	Moderate	Low					
			B & C 22-28	gcl	5.5-6.0					0.63- 2.0	0.12-0.15					62.9	21.0	16.1	SM or SC	A-2,A-4	80- 85	66- 75	30- 50	Low	Moderate	Low					
			C 28-42	gsl	5.5-6.0					2.0 - 6.3	0.04-0.07					74.8	14.4	10.8	SM, SC	A-1,A-2,A-4	60- 85	55- 65	15- 40	Low	Moderate	Low					
			C 42-60	g & s	5.5-6.5					6.3 -12.0	< 0.05					76.6	8.9	14.5	SM, SC	A-1,A-2,A-4	60- 85	55- 65	15- 40	Low	Moderate	Low					
	7 Chili	4,400	A & B 0-12	sil	4.5-5.5	1.4	12.9	0- 8		2.0 - 6.3	0.10-0.14		Stratified Gravel	5+	3+	24.1	60.5	15.4	ML	A-4	80- 90	70- 85	45- 70	Low	---	High	No Limitations	85% Rural	10% Wooded	Fair	Fair
			B 12-26	gl	4.5-5.5	0.2	13.1			2.0 - 6.3	0.04-0.07					21.8	58.0	6.0	GM, ML	A-2,A-4	55- 85	50- 60	25- 55	Low	Low	High					
			C 26-60+	gsl, gl	5.6-6.5	0.1	4.8			> 6.3						77.5	9.2	13.3	GW, GM, SM	A-1,A-2	20- 75	20- 50	5- 25	Low	Low	High					
	14 Olmsted	5,500	SAME AS CHILI SOIL																								No Limitations	85% Rural	10% Wood	Fair	Fair
	8 Painesville	1,300	SAME AS FOR CUYAHOGA COUNTY																								No Limitations	85% Rural	10% Wood	Fair	Fair

CLASSIFICATION OF SOIL ASSOCIATIONS SELECTED AS POTENTIAL LAND TREATMENT AREAS

TABLE II-1 Sheet 3 of 5

(19) COUNTY	(20) SOIL ASSOCIATION MAP NO.	NAME	(30) GROSS AREA (ACRES)	(40) DEPTH HORIZON	INCHES	(50) TEXTURE DOMINANT USDA	(60) REACTION pH	(70) EXISTING ORGANIC MATTER (%)	(80) C.E.C. (MEQ.) 100 GMS	(90) SLOPE (%)	(100) HYDRAULIC CAPACITY INFILTRATION (IN/HR)	PERMEABILITY (IN/HR)	(110) AVAILABLE MOISTURE (IN/IN of SOIL)	(120) SUBSTRATUM DEPTH (FT.)	MATERIAL	(130) ROCK DEPTH (FT.)	(140) PRESENT SEASONAL HIGH WATER TABLE (FT.)	(170) PARTICLE DISTRIBUTION % SAND	% SILT	% CLAY	(200) CLASSIFICATION UNIFIED	AASHO	(220) PERCENT PASSING SIEVES No. 4 (4.7mm)	No. 10 (2.0mm)	No. 200 (0.074mm)	(250) SHRINK SWELL POTENTIAL	(260) CORROSIVITY UNCOATED STEEL	CONCRETE	(270) TERRAIN CHARACTER	(280) LAND USE CURRENT	(290) VEGETAL COVER	(310) ORGANIC REMOVAL	(320) HEAVY METAL STORAGE CAPACITY
HURON Cont'd	15	Wilder	3,400	F B C	0-18 18-32 32-60	l, fsl scl s, g, & sl	5.5-6.5 5.5-6.5 6.0-7.0			0-3		1.0 - 6.3 6.3 +	0.14-0.17 0.05-0.12		Till	5+	1 - 2				ML, SM SC, CL SM, GM	A-4 A-2,A-4 A-1,A-2	80- 95 70- 90 50- 85	70- 90 65- 90 50- 85	40- 60 35- 60 20- 40	Low Low Low	--- Moderate Moderate	Low Low Low	No Limitations	85% Rural	10% Wooded	Fair	Fair
	16	Wooster	2,200	SAME AS FOR SUMMIT COUNTY																										No Limit	85% Rural	10% Wooded	Fair	Fair
		Mahoning-27 Ellsworth-Trumbull	111,200	SAME AS FOR MEDINA COUNTY																										No Limiting Factors	90% Rural	15% Wooded	Excellent	Good
LAKE	7	Chili	2,900	SAME AS FOR CUYAHOGA COUNTY																									Some Steep Terrain	90% Urban	20% Wooded	Fair	Fair
	17	Chili-Colonie	23,600	SAME AS FOR CUYAHOGA COUNTY SAME AS FOR ASHTABULA COUNTY																									Some Steep Terrain	90% Urban 90% Urban	20% Wooded 20% Wooded	Fair Fair	Fair Acceptable
	2	Berrien	5,700	0-11 11-50	lfs fs					2-6				4.0	Lacustrine Loam	5+															60% Urban	40% Wooded	Fair	Acceptable
		Mahoning-27 Ellsworth-Trumbull	64,300	SAME AS FOR MEDINA COUNTY																										Few Limiting Factors	70% Urban	Non-urban Heavily Wooded	Excellent	Good
LORAIN		Wasepe		A A & B B C	0- 8 8-18 18-40 40-60	l or fsl l cl cl	6 -6.5 6 -6.5 6 -6.5 7.4-8.4	3.8 0.6		0-6		0.63- 6.3 0.63- 2.0 0.63- 2.0 0.088-0.2	0.12-0.18 0.16-0.18 0.14-0.18 0.07-0.10	2.5	Silty Clay or Clay	5+	1 - 1½	38 9 34 7 26 4 38 9 19 2 41 9 49 0 20 1 30.9 2 1 43 2 54 7		ML-CL ML CL SC or ML	A-4 A-4 A-6 A-4,A-6	100 100 90-100 85- 95	90-100 90-100 90-100 80- 90	60- 70 70- 80 70- 80 65- 80	Low Low Moderate Moderate	--- High High High	Low Low Low Low	No Limitations	80% Urban or Occupied By Highways	20% Wooded	Excellent	Good
	18	Wooster	36,400	A B B & C	0-10 10-27 27-60	l or fsl gcl gl	5.6-6.0 5 -6.5 5 -6.5			0-2		0.63- 6.3 0.2 - 0.63 0.63- 2.0	0.12-0.18 0.16-0.18 0.14-0.18	3.5	Sand & Fine Gravel	5+	< 1½				ML ML	A-4 A-6	75- 85 55- 90	70- 80 75- 85	65- 75 60- 70	Low Moderate	--- Moderate	Moderate Moderate	No Limitations	Same as above	20% Wooded	Good	Good
		Mahoning-27 Ellsworth-Trumbull	136,900	SAME AS FOR MEDINA COUNTY																										Flat	85% Rural	20% Wooded	Excellent	Good
MEDINA		Mahoning		A & B B C	0-11 11-32 32-74	sil sicl sicl	4.5-5.5 4.5-5.5 7.1-8.0	0.7-2.6 0.4	14.7 21.0 20.6	1-4		0-2 - 0.63 0.088-0.2 <0.063	0.19-0.23 0.15-0.18 0.15-0.18	3.0	Clay Loam or Silty Loam Till	5+	2 - 3½	18.6 44.2 37.2 16.1 38.9 45.0 17.7 42.1 40.2		ML,ML-CL CL,ML-CL CL,ML-CL	A-4, A-6 A-7, A-6	90-100 90-100 85-100	90-100 85-100 80- 95	70- 90 70- 90 70- 90	Low Moderate Moderate	--- High High	Low Low Low	No Limiting Factors			Excellent	Good
	27	Ellsworth	114,600	A B B & C	0- 8 8-37 37-60	sil sicl sicl	4.5-6.0 4.5-5.5 5.1-6.0	1.6 0.5	13.0 18.3 16.6	4		0.63- 2.0 0.063-0.2 0.063-0.2	0.18-0.22 0.16-0.19 0.16-0.19	2.5	Clay Loam or Silty Clay Loam Till	5+	1½ - 3	19.4 60.4 20.2 17.8 48.4 33.8 27.0 44.9 33.1		ML CL, CH CL,ML-CL	A-4 A-6,A-7 A-6	90-100 90-100 85-100	90-100 85-100 80- 95	70- 90 80- 90 80- 90	Low Moderate Moderate	--- High High	Moderate Low Moderate	No Limiting Factors	80% Rural	20% Wooded	Excellent	Good
		Trumbull		A B B & C	0- 8 8-26 26-60	sil sicl sicl	4.5-5.5 4.5-6.0 5.1-7.8	5.6 0.6		1		0.063-0.2 <0.063 <0.063	0.15-0.18 0.15-0.18 0.15-0.18	3.5	Clay Loam or Clay Till	6+	0 - ½	15.1 51.0 33.8 16.2 48.3 35.3 23.4 55.2 25.4		ML-CL,ML CL, CH CL,ML-CL	A-4,A-6 A-7 A-6,A-7	95-100 90-100 95-100	90-100 90-100 90-100	70- 95 70- 95 70- 95	Low Mod to Hi Mod to Hi	--- High High	High Moderate Mod to Low	No Limiting Factors			Excellent	Good
OTTAWA			---0---																															
PORTAGE	19	Chili-Wheeling	32,500	SAME AS FOR CUYAHOGA COUNTY																										No Limit	60% Rural	20% Wooded	Fair	Fair
				A B C	0- 8 8-41 41-50	sil sil gfsl,cos	5.6-6.0 5.1-6.0 4.5-5.0	4.2 0.3 0.2	21.0 14.0 7.0	1-10		0.63- 2.0 0.63- 2.0 6.3 -12.0+	0.17-0.20 0.16-0.20 0.02-0.04	4.0	Gravel, Sand & Silt	5+	4+	17.8 68.9 12.9 21.9 55.9 22.2 69.4 21.1 9.5		ML,ML-CL ML-CL GM,GP, GW	A-4 A-4,A-6 AA,A-2	95-100 95-100 30- 65	90-100 90-100 15- 40	80- 95 80-100 0- 20	Low Low Low	--- Low Low	Moderate Mod to Hi Mod to Hi	No Limitations	60% Rural	20% Wooded	Good	Good
	27	Mahoning-Ellsworth	30,200	SAME AS FOR MEDINA COUNTY																										Some Steep Terrain	45% Urban	30% Wooded	Excellent	Good

CLASSIFICATION OF SOIL ASSOCIATIONS SELECTED AS POTENTIAL LAND TREATMENT AREAS TABLE II – I Sheet 4 of 5

(1) COUNTY	(2) SOIL ASSOCIATION MAP NO.	NAME	(3) GROSS AREA (ACRES)	(4) DEPTH (IN) HORIZ	DESCRIPT	(5) TEXTURE DOMINANT USDA	(6) REACTION pH	(7) EXISTING ORGANIC MATTER (%)	(8) C.E.C. (MEQ/100 GM)	(9) SLOPE (%)	(10) HYDRAULIC CAPACITY PERMEABILITY (IN/HR)	WATER CAPACITY (IN/IN)	(12) AVAILABLE MOISTURE (INCH per FOOT)	(13) SUBSTRATUM DEPTH (FT.)	MATERIAL	(14) ROCK DEPTH (FT.)	(15) PERMANENT SEASONAL HIGH WATER TABLE (FT.)	(17) PARTICLE DISTRIBUTION % SAND	% SILT	% CLAY	(18) CLASSIFICATION UNIFIED	AASHTO	(21) PERCENT PASSING SIEVE No. 4 (4.7mm)	No. 10 (2.0mm)	No. 200 (0.074mm)	(22) SHRINK SWELL POTENTIAL	(23) CORROSIVITY UNCOATED STEEL	CONCRETE	(26) TERRAIN CHARACTER	(24) LAND USE CURRENT	(25) VEGETAL COVER	(31) ORGANIC REMOVAL	(32) HEAVY METAL STORAGE CAPACITY
RICHLAND	1	Bennington- Cardington	17,500	SAME AS FOR ASHLAND COUNTY																									No Limit.	95% Rural	10% Wood	Excellent	Good
				SAME AS FOR ASHLAND COUNTY																									No Limit.	95% Rural	10% Wood	Excellent	Good
		Belmore-		A	0-11	l or sl	6.6-7.4	2.2		2-6		2.0 - 6.3	0.14-0.17	3.5	Sand & Fine Gravel	5+	3	71.3	16.8	11.9	ML	A-4	90-100	90-100	60-75	Low	---	Low	No Limitations	95% Rural	10% Wooded	Fair	Good
				A & B	11-46	gl	6.6-7.4	1.0				6.3 -12.0	0.09-0.12					75.3	10.5	14.2	CL,SC	A-6	95-100	90-100	45-70	Low	Low	Low to Mod					
				C	46-60	gsl	6.6-7.4					6.3 -12.0	0.05-0.10					72.7	16.3	11.0	SM,SW-SM	A-1,2,3	65-100	65-75	6-35	Low	Low	Low					
	20	Honey	2,000	A	0-7	l or sl	6.1-6.5	4.0		2-6	0.2->5.0	0.2 - 1.2	0.17-0.20	3.0	Sand & gc below 42"	5+	1½ - 3				ML	A-4	95-100	90-100	60-75	Low	---	Low	No Limitations	95% Rural	10% Wooded	Good	Good
				B	7-36	cl	6.6-7.3					0.2 - 0.8	0.16-0.19								SC, CL	A-6	95-100	85-95	40-60	Moderate	Moderate	Mod to Low					
				C	36 +	fs, fg, s	6.6-7.3					0.2 - 2.5	0.14-0.18								SM, SW-SM	A-1,A-2-3	65-100	65-75	6-35	Low	Moderate	Low					
SANDUSKY		Oakville-		A	0-10	lfs	6.1-6.6			2-6		6.3 +	0.08-0.12	4.0	Sand	5+													No Limitations	95% Agricultural	5% Wooded	Fair	Fair
				C	10-22	lfs	6.1-6.6					6.3 +	0.08-0.12																				
				C	22-60	fs & lfs	6.6-7.3					6.3	0.04-0.10																				
		Belmore-		SAME AS FOR RICHLAND COUNTY																											Good	Good
		Honey-		SAME AS FOR RICHLAND COUNTY																											Good	Good
	21	Wauseon-	55,700	A	0-8	lfs	6.5-6.9	5.5		0-1		2.0 - 6.3	0.14-0.20	3.5	Lacustrine Clay or Clay Till	5+	0				SM, ML	A-2,A-4	95-100	90-100	25-55	Low	High	Low				Fair	Fair
				B	8-34	lfs	6.5-7.2					2.0 - 6.3	0.08-0.14								SM	A-2,A-4	95-100	90-100	20-40	Low	High	Low					
				C	34-59	fs	6.8-7.4					0.06- 0.2	0.04-0.12								ML-CL, CH	A-6,A-7	95-100	90-100	80-95	High	High	Low					
				C	59-70+	c or cl						0.06- 0.2	0.05-0.10																				
		Digby-		SAME AS FOR HANCOCK COUNTY																											Good	Fair
		Millgrove		SAME AS FOR CRAWFORD COUNTY																											Good	Good
SENECA		Hoskins-		SAME AS FOR LORAIN COUNTY																									No Limit.	95% Agri.	5% Wood	Good	Good
	22	Honey-	41,800	SAME AS FOR RICHLAND COUNTY																									No Limit.	95% Agri.	5% Wood	Good	Good
		Belmore		SAME AS FOR RICHLAND COUNTY																									No Limit.	95% Agri.	5% Wood	Good	Good
		Bennington-		SAME AS FOR ASHLAND COUNTY																									No Limit.	95% Agri.	5% Wood	Excellent	Good
		Cardington		SAME AS FOR ASHLAND COUNTY																									No Limit.			Excellent	Good
			52,900		0-12	s-cl, sc	6.6-7.4	4.6		0-1		0.063-0.63	0.15-0.21	3.5	Clay Loam or Silty Clay Loam	5+	0 - ½	18.1	38.1	43.8	ML,MH,ML-CL	A-6&A-7	100	100	80-95	Moderate	---	Low				Excellent	Excellent
		Pewamo			12-34	sc	6.6-7.4					< 0.063	0.15-0.18					11.3	37.9	25.8	ML-CL, CH	A-6,A-7	95-100	90-100	80-95	High	High	Low					
					34-60	cl	7.4-8.4					0.02 -0.63	0.16-0.18					19.0	41.9	39.1	CH		90-100	80-100	70-85	Moderate	High	Low					
STARK			--0--																														
SUMMIT				A	0-8	s-l	4.6-5.5	2.0		2-6		0.63- 2.0	0.18-0.22	4.5	Loam Till	5+	1½ - 3	16.3	68.4	15.3	ML	A-4	80-95	80-95	60-85	Low	---	High		95% Urban		Fair	Fair
				B	8-25	s-l	4.6-5.5	0.5				0.63- 2.0	0.17-0.21					20.7	54.6	24.7	ML-CL,CL	A-4	80-95	80-95	50-75	Low	Moderate	High					
		Canfield-		B	25-55	l	5.1-6.0					0.2 - 0.63	0.07-0.10					30.9	45.6	23.5	ML-CL,ML	A-4	80-95	80-95	60-70	Low	Moderate	Moderate					
				C	55-62	l	5.6-8.0					0.2 - 0.63	0.10-0.14					34.9	46.4	18.7	ML-CL	A-4	80-95	70-95	50-65	Low	Low	Moderate					
	23		22,200	A & B	0-21	s-l	4.5-6.0	6.4		5-15		0.63- 2.0	0.17-0.20	3.5	Loam Till	5+	4+	37.1	50.6	12.3	ML,CL	A-4	75-100	70-95	50-85	Low	Low	Moderate				Fair	Fair
		Wooster		B	21-40	l	5.1-5.5	0.4				0.63- 2.0	0.10-0.15	< 0	Till			43.2	38.6	18.2	ML,SM	A-4	75-95	70-95	45-70	Low	Low	Moderate					
				B	40-60	l	5.1-6.0	0.3				0.63- 2.0	0.07-0.12					44.7	39.2	16.1	ML,SM	A-4	75-95	70-95	45-70	Low	Low	Low					
		Ch-	27,900	SAME AS FOR CUYAHOGA COUNTY																										95% Urban		Fair	Fair
	27	Mahoning: Ellsworth	46,100	SAME AS FOR MEDINA COUNTY																									No Limiting Factors	80% Rural	50% Wooded	Excellent	Good
TUSCARAWAS	24	Canfield	3,400	SAME AS FOR SUMMIT COUNTY																									No Limit	95% Agri.	10% Wood	Fair	Fair
	27	Mahoning: Ellsworth-Tuscarawas	46,800	SAME AS FOR MEDINA COUNTY																									No Limitation	80% Rural	50% Wooded	Excellent	Good

CLASSIFICATION OF SOIL ASSOCIATIONS SELECTED AS POTENTIAL LAND TREATMENT AREAS TABLE II - 1 Sheet 5 of 5

(1)	(2)	(3)	(4a)	(4b)	(5)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)
COUNTY	SOIL ASSOCIATION NO.	NAME	GROSS AREA (ACRES)	DEPTH HORIZ	DEPTH INCHES	TEXTURE DOMINANT USDA	REACTION pH	EXISTING ORGANIC MATTER (%)	C E C (MEQ / 100 GM)	SLOPE (%)	HYDRAULIC CAPACITY INFILTRATION (IN/HR)	HYDRAULIC CAPACITY PERMEABILITY (IN/HR)	AVAILABLE MOISTURE (IN/IN of SOIL)	SUBSTRATUM DEPTH (FT.)	SUBSTRATUM MATERIAL	ROCK DEPTH (FT.)	PRESENT SEASONAL HIGH WATER TABLE (FT.)	PARTICLE DISTRIBUTION % SAND	PARTICLE DISTRIBUTION % SILT	PARTICLE DISTRIBUTION % CLAY	CLASSIFICATION UNIFIED	CLASSIFICATION AASHO	PERCENT PASSING SIEVE No. 4 (4.7mm)	PERCENT PASSING SIEVE No. 10 (2.0mm)	PERCENT PASSING SIEVE No. 200 (0.074mm)	SHRINK SWELL POTENTIAL	CORROSIVITY UNCOATED STEEL	CORROSIVITY CONCRETE	TERRAIN CHARACTER	LAND USE CURRENT	VEGETAL COVER	ORGANIC REMOVAL	HEAVY METAL STORAGE CAPACITY
WOOD		Dethaven-		SAME AS FOR HANCOCK COUNTY																												
		Granby-		A B C	0-11 11-32 32-37	lfs fs fs	6.4-6.8 6.8-7.0 >7.0	2.0 0.3		0-1																		Flat	95% Agricultural	5% Wooded		
	25	Seward-	70,000	SAME AS FOR HANCOCK COUNTY						2-6																						
		Elmer-		A A B B & C	0-6 6-14 14-22 22-60	fsl lfs fsl, sicl sicl	6.6-7.4 6.6-7.3 7.4-7.8 7.4				6.3 -12.0 6.3 -12.0 6.3 -12.0 0.2 - 0.63	0.12-0.16 0.10-0.14 0.12-0.15 0.19	3.0	Lacustrine Clay or Clay Till?	5+																Fair	Fair
		Wausean		SAME AS FOR SAMDUSKY COUNTY																										Fair	Fair
WYANDOT		Hanshaw-																										No Limit	95% Agri-	10% Wood		
	26	Jennotown-	30,700	A B C	0-10 10-32 32-40+	sil sicl, cl l	5.6-6.6 5.0-5.6 7.0	1.5 0.7		2-6								36.0 19.9 35.0	50.6 43.1 45.4	13.4 37.0 21.6										Excellent	Good
		Patton		A B C	0-14 14-29 29-73	cl cl, sicl l, sl, cl	6.4 6.6-7.0 6.8-7.2	4.6 1.2										46.6 48.4 60.4	39.3 33.9 27.9	14.1 17.7 16.7										Excellent	Good
		TOTAL	1,661,700																												

TABLE II-2

EXPLANATION OF COLUMN HEADINGS IN TABLE II-1

Column (1) - Counties lie either partly or entirely with the Lake Erie drainage basin from the western border of Wood County to the eastern border of Ashtabula County.

Column (2) - A soil association consists of one or more soil series and is identified by a map number for ease in locating the soil association on the accompanying map. Soils in a series can differ in texture of the surface soil and in slope, stoniness, etc., and are divided into phases on the basis of these differences.

Column (3) - This column shows the gross area within each particular county for each selected soil association.

Column (4) - The depth refers to the vertical distance below the ground surface for the "A", "B" and "C" horizons.

Column (5) - The soil texture shows the dominant soil texture, or textures, according to the USDA Classification used by the SCS. (See Figure II-3.)

Columns (6) and (7) - These are soil conditions at present and could be affected by land treatment. Organic matter percentages have not been published for all soils.

Column (8) - C.E.C. represents the cation exchange capacity of the soil in milliequivalents per 100 grams of soil. It is a measure of the soil's ability to remove chemicals from irrigation water.

Column (9) - This column gives the range of slope of the ground surface. Some soils such as the Chili soil may have several phases in one association which will differentiate between slopes and sometimes texture.

Columns (10) and (11) - The hydraulic capacity of the soil is a measure of the soil's capacity to accept and transmit water through the soil column.

- Infiltration rate is determined by impounding a 3-inch head of water on a grass-legume sod surface for 24 to 30 hours and measuring the rate, expressed in inches per hour, at which the water continues to enter the ground surface at the end of this period.

- Permeability (percolation) is determined by maintaining a constant water level in an 8-inch diameter hole 12 inches deep, and measuring the rate at which water continues to be absorbed into this test zone after a 40-hour period. (Rate in inches per hour.)

Column (12) - Available moisture is the amount of water available to the plant and represents the difference between field capacity and the wilting point. For best crop results, water should not be depleted below about one-half of the available moisture content. Available moisture is expressed in inch of water per inch of soil.

Columns (13) and (14) - The substratum is the depth to "C" horizon or to the bottom of the subsoil ("B" horizon). In some soils it is the depth to bedrock, and in some instances the depth to the substratum is a good indicator for the maximum depth of tile. Expressed in feet.

Column (15) - Refers to the depth to a rock stratum. The soil associations which were selected do not include bedrock less than 5 feet from the surface, and in almost all cases the bedrock is more than 10 feet deep. Expressed in feet.

Column (16) - Indicates the depth to the seasonal high water table under present conditions. Expressed in feet.

Columns (17), (18) and (19) - These three columns summarize the distribution of the sand, silt and clay particles in the indicated soil layer. These percentages are used to determine the soil texture for Columns (5), (20) and (21).

Column (20) - Indicates the soil textural classes based on the CE Soil Groups. These can be related to the USDA textural classes in Column (5).

Column (21) - Indicates the soil textural classes based on AASHO Soil Groups. These can also be related to the USDA textural classes in Column (5).

Columns (22), (23), and (24) - These columns indicate the grain size distribution of the soil. These distributions are used in soil mechanics to express size uniformity, but have far wider use in sanitary engineering.

Column (25) - The shrink-swell potential of the soil has engineering application in the designing of foundations for buildings, airports and roads. Indicated as low, moderate, or high.

Columns (26) and (27) - Indicate the corrosivity to steel and concrete.

Column (28) - This column cites special terrain features which may limit a soil association's efficacy for use as a treatment site. Erosion, ponds, hummocking and steep slopes are a few such limiting terrain features.

Column (29) - The current land uses are necessarily generalized for use in this tabulation.

Column (30) - Vegetal cover is based generally on published and unpublished data, including maps and photos.

Column (31) - Organic removal is a qualitative indicator of the soil's ability to adsorb soluble or suspended organics added to the soil with irrigation water and is an indicator of the soil's ability to remove residual BOD in this effluent. Designations range from fair in a loamy sand soil to excellent in a silty clay loam.

Column (32) - The heavy metal storage capacity of the soil is an indicator of the physical-chemical ability to adsorb heavy metals. This indicator is also related to the total amount of metals which the soil can store over a long period of time. The soils are rated excellent, good, fair, and acceptable.

FIGURE II-2

STUDY LOCATION MAP
SHOWING COUNTIES IN LAKE ERIE DRAINAGE BASIN
INCLUDED IN SOILS INVENTORY

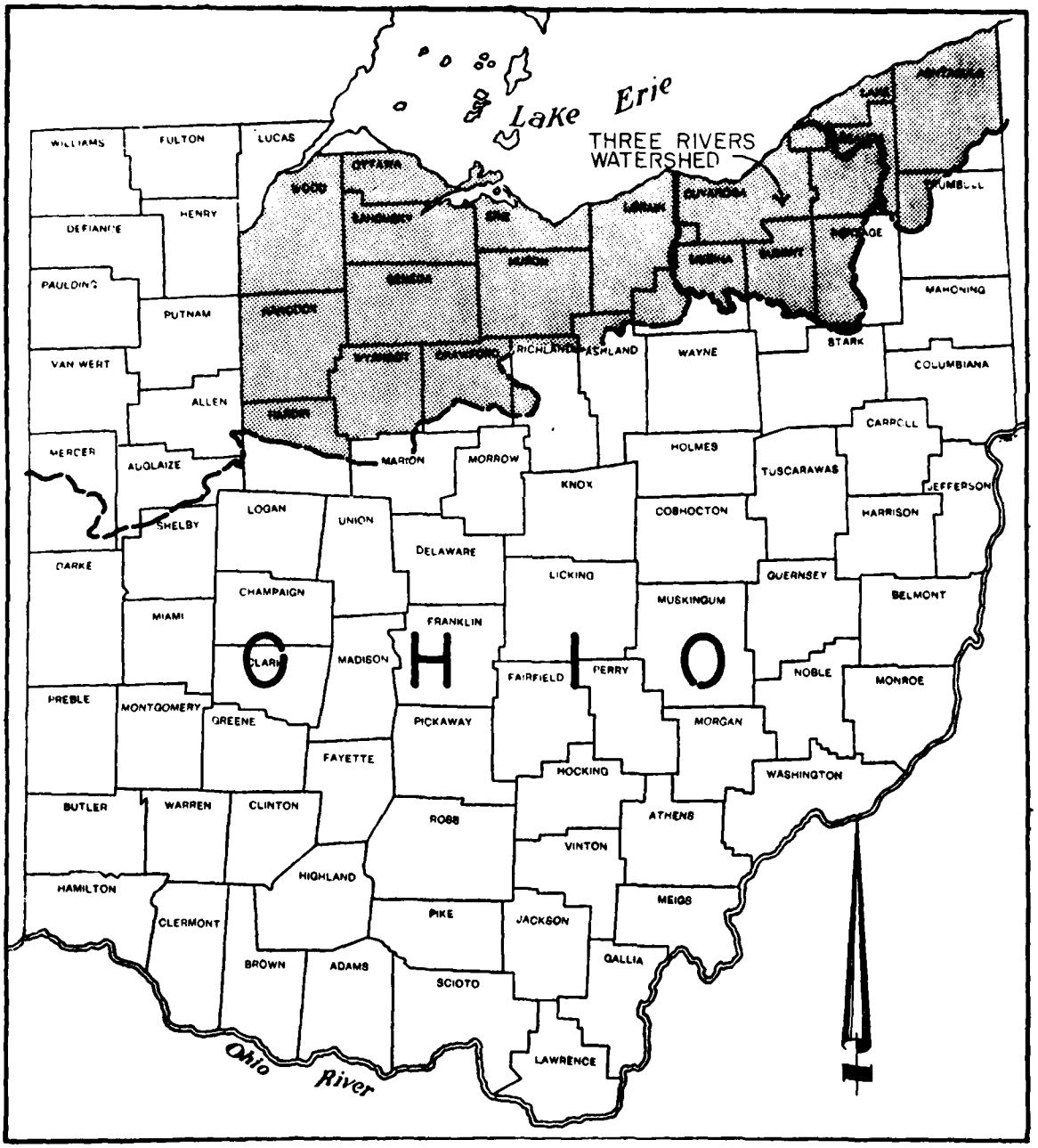
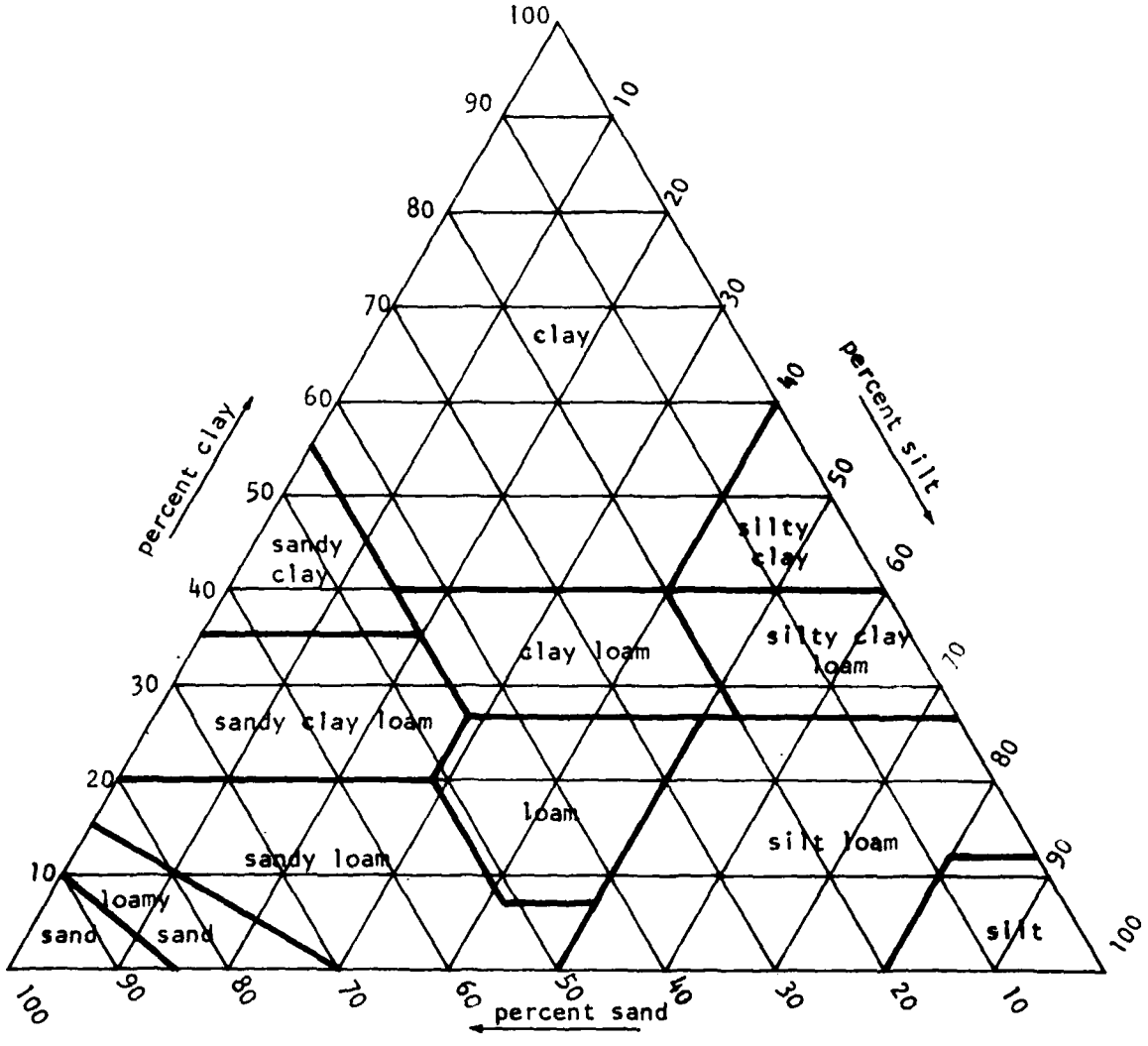


FIGURE II - 3

Column (5)

USDA Soil Textural Classification System



Abbreviations used in Table II - 1:

s	- sand	si	- silt	c	- clay
sl	- sandy loam	sil	- silt loam	cl	- clay loam
scl	- sandy clay loam	sicl	- silty clay loam	l	- loam
sc	- sandy clay	sic	- silty clay	ls	- loamy sand

SECTION III

SOIL DATA SOURCES

It was recognized early in this investigation that the soils and their characteristics would be the basic factor governing the selection of potential land treatment areas. Various local, state and federal agencies conduct soil studies. In the state of Ohio, the Soil Conservation Service of the U. S. Department of Agriculture, the Division of Lands and Soil of the Ohio Department of Natural Resources, and the Ohio Agricultural Research and Development Center are the three main agencies which do agricultural soil field work and classification. Ohio State University also carries out field, technical and laboratory work on soil samples.

COUNTY SOIL MAPS AND REPORTS

Published county soil maps and reports were the first source of data to be reviewed and analyzed; they are listed in the bibliography at the end of this section, and include the following publications: (1) Soil Survey reports, compiled jointly by the three agencies listed above; (2) GeneralSoil Maps, prepared by the Ohio Division of Lands and Soil and the Soil Conservation Service; and (3) the Inventory of Ohio Soils, a series prepared by the Ohio Division of Lands and Soil. These sources supplied the data presented in Table II-1 and in Figure II-1.

SOIL CONSERVATION SERVICE FILE DATA

To provide additional information for the wastewater management study, the state office of the Soil Conservation Service tabulated special soil data for an area bounded by specified counties in the northern

Ohio Lake Erie Basin. This data was supplemented by a map (Figure III-1) showing the approximate limits of the soil associations in this area. Together the map and tables contained consistent, region-wide information not available in published form and provided a dependable check on previously published material.

Each of the soil associations listed in Table III-1 was defined on a standardized form by the SCS in terms of estimated physical and chemical properties as follows:

1. Soil Series and Map Symbol. Series according to SCS classification with appropriate symbol keyed to the SCS soil map, Figure III-1.

2. Depth to Bedrock. In feet.

3. Depth to Seasonal High Water Table. In feet.

4. Depth from Surface of Typical Profile. Depth from soil surface to top and bottom of each soil horizon.

5. USDA Texture. The relative proportions of sand, silt and clay in a soil; this system is used by the SCS.

6. Classification Unified. Engineering classification for soil texture. Soils are grouped on the basis of their texture and plasticity and their performance as material for engineering structures.

7. Classification AASHO. Textural classification system used by the American Association of State Highway Officials.

8. Coarse Fraction (<3"). Particle fraction greater than three inches in diameter.

9. Percent Passing Sieve (No. 4, No. 10, No. 200. Particle size analysis used in engineering classifications (No. 4 - <4.7 mm; No. 10 - 4.7 - 2.0 mm; No. 200 - 2.0 - p.075 mm).

10. Permeability. Steady-state rate of movement of water through soil (inch per hour).

11. Available Water Capacity. The amount of water that is available for plant uptake (between 1/3 and 15 bars) in inches of water per

inch of soil. Also, soil water between field capacity and wilting point.

12. Reaction (pH Value). Soil pH is a function of hydrogen ion activity, which shows acidity or basicity of the soil.

13. Shrink-Swell Potential. Ability of soil to shrink or swell when drying or receiving moisture. (low, medium, high).

14. Corrosivity (Uncoated Steel and Concrete). Corrosion properties of soil with respect to uncoated steel and concrete.

In addition, the SCS data tabulation included these interpretations and definitions for each of the soil associations:

1. Estimated Representative Soils. The component soil series of each soil association mapped as a unit in Figure III-1.

2. Estimated Percent of Association. The percent each soil comprises of the total mapping unit (less than 5% was ignored).

3. Slope Group. Each soil series within the association was given a letter designation:

A = 0 to 2% - Level
B = 2 to 6% - Gently sloping
C = 6 to 12% - Sloping
D = 12 to 18% - Moderately steep
E = 18 to 25% - Steep
F = 25%+ - Very steep

4. C.N.I. Dominant Percent. (C.N.I. = Conservation Needs Inventory) The dominant percent slope for each soil series within the association.

5. Erosion Class. Each soil series within the association was given a symbol as follows:

0 - No apparent erosion
1 - Slight erosion; plowlayer mostly surface soil
2 - Moderate erosion; plowlayer is a mixture of surface soil and subsoil
3 - Severe erosion; plowlayer is mostly sub-soil
θ - Disturbed soils in towns and cities as a result of home building, sewer and water line installation, etc.

6. C.N.I. Land Capability Units (L.C.U.) Each soil series was given a number-letter code:

Class (first number)

1 - Soils have few limitations that restrict their use.
2 - Soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
3 - Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
4 - Soils have very severe limitations that reduce the choice of plants, require very careful mangement, or both.
5 - Soils are not likely to erode, but have other limitations, impractical to remove, that limit their use largely to pasture, woodland, or wildlife.
6 - Soils have severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woodland, or wildlife.
7 - Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woodland, or wildlife.
8 - Soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to aesthetic purposes.

Subclasses (lower case letter following class number)

e - The main limitation is risk of erosion unless close-growing plant cover is maintained.
w - water in or on the soil interferes with plant growth or cultivation (in some soils wetness can be partly corrected by artificial drainage).
s - soil is limited mainly because it is shallow, droughty, or stony.
c - chief limitation is climate that is too cold or too dry.

7. Estimated Rural Land Use (By Percent). The relative percentages of land used for cropland, pasture, forest, and other for each soil series.

The basic soil characteristics, listed on the data sheets and codified on the map, can be used directly in determining potential land areas for spray irrigation purposes. Additional data included on these standard forms may help to define further aspects of land-based systems besides the physical ability of the soil to receive and transmit sewage effluent.

Such items as present land use, soil corrosivity, shrink-swell potential, and texture classifications may be used by soil engineers, land planners, agronomists, storm drainage engineers, and others in final design functions. This important supplemental data testifies to the advanced state of information available in the field of soils and agriculture.

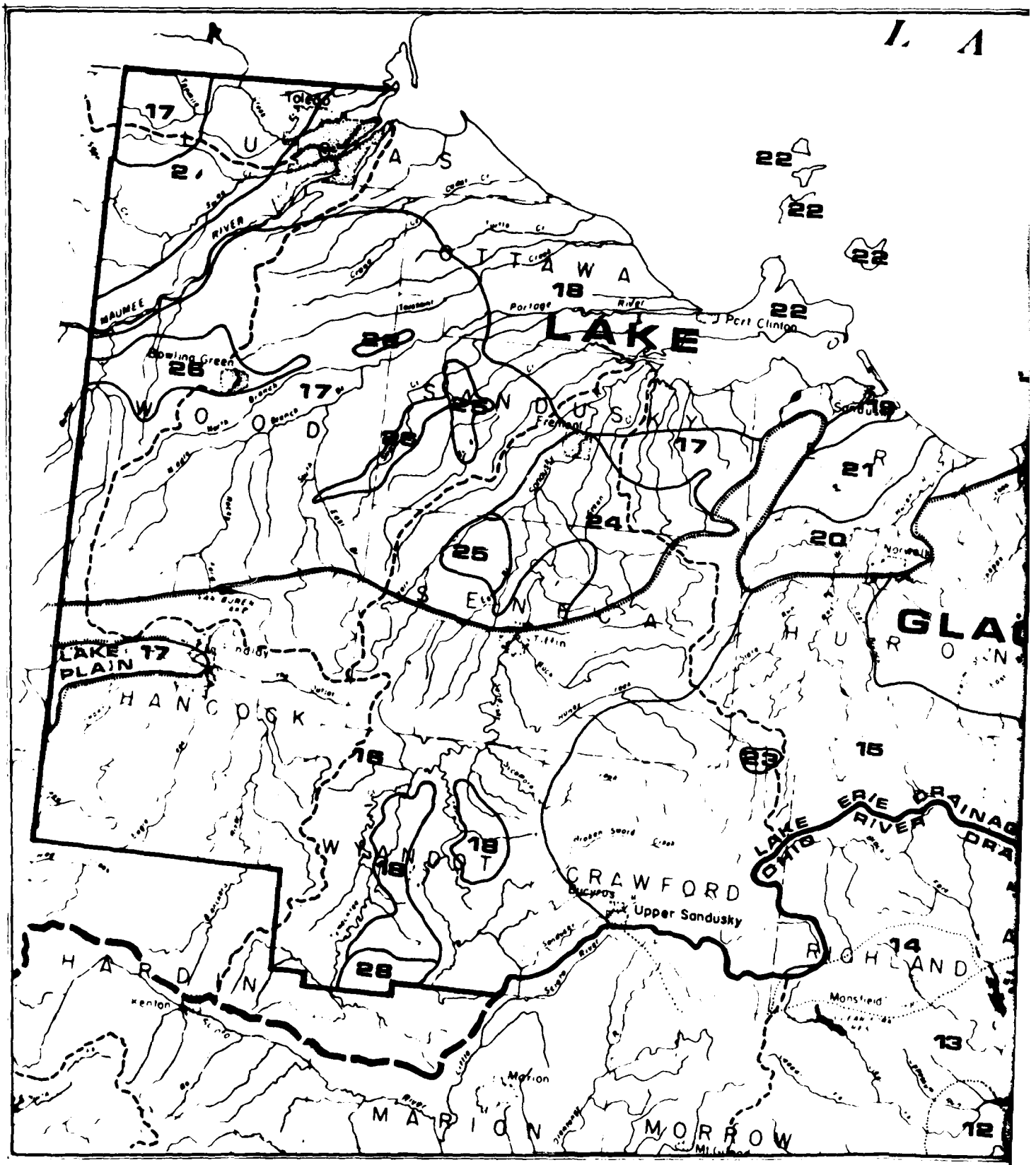
The data from this special SCS tabulation has been presented to a limited extent in Table II-1. The balance of the data is on file for reference. (See Heading IV in the Bibliography for this Section.)

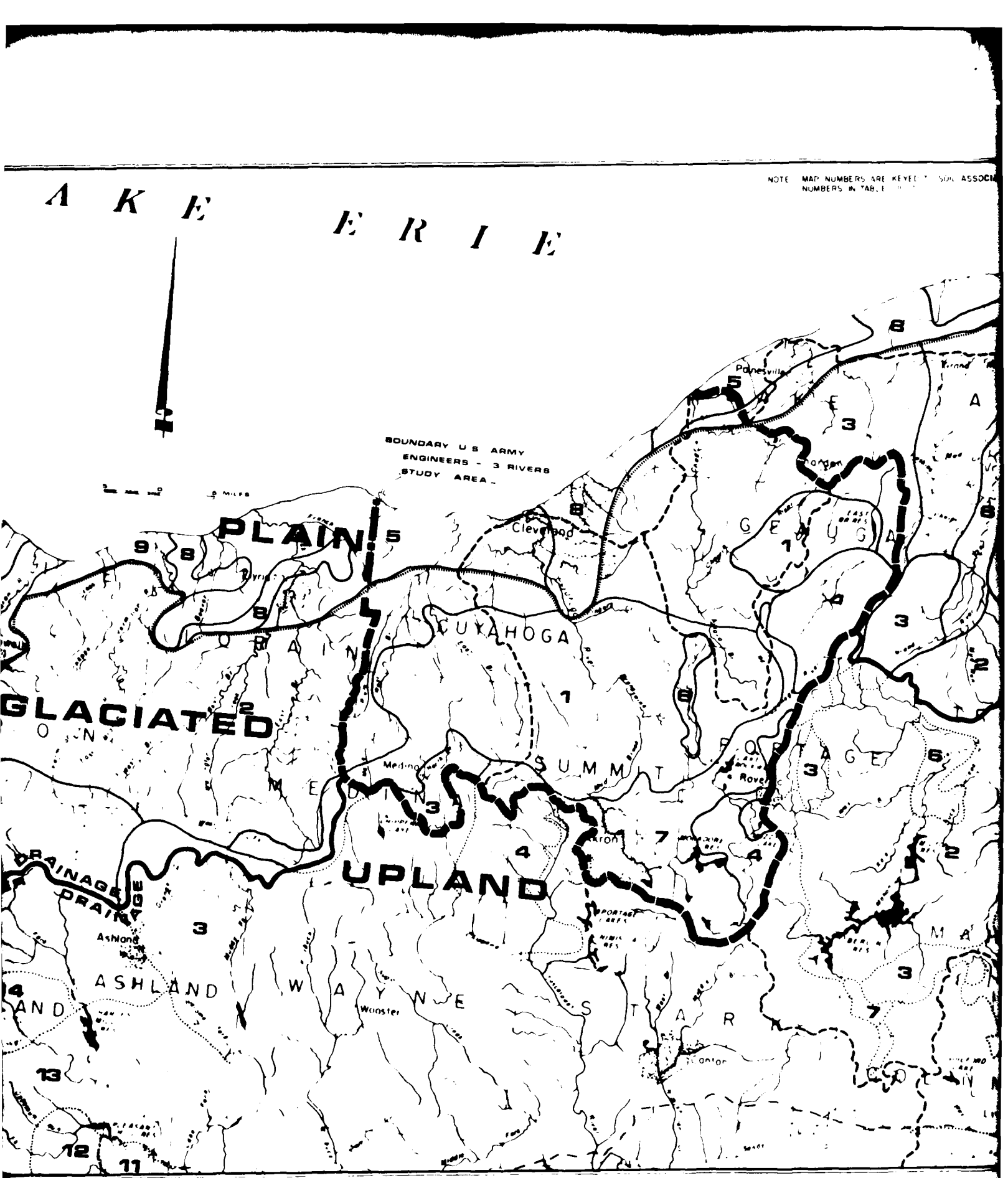
Table III-1 lists the SCS soil associations and the related key map numbers; the map follows in Figure III-1.

TABLE III-1

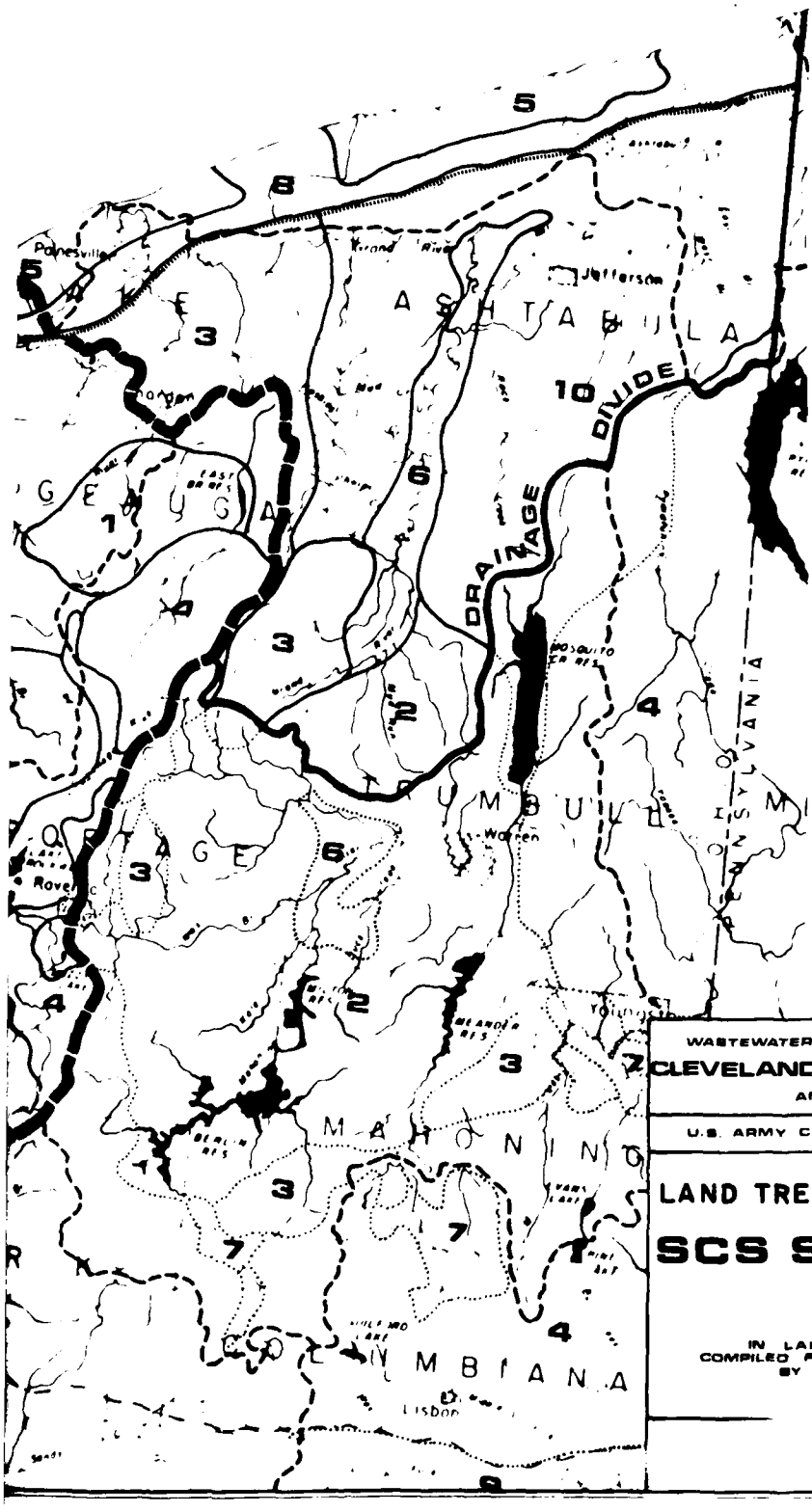
AREAS OF VARIOUS SOIL ASSOCIATIONS
AS SHOWN ON BASE MAP (Figure III-1)

Map No.	Soil Association	Area (Sq. Mi.)	Area (Acres)
1	Mahoning-Ellsworth	575	368,000
2	Mahoning-Ellsworth Remsen	796	509,000
3	Wadsworth-Rittman	533	341,000
4	Canfield-Ravenna	160	103,000
5	Conneaut-Canadice-Caneadea	342	219,000
6	Canadice-Sebring	88	56,000
7	Chili-Wheeling-Carlisle	177	113,000
8	Otisville-Elnora-Chenango	240	154,000
9	Welkert-Loudenville	30	18,900
10	Sheffield-Platea	497	318,000
11	Berks-Muskingum		
12	Hanover-Muskingum		
13	Wooster-Canfield		
14	Rittman-Wadsworth	2	1,090
15	Cardington-Bennington-Marengo	655	484,000
16	Blount-Pewamo-Morley	1,150	734,000
17	Hoytville	977	626,000
18	Toledo-Fulton-Lenawee	574	372,000
19	Del Rey-Lenawee	14	9,270
20	Kibbie-Tuscola-Colwood	89	56,900
21	Lewisburg-Arkport	58	36,900
22	Lewisburg-Castalia-Millsdale	41	26,200
23	Carlisle	5	3,290
24	Haskins-Haney-Belmore	134	85,500
25	Millsdale-Randolph	39	25,900
26	Wauseon-Ottokee-Spinks	80	50,600
27	Tedrow-Ottokee-Spinks	136	87,200
28	Paulding-Roselms	18	11,700
Total		7,410	4,810,450


LAKE
LAKE PLAIN
HANCOCK
WOOD
SANDUSKY
SENECA
OTTAWA
WYANDOT
CRAWFORD
HARDIN
MARION
MORROW
HURON
RICHLAND
Toledo
Bowling Green
Fremont
Upper Sandusky
Port Clinton
Kenton
Marion
Mansfield
Norwalk
Portage River
Sandusky
LAKE ERIE DRAINAGE
OHIO RIVER


NOTE MAP NUMBERS ARE KEYED TO SOIL ASSOCIA
NUMBERS IN TABLE
A K E
E R I E
BOUNDARY U S ARMY
ENGINEERS - 3 RIVERS
STUDY AREA
PLAIN
GLACIATED
UPLAND
DRAINAGE
DRAINAGE
CUYAHOGA
SUMMIT
PORTAGE
WAYNE
ASHLAND
STARK
Cleveland
Akron
Wooster
Ashland
Canton

NOTE MAP NUMBERS ARE KEYED TO SOIL ASSOCIATION NUMBERS IN TABLE III-1



WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

CLEVELAND-AKRON METROPOLITAN AREA

AND THREE RIVERS WATERSHED

U.S. ARMY CORPS OF ENGINEERS — BUFFALO DISTRICT

LAND TREATMENT — PHASE I REPORT

SCS SOIL ASSOCIATION MAP

IN LAKE ERIE BASIN OF NORTHERN OHIO
COMPILED FROM PUBLISHED AND UNPUBLISHED DATA
BY THE SOIL CONSERVATION SERVICE

FIGURE III-1

BIBLIOGRAPHY - SECTION III

I. SOIL SURVEY REPORTS

1. United States Department of Agriculture - Bureau of Plant Industry, in cooperation with Ohio Agricultural Experiment Station. Soil Survey Lucas County, Ohio. Washington: U. S. Government Printing Office, 1943.

2. United States Department of Agriculture - Soil Conservation Service in cooperation with Ohio Agricultural Experiment Station. Soil Survey Huron County, Ohio, Series 1942, No. 9. Washington: U. S. Government Printing Office, 1955.

3. United States Department of Agriculture - Soil Conservation Service in cooperation with Ohio Department of Natural Resources, Division of Lands and Soil and Ohio Agricultural Experiment Station. Soil Survey Wood County, Ohio. Washington: U. S. Government Printing Office, 1966.

4. United States Department of Agriculture - Soil Conservation Service, in cooperation with Ohio Department of Natural Resources, Division of Lands and Soil and Ohio Agricultural Research and Development Center.

    1. Soil Survey Erie County, Ohio. Washington: U. S. Government Printing Office, 1971.

    2. Soil Survey Mahoning County, Ohio. Washington: U.S. Government Printing Office, 1971.

    3. Soil Survey Stark County, Ohio. Washington: U. S. Government Printing Office, 1971.

    4. Supplement to the Soil Survey of Huron County, Ohio. Series 1942, No. 9. April, 1969.

II. COUNTY SOIL MAPS (GENERAL SOIL MAPS)

1. General Soil Map of Ashland County. Dept. of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1965.

2. General Soil Map of Ashtabula County. Dept. of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1957. Revised 1965.

3. Crawford County. Incomplete identification. Map and table for Crawford County General Soil Associations based on Soil Conservation District.

BIBLIOGRAPHY - SECTION III (Continued)

4. General Soil Map of Cuyahoga County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, Revised, 1960.

5. General Soil Map Erie County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1967.

6. General Soil Map of Geauga County. Not identified.

7. General Soil Map of Hancock County. (Amanda, Biglick, and Washington Townships) Dept. of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1963.

   General Soil Map of Hancock County. (Pleasant and Portage Townships) Dept. of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1963.

8. General Soil Map of Hardin County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1961.

9. General Soil Map of Lake County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1964.

10. General Soil Map Lorain County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1969.

11. General Soil Map Medina County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1960.

12. An Inventory of Soil and Water Conservation Needs for Ottawa County. The Ottawa County Conservation Needs Committee, Oak Harbor, Ohio. (With a perspective sketch of area soils by Finkbeiner, Pettis and Stront, Ltd., Consulting Engineers & Planners, Toledo Ohio)

13. General Soil Map Portage County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1969.

14. General Soil Map Richland County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1972.

15. Map of Sandusky County Soil and Water Conservation District, Cartographic Division. Soil Conservation Service (Cooperating with the District Governing Body)

16. General Soil Map of Seneca County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1968.

17. General Soil Map Summit County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1968.

18. General Soil Map Trumbull County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1957.

19. General Soil Map Wood County. Ohio Department of Natural Resources, Division of Lands and Soil, Columbus, Ohio, 1962.

20. Wyandot Soil Conservation District, Ohio, Generalized Soils Map. October, 1962. (Map and Legend by Thorton, J.F. Hole, U. S. Department of Agriculture - Soil Conservation Service, February, 1963)

III. INVENTORY OF OHIO SOILS

1. United States Department of Agriculture (sponsor). Ohio Soil and Water Conservation Needs Inventory. Columbus, Ohio: The Ohio Soil and Water Conservation Needs Committee, 1971.

2. United States Department of Agriculture (sponsor). Ohio Soil and Water Conservation Needs Inventory. Columbus, Ohio: The Ohio Soil and Water Conservation Needs Committee, 1961.

3. An Inventory of Ohio Soils: Allen County, Progress Report No. 18. Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1961.

4. An Inventory of Ohio Soils: Ashtabula County, Progress Report No. 26, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1965.

5. An Inventory of Ohio Soils: Erie County, Progress Report No. 28, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1967.

6. An Inventory of Ohio Soils: Hancock County, Progress Report No. 23, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1963.

7. An Inventory of Ohio Soils: Henry County, Progress Report No. 30, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1969.

BIBLIOGRAPHY - SECTION III (Continued)

8. An Inventory of Ohio Soils: Putnam County, Progress Report No. 33, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1963.

9. An Inventory of Ohio Soils: Stark County, Progress Report No. 29, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1968.

10. An Inventory of Ohio Soils: Summit County, Progress Report No. 31, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1969.

11. An Inventory of Ohio Soils: Wood County (Jackson, Henry, Bloom, Milton, Liberty, Portage Townships) Progress Report No. 7, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1956.

12. An Inventory of Ohio Soils: Wood County (Perry, Montgomery, Freedom, Center, Webster, Troy Townships), Progress Report No. 8, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1958.

13. An Inventory of Ohio Soils: Wood County, Progress Report No. 21, Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1962.

14. Our Ohio Soils. Columbus, Ohio: Ohio Department of Natural Resources, Division of Lands and Soil, 1964.

15. Ohio Department of Natural Resources, Division of Lands and Soil in cooperation with Board of County Commissioners. Preliminary General Soil Report for Geauga County. Geauga County Sanitary Engineering Department, 1972.

IV. INFORMATION TABULATED BY RALPH MEEKER, SOIL SCIENTIST, SPECIALIST, OF THE U. S. SOIL CONSERVATION SERVICE AT COLUMBUS, OHIO.

(The generalized soil map and legend (our Figure III-1) for Northern Ohio was compiled by the U. S. Soil Conservation Service. Sources of information used in compilation include C.N.I. data, published soil surveys, soil survey manuscripts, SCS Soil Handbooks, general soil maps of counties published by the Division of Lands and Soil O.D.N.R., and communications with professional Soil Scientists working in the area.)

SECTION IV

GEOLOGY

The geology of the study area, with special emphasis on the potential western land treatment area, is discussed in this section. Certain aspects of the subject, especially the regional glacial geology, and the bedrock underlying Cleveland, require a more detailed geological interpretation; the reader is directed to references in the bibliography of this section.

The area-wide geology is significant to land treatment studies for several primary reasons. In the first place, underground tunnels constructed with mole machines are proposed to transport efficiently large amounts of sewage effluent without disrupting surface features. Secondly, underground mined storage for storm runoff and combined sewage can be economically constructed in shale using mining techniques. Geology also controls to a large extent the type of subsurface drainage needed in the irrigated fields.

This section includes detailed discussions of bedrock stratigraphy, the surface mantle of glacial till and their implications for tunnels, reservoirs and irrigation. The geologic conditions in most of the area are generally favorable for the structures contemplated and would tend to minimize downward percolation of water from either reservoirs or irrigation operations, if properly sited and constructed.

Three major features of the Western Land Treatment Area are the layer of glacial till, which blankets most of the area with a relatively impervious mantle of variable depth generally within the range of 0 to 100 feet;

the system of shale and sandstone bedrock, which underlies the eastern portion of the study area and would provide a very favorable environment for tunneling, as well as a tight substratum for reservoirs and irrigation areas; and, third, the system of limestone and dolomite bedrock, which underlies the western portion of the study area and could pose problems both for tunneling and for storage and irrigation facilities due to systems of fissures and sink holes near the surface. Where irrigation is contemplated over limestone bedrock, careful studies will be necessary to further establish the depth and permeability of the glacial till in each locality.

Data for this preliminary geological investigation have been based upon publications of the Ohio Department of Natural Resources and studies by consulting engineers and geologists as tabulated in the bibliography.

PHYSIOGRAPHY

The Lake Erie Basin of northern Ohio lies within two physiographic provinces: the Appalachian Plateau and the Central Lowlands. The Appalachian Plateau, comprising the eastern half of Ohio, slopes to the west; it is deeply incised by winding stream valleys and is characterized by considerable local relief and steep hillsides. The portion of this plateau within the Lake Erie Basin has been glaciated in the past, consists of rolling hills and valleys, and has somewhat more fertile soils than the unglaciated southern portion of the plateau. The Central Lowlands, comprising the western half of Ohio, slope to the west, are made up mainly of plains interrupted by low morainal ridges, are covered by surficial deposits from past glaciation, and have fertile soils.

The major geologic influences in Ohio can be briefly summarized as follows: The bedrock of the eastern half of Ohio is composed predominantly of old-aged sandstone which is very resistant to erosion. The bedrock of the western half of Ohio is composed predominantly of old-aged limestone which is easily eroded. Preglacial erosion over millions of years wore down the limestone to a plains area and left the more resistant sandstone as hills. Glaciers, which covered the bedrock formations in the western and northeastern portion of Ohio in relatively recent times, modified the terrain, deposited a mantle of glacial drift over the land and buried preglacial river valleys as they receded. Present Ohio streams, flowing in post-glacial channels, continue to alter the existing landscape. Soils weathered from the sandstone bedrock in southeastern Ohio tend to be less fertile than those derived from the limestone glacial drift, which are suitable for agriculture.

STRATIGRAPHY

All sedimentary bedrock formations in northern Ohio were formed within the Paleozoic Era, which dates from 225 million to 600 million years ago. These sandstone, shale, and limestone formations were originally deposited in horizontal layers. (In Wyandot County, at the shallowest point in the study area, the combined thickness of these sedimentary layers is 2,800 feet; elsewhere in Ohio it reaches 10,000 feet.) Regional uplifts, in particular the Cincinnati Arch, which transverses western Ohio from the northeast to the southwest, have tilted the horizontal layers slightly. Therefore, formations to the west of the Cincinnati Arch slope to the

west while those formations to the east of the arch slope to the east. The gradual dip to the east continues to a structural trough which lies parallel to the Appalachian Mountains in West Virginia and Pennsylvania. The study area east of Fremont and Tiffin near the crest of the Cincinnati Arch is, therefore, underlain by eastward dipping formations.

Much of the structure in Ohio is masked by erosion at the surface and by deposition of surficial materials, which generally conceal the underlying rocks. The largest fold in Ohio is a north-plunging portion of the Cincinnati Arch, called the Findley Arch. It is a broad, low fold with the formations dipping away from the axis toward the Appalachian syncline in the east. The anticlinal axis and the synclinal axis extend northeast-southwest. Due to the anticline/syncline relationship, the formations tend to thicken in an easterly direction. The oldest rocks exposed along the Findley Arch are of the Logan Group. The regional dip is in the neighborhood of eleven to twelve feet per mile in a southeasterly direction. However, locally, dips of up to 53 feet per mile have been recorded. Although some intraformational slumps have been reported with movements of a few hundred feet, no major fault systems are thought to exist in the study area.

The Paleozoic Era can be subdivided into the Cambrian (500-600 million years ago), Ordovician (440-500 million years ago), Silurian (400-440 million years ago), Devonian (350-400 million years ago), Mississippian (310-350 million years ago), Pennsylvanian (270-310 million years ago), and Permian (225-270 million years ago) Periods. Bedrock formations from the Silurian, Devonian, Mississippian, and Pennsylvanian Periods are

present directly beneath the surficial deposits of northern Ohio. The following paragraphs describe the physical and hydrologic properties of the various groups of rock laid down during these four periods. The order of discussion is from the oldest to youngest, or from the bottom upward through successively more recent layers, which corresponds to a sequence of appearance at the surface from west to east across the study area, since the formations dip to the east (See Figures IV-1 and IV-2.)

SILURIAN SYSTEM

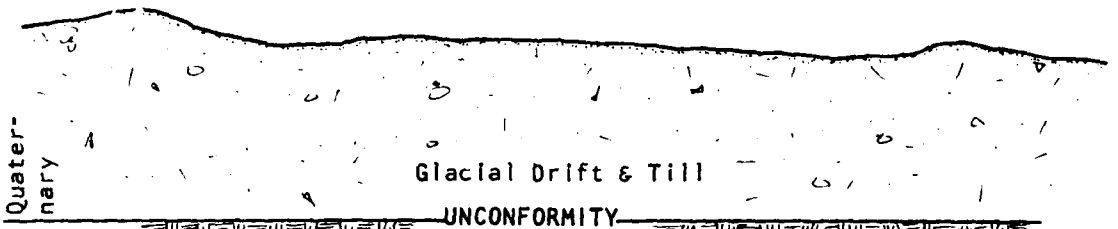
Lockport Group. The oldest rocks exposed in the western land treatment area belong to the Lockport Group, which is the uppermost group of the Niagran Series and overlies the Clinton Group. The Lockport Group includes the Gasport, Goat Island, and Guelph Formations in the south, but, in the north, the group is not easily separated due to the similar lithologies of the formations.

The rock is highly crystalline, open and porous in texture, and of light color. The formation is always massive in structure with very few well-defined partings. The constitution and physical properties of the dolomite favor the storage of water. When exposed at or near the surface, the rock decays to an open, porous, even cavernous, texture favorable to the accumulation of water. The Lockport Group varies from 120 to 520 feet in thickness.

Salina Group. The Salina Group, composed of the Greenfield and Tymochtee Formations, was formerly assigned to the Bass Island Group. The Greenfield Formation, with few exceptions, is true dolomite in composition and ranges

FIGURE IV-1

VERTICAL SEQUENCE OF BEDROCK FORMATIONS IN NORTHERN OHIO



System	Group	Formation	Material
Quaternary		Glacial Drift & Till	
		UNCONFORMITY	
Pennsylvanian		Pottsville	
		UNCONFORMITY	
Mississippian		Maxville	Limestone
		Logan	Sandstone Shale
		Cuyahoga	Sandstone Shale
	Waverly	(Sunbury	Shale
		(Berea	Sandstone
		(Bedford	Shale
		UNCONFORMITY	
Devonian	Ohio Shale	(Cleveland	Shale
		(Chagrin	Shale
		(Huron	Shale
		UNCONFORMITY	
	"Olentangy" Shale	(Prout	Shale
		(Plumb Brook	Shale
		Delaware	Limestone
		Columbus	Limestone & Dolomite
		UNCONFORMITY	
	Detroit River	(Lucas	
		(Sylvania	Sandstone
		Bois Blanc	Limestone & Dolomite
		UNCONFORMITY	
Silurian	Bass Islands	(Raisin River	Dolomite
		(Put In Bay	Dolomite Shale
	Salina	(Tymochtee	Dolomite
		(Greenfield	Anhydrite
		UNCONFORMITY	
	Lockport	(Guelph	Limestone
		(Goat Island	Limestone
		(Gasport	Limestone

from 175 to 225 feet in thickness. In general, the rock is dense and hard, but some layers are decidedly granular. The beds vary from a definite flaky layer to massive strata of many feet, but generally range from a few inches to two feet in thickness.

The Tymochtee Formation varies in thickness from 125 to 175 feet and consists of thin to massive beds and of considerable thin, flaky material. The lithology varies both areally and vertically but is primarily dolomite. Physically, it varies from close-grained, tough, homogeneous rock to coarse, cavernous stone. It is used to some extent for lime burning and mainly for crushed rock products. The thin-bedded, highly laminated, and much-jointed character of the Tymochtee Formation favors ground water storage. Fissures and cavernous openings are not uncommon in the zone of water circulation.

The Bass Islands Group. The Bass Islands Group, which formerly included the present Salina Group, is equivalent to the old lower Monroe Group. The Put-in-Bay Formation, the lower unit of the Bass Islands Group, is composed of dolomite of fair purity and is gray to light brown in color. The bedding is thin to massive. Where appearing at the surface or under shallow cover, the rocks are much broken by joint bedding plains and solution cavities. This texture makes the Put-in-Bay Formation a fair source for ground water.

The uppermost division in the Bass Islands Group is the Raisin River Formation. The dolomite varies in color from bluish-gray to brownish-gray and is regularly bedded, the layers being two to six inches in thickness. However, locally more massive strata may be encountered.

The formation, due to the unconformity under the Bois Blanc Formation, varies in thickness from location to location. Due to the grainy texture of dolomite, the thinness of the beds, and the numerous joints, the Raisin River Formation, where appearing near or at the surface, is water-bearing.

DEVONIAN SYSTEM

The Bois Blanc Formation saddles the Silurian/Devonian boundary and overlies the Raisin River Formation, where present. The rock is composed of limestone, dolomitic limestone with chert nodules, and dolomite. The formation varies in thickness from 60 feet in Erie County to 140 feet in Cuyahoga County.

The Detroit River Group. The Detroit River Group, overlying the Bois Blanc Formation, is referred to as the upper Monroe in early literature. It is not present to any great extent in the area due to the unconformity below the overlying Columbus Formation. In the South Birmingham Pool area, the Detroit River Group has been included with the Columbus Formation. In this area, the Detroit River Group consists of gray to brown, fine to coarsely crystalline limestones and dolomites. At the base of the group there is generally a white, medium-grained sandstone designated the Sylvania Formation.

The Columbus Formation. The Columbus limestone overlies rocks from the Detroit River Group to rocks of Silurian age. In general, the Columbus strata is massive in bedding and somewhat earthy in appearance. The composition changes with locality and with different layers. It varies

from a magnesium limestone in the upper portion to dolomite in the lower part. The formation, where normally developed, ranges from 80 to 125 feet in thickness. The limestone and dolomitic deposits are regular but rather widely jointed. Through solution, these joints are often opened into fissures that lead to sink holes and underground passages. This characteristic accounts for the many springs, some of large size, associated with the formation.

The Delaware Formation. The overlying Delaware Formation ranges from 30 to 70 feet in thickness. It varies in character from shales with thin limestone layers to rather massive limestone with only bedding plain partings of shale matter. The composition is that of an impure limestone. In general, the Delaware limestone is too hard and dense to act as a reservoir for ground water storage. However, at the surface, weathering and solution open up the deposits sufficiently for the accumulation of small ground water supplies.

The Olentangy Formation. The Olentangy Formation, lying above the Delaware limestone and below Ohio shale, is gray, siliceous, calcareous shale with plastic clay-like properties. Because of the unconformity below the Ohio shale, the formation is not present in all localities.

The Ohio Formation. The Ohio Formation is a thick mass of shales in the upper part of the Devonian System and is composed of the Huron, Chagrin, and Cleveland Members. The Huron and Cleveland Members are typical black or brownish-black fissile shales with a high carbonaceous content. The Chagrin Member is a gray siliceous shale differing from the others by the lack of carbonaceous material. The Ohio shale produces very little, or

no water. About the only water absorption is along the joint and bedding plains in the zone of weathering at or near the surface.

MISSISSIPPIAN SYSTEM

The Waverly Group. The Mississippian System has at its base the Waverly Group, composed of the Bedford,Berea, and Sunbury Formations.

The Bedford Formation. The Bedford Formation is the oldest formation of the Mississippian System and is the beginning of a large series of siliceous deposits, including a variety of shales and sandstones in the Waverly Group. The formation is made up largely of shale, which varies in character. In the Cleveland area, a group of sandstone layers, known as the Euclid Lentil, appears in the basal portion of the formation. Generally there is little or no ground water in the Bedford Formation.

The Berea Formation. The middle formation in the Waverly Group is the Berea sandstone. The sandstone deposits vary considerably in thickness and character. In this area of northern Ohio there are thick deposits of medium coarse-grained, open in texture, massively structured sandstones. The sand grains are rather fine and uniform in size. The cementing agent, consisting largely of clay matter and iron minerals, is from ten to twenty percent of the whole and gives the sandstone excellent strength characteristics. The Berea sandstone is considered a good aquifer and is responsible for many springs of small size.

The Sunbury Formation. The Sunbury Formation is the uppermost formation of the Waverly Group. This shale formation is high in carbonaceous matter, black to brown in color, and fissile to laminated in structure. The small

quantities of water produced from the formation are usually contaminated with salts.

The Cuyahoga Formation. The Cuyahoga Formation, overlying the Waverly Group, is highly variable, both laterally and vertically. Generally the formation consists of interbedded shales and sands. The sandstone, averaging from one to three inches in thickness, is fine-grained and often very micaceous. The shales are also micaceous and usually fissile and very soft. Generally, the Cuyahoga Formation is not a good water producer.

The Logan Formation. The Logan Formation is like the Cuyahoga, which it overlies, in that it consists of interbedded shales and sandstones. The shales are generally blue-gray, but locally change to reddish-brown. In most areas, the sandstone has a finer grain than that of the Cuyahoga.

Through crustal movements and erosion, the Maxville limestone is usually absent in the study area. Where present, the limestone appears to be massively bedded, but, in reality, it is broken every few inches by a papery parting of calcareous shale.

PENNSYLVANIAN SYSTEM

The basal unit of the Pennsylvanian System is the Pottsville Formation, which unconformably overlies the Maxville and older Mississippian formations. In eastern Ohio, vast mineral resources are extracted from the Pottsville Formation. However, in the study area, the Pottsville Formation is found only in small patches and has little economic significance.

ECONOMIC SIGNIFICANCE OF SEDIMENTARY DEPOSITS

The sedimentary deposits in northern Ohio are high in mineral resources. Following is a list of the formations and the minerals or building materials that are derived from them.

From the Guelph Formation oil and gas are produced. Also, limestone quarries are abundant in the study area.

The Greenfield Formation produces road metal, railroad ballast, and concrete aggregate from deposits near the surface.

The Tymochtee Formation of the Salina Group produces large quantities of mined salt.

The Raisin River Formation produces salt brines from bore holes.

The Delaware limestone is often used for building material.

The Bedford shale is also used as a building stone.

The Berea sandstone formation not only produces oil and gas wells, but is used for abrasives and building stone.

The Maxville limestone is commonly used for Portland Cement.

The Pottsville Formation, probably absent in the study area, is a good coal producer.

TUNNELING

One proposed means of transporting treated sewage effluent from load points in the Cleveland and Akron areas to land treatment sites in western Ohio is by a deep tunnel, which might range in diameter from eight to twenty feet. This preliminary investigation has been made in part to determine the major geological conditions along typical tunnel routes and to formulate preliminary opinions concerning the impact of the conditions on tunnel design and construction. The routing considered most applicable

for this project is the third to be described below as the Unified Effluent Transmission Tunnel.

Three potential tunnel alignments have been reviewed. One would extend from the Akron area westward to northwestern Ashland County. The second tunnel route would follow a course from Cleveland to Elyria and from Elyria to northeastern Seneca County. The third tunnel route would extend from Eastlake in Lake County along the Lake Erie shoreline to Cleveland and then west-southwest to the centralized western land treatment area at the "four-corners" of Huron, Richland, Crawford and Seneca Counties.

The Akron Tunnel. The first and southernmost of these three potential tunnel routes would originate near the Akron Sewage Treatment Plant in the Cuyahoga River valley, where a buried valley filled with glacial till cuts into the shale and sandstone bedrock to a possible depth of 450 feet. West of the load point, Mississippian-age shales with a few interbedded sandstones, mainly of the Logan and Cuyahoga Formations, dip gently eastward along the tunnel route and generally constitute bedrock to tunnel depth and below. The tunnel might intercept several one to two-mile sectors of the overlying Pennsylvania-age Pottsville Formation, comprising interbedded sandstones, shales, and coals, depending upon the tunnel invert elevation. Both the sandstones and the shales should be moderately-well to well lithified below the zone of weathering, which should not extend to tunnel depth. Some of the sandstones may be massively bedded, but, for the most part, both the shales and the sandstones are thin-bedded

and are massively jointed. These are essentially competent rock, but the shales may air slake unless protected.[13]

There is no record of faults along the tentatively proposed alignment, but it is possible that at least minor faults could be concealed beneath the mantle of glacial till, outwash, and lacustrine sediments. These faults, however, should incorporate only narrow zones of broken or gougy rock, and should not significantly influence tunneling.

There appear to be no unusual or especially difficult geological conditions along this potential tunnel route. Light rock supports, such as rock bolts or shotcrete, probably will be required to prevent rock slabbing across the tunnel crown in the well-bedded sedimentary rocks, and the tunnel probably will have to be lined because the shales otherwise could deteriorate in a relatively short time, due either to the hydraulic or chemical action of the effluents.[13]

Ground water inflows should be nominal, but it would be reasonable to expect flush flows on the order of several hundred gallons of water per minute from localized zones of fractures and joints.

Rock conditions appear to favor tunneling by a mechanical boring machine. The shales should be relatively dry, and should have relatively low compressive strength, thus being easy to drill. They should also have low abrasiveness, so that drilling bit wear should be relatively low. The sandstones would be relatively easy to bore also, but the bit wear could be substantially increased due to the greater abrasiveness of the quartzose sands of these sandsone units.

In summary, tunneling along this or geologically similar routes should be relatively fast and easy, and costs should not be escalated by severely adverse geological conditions.[13]

The Cleveland-Seneca County Tunnel. The second potential tunnel system would collect effluent from the Cleveland metropolitan area and would carry it west-southwest from Cleveland across Lorain County to areas in Seneca County.

Shales of the Devonian-age Ohio Formation and the Mississippian-age Bedford Formation constitute bedrock across most of the tunnel route to depths in excess of 1,000 feet. Locally, erosional remnants of the Mississippian-age Berea sandstone cap the Bedford shale. The initial fifteen miles of the tunnel would be in the Ohio shales, but the terminal 45± miles would extend in part through Bedford shales and in part through Berea sandstones.[12] The shales range from soft to moderately hard, are thin-bedded to fissile, and, in general, are massively jointed. The Berea sandstone is fine-grained, thin to massively bedded, commonly massively jointed, and moderately well lithified.

Some buried valleys have been discovered during the course of water well drilling in northern Ohio, but it seems possible that others, still undiscovered, could intersect the tentatively proposed tunnel alignments. Tunneling through these deposits could be especially difficult and expensive, due to ground water and tunnel support problems. Thus, it would be important to locate these trenches and avoid them if possible.[12]

Rock conditions appear to be almost ideal for tunneling with a mechanical boring machine (mole) because the rock, mainly shale, should be relatively soft (low compressive strength), dry, and have low abrasiveness. More important, possibly, the rock to be bored would have a relatively narrow range of physical characteristics. Boring machines commonly have a difficult time coping with widely diverse rock conditions.

Both the sandstones and the shales should require only light supports. Rock bolts probably would be appropriate through the sandstone-crowned sectors, but shotcrete could be a better choice in the shale sectors because it would also protect the shale from exposure to the air, which would help to minimize air slaking. Structural steel ribs would be needed only through a few short sectors of the rock, but would be needed throughout any sections that penetrate unconsolidated sediment-filled buried valleys.[12]

Although the tunnels may be below the regional ground water table, water inflows to the tunnels should be low. Shales characteristically are more likely to be aquicludes than aquifers; thus, the rock through long sectors of these tunnels may be essentially dry. Flows of water issuing locally from fracture zones in the shales could peak as high as 50 to 100 gallons per minute, but flows of that magnitude would not create a significant tunneling problem. Similarly, the sandstones of the Berea Formation reportedly are relatively tight and yield only small volumes of water to wells in the project area, probably from joints and fractures. Ground water inflows to the tunnel from these sandstones should be somewhat higher than anticipated from the shales, but probably would not exceed,

on the average, more than a few tens of gallons per minute per 1,000 lineal feet of tunnel.[12]

The tunnel, if extended far enough west, could cross out of the Ohio into the Delaware and ultimately into the Columbus Formation. The Columbus Formation comprises medium to massive-bedded, cherty, finely-crystalline limestone and dolomite. The Delaware Formation in this area of north-central Ohio consists of thin-bedded, cherty limestone, with a few thin interbeds of shaly limestone and limey shale. Both the Columbus and Delaware limestones are utilized for building stone and are described as dense, tough, and durable.[14]

Limestones have been machine-bored successfully, both in Chicago and St. Louis, as well as other areas more geographically remote from the Cleveland area. Probably both the Delaware and Columbus limestones would be similarly boreable. The cherty units would be quite abrasive; thus, bit-wear in them would be considerably higher than in the relatively chert-free units of the limestone, but, otherwise, there would be no unusual problems.

Since the limestones might deteriorate as a result of either chemical reaction with the effluent or as a result of hydrologic erosion, the tunnel would be lined. Although the limestones are competent rock and should be self-supporting in large measure, the rock across the tunnel crown might require at least intermittent light support, such as rock bolts, to minimize slab-type fallouts. Locally, shotcrete or gunite might be used to support sectors of interbedded shaly limestone and limey shales and to minimize air slaking of the shales as much as possible.[14]

Water inflows from the limestones to the tunnel bore could be large, especially from the Columbus Formation, which reportedly yields moderate supplies of water to wells from open fissures, sink holes, joints, and other underground passageways. For early planning, flush flows on the order of 500 gallons per minute should be anticipated.

Similar shales and limestones have been tested to determine compressive strengths and the results published. These published test results indicate a range of 8,000 to 32,000 psi for limestones and 5,000 to 14,000 psi for shales. The Delaware and Columbus limestones, reportedly tough and durable, probably have compressive strengths of the order of 12,000 to 25,000 psi. The Logan Cuyahoga, and Ohio shales are moderately well lithified, and may have compressive strengths of the order of 8,000 to 12,000 psi. The Bedford shale, less well lithified than its neighbor shales in the stratigraphic sequence, probably has compressive strengths ranging from 5,000 to 8,000 psi. [14]

THE UNIFIED EFFLUENT TRANSMISSION TUNNEL

The tunnel alignment would traverse the Lake Erie shoreline from near Eastlake to a load point at the present Cleveland Westerly Sewage Treatment Plant and then follow a line southwesterly across Cuyahoga, Lorain and Huron Counties to a centralized winter storage reservoir site near the southwest corner of Huron County. This route lies between the two tunnel alignments described above and would penetrate similar bedrock formations. The only major difference between the route discussed for the Cleveland-Seneca County Tunnel and the Unified Effluent Transmission

Tunnel route is that the latter is somewhat shorter and terminates farther to the south, so that it probably would be able to remain in the relatively more favorable shale tunneling environment, rather than extending into limestone.

STORAGE RESERVOIRS

During the initial stages of this study seven potential reservoir sites in the western land treatment area outside the Three-Rivers Watershed were reviewed with respect to bedrock conditions and the impermeability of the overburden of glacial till. The primary distinction that could be made among these sites on the basis of available published information was that some type of lining might be required for reservoirs located farthest to the west over predominantly limestone and dolomite bedrock, whereas sites underlain by shale or sandstone were not expected to require lining, as percolation losses would be minimal.

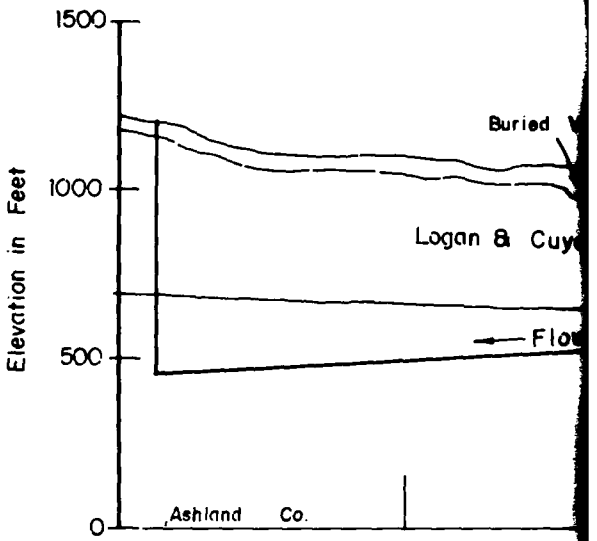
Subsequently, a single reservoir site at the common corner of Huron, Seneca, and Crawford Counties was selected to provide a centralized location for both winter storage capacity and, if applicable, aerated lagoon treatment. The area is underlain by Ohio shale covered with glacial till, and the reservoir might extend into areas of recessional glacial moraines. There would not appear to be severe percolation problems associated with this centralized reservoir site.

CONCLUSIONS

This preliminary review of the technical literature relating to geologic conditions in northern Ohio supports the conclusion that it would

be feasible to construct components of a wastewater treatment system including effluent transmission tunnels, winter storage reservoirs, and land treatment sites in the study area. Tunnels would probably have to be lined through limestone and shale environments, but would require only light supports. Special measures would need to be taken if a tunnel route intercepted a sediment-filled buried valley. Reservoir bottoms would require special type lining if constructed over limestone bedrock. The surface mantle of glacial till would generally be expected to provide good insulation between surface water and bedrock aquifers.

GEOLOGIC CROSS



Scales

Horizontal 1" = 7 miles
Vertical 1" = 500'

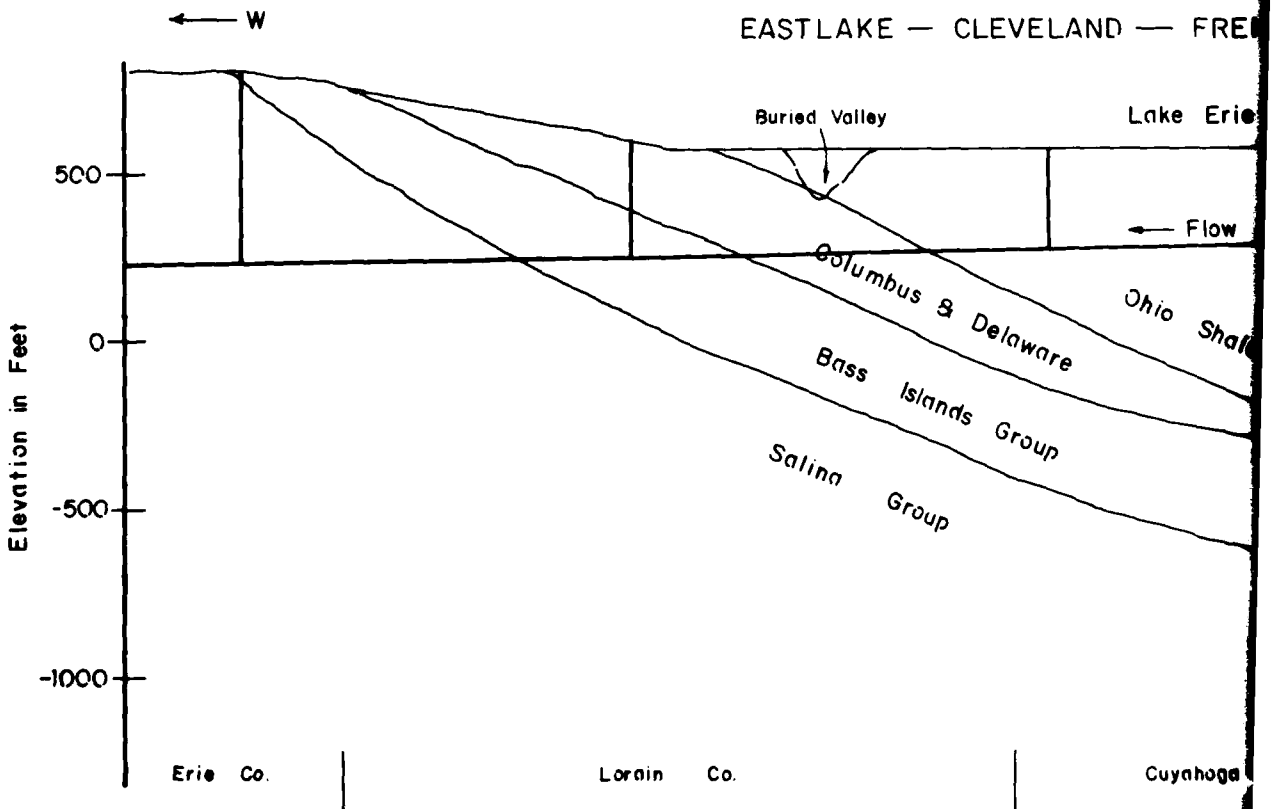
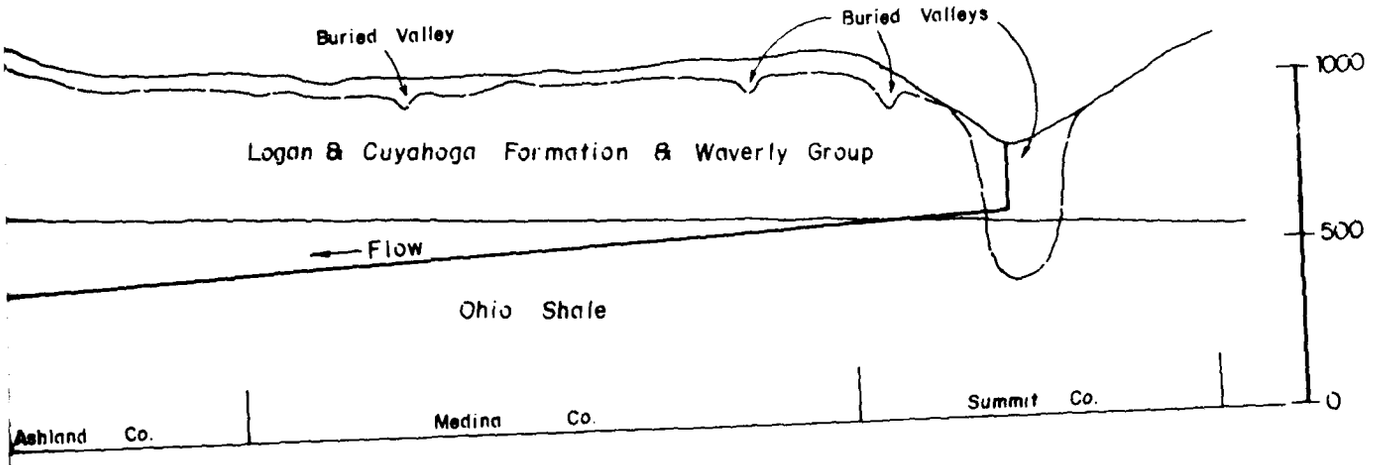


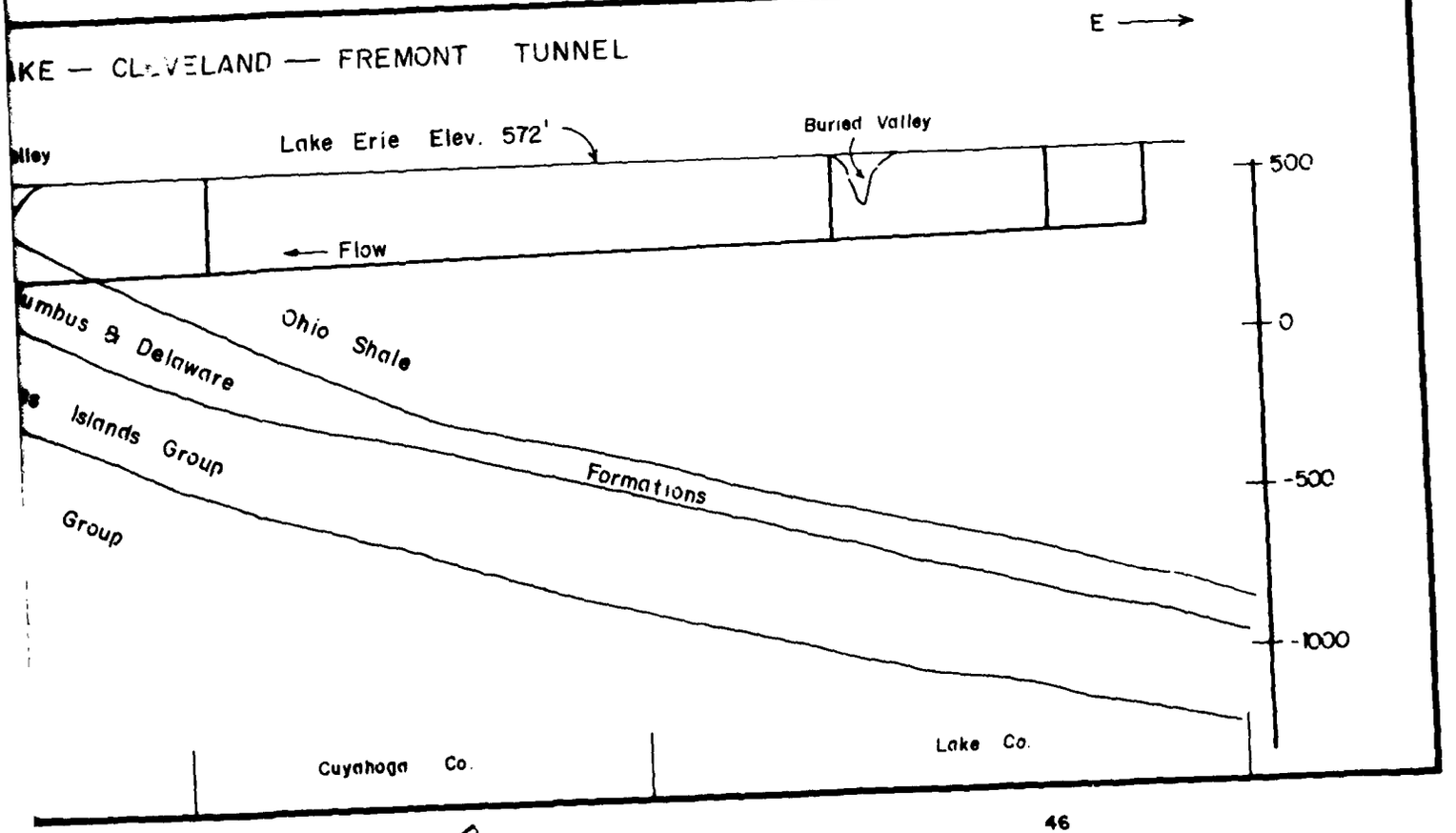
Figure IV-2

GEOLOGIC CROSS SECTION OF TYPICAL TUNNEL ROUTES

AKRON — ASHLAND TUNNEL



KE — CLEVELAND — FREMONT TUNNEL



1 2

FREMONT
CLYDE
BELLEVUE
TIFFIN
LOCKPORT GROUP
SALINA GROUP
BASS ISLAND
COLUMBUS & DELAWARE LIMESTONE
OHIO SHALE

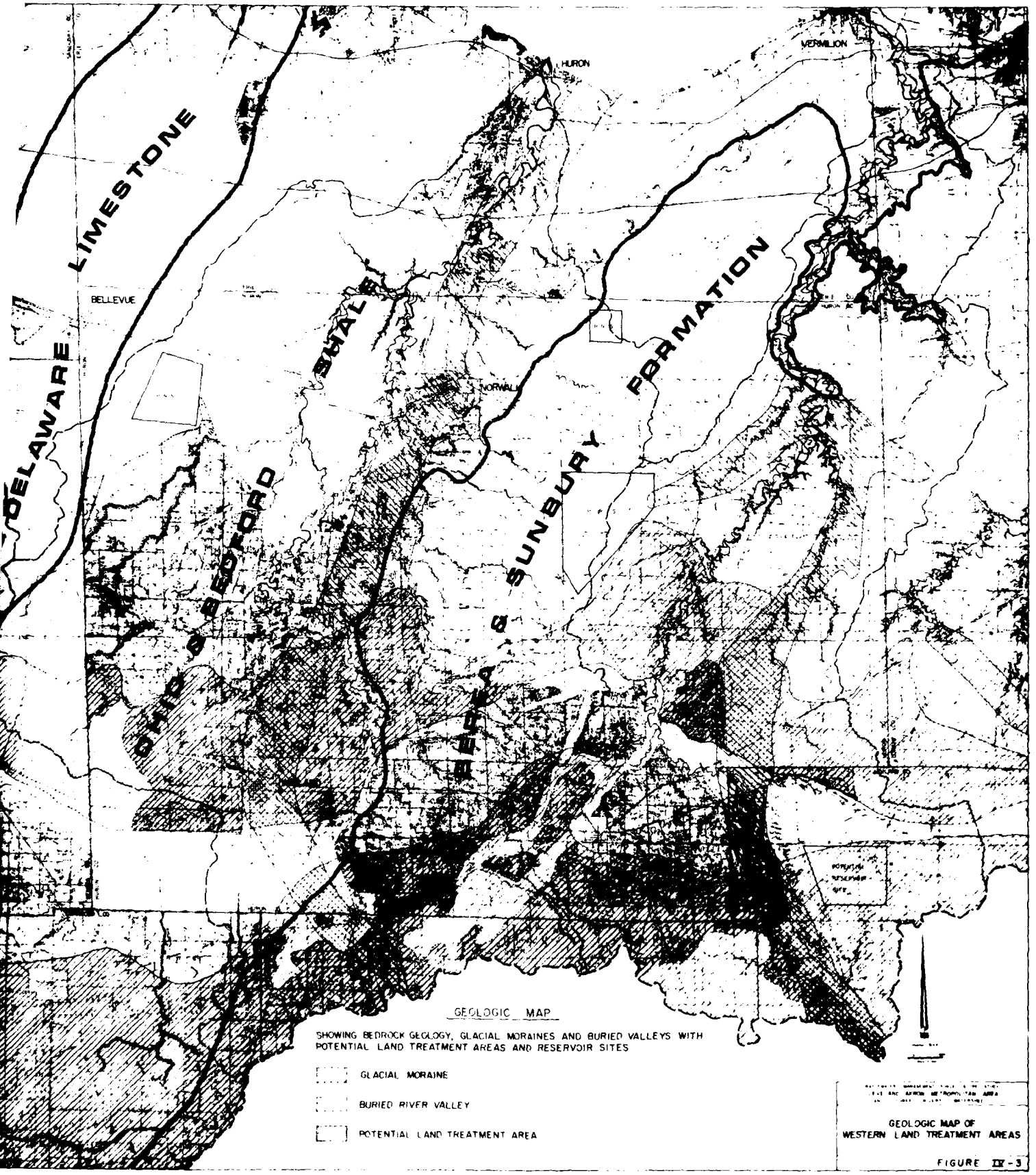

HURON
VERMILION
BELLEVUE
NORWALK
DELAWARE LIMESTONE
OHIO SHALE
BEDFORD SHALE
BEREA & SUNBURY FORMATION
GEOLOGIC MAP
SHOWING BEDROCK GEOLOGY, GLACIAL MORAINES AND BURIED VALLEYS WITH POTENTIAL LAND TREATMENT AREAS AND RESERVOIR SITES
GLACIAL MORAINE
BURIED RIVER VALLEY
POTENTIAL LAND TREATMENT AREA
GEOLOGIC MAP OF WESTERN LAND TREATMENT AREAS

FIGURE IV-3

BIBLIOGRAPHY - SECTION IV

1. Dow, John W. Lower and Middle Devonian Limestones in Northeastern Ohio and Adjacent Areas. Ohio Division of Geological Survey, Report of Investigations No. 42, Columbus, Ohio: The F. J. Meer Printing Company, 1962.

2. Hoover, Karl V. Devonian-Mississippian Shale Sequence in Ohio. Ohio Division of Geological Survey, Information Circular No. 27. Columbus, Ohio: Columbus Blank Book Company, 1960.

3. Janssens, A. Middle Devonian Formations in the Subsurface of Northwestern Ohio. Ohio Division of Geological Survey, Report of Investigations No. 78. Columbus, Ohio, 1970.

4. Janssens, A. Stratigraphy of Silurian and Pre-Olentangy Devonian Rocks of the South Birmingham Pool Area, Erie and Lorain Counties, Ohio. Ohio Division of Geological Survey Report of Investigations No. 70. Columbus, Ohio: Columbus Blank Book Company, 1968.

5. Lamborn, Raymond E. Limestones of Eastern Ohio. Ohio Division of Geological Survey, Fourth Series, Bulletin 49. Columbus, Ohio: Warner P. Simpson Company, 1951.

6. Lamborn, Raymond E. Recent Information on the Maxville Limestone. Geological Survey of Ohio, Fourth Series, Information Circular No. 3. Columbus, Ohio: Heir Printing Company, 1945 (reprinted 1961).

7. Pepper, James F. Areal Extent and Thickness of the Salt Deposits. Ohio Division of Geological Survey, Report of Investigations No. 3. Columbus, Ohio: 1947 (reprinted 1961).

8. Shearrow, George G. Geological Cross Section of the Paleozoic Rocks from Northwestern to Southeastern Ohio. Ohio Division of Geological Survey, Report of Investigations No. 33. Columbus, Ohio: Columbus Blank Book Company, 1957 (reprinted without revision, 1968).

9. Smith, William H. Sand and Gravel Resources in Northern Ohio. Geological Survey of Ohio, Report of Investigations No. 6. Columbus, Ohio: 1949 (reprinted without revision 1968).

10. Stout, Wilber, Karl Van Steeg and G. F. Lamb. Geology of Water in Ohio. Ohio Division of Geological Survey, Bulletin 44. Columbus, Ohio: 1943.

11. Ulteig, John R. Upper Niagaran and Cayugan Stratigraphy. Ohio Division of Geological Survey, Report of Investigations No. 51. Columbus, Ohio: Columbus Blank Book Company, 1964.

BIBLIOGRAPHY CONTINUED - SECTION IV

12. Report from Robert James Irish, Chief Engineering Geologist, Woodward-Clevenger and Associates, on the subject "Preliminary Engineering Geologic Evaluation for Proposed Waste Effluent Transportation Tunnels in Northern Ohio". Denver, Colorado, June 16, 1972.

13. Report from Robert James Irish, Chief Engineering Geologist, Woodward-Clevenger and Associates, on the subject "Preliminary Engineering Evaluation for a Proposed Akron-Medina-New London Waste Effluent Tunnel, North Central Ohio". Denver, Colorado, July 11, 1972.

14. Report from Robert James Irish, Chief Engineering Geologist, Woodward-Clevenger and Associates, on the subject "Continued Engineering Geologic Consultations for a Proposed Waste Effluent Transportation Tunnel in Northern Ohio". Denver, Colorado, July 20, 1972.

BIBLIOGRAPHY - SECTION IV
Additional References

15. Bownocker, J. A. "Geologic Map of Ohio." Geological Survey of Ohio, 1920.

16. DeLong, R M. and G. M. White. "Geology of Stark County." Ohio Division of Geological Survey, Bulletin 61, 1963.

17. Forsyth, Jane L. "Geology's Contribution to Ohio's Soils." Ohio Conservation Bulletin, May, 1965.

18. Forsyth, Jane L. "What Ohio Hills Tell." Ohio Conservation Bulletin, January, 1965.

19. Forsyth, Jane L. "What Ohio Valleys Tell." Ohio Conservation Bulletin, April, 1965.

20. Fuller, J. O. "Bedrock Geology of the Farrettsville Quadrangle." Ohio Division of Geological Survey, Report of Investigations No. 54, 1965.

21. Gilluly, J., A. Water, and A. Woodford. Principles of Geology. 3rd Edition, 1968. W. H. Freeman and Company.

22. Goldthwait, R.P., George W. White, and Jane L. Forsyth. "Glacial Map of Ohio." United States Geological Survey Map I-316, 1961.

23. Herdendorf, C. E. "Geology of the Vermilion West and Berlin Heights Quadrangles, Erie and Huran Counties, Ohio." Ohio Division of Geological Survey, Report of Investigations, No. 60, 1966.

24. Hunt, C. F. Physiography of the United States, 1967. W. H. Freeman & Company.

25. Moore, R. C. Introduction to Historical Geology. 2nd edition, 1958. McGraw-Hill Book Company.

26. Multer, H. G. "Bedrock Geology of Wayne County, Ohio," Ohio Division of Geological Survey, Report of Investigations No. 61, 1967.

27. Rau, J.L. "Hydrogeology of the Berea and Cussewago Sandstones in Northeastern Ohio." United States Geological Survey Atlas HA-341, 1969.

28. Sedam, A. C. and R. B. Stein. "Saline Ground-Water Resources of Ohio." United States Geological Survey Atlas HA-366, 1970.

SECTION V

GROUND WATER HYDROLOGY

Western Land Treatment Area

The ground water aspects of an area considered for land treatment are an important contributing factor to design criteria. Ground water hydraulics, for example, have a significant bearing on the type of drainage system selected. This section of the report deals with the potential western land treatment areas.

The basic data and information used in this ground water section were obtained from the Ohio Department of Natural Resources (Division of Water and Division of Geological Survey), as well as from reports prepared by consulting engineers in the area.

The geology of a given area dictates the aquifers or water-bearing formations which will exist in that area. The geology generally consists of underlying bedrock overlain by unconsolidated material, either or both of which can provide suitable aquifers. The hydrologic properties of these aquifers are basically determined by their porosity and permeability. Porosity is a function of the volume of voids in a given aquifer material, and is determined by such factors as particle size, shape, degree of sorting, compaction, weathering, fractures and solution. Permeability relates to the movement of water through inter-connecting voids within the aquifer material. Thus, formations such as clay may have a high porosity but an extremely low permeability due to their small pore size.

The Western Land Treatment Area lies in the Sandusky, Huron, and Vermilion River Basins, as well as the Pickerel Creek - Pipe Creek area.

This includes most of Seneca and Huron Counties, in addition to northern sections of Wyandot, Crawford, Richland and Ashland Counties, and parts of Sandusky, Erie and Lorain Counties. The proposed land sites for sewage effluent are located in rural sections of this general area where soils have been deemed suitable for irrigation and drainage practices.

For the entire state of Ohio ground water represents about 4.5 percent of the total water use of all users, both private and public.[1] This figure varies from area to area depending on the relative availabilities and qualities of surface and ground waters. Communities in areas underlain by shale bedrock in the Huron River Basin, as well as adjoining basins, derive most of their water supplies from surface sources since wells in the shale bedrock and overlying clayey glacial drift generally produce less than five gallons per minute (gpm).[2, 3, 4, 5, 7] Municipalities in the limestone areas in the western portions of the study region (Sandusky River Basin and Pickerel Creek - Pipe Creek area) generally rely more heavily on ground water resources than do those in the shale areas.[4, 5, 6, 7]

The aquifers in the study area are recharged by precipitation infiltrating through the soil and overburden into the underlying formations. The amount of ground water recharge occurring in each area depends on such factors as the following:

1. Amount, type and distribution of precipitation
2. Soil texture, permeability and depth
3. Depth and permeability of overburden
4. Permeability of bedrock

5. Evapotranspiration
6. Ground water levels and gradients.

In the study area the average precipitation is 34 inches per year and generally increases from north (32 inches per year) to south (37 inches per year) within the area. The portions of the land treatment areas included in Erie, Huron and Lorain Counties are underlain largely by shale bedrock, with varying depths of glacial overburden containing predominantly clay and gravel. Due to the extremely low permeability of the shale and the overlying soils and glacial till, very little precipitation would be expected to recharge the aquifers in this area. Most of the precipitation would be lost through evapotranspiration or through infiltration and overland flow into existing stream channels where it would be carried as surface runoff. The southeastern portion of the study area located in Ashland and Richland Counties contains soils largely of the Cardington-Bennington Association, which were formed in moderately calcareous clay loam till. These soils are moderately to poorly drained, and this, together with the underlying shale bedrock, would indicate that the recharge in this area would be relatively low. Again, a large portion of the precipitation would be lost to evapotranspiration. The southwestern portion of the study area located in Wyandot and Crawford Counties contains relatively poorly drained soil underlain by 50 to 60 feet of glacial till.[4, 5] The bedrock west of Chatfield in Crawford County is limestone while that to the east is predominantly shale.[5] In this general area recharge would probably be very low in the shale bedrock areas and

low in the limestone areas due to the impervious nature of the overlying glacial till. Seneca and Sandusky Counties contain the northwestern land treatment areas. The bedrock underlying the designated land treatment areas in this region is limestone with an overburden of 25 to 50 feet of glacial till containing some sand and gravel layers.[5, 6, 7] The soils are generally sandy and gravelly and are moderately well drained except in southern Seneca County. Generally this area has the greatest ground water recharge potential among the land treatment areas. It should be noted that the area surrounding Bellevue has contaminated ground water as a direct result of the disposal of raw sewage into more than 1600 publicly and privately owned sewage disposal wells. This area will be examined in more detail later in this section.

The major types of aquifers to be considered in the study region are bedrock, glacial, and alluvial or stream deposits. Each of these aquifers will be examined in detail in the following portions of this supplement as they relate to wastewater irrigation.

BEDROCK AQUIFERS

The bedrock geology of the study area can be divided basically into two general sections: limestone in the western section, and shale and sandstone in the eastern section. The contact between these two regions lies along a north-northeasterly line through Chatfield in Crawford County and east of Bellevue in Huron County. (See Geologic Map of Western Land Treatment Areas in Section IV, GEOLOGY.)

The limestone-dolomite or carbonate rock aquifers are by far the most productive in terms of ground water supply in the study area. In northwest Ohio this aquifer system yields 32.7 million gallons per day (mgd) to municipal and industrial wells, as well as large quantities for domestic and agricultural supplies.[8]

Generally, the limestone-dolomite bedrock is overlain by glacial till which increases in thickness from less than 25 feet near Lake Erie to more than 60 in the upper portion of the Sandusky River Basin. Exceptions to the above trends would be buried river valleys which exist to a limited extent in the limestone area. The surface of the limestone bedrock (feet above mean sea level elevation) ranges from a low of 500 feet near Sandusky Bay to a high of about 950 feet in the northwestern portion of Crawford County.[9]

Ground water in limestone-dolomite aquifers moves through a complex system of interconnected openings such as joints, fractures, solution channels, and minor permeable zones. In very few areas involving carbonate bedrock is it possible to predict whether or not the formation will be a suitable aquifer. In areas of thick limestone or dolomite bedrock wells drilled in valley bottoms will generally produce more water than those drilled on valley slopes. This is partially due to the greater amount of water in storage in the valley alluvial fill. Also, solution openings and fractures tend to be more abundant on crests of anticlines and within synclinal troughs than they are on the flanks of folds.

The quality of ground water is directly related to the soluble mineral constituents of the aquifer and of the overlying glacial till

and soil through which recharge water percolates. For the carbonate aqulfer, the predominant dissolved constituents are calcium and sulfate which are derived from gypsum, a major impurity of the Silurian and Devonian carbonate rocks. Calcium and sulfate constitute from 50 to 90 percent of the total mineral content in ground water from these carbonate aquifers. Some 20 test wells drilled under the recommendation of the Ohio Water Commission are located in the designated wastewater disposal areas overlying carbonate aquifers. The chemical analyses from these wells showed average concentrations of sulfate and total dissolved solids (TDS) to be 479 ppm and 1061 ppm respectively. These are about double the U. S. Public Health Service recommended limits for sulfate (250 ppm) and TDS (500 ppm). The highest sulfate and TDS concentrations encountered in the study area were in the eastern portion of Sandusky and Seneca Counties and a central sector of Crawford County. The ground water in this region is generally considered brackish and often has TDS, sulfate, and total hardness concentrations greater than 1500 ppm, 800 ppm, and 1000 ppm respectively.[5, 7, 8] Water with a hardness greater than 180 ppm is considered "very hard" and would probably require softening treatment in order to be used for domestic purposes. Generally, drinking water containing greater than the U. S. Public Health Service limits for TDS and sulfate has undesirable taste and laxative properties. The suspected origin of these high levels of TDS, hardness, and sulfate are the gypsum deposits in the carbonate aquifers. Fluoride concentrations generally ranged from 1.0 to 2.0 ppm in the study area. The median iron concentration was 0.8 ppm in the tested wells which is considerably greater than

the USPHS recommended limit of 0.3 ppm. Concentrations of iron in excess of the recommended limit can cause staining. More than 70 percent of the samples analyzed from the region contained varying amounts of hydrogen sulfide.[8] This soluble gas, derived from sulfur-bearing impurities within the carbonate aquifer, produces an undesirable odor of rotten eggs. The ground water in this area contains moderate to very low concentrations of silica, manganese and potassium. Throughout the study area the most prominent water quality problems are the high hardness and sulfate concentrations as well as the occurrence of hydrogen sulfide.

A particular water quality problem within the study area exists near the city of Bellevue. Since the 19th century Bellevue has disposed of its raw sewage and wastes into drilled wells or "sinkholes" in the underlying cavernous limestone aquifer. This practice was continued until a few years ago and has resulted in the contamination, both bacteriologically and chemically, of the entire ground water resources in a five to eight mile wide area extending north of Bellevue to Sandusky Bay and south to Flat Rock. Until the widespread contamination of the ground water near Bellevue, many of the existing water wells in the limestone aquifer produced up to 500 gpm.[10] Homeowners in this contaminated ground water region are now forced to rely on inadequate cistern supplies. During a flood in 1937 many sewage disposal wells overflowed and polluted the surrounding area for several miles. Probably the most serious danger involving the disposal of raw sewage in a limestone aquifer would be the introduction of pathogenic micro-organisms to the ground water system.[11]

Professor Mallman indicates that viruses could be the greatest problem since they can travel extreme distances in the cavernous limestone aquifer. Similar bacteria travel only a few feet in fine-grained material such as soil or sandstone. The most significant chemical pollutant found in this ground water is nitrate. Nitrate concentrations up to 158 ppm with an average of 25 ppm were found in the contaminated area.[10] Nitrate concentrations of greater than 10 ppm (expressed as nitrogen) have been known to cause methemoglobinemia in infants (blue babies).[12] Also, TDS values as high as 1000 ppm were reported in the area, and more recent data seems to indicate that these should be even higher.[7] Undesirable concentrations of ammonia and alkyl benzyl sulfonate (ABS) were also found in the area.

Water levels in the limestone-dolomite aquifer range from 10 to 40 feet below ground level.[8, 13] An area through the eastern portion of Crawford County contains the highest potential well yields in the study area. Recharge through the overlying soils and glacial till is significant in this area. Specific capacities of the wells average about 0.144 gpm per foot of drawdown per foot of penetration (gpm/ft/ft). The maximum projected safe yields for the area range from 500 to 1000 gpm.[8] An area of between one and five miles in width just to the west of this region is characterized by the low permeability of the overburden, thus inhibiting recharge. The specific capacities of test wells in this region averaged 0.028 gpm/ft/ft. The expected well yields for this region are from 150 to 600 gpm. Another area in the western portion of Seneca and Sandusky counties exhibits lower well productions. The specific capacities of the wells in this area averaged 0.0038 gpm/ft/ft, while the projected

safe well yields range from 50 to 200 gpm. The average transmissivity for the entire limestone-dolomite aquifer is between 10,000 to 20,000 gpd per foot.[8]

Much less important in terms of ground water production are the shale and sandstone aquifers in the eastern portion of the study area. Generally wells in the Berea sandstone provide a large portion of the ground water in the Vermilion River Basin, eastern Huron River Basin and a small portion of southeastern Sandusky River Basin. Water levels in the sandstone wells vary from five to 30 feet below ground level depending on pumping rates and recharge in the particular area.[13] The sandstone aquifer is overlain by ten to 50 feet of glacial till, and well yields range from five to 50 gpm with an average of about 20 gpm.[2, 3, 4] The yields are governed by the amount of fracturing of the sandstone and the degree of cementation of the individual sand grains. Shale bedrock underlies the northern portion of the Vermilion River Basin, most of the north and eastern sections of Huron River Basin and portions of southeastern Sandusky River Basin. The shale formations are by far the poorest bedrock aquifers in the study area. Water levels in wells in the shale aquifers generally average between 15 and 40 feet below ground level depending upon the pumping and recharge of the particular area.[13] Wells in the shale bedrock yield little or no water with a maximum of about five gpm.[2, 3] The water quality of the shale and sandstone aquifers could be termed "highly mineralized." The major problems are hardness, iron TDS and hydrogen sulfide. Concentrations generally exceed the USPHS recommended limits and could cause stuining problems.

GLACIAL AQUIFERS

A layer of glacial drift varying in thickness from ten to 125 feet covers most of the study area. These deposits are composed largely of clay and silt of lacustrine origin and yield little or no ground water. Glacial moraines in the southern portion of the study area vary in thickness from 50 to 100 feet and frequently contain sand and gravel layers. Wells drilled into these sand and gravel deposits can yield adequate farm and domestic supplies.

The glacial moraines in the Vermilion and Huron River Basins vary in thickness from 75 to 100 feet and contain scattered lenses of sand and gravel interbedded in the glacial till. Wells developed in these areas generally yield five to 25 gpm.[2, 3] Glacial moraines also exist along the eastern sector of the Sandusky River Basin and average over 50 feet in thickness. The majority of the wells drilled in the northern portions of Crawford County are developed in the sand and gravel contained in these moraines and yield from five to 40 gpm.[4, 5] Data is lacking concerning water levels and other aquifer characteristics for glacial aquifers.

Water obtained from the glacial aquifers is generally very hard (300 to 600 ppm) and would require softening treatment for domestic uses. In a few water samples tested from these glacial aquifers, the iron content ranged from 0.53 to 2.1 ppm,[3, 4, 5] which is in excess of the USPHS standards and could cause staining. Total dissolved solids were generally lower than from wells in bedrock aquifers. Concentrations of TDS ranged from 415 to 874 ppm in wells drilled into glacial moraines. The water from these wells was neutral to slightly basic and would cause no corrosion

problems. Generally, the ground water obtained from these shallower glacial wells is of better quality than that from bedrock wells in the study area.

The soils overlying the glacial moraine aquifers are moderately to poorly drained. Recharge to the underlying sand and gravel via percolation through the soil would be minimal. Some recharge is likely to occur from existing influent streams in the area, as well as by seepage from buried stream valleys.

ALLUVIAL OR STREAM DEPOSITS

Buried river valleys extend in a north-south direction in the Vermilion and Huron River Basins, as well as in the northern portion of the study area near Sandusky Bay. A report published as part of the Ohio Water Plan inventory[9] suggests that knowledge is lacking concerning the existence of buried river valleys and that ground water from presently known valleys has only been tapped. Coarser materials (i.e. gravel) provide the most favorable water-bearing conditions in buried valley systems.

A network of buried river valleys about one and one-half miles to two miles in width, which are a vestige of an ancient drainage system, roughly parallel the Vermilion River and its major tributaries. These valleys in the south and central portions of the basin are filled with up to 150 feet of glacial material. The buried river valley in the Huron River Basin extends from north to south through the towns of Milan, Norwalk, Willard and Plymouth. It is covered by more than 100 feet of glacial material consisting of thick layers of clay and till inter-bedded

with less extensive, discontinuous layers of silt, sand and gravel. This valley is from one and one-half to two and one-half miles wide and is also a remnant of an ancient drainage system. A shallow buried valley is present in Sandusky County in the northwestern portion of the study area. This valley generally follows the present course of Green Creek from Green Springs north to Sandusky Bay. The width of the Valley ranges from two to four and one-half miles, and it is filled with up to 100 feet of clay, sand and gravel.

The quality of ground water in these buried river valleys seems to be best in the Huron River Basin. Analyzed water samples from wells in this aquifer range in TDS from 420 to 625 ppm.[2] Iron concentrations (0.4 to 1.9 ppm) are above USPHS recommended limits. Total hardness values (346 to 460 ppm) indicate that softening would probably be necessary, but not to the degree required for bedrock derived ground water. Chemical analysis was available from only one well water sample in the buried river valley aquifer in the Vermilion River Basin.[3] This sample was obtained from an area just west of New London, which is located directly adjacent to a proposed land treatment area. Based on this sample, the water quality of the aquifer seems to be poorer in terms of TDS (1055 ppm). This could be due to soluble mineral deposits (e.g. gypsum) incorporated within the valley fill. There was no water quality information available concerning the Green Creek buried valley.

The hydrologic information relating to the buried river valley aquifers is very meager. Water levels seem to vary from about 20 to 60

feet depending on local use and recharge.[13] The buried valley in the Green Creek area generally yields from five to 20 gpm, depending on the thickness and amount of gravel deposits in the valley fill. Wells developed in the sand and gravel deposits of the buried valley in the Huron River Basin generally yield from 20 to 50 gpm.[6] Productions have been reported exceeding 100 gpm in this valley. The buried valley which parallels the Vermilion River and its tributaries yields 25 to 100 gpm in wells drilled in the southern portion of the basin, while wells in the central section normally yield less than 25 gpm.[3] However, wells yielding more than 100 gpm are known to exist near New London and Savannah. Generally, the water-bearing properties of valley fill material are highly variable in regard to location, and test drilling is helpful in order to locate favorable materials for developing relatively high yields.

The soils overlying these buried river valleys are moderately to poorly drained. The recharge to the buried valley aquifers as a result of soil water percolation would be fairly low in all cases.

RELATIONSHIP OF POTENTIAL LAND TREATMENT AREAS TO THE AQUIFER SYSTEM

The effect of irrigation with treated sewage effluent on water levels or storage in the underlying aquifers will be slight, assuming an adequate drainage system has been designed. The following hydrologic parameters would be affected with the advent of effluent irrigation and sub-drainage in a previously non-irrigated, undrained land area:

1. Infiltration would be somewhat higher due to more vigorous crop cover (and root density).

2. Evapotranspiration would be slightly higher due to transpiration from higher yielding crop cover.

3. Surface runoff would generally be lower because of the artificial drainage system. Farm management and interception of storm runoff from the fields for storage and recycling must be practiced.

4. Total input of water would be increased from 34 inches per year (average rainfall) to a maximum of 94 inches per year (average rainfall plus 60 inches of irrigation with effluent.)

In light of the above-mentioned effects of effluent irrigation, a drainage system designed to remove most of the percolating water moving below the root zone is necessary as far as ground water levels and ground water in storage are concerned. This would be the most desirable case for most of the aquifers in the study area. If the drainage system were "too efficient", ground water levels might gradually decline in the immediate area. In the case of the drainage system not being efficient enough, water levels would rise in the area. One can generalize, however, that unless artificial drainage is adequate enough to remove the water passing the root zone (that not evaporated or transpired), a local water table will rise until hydraulic equilibrium is reached. With a low permeability below the drains, the system must be capable of draining off all percolating water.

Irrigation with secondarily treated sewage effluent should be designed to have a minimal effect on the quality of ground water in the study area. It is assumed that the effluent to be used for irrigation will have undergone adequate chlorination. Remaining pathogenic microorganisms will be removed in the first few feet of percolation in the soil. This is especially true with regard to the soils of the designated

study region, since many of them have high clay and silt contents. All of the suspended or colloidal organic material will be removed in the first foot of soil. Almost all of the organic compounds in solution (with the possible exception of organic phosphate) are removed to a large degree by the soil. Any heavy metals present in the effluent should be removed by the soil to a safe level in water reaching the aquifer. Sulphates and chlorides are expected to pass through the soil zone without being diminshed in total quantity. Nitrate, the mobile form of nitrogen in soils, deserves particular attention since concentrations greater than 10 ppm (expressed as N) have been known to cause methemoglobinemia in infants. Usually, about 70 percent to 85 percent of the nitrogen present in sewage effluent is present in the ammonia form, which is relatively immobile in soils. However, with free oxygen present in the soil environment, ammonium is rapidly transformed microbially to the mobile nitrate form. In this form, nitrate is a potential pollutant of ground water; however, crops have a high nutrient demand for nitrogen and generally prefer the nitrate form to other available forms. Generally, grasses have a greater demand for nitrogen than row crops, due to their greater root density. Thus, with adequate crop cover, there would be virtually no chance of nitrate buildup in the underlying ground water.

SUMMARY - WESTERN LAND TREATMENT AREAS

Neither the level nor the quality of the ground water should be affected in most of the designated western land treatment

areas with appropriate design and system management. The quality of most of the existing ground water derived from the area would generally be classed as fair-to-poor, due to high TDS concentrations, as well as hardness, sulfate, hydrogen sulfide, and iron in certain areas. Perched water table conditions could develop in the eastern portion of the study area if drainage were insufficient. This area is underlain by shale and sandstone bedrock, with an overburden of clayey glacial till. The moderately-to-poorly drained soils in this area could contribute to a perched water table without adequate drainage.

A major ground water problem in the Western Land Treatment Area is the contaminated ground water region centered around Bellevue. The present region of pollution extends to one mile east of Clyde and south several miles into Seneca County. This contaminated region underlies about 3,200 acres considered earlier in this study as a potential land treatment site.

Although this site is no longer included in land treatment proposals for wastewaters generated in the Cleveland-Akron vicinity, it illustrates the potential of well-designed land treatment systems as a means of improving a variety of hydrological conditions. A possible response to the ground water setting around Bellevue would be to rule out irrigation, due to the increased flooding risk of contaminated groundwater "backing up" through the system of surface sink holes and fissures in the limestone as occurred in 1937.

An alternative course of action, which would benefit the long-range utility of the aquifer, would be to pump the existing polluted ground water and transport it outside the contaminated region where it could be

used to irrigate crops (grasses). It would be best to use this polluted water for irrigation only at times when cover crops can be grown, in order that nutrient removal would be at a maximum.* While the contaminated ground water was being pumped out of the area, the land overlying the region could be irrigated with treated effluent of a relatively superior quality. Thus, the region would still be available for land treatment. Additional acreage would, however, have to be found outside the study area to use for irrigation with the contaminated ground water. The latter of the two alternatives would have the benefits of gradually improving the existing ground water quality around Bellevue and inhibiting the encroachment of polluted ground water into nearby areas. Also, irrigation with the polluted ground water outside the contaminated area would not jeopardize the ground water quality of the new area if proper precautions were taken regarding land treatment. At present it is known that large springs exist on land and in Lake Erie which are discharge points for the limestone aquifer. It is estimated that perhaps 500 to 1,000 cfs total flow issues from the various springs. Water quality analyses of the various spring waters could not be located; however, in light of the water quality farther south, it is expected that the total limestone aquifer pollution discharge into Lake Erie is significant in terms of TDS.

*The polluted ground water might also be used on land directly over the aquifer for renovation purposes.

SECTION V-A

GROUND WATER HYDROLOGY
Three Rivers Watershed

BEDROCK AQUIFERS

The northern and western portions of Chagrin River Basin are underlain with shale bedrock, an extremely poor aquifer yielding from 0 to 2 gpm in drilled wells.[14] The water quality of this formation is fair, with iron concentration and hardness being the major problems. Iron concentrations average about 1.0 ppm and hardness about 200 to 250 ppm ($CaCO_3$).[14]

Mississippian and Pennsylvanian sandstone and shale provide suitable aquifers for domestic wells in the central portion of the basin (5 to 10 gpm).[14] Pennsylvanian sandstones, known as Sharon conglomerates, are typically found at depths of less than 150 feet below ground surface in the eastern portion of the Chagrin River Basin.

These sandstones yield up to 50 gpm in existing wells. Water levels in these sandstone aquifers range from 30 to 50 feet below ground level[13]. Iron concentration in the ground water ranges from .03 to 1.2 ppm and would require treatment in some cases. Hardness ranges from 100 to 250 ppm in the sandstone aquifer[14].

The upper portion of the Cuyahoga River Basin is largely underlain by sandstone interbedded with some shale. Water well yields in the sandstone formation are about 50 gpm, compared with 5 to 25 gpm in sandstone interbedded with shale[15]. Water levels vary from 25 to 40 feet below ground level.[13] Treatment for iron would be necessary since concentrations range from one to four ppm. Total dissolved solids (TDS) average

about 300 ppm for the sandstone aquifers. Hardness values range from 150 to 300 ppm and would require softening treatment in most cases[15].

In the lower portion of the Cuyahoga River Basin, extending from Akron on either side of the Cuyahoga River north to Lake Erie, lies a shale aquifer. This is a very poor ground water supply, yielding from 0 to 2 gpm in drilled wells. Further east and west of the Cuyahoga River, lie sandstones and shales which will yield up to 25 gpm in water wells[16]. The water quality of these interbedded sandstone and shales is fair to poor. Iron concentrations have been found as high as 18 ppm and would definitely require treatment used as a ground water supply. Hardness averages 250 ppm and would require treatment for domestic uses[16].

Isolated areas of Sharon conglomerate appear in the southern portion of the lower Cuyahoga River Basin. Wells in these areas have water levels ranging from 20 to 30 feet below ground level and yield up to 50 gpm[13]. Iron concentrations are lower (.3 to .7 ppm) than in most aquifers encountered in the Three Rivers Watershed. Hardness ranges from 150 to 500 ppm and would require treatment for most uses. Total dissolved solids are fairly high, ranging from 250 to 650 ppm[16].

The northern portion of the Rocky River Basin near Lake Erie is underlain with shale. Wells drilled in this aquifer generally yield less than 5 gpm[17]. Iron concentrations range from .3 to 6.0 ppm, while hardness ranges from 100 to 600 ppm. Also, extremely high chloride concentrations have been reported in several wells in this shale aquifer[17]. The remainder of the Rocky River Basin is underlain by sandstone interbedded with shale. Yields from existing wells range from 5 to 25 gpm[17].

Water quality in this interbedded sandstone aquifer is fair to poor. Total dissolved solids average about 500 ppm and most of the ground water would require softening treatment. Iron concentrations range from .5 to 1.0 ppm[17]. Scattered areas of sandstone conglomerate exist in the southern portion of the basin and yield up to 50 gpm in drilled wells.

GLACIAL AQUIFERS

A mantle of thick glacial drift, containing sand and gravel lenses, extends over the Chagrin River Basin. Domestic wells producing from 10 to 25 gpm can be obtained by drilling into these lenses in the central portion of the basin[14]. Generally, test hole drilling is necessary to ensure an adequate ground water supply. Water levels in the sand and gravel wells range from 15 to 25 feet in the Chagrin River Basin[13]. Water quality is fair, with hardness averaging about 200 ppm and iron about one ppm. Sulphate concentrations as high as 100 ppm have been noted in gravel aquifers[13]. Most of the shale bedrock of the Chagrin River Basin, as well as the other basins in the Three Rivers Area, is covered by a layer of impermeable clay drift. This is an extremely poor water supply in terms of production.

Sand and gravel deposits within the thick glacial drift occur to a large extent in the southern portion of the Upper Cuyahoga River Basin. Wells drilled in these deposits yield from 5 to 50 gpm[15], with water levels ranging from 20 to 45 feet below ground level[13]. No information was available on water quality from these sand and gravel wells.

The area along the Cuyahoga River in the lower portion of the basin contains sand and gravel deposits within the glacial drift capable of producing 25 to 100 gpm. Other isolated areas of glacial drift containing sand and gravel lenses will produce from 5 to 25 gpm in the lower Cuyahoga River Basin[16].

Glacial moraine deposits in the southern portion of the Rocky River Basin yield from 5 to 25 gpm of fair quality ground water[17]. Total dissolved solids range from 500 to 600 ppm in a limited number of tested samples.

BURIED RIVER VALLEYS

A buried river valley exists along a portion of the Chagrin River in the eastern sector of its basin. Another buried valley lies just west of Chagrin Falls running south into the Cuyahoga River Basin[18]. Wells drilled in these valleys have yields of 25 to 100 gpm[14]. Based on limited information, hardness appears to be 200 ppm and iron concentrations about 1.0 ppm[14].

In the upper portion of the Cuyahoga River Basin, a buried river valley runs southwest of the Town of Burton[18]. The sand and gravel deposits existing in this valley typically yield from 5 to 25 gpm in water wells[15]. A small buried river valley traversing east-west through the Town of Mantua produces similar ground water supplies[18]. Another valley runs from Streetsboro Township south to Brady Lake and yields 25 to 100 gpm in drilled wells[15, 18].

Extending south from Cuyahoga Falls, Akron, Mogadora, and an area

southeast of Akron, is a buried river valley capable of producing 500 to 1,000 gpm in drilled wells[15, 18]. No information is available concerning water quality in these buried river valleys; however, the qualities should be similar to that of the water derived from the sand and gravel aquifers in the nearby glacial drift. Water levels in these buried river valley aquifers vary from 10 to 45 feet below ground level[13].

In the lower and extreme eastern portion of the Cuyahoga River Basin, a buried river valley extends in a north-south direction[18]. It can produce 25 to 100 gpm in drilled wells[16]. A buried valley, capable of producing 500 to 1,000 gpm in water wells, is located in the southern portion of the basin. Also, north of the Town of Hudson, there exist buried valley aquifers, which can produce from 5 to 25 gpm.[16, 18]

In the Rocky River Basin, extending from the southwest corner of Richfield Township in Summit County to Lake Erie at Rocky River, lies an extensive buried river valley capable of producing from 5 to 25 gpm from sand and gravel lenses.[17, 18] Another valley runs in a north-south direction in central Montville and Medina Townships.[18] A small valley also exists in central Lafayette Township.[18] The yields of the above two buried river valleys range from 5 to 25 gpm.[17]

SUMMARY - THREE RIVERS WATERSHED

A comparison of finally-selected land treatment and reservoir sites, with the geographical features discussed above, indicates that ground

water relationships present no constraints, identifiable at this stage of investigation, upon the land treatment proposals within the Three Rivers Watershed area. In general, relatively tight soil conditions and extremely impermeable substrata would retard ground water recharge from the winter storage reservoirs and the artificially drained irrigation sites. Moreover, whatever recharge did result would cause no appreciable deterioration in ground water quality. These conclusions are based upon published soil, geological, and hydrological data available from the Ohio Department of Natural Resources and would, of course, be subject to more detailed engineering field studies prior to final design. In addition, a system of ground and surface water quality monitoring stations would be designed for each treatment site to establish the hydrological impact over time of the land treatment system.

BIBLIOGRAPHY - SECTION V

1. Rudnick, Anthony R. "Water Use in Ohio," Ohio Department of Natural Resources, Division of Water, Report No. 6, 1959.

2. Stein, Russell B. "Underground Water Resources - Huron River Basin," Ohio Department of Natural Resources, Map No. D-2, 1962.

3. Stein, Russell B. "Underground Water Resources - Vermilion River Basin," Ohio Department of Natural Resources, Map No. D-3, 1962.

4. Stein, Russell B. "Underground Water Resources - Sandusky River Basin (Upper portion)," Ohio Department of Natural Resources, Map No. C-2, 1962.

5. Stein, Russell B. "Underground Water Resources - Sandusky River Basin (Middle portion)," Ohio Department of Natural Resources, Map No. C-3, 1962.

6. Stein, Russell B. "Underground Water Resources - Sandusky River Basin (Lower portion)," Ohio Department of Natural Resources, Map No. C-4, 1962.

7. Walker, Alfred C. "Underground Water Resources - Pickerel Creek - Pipe Creek Area," Ohio Department of Natural Resources, Map No. D-1, 1962.

8. "Ground Water for Planning in Northwest Ohio," Ohio Department of Natural Resources, Division of Water, Report No. 22, 1970.

9. Cummins, James W. "Buried River Valleys in Ohio," Ohio Department of Natural Resources, Division of Water, Report No. 10, 1959.

10. "Contamination of Underground Water in the Bellevue Area," Ohio Division of Water, June, 1961.

11. Mallman, W.L. "Review of Biological Contamination of Ground Water," Symposium on Ground Water Contamination, Cincinnati, 1961.

12. Keeney, D. R. "Nitrates in Plants and Waters," Journal of Milk and Food Technology, October, 1970, Vol. 33, No. 10.

13. Kaser, P. and L. J. Harstine. "Ground-Water Levels in Ohio, October 1959 - September 1964," Ohio Department of Natural Resources, Division of Water, Bulletin 41, 1965.

BIBLIOGRAPHY - SECTION V - (Continued)

14. Walker, Alfred C. "Underground Water Resources - Chagrin River Basin," Ohio Department of Natural Resources, Map No. E-3, 1962.

15. Walker, Alfred C. "Underground Water Resources - Upper Cuyahoga River Basin," Ohio Department of Natural Resources, Map No. E-1, 1962.

16. Walker, Alfred C. "Underground Water Resources - Lower Cuyahoga River Basin," Ohio Department of Natural Resources - Map No. E-2, 1962.

17. Prée, Henry L., Jr. "Underground Water Resources - Rocky River Basin," Ohio Department of Natural Resources - Map No. D-5, 1962.

18. The Ohio Department of Natural Resources, "Ground Water Potential in Bedrock Valleys," Northeast Ohio Water Development Plan. (No date given on map) The State of Ohio, Department of Natural Resources, Division of Water.

SECTION VI

SURFACE HYDROLOGY

INTRODUCTION

This section of the report discusses the surface hydrology of the western land treatment areas in the Sandusky, Huron and Vermilion River basins. The hydrologic situation as it exists presently and the impact that land treatment of compatible wastewater and wastes (secondary treated wastewater and stabilized sludge) would have on the surface flow of these streams will be examined. The normal flow conditions and extreme (flood and low flows) flow conditions will be considered.

The streams within the study area all flow north into Lake Erie in north-central Ohio. Certain portions of these drainage basins have been selected as potential land treatment sites for wastewater transported from the Cleveland-Akron metropolitan area. The major uses of surface water within these three stream basins are for power and manufacturing. Lesser uses are for domestic, commercial, irrigation, and rural purposes. The surface water of the Huron and Vermilion Rivers is presently used by humans much more than is the Sandusky River. Domestic water supplies for some of the larger towns, however, depend on the surface water of the Sandusky River. The smaller towns tend to rely on wells for municipal water supply. A greater dependence on surface water as a municipal supply will develop as the area continues to grow and proposed storage reservoirs are actually constructed to improve the flow conditions of the streams.

The Sandusky River was officially designated an Ohio scenic river in

1970 from upper Wyandot County through Fremont, Ohio. This is a special use of the surface water which must be considered with regard to land treatment feasibility in this basin.

CLIMATE

All of the streams in the study area derive their water from precipitation and, therefore, it is important to understand the basic climatic characteristics of the drainage basins.

The average precipitation for the State of Ohio is 37 inches per year and varies from 32" in northwestern Ohio to 44" in southwestern Ohio. Within the study area, the precipitation averages 34" per year and varies from 32" near Lake Erie to 37" near the drainage divide separating the Lake Erie basin from the Ohio River basin. The study area receives less than the average rainfall for the entire state.

Although Lake Erie affects the climate near the shoreline, the main influence is from air masses moving eastward across the great plains. The study area is on the fringe area of storms produced by air masses from the Gulf of Mexico or Canadian sub-Arctic and, therefore, receives less precipitation than other areas of the state.

Six climatic stations in the study area were studied to learn the characteristics of precipitation and snowfall. These stations are listed in Table VI-1.

TABLE VI-1
CLIMATIC STATIONS

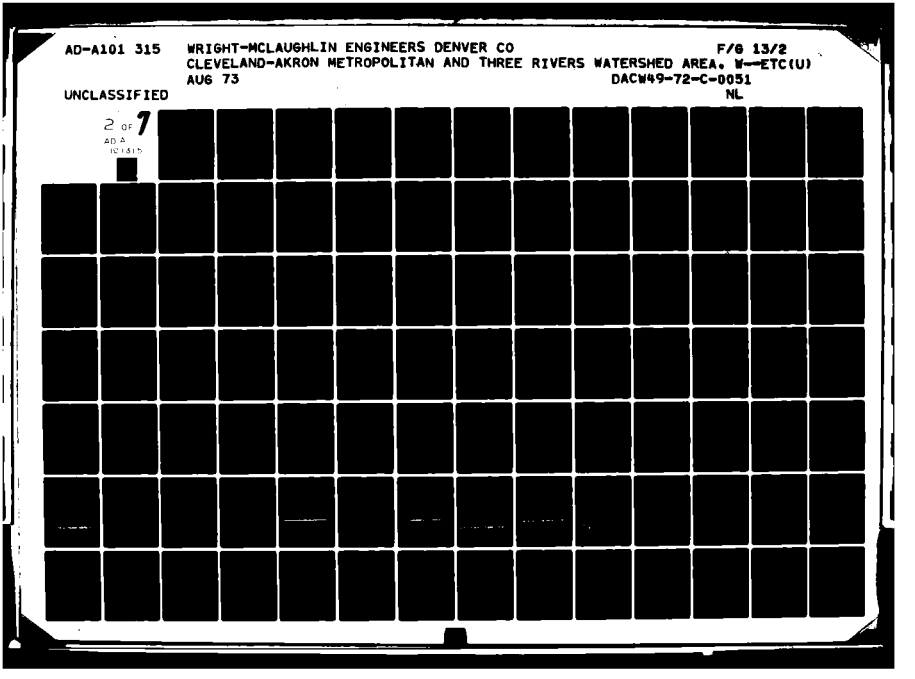
Station	County	Elevation in Feet	Years of Record (Prior to 1960)
Fremont	Sandusky	600	60
Sandusky WB City	Erie	606	83
Norwalk Sewage Plant	Huron	684	79
Tiffin	Seneca	760	80
Bucyrus	Crawford	1000	69
Plymouth	Richland	1013	28

The monthly distribution of average precipitation is fairly uniform at these six stations; however, somewhat higher values occur in May, June, and July, with lower values in December and February. The average monthly distribution of precipitation for the six stations is shown in Table VI-2.

TABLE VI-2
PRECIPITATION (INCHES)

	Fremont	Sandusky	Norwalk Sew.	Tiffin	Bucyrus	Plymouth
Jan	2.46	2.40	2.41	2.58	2.88	2.67
Feb	2.01	2.09	1.96	2.16	2.34	2.21
Mar	2.72	2.84	2.79	3.08	3.15	3.05
Apr	3.31	3.15	3.40	3.29	3.18	3.41
May	3.56	3.52	3.74	3.58	3.35	3.80
June	3.96	4.10	4.15	4.19	4.50	4.48
July	3.52	3.53	3.75	3.54	3.22	3.68
Aug	2.98	3.27	3.41	3.18	3.23	3.52
Sep	2.67	2.77	3.07	2.80	2.73	2.76
Oct	2.34	2.05	2.24	2.33	2.40	2.26
Nov	2.30	2.23	2.42	2.53	2.45	2.31
Dec	2.01	2.06	2.01	2.10	2.24	2.11
Annual	33.84	34.01	35.35	35.36	35.67	36.26

AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA. W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL



It is evident that precipitation increases slightly in the study area from north to south.

Snowfall contributes to the annual precipitation quantity during the winter months. Most of the snowfall occurs during December, January, February and March, with January receiving the greatest amount. The snowfall does not necessarily accumulate from one month to the next, but often melts off due to a few days of above-freezing temperatures or winter rains. Snowfall depths are shown in Table VI-3 for four climatic stations.

TABLE VI-3
SNOWFALL (INCHES)

	Sandusky	Tiffin	Bucyrus	Plymouth
January	8.3	8.9	8.6	7.2
February	6.6	7.8	7.2	5.9
March	4.5	5.7	4.6	5.4
April	1.2	1.2	1.0	1.0
May	T*	T	0.1	T
June	T	T	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	T	0.1	0.1	T
November	1.8	2.5	2.5	2.9
December	6.0	7.0	6.9	6.5
Annual	28.4	33.2	31.0	28.9

T* - Trace

The annual snowfall for the study area would be about 30" per year.

The mean annual temperature for the study area is about 52° F with the highest mean monthly temperature in July of 72° and the lowest mean monthly temperature in January-February of 27° F. The last occurrence of 32° F in the spring is about May 1 and the first occurrence of 32° F in

the fall is about October 10, giving a frost free (32° F) period of about 160 days. The relative humidity is generally about 70-80% throughout the year. Average windspeeds are about 10 miles per hour from the southwest. Lake evaporation is about 31 inches per year with the largest percentage occurring between May and October.

Storms in Ohio generally move from southwest to northeast. The axes of movement for the storms affecting the study area generally are located on or south of the Lake Erie-Ohio River drainage divide. Therefore, the study area is generally off the major storm track for Ohio. However, there have been several major storms in the last 100 years which have deposited in excess of 5-inches of precipitation over large areas within 3-5 days.

The U. S. Weather Bureau has determined rainfall occurrence for the United States (2,3). Rainfall depths for various durations and frequencies are shown in Table VI-4 for the study area.

TABLE VI-4
RAINFALL DEPTH (INCHES)

Duration	Frequency (Years)					
	2	5	10	25	50	100
30 min	1.0	1.2	1.4	1.6	1.8	2.0
1 hr	1.2	1.6	1.8	2.1	2.3	2.6
2 hr	1.4	1.8	2.2	2.4	2.8	3.0
3 hr	1.6	2.0	2.3	2.7	2.9	3.2
6 hr	1.8	2.3	2.8	3.1	3.4	3.8
12 hr	2.2	2.8	3.2	3.5	3.8	4.5
24 hr	2.5	3.2	3.5	4.0	4.5	4.9
2 day	2.9	3.4	4.0	4.6	4.9	5.5
4 day	3.3	4.0	4.6	5.3	5.8	6.5
7 day	3.8	4.5	5.3	6.0	6.6	7.0
10 day	4.3	5.1	5.9	6.6	7.1	7.8

Short duration thunderstorms can provide 0.4 to 0.6 inches of rain in five minutes for the two and ten year storm frequency, respectively. This indicates the desirability of high rainfall detention crops such as grass covering, and the need to provide for detention and treatment of runoff which does occur. Most of the water detained by a grass covering will infiltrate. Summer thunderstorms do occur in the study area; however, most flood-producing storms occur during the winter months. Runoff from these winter storms is aggravated by melting of snow accumulations and by ice jams. Hurricane storms have occurred during the fall in the northeastern part of Ohio; however, none have occurred in the rest of the state.

The occurrence of low rainfall conditions or droughts in the study area is a random event.[9] No trends have been found. Quantities of rainfall during a dry year will vary considerably from station to station.

BASIN CHARACTERISTICS

The Sandusky, Huron, and Vermilion River basins lie in north-central Ohio and face toward Lake Erie and the north. These basins lie about half in the old lake bottom and about half in the till plains. The rivers flowing across this relatively low-relief land have fairly low gradients and are sluggish and meandering. Table VI-5 summarizes some of the physical information about the three major streams and their main tributaries in the study area.

TABLE VI-5
BASIN CHARACTERISTICS (5,6)

Stream	Length (Mi)	Elev. at Source (Ft)	Elev. at Mouth (Ft)	Average Gradient (Ft/Mi)	Drainage Area (sq.mi)
SANDUSKY R.	130.2	1093	573	3.9	1420.0
Green Cr.	22.9	727	574	6.7	80.8
Bark Cr.	10.7	656	575	7.5	12.8
Muskellunge Cr.	18.3	705	576	7.0	26.7
Indian Cr.	7.5	705	633	9.6	11.8
Wolf Cr.	23.9	802	637	6.9	158.0
Honey Cr.	39.3	1005	728	7.1	179.0
Buckeye Cr.	6.0	928	805	20.5	9.2
Sycamore Cr.	20.0	955	745	10.5	64.2
Tymochtee Cr.	54.8	901	757	2.6	302.0
Broken Sword Cr.	32.0	1018	855	5.1	94.7
HURON R.	59.7	1090	573	8.6	406.0
E. Branch	24.0	966	595	15.4	87.8
W. Branch	46.0	1090	595	10.8	262.0
Frink Run	16.1	891	693	12.3	29.8
Slate Run	19.5	950	697	13.0	46.4
VERMILION R.	58.7	1030	573	7.8	268.0
SW Branch	10.4	1115	935	17.3	31.1

The major river basins are wider at the upper or southern end and narrow to their discharge point in Lake Erie. The Sandusky River has a variation of gradients from 25 feet per mile near Tiffin to as low as 2 feet per mile. The basins are underlain by limestone and shale formations, which do not contribute greatly to streamflow. Glacial and lacustrine deposits are thin and impermeable. However, in the upper Sandusky River basin, the drift thickens and is more permeable in areas of moraine deposits. No prominent buried valleys exist (7).

LAND DISPOSAL AREAS

Soils information for the Sandusky, Huron, and Vermilion River basins

has been studied and is described in other sections of this appendix. It was found that suitable soil types for land treatment of wastewater exist within each river basin. The quantity of selected land is shown in Table VI-6 by major river basins and some of their main tributaries.

TABLE VI-6
POTENTIAL LAND TREATMENT AREAS

Basin	Total Basin Area (Acres)	Potential Land Treatment Area (Acres)	(% of Basin)
SANDUSKY R.	910,000	194,340	21.4
Green Cr.	51,700	12,470	24.1
Bark Cr.	8,200	4,080	49.8
Muskellunge Cr.	29,900	2,730	9.1
Indian Cr.	7,560	4,940	65.3
Wolf Cr.	101,200	7,420	7.3
Honey Cr.	114,600	67,500	59.0
Buckeye Cr.	5,900	3,100	52.6
Sycamore Cr.	41,100	32,900	80.1
Tymochtee Cr.	193,500	17,860	9.2
Broken Sword Cr.	60,700	26,700	44.0
HURON R.	260,000	100,250	38.6
East Branch	56,200	12,410	22.1
West Branch	168,000	81,360	48.4
Frink	19,100	10,200	53.4
Slate	29,700	13,440	45.3
VERMILION R.	172,000	33,610	19.6
SW Branch	19,900	14,650	73.7
Vermilion R. above SW Branch	47,800	15,200	31.8

Wastewaters would be applied to these lands at an average rate of 2.3 inches per week during the growing season (average of 68 inches per year), and no application would be made during the winter months, when the effluent would be stored. An application rate of 2.3 inches per week is equivalent to 0.014 cubic feet per second (cfs) per acre or 14

cfs per 1,000 acres. This would be the theoretical maximum rate of return flow due to irrigation from lands with underdrainage and would occur only if irrigation were practiced during periods when the water requirements of the crops were completely satisfied by natural precipitation. During the months of July, August and September, the return flow due to irrigation would generally be less than 90% of the application rate with the balance being consumptively used by the crops.

Irrigation with wastewater would be suspended during storms to minimize overland flow runoff and flood peaks.

Discharge points for the water collected by underdrains are an important consideration so that the physical capacity of the natural drainage channels are not exceeded. Indications of the relative ability of these drainage channels to accept additional water from the irrigated areas will be discussed in the following pages of this section. A detailed determination of drainage channel capacity of smaller and smaller tributaries is not consistent with the present phase of this study. This would require channel cross-section and slope information and may be appropriate at a later time.

NORMAL FLOW CONDITIONS

Within the study area, there are presently 7 gaging stations maintained by the U. S. Geological Survey (11). Most of these stations have operated for a number of years so that average flow conditions can be determined. These 7 stations are listed in Table VI-7 with some of their characteristics. In general, the highest average flows occur during the

the months of March and April, and the lowest flows occur during September and October. The average flow constantly decreases from a peak in March or April to a low in September or October when it begins to increase again. From 40% to 50% of the average annual runoff volume occurs during March and April. For an individual water year, low flows can extend into November and December, and some large winter storms between December and March can cause high peak runoff values and discharge volumes. The stream flow from June to October is generally lower than the average discharge and is less erratic from one year to the next. Summer and fall flows are less variable than winter and spring flows. Flow-duration values for various streams and locations are given in Table VI-8 for the study area (7, 12).

TABLE VI-7

U. S. GEOLOGICAL SURVEY, GAGING STATIONS

Station Name	Tributary Area (Sq. Mi.)	Elevation (Feet)	Period of* Record (Yrs.)	Average* Discharge (cfs)	Maximum* Discharge (cfs)	Minimum* Discharge (cfs)
1. Sandusky R. near Bucyrus	88.8	955	29	81.2	13,500	0.4
2. Sandusky R. near Upper Sand.	298	792	46	235	10,000	0.5
3. Tymochtee Creek	299	786	6	166	6,040	0
4. Sandusky R. near Mexico	774	733	44	558	19,000	1.8
5. Sandusky R. near Fremont	1251	626	44	920	28,000	4.4
6. Huron R. at Milan	371	573	20	283	49,600	2.2
7. Vermilion R. near Vermilion	262	595	20	230	40,800	0

*Value as of 1970 Water Year

TABLE VI-8

FLOW-DURATION[12]

Per Cent of Time Discharge (cfs) Indicated was Equalled or Exceeded

Station	5%	10%	15%	20%	25%	30%	40%	50%	60%	70%	75%	80%	85%	90%	95%
1. Sandusky R. near Bucyrus	350*	170	108	79	59.5	45	27.0	16.8	10.1	6.1	4.8	3.8	3.1	2.4	1.8*
2. Sandusky R. near Upper Sand.	1060	590	375	262	193	146	85.5	49.5	30.0	18.5	14.6	11.4	8.7	6.3	4.0
3. Sandusky R. near Mexico	2800	1450	890	650	450	285	195	117	72	47	38.2	31.3	25.5	20.4	15.2
4. Sandusky R. near Fremont	4600	2450	1480	1000	730	540	360	195	113	70	57	46.5	38	30.5	23.3
5. Huron R. at Milan	1200	600	375	260	193	150	90	55	36	24.6	20.2	16.8	13.7	10.9	8.1
6. Vermilion R. near Vermilion	1110*	565	310	205	144	105	62	36	19.5	10.8	7.6	4.9	3.2	2.0	1.0*

* All values in cfs

The impact of return flow from irrigation with imported wastewater on the normal flow conditions of the streams in the study area will be to increase discharge during the irrigation season. The irrigation season will vary somewhat from year to year, but generally would extend from April to October. For these months, normal streamflows are diminishing from their peak flow in March or April. The relative impact on normal flow conditions is shown in Table VI-9. This table compares the annual average flow, maximum potential wastewater return flow, and the mean annual flood flow. For this phase of the hydrology study, it has been assumed that the mean annual flood (the flood recurring every 2.33 years) represents the approximate maximum channel capacity without overtopping. In actual practice, only a portion of the potential wastewater disposal area would be used. Therefore, the return flow value given is a maximum for each basin listed in Table VI-9. Also, the total annual volume of wastewater to be imported is much less than the sum of the maximum potential return flows for each basin as shown in the table.

Table VI-9 shows that the maximum potential wastewater return flow is never greater than 17% of the mean annual flood, although in many cases the return flow is much larger than the annual average flow. The main conclusion to be drawn from Table VI-9 is that although the stream regime would change due to increased flow, the potential western land treatment areas identified on Figure II-1 are considered to be feasible sites for wastewater disposal from the standpoint of surface hydrology. This conclusion applies to rather large sub-basins within the three

major river basins and smaller drainages will require special study. The distribution of annual runoff and deviations from expected runoff conditions will require further study to optimize wastewater return flow impact on the streams. Erosion and deposition mechanisms will change in the streams and will require definition.

TABLE VI-9
IMPACT OF WASTEWATER TREATMENT (1)
ON STREAMFLOW

Stream	Annual Average Flow (cfs) (3)	Maximum Potential Wastewater Return Flow (cfs) (2)	Mean Annual Flood Flow (4) cfs
SANDUSKY R. at mouth	1050	2691	18,000
Green Cr.	64	173	2,800
Bark Cr.	10	56	690
Muskellunge Cr.	37	38	1,900
SANDUSKY R. near Fremont	920	2392	15,500
Indian Cr.	10	68	690
Wolf Cr.	120	102	4,000
Honey Cr.	131	932	5,700
Buckeye Cr.	7	43	700
SANDUSKY R. near Mexico	558	1139	9,300
Sycamore Cr.	41	460	2,800
Tymochtee Cr.	208	247	3,700
Broken Sword Cr.	61	368	2,500
HURON R. at mouth	310	1392	9,800
HURON R. at Milan	283	1300	9,000
East Branch	63	173	2,800
West Branch	218	1127	7,100
Frink	30	138	1,550
Slate	45	184	2,300
Unnamed Cr. north of Willard	23	161	1,500

(Continued on next page)

TABLE VI-9 CONTINUED

Stream	Annual Average Flow (cfs) (3)	Maximum Potential Wastewater Return Flow (cfs) (2)	Mean Annual Flood Flow (4) cfs
VERMILION R. at mouth	230	460	5,500
SW Branch	30	201	1,850
VERMILION R. above SW Branch	72	213	3,900

(1) See Table VI-6 for drainage basin and sewage disposal area.
(2) Assume 14 cfs per 1000 acres during summer-fall months only. All designated sewage disposal land within sub-basin utilized.
(3) Rough estimate of average flow for some stations determined by correlation with nearby basins.
(4) Mean annual flood determined by reference 14, "Floods in Ohio".

During the winter months, there would be little or no alteration of the natural runoff conditions. Once irrigation was terminated in October, there would be a short-duration decreasing discharge from the land as the groundwater in storage percolated through the soil into the underdrains.

FLOODS

As brought out in the climatic portion of this section, the flood producing storms for the study area generally occur during the winter months and are aggravated by melting of snow accumulations, ice jams, and frozen soil. However, high intensity rainfall does occur during summer thunderstorms. The ten largest floods at the Sandusky River near Fremont are shown in Table VI-10(4).

TABLE VI-10
MAJOR FLOODS
SANDUSKY RIVER NEAR FREMONT

ORDER BY DISCHARGE	DATE	DISCHARGE IN CFS
1	Mar 1913	65,000
2	Apr 2, 1904	41,000
3	Feb 10, 1959	28,000
4	Jan 15, 1930	27,300
5	June 1937	25,700
6	Jan 24, 1959	25,000
7	Feb 15, 1950	22,900
8	Mar 14, 1933	22,600
9	Mar 6-7, 1963	21,500
10	Mar 22, 1927	20,000

The study area has not experienced flood flows per unit of drainage area as great as those which occur in other parts of Ohio. However, major floods have occurred (4). In the 1959 floods, a unit discharge of 150 cfs/sq mi was recorded. Flood damage has occurred in the past in the larger communities of the Sandusky River such as Fremont, Tiffin, Upper Sandusky, and Bucyrus. The flood plains in these towns have been built upon by man.

The flood frequency relationships for six stream locations in the study area are shown in Table VI-11 (13, 14).

TABLE VI-11
FLOOD MAGNITUDE (CFS) AND FREQUENCY

Station	Recurrence Interval (yrs) 2.3	5	10	25	50
1. Sandusky R. near Bucyrus	2800	3800	4800	5800	6900
2. Sandusky R. near Upper Sandusky	4800	6500	7800	9000	11000
3. Sandusky R. near Mexico	9300	12400	14200	17600	20000
4. Sandusky R. near Fremont	15500	20500	24500	29500	33500
5. Huron R. at Milan	9000	12000	14500	18000	20500
6. Vermilion R. near Vermilion	5500	7500	9000	11000	12500

Most damaging floods occur in the study area during the winter when snow accumulations, soil infiltration, and ice jams can aggravate runoff and create large peak flows. Irrigation of wastewater would not occur during the winter months and the surface hydrology of the streams would be affected very little. The only flow contribution that may extend into the winter months would be from draining the land after the irrigation was completed for the season.

Although floods are less likely to occur in summer and fall, there have been floods during these seasons in the past. Operation of the irrigated areas would be such as to minimize the impact on flood producing storms. Irrigation would be terminated when the rainfall was forecasted

or when it occurred. There would be a lag time when continued flow would occur from the previously irrigated land. This flow might tend to aggravate any flooding by increasing the flood peaks (as shown in Table VI-9). An opposing effect on floods is that keeping an area in agricultural use for wastewater disposal by irrigation of crops will be better for minimizing future flood damage than if the area became urbanized. The increased impervious area for urban lands increases runoff considerably. The flood peaks for higher frequency storm would be increased less than 15% due to wastewater return flow.

LOW FLOW

The periods of low flow of Ohio streams represent another extreme flow condition which is of importance. Low flows of streams are important for understanding the water supply potential of a stream without storage, for utilizing the stream, for recreational purposes, for visual amenities, and for diluting sewage as has been the practice in the past. Although rainfall is relatively evenly distributed throughout the year in the study area, droughts do occur and streams become very low or dry up completely for short periods. The study area receives less rainfall on the average than does the rest of the state and, therefore, low flows of streams are especially important. Streamflow records previously discussed illustrated how low flow conditions normally exist in September or October in the study area following the period of maximum evapotranspiration from vegetation.

The base flow in streams is usually sustained by ground water inflow or by return flow of the wastewater effluent from towns. The measure of low flow currently used in Ohio is the flow equalled or exceeded 90% of the time. This measure of low flow will be higher in areas having large permeable glacial deposits (7). The Sandusky River basin, however, has generally thin impermeable glacial drift except in the upper basin (7). The 90% low flow value is shown previously for six stations in the study area in Table VI-8, FLOW-DURATION.

The occurrance of low flow is a random event which must be analyzed and described by statistical techniques. The average 7-day duration low flow discharge having a 2-year frequency is shown in Table VI-12 for six stations in the study area (10).

TABLE VI-12
LOW FLOW (2-YEAR FREQUENCY, 7-DAY DURATION) IN CFS

1.	Sandusky River near Bucyrus	1.80
2.	Sandusky River near Upper Sandusky	4.20
3.	Sandusky River near Mexico	13.5
4.	Sandusky River near Fremont	22.0
5.	Huron River at Milan	10.2
6.	Vermilion River near Vermilion	2.38

In general, low flow conditions are poor in the study area except for Green Creek (Sandusky River tributary) which is fed by springs issuing from the dolomite and limestone (4).

Irrigation of treated wastewater on agricultural lands will definitely improve the low flow conditions of the three major river basins. The return flow will occur during the months of worst low flow conditions and will add to the natural waters. In some water years, the low flow conditions extend into November, December, and January. For these months wastewater irrigation would not help much unless management of the operation provided for storage in "upground" reservoirs.

BIBLIOGRAPHY - SECTION VI

1. "Climatic Summary of the United States - Supplement for 1951 through 1960 - OHIO," United States Department of Commerce, Weather Bureau, 1964.

2. "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," U. S. Department of Commerce, Weather Bureau, Technical Paper No. 40, 1963.

3. "Two-to-Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States," United States Department of Commerce, Weather Bureau Technical Report No. 49, 1964.

4. "Water Inventory of the Portage River and Sandusky River Basins and Adjacent Lake Erie Tributary Areas," Ohio Department of Natural Resources, Division of Water, Report No. 20, 1966.

5. "Gazetteer of Ohio Streams," Ohio Department of Natural Resources, Division of Water, Report No. 12, 1960.

6. "Drainage Areas of Ohio Streams," Ohio Department of Natural Resources, Division of Water, Report No. 12a, 1967.

7. "Flow Duration of Ohio Streams," Ohio Department of Natural Resources, Division of Water, Bulletin 31, 1959.

8. Rüdnick, Anthony R. "Water Use in Ohio," Ohio Department of Natural Resources, Division of Water, Report No. 6, 1959.

9. Cross, William. "Low-Flow Frequencies and Storage Requirements for Selected Ohio Streams," Ohio Department of Natural Resources, Division of Water, Bulletin 37, 1963.

10. Cross, William. "Low-Flow Frequency and Storage-Requirement Indices for Ohio Streams," Ohio Department of Natural Resources, Division of Water, Bulletin 40, 1965.

11. "Water Resources Data for Ohio, Part 1. Surface Water Records," United States Department of Interior, Geological Survey.

12. Cross, William P. "Flow Duration of Ohio Streams," Ohio Department of Natural Resources, Division of Water, 1968.

13. Cross, William P. and Earl E. Webber. "Floods in Ohio, Magnitude and Frequency," Ohio Department of Natural Resources, Division of Water, Bulletin 32, 1959.

BIBLIOGRAPHY - SECTION VI (Continued)

14. Cross, William P. and Ronald J. Mays. "Floods in Ohio, Magnitude and Frequency, a Supplement to Bulletin 32," Ohio Department of Natural Resources, Division of Water, Bulletin 43, 1961.

SECTION VII

SOIL SELECTION CRITERIA

INTRODUCTION

The investigations of soil, geological, and hydrological conditions summarized in the preceding sections of this Appendix were performed in order to permit an assessment of the physical suitability of areas within the Lake Erie Basin of Ohio for land treatment of secondary sewage effluent. Ideally, the identification of land treatment sites would proceed by screening this inventory of basic data with a comprehensive set of criteria. Any area which failed to satisfy one or more of the physical criteria would be eliminated from further consideration.

In practice, the geological and hydrological conditions in the study area were found to present few major constraints for land treatment. In areas of possible ground water problems, if a site were found to be otherwise suitable, it could be designated a potential treatment site, subject to verification by field studies that subsurface conditions were satisfactory. Land use, proximity to development, and other geographic factors also strongly influence land treatment site selection, but they tend to be more susceptible to ready evaluation. The most limiting and significant physical criteria have been found to be those related to soil characteristics, terrain, and land use.

SOILS CRITERIA PHILOSOPHY

The Office of the Chief Engineer of the United States Army Corps of Engineers has issued guidelines for the selection of spray irrigation

land treatment areas, including abbreviated criteria for the more important soil parameters, which may be summarized as follows:

1. Soil textural class: Loam to silt loam surface horizons with similar texture for underlying strata.
2. Surface infiltration rate for soil: Minimum maintained rate of two inches per day, or 0.08 inches per hour.
3. Effective length of travel of effluent within soil: Minimum of six feet* through aerobic, free-draining soil.[1]

These simplified criteria represent an approach to selecting soils which, ideally, would lend themselves to land treatment using normal agricultural land preparation, irrigation (usually spray irrigation), and cropping practices. The paramount requirement for a soil would be hydraulic capacity -- that is, good irrigation and potential drainage characteristics -- qualified by a requirement of adequate removal and storage capacities for wastewater constituents. The former criterion requires moderate to somewhat coarse-textured soils, while the latter adds that such soils need to be fairly deep to ensure adequate renovation of wastewaters.

Other criteria have been developed by agriculturalists and researchers for the "overland runoff" method of land treatment, and for the "rapid infiltration" method. These criteria have been presented in numerous publications related to land treatment, and are summarized in

*This minimum applies to sandier soils having less renovative capacity than the fine grained soils.

the CRREL Report[2], the Washington Report[3], and the Campbell Soup Publication[4].

> (There are three conventional methods of applying treated effluent to agricultural lands. These include spray irrigation, overland runoff, and rapid infiltration, which are described as follows: Spray irrigation is the controlled spraying of liquid onto the land, with the flow path being infiltration and percolation within the boundaries of the disposal site. Overland runoff is the controlled discharge, by spraying or other means of liquid onto the land, with the flow path being downslope sheet flow. Rapid infiltration is the controlled discharge, by spreading or other means, of liquid onto the land, at a rate measured in feet per week, with the flow path being high-rate infiltration and percolation[5].)

These other criteria broaden the range of soil characteristics suitable for effluent treatment to include very tight soils, with almost no permeability or infiltration capacity, to extremely coarse soils such as one would find in sand and gravel pit areas. As the type of soil criteria varies from that identified for spray irrigation, the land treatment management and farming practices significantly vary, all as described in the above references.

Logically, with three basic methods of land treatment proposed by the United States Army Corps of Engineers to suit specific types of soils, i. e.:

a) spray irrigation,

b) overland runoff, and

c) rapid infiltration,

it follows that an almost infinite number of variations could be developed to suit soils falling between the coarse and fine-grained soil extremes. By pursuing this logic with agriculturalists and physical scientists/engineers, a selection philosophy was developed which was based on tailoring of unique farm management techniques to best suit specific and unique soils which generally met detailed and somewhat more sophisticated criteria than previously considered.

INITIAL SELECTION CRITERIA

An initial study of northern Ohio soils was made to identify potential land treatment areas on the basis of the initial and more traditional spray irrigation criteria. The results of that survey were recorded in a draft of the Phase I Land Treatment Report completed in June of 1972.[6] Essentially, the findings of that initial survey were that coarse and well-drained soils, although present in significant amounts, are not overly abundant in the study area and have frequently been preempted by urbanization or by use as transportation corridors. A number of these coarser soil areas are, however, well situated to provide treatment opportunities for the wastewaters of nearby small and middle-sized communities, both inside and outside the Three Rivers Watershed Area, such as Burton, Ravenna, Middlefield, Sandusky, and Toledo.

The findings of the initial survey led to a broadened scope of

investigation influenced by the following considerations:

1. The criteria provided by the Office of the Chief Engineer describe soil conditions desirable for spray irrigation land treatment, particularly since they would be quite economical to prepare for land treatment and since modifications in existing crops and farm practices could be minimized. However, tighter soils would be capable of providing higher renovation efficiencies with respect to treatment of secondary effluent.
2. Farm management techniques, including deep plowing, choice of crops, land forming and selective water application methods, offer a powerful tool in adapting land treatment to a variety of soil conditions.
3. The initial soil inventory had identified large, contiguous acreages in the study area of somewhat tighter more finely-textured soils than those meeting the traditional criteria.

Consequently, it was decided to investigate the potential for developing specific management programs suited to the use of particular soils for land treatment. This undertaking was consistent with both the scope of the Land Treatment Contractor's assignment and the Pilot Wastewater Management Program, as a whole, in that its objective was to explore the full range of wastewater management opportunities for the Cleveland-Akron area.

This phase of the land management study did not proceed deductively from a previously-fixed set of criteria for soil characteristics, but rather concurrently with the development of farm management methods and the further study of soil characteristics. Still, it was possible to postulate a new range of values for the soil parameters, which would prove feasible for land treatment. Table VII-1 presents the initial criteria which indicated the general range of soil characteristics that would receive further consideration for spray irrigation and related living filter infiltration methods during this phase of the Land Treatment Study.

This Table VII-1 is not meant to give rigid and fixed limits, but to identify the wide range of soil characteristics which can be considered. The various ranges of characteristics from A through D are not meant to be exclusively identified with either Ranges I, II, or III.

The water table control criteria given in Table VII-1 are intended to differentiate ideal lands from those less so. They assume that if saturation extends to the surface after irrigation, the soil and site conditions would allow drain-out to 36 inches within five days with the drain spacing given.

TABLE VII-1

INITIAL CRITERIA FOR SELECTION OF LANDS FOR IRRIGATION WITH SEWAGE EFFLUENT
LAKE ERIE BASIN OF OHIO

A. Soil Characteristics	Generalized Minimum or Maximum Range of Acceptable Characteristics Related to Effluent Renovation		
	Range I Ideal Conventional	Range II Acceptable	Range III Acceptable
1. Texture			
Plow Layer	Loam to sandy loam*	Sandy clay loam to silt loam*	Clay to silty clay*
Subsurface	Clay < 40% Silt < 50 Sand > 20	Clay < 60% Silt < 40 Sand > 20	Clay > 60% Silt < 40 Sand < 10
2. Depth			
to barrier	> 60"	> 48"	< 48"
to gravel	> 30"	18 ≤ d ≤ 36	< 18
3. Chemical properties in drainable profile in equilibrium with effluent			
Electrical conductivity, E.C.x10^{-3}	< 2.0	2 to 8	>8
pH	5 to 7.5	3-5 or 7.5-9	< 3 or >9
Exchangeable Sodium Percentage, E.S.P.	< 15	< 15	< 15
Cation Exchange Capacity, C.E.C.	>15 meq/100 gr	7-15	< 7
4. Hydraulic Conductivity of Subsurface, K	3" ≤ K ≤ 20"/day	2-3" ≤ K ≤ 20"/day	2-3" ≤ K ≤ 20"/day
5. Infiltration Rate, i	i > 0.4"/hr	0.20 ≤ i ≤ 0.40"/hr	i < 0.2"/hr
6. Bubbling Pressure, P_b	P_b < 18"	18 ≤ P_b ≤ 24	P_b > 24"

*Range I (soil characteristics Nos. A-1, 2, 4, and 5). Represents sandy soil with larger hydraulic capacity, the soil often selected for land treatment because of minimal hydraulic constraints, and routine irrigation and drainage management.
Range II (Nos. A-1, 2, 4, and 5). Is moderately tighter soil requiring better land management and closer drain tile spacing
Range III is tight soil where good land management techniques are required, drain tile spacing will be close, and application rates must be more carefully chosen and controlled.

TABLE VII-1
Continued

INITIAL CRITERIA FOR SELECTION OF LANDS FOR IRRIGATION WITH SEWAGE EFFLUENT
LAKE ERIE BASIN OF OHIO

	Generalized Minimum or Maximum Range of Acceptable Characteristics Related to Effluent Renovation		
	Range I Ideal Conventional	Range II Acceptable	Range III Acceptable
B. Topography Characteristics			
7. Slope	< 2%	2≤ S≤ 15%	>15%
8. Surface	Smooth, planar	Slightly hummocky, moderate grading necessary	Hummocky, heavy grading necessary
9. Cover			
Woods	No limitations on density or type.		
Brush	No limitations on density or type. Sprinklers must extend above canopy.		
C. Surface Drainage Characteristics			
1. Outlet	No restriction for surface water disposal	Surface water disposal may require minor ditching	Surface water disposal requires extensive ditching
2. Flooding	Not susceptible to surface backwater.	Surface backwater recurrence interval >10 years.	Surface backwater recurrence <10 yr.
D. Internal Drainage Characteristics			
1. Artificial water table control	Tile drains spaced ≥100 ft. will lower w.t. to 36" in five days	Tile drains spaced 40≤L≤100' will lower w.t. to 36" in five days	Tile drains spaced <40' will lower w.t. to 36" in five days
2. Outlet	Gravity outlet immediately available	Gravity outlet requires limited conveyance	Gravity outlet requires extensive conveyance

FINAL SELECTION CRITERIA

The final soil selection criteria was based upon testing the overall soil renovative capacity and character against specific objective and subjective measuring constraints including:

1. Reasonably high and suitably safe hydraulic capacity, as related to specific irrigation application and management methods, of more than 50 inches per year.
2. A high degree of heavy metal removal and storage capacity approaching 100 per cent.
3. Nitrogen removal, with reuse, temporary storage, and atmospheric loss potential without significant leaching, of between 80 and 99 per cent.
4. Phosphorous and calcium removal, with reuse or storage potential without significant leaching, approaching 99 per cent.
5. Suitability for economically reasonable artificial and natural drainage control.

The soil associations which can be utilized for effluent renovation should provide the following properties for each of the designated generalized irrigation management methods, as given in Tables VII-2 through 5.

Specific removal parameters are defined and the estimated performance of specific soils are quantified in Section X of this appendix.

These soil associations constitute a major potential resource for wastewater treatment for the Cleveland-Akron metropolitan area. Investigations into the question of farm management have led to the proposal of several approaches, which appear very promising. Section IX of this appendix presents a discussion and schematic diagrams of some proposed techniques for farm management of land treatment sites.

TABLE VII-2

SOIL PARAMETERS SUITABLE FOR CONVENTIONAL SPRAY IRRIGATION

1.	Texture	:	Less than 1/2 silt in A Horizon, or susceptibility to reduction of silt content by plowing. Less than approximately 1/3 clay in A and B Horizons.
2.	Permeability	:	Rate of 0.6 inch per hour in A Horizon. Rate of over 3 inches per day in B Horizon.
3.	pH	:	Over 4.5, but less than 7.5 in A & B Horizons.
4.	Organic Matter	:	At least 2% in A Horizon, or susceptible to buildup with crop residue or sludge.
5.	CEC	:	Over 7.5 MEQ/100 GM.
6.	Land Slope	:	From 0 to 15%.
7.	Depth to Impermeable Substratum	:	No less than 5 feet.
8.	Rock Depth	:	Greater than 6 feet.
9.	High Water Table	:	Controllable with artificial drainage.

TABLE VII-3

SOIL PARAMETERS SUITABLE FOR OVERLAND RUNOFF/INFILTRATION IRRIGATION

1.	Texture	:	Over 1/3 clay in A Horizon, or B Horizon, or both A and B Horizons.
2.	Permeability	:	Rate of 0.2 to 0.6 inch per hour in A Horizon, or B Horizon, or both A and B Horizons.
3.	pH	:	Over 4.5.
4.	Organic Matter	:	At least 2%, or susceptible to buildup with vegetative residue or sludge.
5.	CEC	:	Over 7 MEQ/100 GM.
6.	Land Slope	:	Greater than 1/2%, but less than 15%.
7.	Depth to Impermeable Substratum	:	No less than 2.5 feet.
8.	Rock Depth	:	Greater than 5 feet.
9.	High Water Table	:	Controllable with artificial drainage.

TABLE VII-4

SOIL PARAMETERS RELATED TO LOW DROPLET IMPACT IRRIGATION*

1.	Texture	: Over 1/2 silt in A Horizon. Less than approximately 1/3 clay in A and B Horizons. Over approximately 1/5 sand in A and B Horizons.
2.	Permeability	: Rate of over 0.6 inch per hour in A Horizon. Rate of over 3 inches per day in B Horizon.
3.	pH	: Over 4.5, but less than 7.5 in A and B Horizons.
4.	Organic Matter	: At least 2% in A Horizon, or susceptible to buildup with crop residue or sludge.
5.	CEC	: Over 15 MEQ/100 BM.
6.	Land Slope	: Less than approximately 7-1/2%.
7.	Depth to Impermeable Substratum	: No less than approximately 3 feet, and preferably more than 3 feet.
8.	Rock Depth	: Greater than 5 feet.
9.	High Water Table	: Controllable with artificial drainage.

*Refers to spray application through nozzles which produce very fine droplets at relatively high pressure (50 psi). Kinetic energy of these droplets is low. Suitable with low pressure nozzles if grass cover, such as Canary Reed grass, is maintained.

TABLE VII-5

SOIL PARAMETERS SUITABLE FOR OVERLAND RUNOFF IRRIGATION

1.	Texture	:	Over 1/3 clay in A Horizon, B Horizon, or both A and B Horizons.
2.	Permeability	:	Rate of less than 0.2 inch per hour in A Horizon, or B Horizon, or both A and B Horizons.
3.	pH	:	Over 4.5 in A Horizon.
4.	Organic Matter	:	At least 2% in A Horizon, or susceptible to buildup with crop residue or sludge.
5.	CEC	:	Over 7.5 MEQ/100 GM.
6.	Land Slope	:	Greater than 1%, but less than 6%.
7.	Depth to Impermeable Substratum	:	No less than 1.5 feet.
8.	Rock Depth	:	Not applicable.
9.	Depth to High Water Table	:	More than 1 foot, but shallower depths permitted periodically without artificial drainage.

LAND USE CONSTRAINTS

Present and future land use is the most limiting factor affecting the selection of land treatment sites. For instance, some of the best potential soils lie within the City of Akron, but urban development precludes any consideration of this land.

Using the detailed $7\frac{1}{2}$-minute USGS Quadrangle Maps, the extent of urbanization in the twenty-one county area could be estimated. In the western agricultural areas, approximately 75 per cent of the gross acreage might be used for land treatment without imposing on existing development. Minor alterations may be necessary if large pivot machines are used to distribute effluent; for example, it may be necessary to clear some trees and raze some structures.

Within the Three Rivers Watershed, the constraints of urbanization, forests, and vehicular arteries tend to reduce, or make impractical, the use of some of the suitable soils for land treatment. However, smaller tracts of remaining land are often ideally suited for the smaller municipalities. The use of these areas for land treatment would preclude future urbanization, thereby conserving open space.

In the Lake Erie Basin, the major rural areas are currently used for agricultural lands, interspersed with woodland and forests. The forests include oak, hickory, elm, ash, cottonwood, maple, beech, and birch. The composition of the major crops and the livestock in each county is tabulated in Table VII-2. Other crops not listed in this table include those raised by truck farming, fruit, and sugar beets.

In 1965, the average farm size in Ohio was 150 acres; in Northern Ohio, the average farm size was believed to be slightly larger.[7]

The extensive farming enterprises of Northern Ohio show impressive crop yields, as indicated by farm census data for 1970, despite significant drainage handicaps. Whereas less than one per cent of the farm land was irrigated in 1967, over 25 per cent of the land was drained by artificially-created surface or subsurface system.[8,9] Experiments by Ohio State University Cooperative Extension Service have shown that yields can be nearly doubled with tile drainage.[9]

The following drainage problems and needs have been described by the Great Lakes Basin Commission:

1. The "problem lands" are concentrated in northwestern Ohio, in an area of 5.5 million acres (four million of these are in crop and pasture land);

2. One and half million acres of drainage work must be done if the basin is to meet its allocation of the national requirement for food and fibers from this area.[10]

In 1968, some 10,000 acres were irrigated in the general area west of Cleveland. In April, 1971, the Great Lakes Basin Commission pointed out that irrigation would improve the existing form of agriculture and enable farmers to increase their income without competing for additional high value land.[11]

The Commission established gross irrigation requirements for the normal year for the sub-basin lying west of Cleveland, based on 75 per cent irrigation efficiency. While these values are subject to some variation and error, the reported values range from about 24 inches of water

for sod to about 12 inches for corn silage.[11] The amount for vegetables is less.

Commercial fertilizers are commonly used to improve yields and these costs often exceed $30 per acre per year. Many of the soils in Northern Ohio have a low pH. To improve crop yields, lime is often used to increase the pH and, therefore, the availability of most nutrients; to supply calcium and sometimes magnesium; to increase the microbial activity and improve soil structure and tilth.[9]

The following table of 1970 agricultural yields for selected counties is indicative of a significant agricultural economy. Land treatment planning which incorporates and improves upon present land use should be a basic planning objective.

TABLE VII-6
SUMMARY OF AGRICULTURAL PRODUCTS*
Northern Ohio Counties

County	Crops - Acres Harvested - 1970					Livestock on Farms 1970 to 197i		
	Corn for Grain	Soybeans for Beans	Wheat	Oats	All Hay	All Cattle & Calves	Hogs & Pigs	Stock Sheep
Ashland	29,900	5,300	9,900	11,400	30,000	41,800	21,300	9,000
Ashtabula	12,100	1,500	2,800	9,600	30,600	33,000	6,100	1,300
Crawford	48,300	52,400	19,300	9,100	13,000	24,500	59,300	21,300
Cuyahoga	400	500	400	200	1,200	1,000	200	400
Erie	17,400	20,400	9,700	3,800	5,400	9,400	8,100	2,000
Geauga	2,800	--	1,000	3,500	13,700	10,400	1,900	800
Hancock	77,000	96,800	31,600	9,200	11,800	20,600	48,300	16,600
Hardin	68,500	75,600	21,300	11,400	13,600	24,300	60,200	22,900
Huron	46,800	67,800	21,300	10,000	12,200	17,300	29,400	12,300
Lake	1,000	--	600	300	2,000	1,300	400	400
Lorain	18,800	25,100	9,300	6,400	14,300	19,000	9,000	2,900
Medina	16,500	6,100	5,600	7,000	24,100	24,800	8,900	1,900
Ottawa	11,500	41,900	13,600	4,500	13,400	6,400	6,500	1,100
Portage	13,200	--	3,800	6,700	19,000	20,100	4,700	1,200
Richland	25,700	21,500	11,000	9,300	18,100	24,100	23,500	9,700
Sandusky	48,900	56,600	20,200	6,300	11,200	21,200	25,700	6,500
Seneca	57,800	80,000	30,200	11,800	16,400	21,800	44,400	19,500
Stark	29,300	1,200	9,500	11,900	28,000	37,200	17,100	2,000
Summit	1,900	100	1,100	1,400	4,200	3,900	1,000	1,000
Trumbull	11,600	1,500	2,200	6,300	16,100	18,800	2,400	1,000
Wood	96,900	104,500	39,800	16,800	19,400	26,800	26,200	5,900
Wyandot	56,900	62,100	21,200	8,300	9,400	14,900	38,700	21,100
Total	693,200	720,900	285,400	165,200	327,100	422,600	443,300	160,800

*Data taken from Ohio Crop Reporting Service, Ohio Agricultural Statistics, 1971, Columbus, Ohio: Ohio Department of Agriculture, 1972.

OPEN SPACE AND GREENBELT PLANNING

In the Three Rivers Basin, about 25 per cent of the land is urbanized. If present trends continue, there will be little open space left in the year 2020.

Land treatment provides an opportunity to establish open space, greenbelts, and related refuge for wildlife, thus pre-empting unplanned urban sprawl. Large areas could be set aside for the future, used in the meantime, and incorporated into land treatment sites during the next century.

Toward this end, selection of lands may be oriented to urbanized regions. The reader is referred to a publication entitled Where Not to Build; A Guide to Open Space Planning, Tech. Bulletin No. 1, Bureau of Land Management, U. S. Department of the Interior, Washington, D. C. for specific planning discussions on holding lands open for present and future use.

BIBLIOGRAPHY - SECTION VII

1. Army Corps of Engineers, Engineer Technical Letter No. 110-2-503, February 29, 1972.

2. Reed, S. C. (Coordinator) Wastewater Management by Disposal on the Land. Corps of Enginers, U. S. Army, Cold Regions Research and Engineering Laboratory. Hanover, New Hampshire, 1972.

3. Christman, Russel F., and others at the University of Washington, Seattle, Washington. Assessment of the Effectiveness and Effects of Land Disposal Methodologies of Wastewater Management. Wastewater Management Report 72-1. Washington: United States Government Printing Office, 1972.

4. "An Evaluation of Cannery Waste Disposal by Overland Flow Spray Irrigation", Final Report on a study project prepared for the Campbell Soup Company by C. W. Thornthwaite Associates. Publications in Climatology, Vol. XXII, No. 2, Elmer, New Jersey, September, 1969.

5. Reed S. C. (Coordinator) Wastewater Management by Disposal on the Land. Corps of Engineers, U. S. Army, Cold Regions Research and Engineering Laboratory. Hanover, New Hampshire, 1972.

6. Wright-McLaughlin Engineers, Land Treatment Considerations of Wastewater Management Survey Scope Study, Cleveland-Akron Metropolitan and Three Rivers Watershed Areas, Phase I Report. Denver, Colorado, June, 1972.

7. Ohio Agricultural Statistics 1960-65, Research Bulletin 1019. The Ohio Agricultural Research and Development Center, with the Ohio Crop Reporting Service, and the U. S. Department of Agriculture. Columbus, Ohio: October, 1968.

8. The National Atlas of the United States of America, United States, Department of the Interior, Geological Survey. Washington, D. C., 1970.

9. Cooperative Extension Service, The Ohio State University. 1970-71 Agronomy Guide, Bulletin 472. Columbus, Ohio: The Ohio State University, 1970.

10. Great Lakes Basin Framework Study, Appendix No. 16,"Drainage," Great Lakes Basin Commission, Draft No. 2, July, 1971.

11. Great Lakes Basin Framework Study, Appendix No. 15,"Irrigation," Great Lakes Commission, Draft No. 2, April, 1971.

BIBLIOGRAPHY - SECTION VII

12. Luthin, James N. (ed.) Drainage of Agricultural Lands. The American Society of Agronomy, Vol. VII, 1957.

13. Ohio Crop Reporting Service. Ohio Agricultural Statistics, 1971. Columbus, Ohio: Ohio Department of Agriculture, 1972.

14. Ohio Drainage Guide, prepared jointly by United States Department of Agriculture, Soil Conservation Service, Ohio Agricultural Experiment Station, Cooperative Extension Service, The Ohio State University, Ohio Department of Natural Resources, Division of Lands and Soil, 1965.

15. Palmer, Melville L., "Sprinkler Irrigation in Ohio," The Ohio State University, September 15, 1967.

SECTION VIII

SELECTION OF OPTIMUM LANDS

The selection of the optimum lands for further consideration for use in the Cleveland-Akron-Three Rivers Wastewater Management Study was a process which resulted in the final selection of three basic soil associations listed below:

1. Mahoning-Ellsworth
2. Cardington-Bennington
3. Chili

Many additional soil associations could continue to receive consideration in future work; however, the three selected appear to be the most suitable at this time.

The total area of the soil associations presented in Table II-1 amounts to 1,661,700 acres, or approximately 2,600 square miles. Depending upon the method of irrigation or renovation, other land areas might also have been included. Some of the soils overlying limestone rock might be ideally suited for renovation purposes, since drainage tile might not be required, especially if the soil mantle above the limestone were reasonably fine-textured and had a thickness of 40 to 50 inches. The soils which might fall into this category are located in eastern Sandusky and Seneca Counties. Water renovated by the soil mantle would be available by pumping from wells.

The acreages shown in Table II-1 for each association denote the total gross areas for these soils. In developing the optimal land treatment plans for the Cleveland-Akron-Metropolitan and Three Rivers

Watershed area, final land selection was made, based on carefully considered parameters such as preferred soil characteristics, site location, site configuration, and land use.

Soils for Conventional Spray Irrigation

The soils suitable for conventional spray irrigation, some requiring a manipulation of the A Horizon silt content, include:

a. Chili
b. Wooster
c. Chenango-Red Hook
d. Colonie-Elnora
e. Otisville-Chenango
f. Digby-Haney-Millgrove
g. Painesville
h. Sisson-Tuscola
i. Arkport-Galen
j. Belmore-Digby-Seward-Ottokee
k. Berrien
l. Bogart
m. Olena
n. Wilmer
o. Haskins-Jimtown
p. Chili-Wheeling
q. Belmore-Haney
r. Oakville
s. Wauseon
t. Canfield
u. Granby
v. Rimer

Other soils, including Bennington and Cardington and related series, are suitable if the A Horizon silt problem can be overcome by selected crops, application techniques, or surface preparation.

TABLE VIII-1

SOIL PARAMETERS
CHILI SOIL SERIES

Parameter	Soil Horizon			General
Depth (inches)	0-12	12-26	26-60	
Texture USDA	Silt Loam	Gravelly Loam	Gravelly Sandy Loam	
Per Cent Sand	23.6	21.8	64.3	
Per Cent Silt	60.5	58.0	18.0	
Per Cent Clay	15.4	20.2	17.7	
Permeability (Inches per hour)	2.0-6.3	2.0-6.3	>12.0	
Available Soil Moisture (Per Cent)	0.10-0.18	0.10-0.14	0.02-0.04	
pH	4.5-5.5	4.5-5.5	5.6-6.5	
Organic Matter (Per Cent)	2.2	0.4	0.1	
C.E.C. (meq/100gm)	14.0	12.8	8.9	
Land Slope (Per Cent)				1-15
Substratum				
Depth (feet)				3.5
Material				Gravel & Sand with fines
Rock Depth (feet)				>5
Seasonal High Water Table (feet)				3+

Soils for Overland Runoff/Infiltration Irrigation

The soils best suited for the combination overland flow-infiltration method of land treatment are fine-textured in the A Horizon so that water will not readily infiltrate, but will tend to flow over the surface for long distances as in the overland runoff method. On the other hand, the infiltration and permeability rates need to be within ranges which will permit the overland flow to finally infiltrate into, and through, the living filter.

Comparing soils in Table II-1 against criteria in Table VII-3, one finds that the Mahoning-Ellsworth Soil Association is suitable, provided that subsurface drainage can be maintained with tile drains. Otherwise, this soil association would be limited to the overland runoff method.

The Mahoning-Ellsworth-Trumbull Association is listed in Table II-1, and shown on Figure II-1, as Map No. 27. The association is listed variously as Mahoning-Ellsworth-Trumbull, Mahoning-Ellsworth, and, in one case, as Mahoning-Bogart, Haskins-Jimtown to correspond to the names given in each County on the General Soils Maps. The latter soil is made up predominantly of the Mahoning series, interspersed with the Bogart, Haskins, Jimtown, and minor amounts of other soils.

The Mahoning-Ellsworth-Trumbull Association is the dominant soil association within the basin; it also occurs extensively in Lorain and Huron Counties to the west. For conventional crops and irrigation, these soils are not permeable enough to allow for high application rates.* Because of its low permeability, however, the overland flow/infiltration

*High application rates generally imply four inches per week or more, but for Mahoning soils, a high application rate would be 60 inches/year.

technique (called the mini-border/open space method) was developed. The Mahoning and Ellsworth soil parameters are presented in Table Nos. VIII-2 and VIII-3.

TABLE VIII-2

SOIL PARAMETERS
MAHONING SOIL SERIES

Parameter	Soil Horizon			General
Depth (inches)	0-11	11-32	32-74	
Texture USDA	Silt Loam	Silty Clay Loam	Silty Clay Loam	
% Sand	18.6	16.1	17.7	
% Silt	44.2	38.9	42.1	
% Clay	37.2	45.0	40.2	
Permeability (in./hr.)	0.2-0.63	0.063-0.2	<0.063	
Available Soil Moist. (%)	0.19-0.23	0.15-0.18	0.15-0.18	
pH	4.5-5.5	4.5-5.5	7.1-8.0	
Organic Matter (%)	0.7-2.6	0.4	?	
C.E.C. (meq/100gm)	14.7	21.0	20.6	
Land Slope (%)				1-4
Substratum				
Depth (ft.)				3.0
Material				Clay loam or silty clay loam till
Rock Depth (ft.)				>5
Seasonal High Water Table (ft.)				$\frac{1}{2}$-1$\frac{1}{2}$

TABLE VIII-3

SOIL PARAMETERS
ELLSWORTH SOIL SERIES

Parameter	Soil Horizon			General
Depth (inches)	0-8	8-37	37-60	
Texture USDA	Silt Loam	Silty Clay Loam	Silty Clay Loam	
% Sand	19.4	18.4	22.0	
% Silt	60.4	53.0	44.9	
% Clay	20.2	38.6	33.1	
Permeability (in./hr.)	0.63-2.0	0.063-0.2	0.063-0.2	
Avail. Soil Moist. (%)	0.18-0.22	0.16-0.19	0.16-0.19	
pH	4.5-5.0	4.5-6.5	7.1-8.0	
Organic Matter (%)	1.6	0.5	0	
C.E.C. (meq/100gm)	13.0	18.3	16.6	
Land Slope (%)				4
Substratum				
Depth (ft.)				2.5
Material				Clay loam or silty clay loam till
Rock Depth (ft.)				>5
Seasonal High Water Table (ft.)				1½-3

Soils for Low Droplet Impact Irrigation

The soil series in Northern Ohio which have high silt content, a pH above 5, a high C.E.C., and good hydraulic capacity with proper artificial drainage (over 4.8 inches per day) are the Cardington-Bennington and related soil series.

The soil associations, earlier identified by Map Numbers 1A and 5, have been combined and termed the Cardington-Bennington Association, even though this association is also identified as the Cardington-Bennington-Pewamo in Seneca County and Cardington-Bennington-Lobdell in Crawford County. The differences between these soils are slight, and for the purposes of this Report, can be grouped into one association that is dominated by the two soil series, Cardington and Bennington.

The Cardington-Bennington Association occurs extensively in Huron, Seneca, and Crawford Counties just west of the Mahoning-Ellsworth-Trumbull Association. The permeability of this soil is greater than that of the Mahoning soil and it is believed that a viable agriculture can be maintained with application rates higher than 75 inches per year, provided management techniques for water application are employed.

A fine-textured soil, such as the Cardington-Bennington soil has the advantages of large absorption capacities. The main concern will be to ensure against extended anaerobic periods in the root zone.

Soil parameters are tabulated on Tables VIII-4 and VIII-5. The content requires low impact droplet control on bare surfaces, achievable with solid set sprinklers.

TABLE VIII-4

SOIL PARAMETERS
CARDINGTON SOIL SERIES

Parameter	Soil Horizon				General
Depth (inches)	0- 8	8-18	18-30	30-60	
Texture USDA	Silt Loam	Silty Clay Loam	Silty Clay Loam	Clay Loam	
% Sand	24.3	19.1	23.4	24.2	
% Silt	57.0	48.6	48.9	51.6	
% Clay	18.7	32.3	27.7	24.2	
Permeability (in./hr.)	0.63-2.0	0.2-0.63	0.2-0.63	0.2-0.63	
Avail. Soil Moist. (%)	0.18-0.23	0.19-0.21	0.18-0.19	0.16-0.18	
pH	5.1-6.0	5.1-6.0			
Organic Matter (%)					
C.E.C. (meq/100gm)					
Land Slope (%)					0-6
Substratum					
Depth (ft.)					2.5
Material					Clay loam till
Rock Depth (ft.)					> 5
Seasonal High Water Table (ft.)					1½-3

TABLE VIII-5

SOIL PARAMETERS
BENNINGTON SOIL SERIES

Parameter	Soil Horizon				General
Depth (inches)	0-6	6-12	12-32	32-60	
Texture USDA	Silt Loam, Loam	Silty Clay Loam	Clay Loam	Silty Clay Loam	
% Sand	20.3	20.7	27.4	19.8	
% Silt	62.2	53.9	41.1	49.9	
% Clay	17.5	25.4	31.5	30.3	
Permeability (in./hr.)	0.63-2.0	0.2-0.63	0.2-0.63	0.2-0.63	
Avail. Soil Moist. (%)	0.16-0.20	0.15-0.18	0.15-0.18	0.15-0.18	
pH	5.0-6.0	5.0-6.0	5.1-7.3	7.1-8.0	
Organic Matter (%)	2.6	0.6	0.5		
C.E.C. (meq/100gm)	15.2	15.9	22.5	14.8	
Land Slope (%)					0-6
Substratum					
Depth (ft.)					2.7
Material					Clay loam till
Rock Depth (ft.)					>5
Seasonal High Water Table (ft.)					$\frac{1}{2}$-1$\frac{1}{2}$

Soils for Overland Runoff Irrigation

Even though the overland runoff was discovered in Ohio by the Campbell Soup Company[1], most of the soils in Northern Ohio tend to be somewhat too permeable for the established criteria as set forth in Table VII-5. However, the Ravenna Arsenal fragipan lands appear to be suitable, and it is believed that the Mahoning-Ellsworth could be used for the overland runoff method.

Area of Soils Available

To be economically feasible, the soil types selected for land treatment must occur in area magnitudes reasonably related to requirements.

The tabulated areas of each of the identified soil associations are presented below, without regard to present urbanization or development.

TABLE VIII-6

SOIL ASSOCIATION - IRRIGATION METHODS

Soil Association	County	Area in Acres
CONVENTIONAL SPRAY IRRIGATION		
Chenango-Red Hook	Ashtabula	35,500
Colonie-Elnora	Ashtabula	
Otisville-Chenango	Ashtabula	
Chili	Cuyahoga	28,400
Painesville	Cuyahoga	
Sisson-Tuscola	Erie	19,800
Arkport-Galen	Erie	
Chili	Geauga	13,100
Belmore-Digby-Seward-Ottokee	Hancock	21,800
Berrien	Hancock	
Bogart	Hancock	
Chili	Hancock	
Olena	Hancock	
Painesville	Hancock	
Wilmer	Hancock	
Wooster	Huron	19,200
Chili	Huron	
Chili-Colonie	Huron	
Berrien	Lake	32,200
Haskins-Jimtown	Lorain	36,400
Chili-Wheeling	Partage	32,900
Belmore-Haney	Richland	2,000
Oakville-Belmore-Haney	Richland	
Wauseon-Digby-Millgrove	Sandusky	55,700
Haskins-Haney-Belmore	Seneca	41,800
Canfield-Wooster	Seneca	
Chili	Summit	50,100

TABLE VIII-6
continued

Soil Association	County	Area in Acres
Canfield	Trumbull	3,400
Ottokee-Granby-Seward	Trumbull	
Rimer-Wauseon	Wood	70,000
Henshaw-Uniontown-Patton	Wyandot	30,700
SUB-TOTAL		493,000
OVERLAND RUNOFF/INFILTRATION IRRIGATION		
Mahoning-Ellsworth	Ashland	5,600
Mahoning-Ellsworth-Trumbull	Cuyahoga	179,000
Mahoning-Bogart-Haskin-Jimtown	Erie	29,000
Mahoning-Ellsworth	Geauga	43,900
Mahoning-Ellsworth-Trumbull	Huron	111,200
Mahoning-Ellsworth-Trumbull	Lake	64,300
Mahoning-Ellsworth-Trumbull	Lorain	136,900
Mahoning-Ellsworth-Trumbull	Medina	114,600
Mahoning-Ellsworth	Portage	30,200
Mahoning-Ellsworth	Summit	46,100
Mahoning-Ellsworth-Trumbull	Trumbull	44,800
SUB-TOTAL		805,600
LOW DROPLET IMPACT IRRIGATION		
Cardington-Bennington	Ashland	9,800

TABLE VIII-6
continued

Soil Association	County	Area in Acres
Cardington-Lobdell-Bennington	Crawford	203,700
Bennington-Cardington	Huron	79,200
Bennington-Cardington	Richland	17,500
Bennington-Cardington-Pewamo	Seneca	52,900
SUB-TOTAL		363,100
TOTAL		1,661,700

GENERAL

The selection of optimum lands for treatment of wastewater effluent for the Three Rivers Basin demonstrates that a wide variety of lands are available without going to the tested and proven extremes of "rapid infiltration" and "overland runoff".

For the soils selected, land treatment of wastewater effluent would generally involve application rates varying from 26 inches per year by spray irrigation on golf courses to 90 inches using the overland flow/infiltration method.* Using the latter method for separate stormwater runoff, a rate of 150 inches per year may be used. It is believed that field testing in early action projects will demonstrate that higher rates can be used successfully with high renovation of wastewater. The actual application rate would depend on the method of application, the crops grown, and the soil characteristics. The average April-September precipitation is generally adequate for most crops and soils, except for the droughty soils. In a wet year, adequate drainage is more of a concern than lack of optimum soil conditions. However, during a dry year (with a recurrence interval of ten years), as much as 15 inches of supplemental moisture would be welcomed by the farmers. On the average, it can be assumed that 90 per cent or more of the water applied will be surplus to crop needs. Under these conditions, sub-surface tile drainage is essential to maintain a well-aerated root zone, unless the topography and geology allow alternatives, such as pumping for reuse out of an aquifer underlying the land treatment area.

*See Section IX.

Although the texture of the soil cannot be changed, the layers can be economically altered* by deep plowing.[2] The soil can either be turned on edge or turned over with a mould-board plow, depending on the desired results. For example, the Chili soils have an upper "A" horizon with a high silt content and a "C" horizon of sandy soil two feet below the surface. Although the upper layer is very permeable (2.0 to 6.3 inches per hour), the high silt content may cause the soil to lose its structure when wet. The soil may puddle under sprinkler irrigation, and the infiltration rate may be substantially reduced. When the soil dries, a thin surface crust forms, further reducing the infiltration rate. By plowing three feet deep, the Chili soil horizons can be essentially reversed, with some mixing occurring. The resultant soil will be suitable for sprinkler irrigation and still have the renovating capacity desired.

Maintaining a ground cover of grass or hay would be an alternative solution for keeping surface infiltration rates at a higher level. On the other hand, soils with a clay bulge in the "B" horizon become increasingly impervious as one proceeds downward. Placing these soil layers on edge will increase the vertical permeability significantly.

The permeabilities of the various soils listed in Table II-1 cover a wide range. The range of permeabilities for the three soil associations selected are listed below:

*Deep plowing has been found to be "economical" when it rehabilitates otherwise unproductive soil, or improves soil for continued use. Plowing costs are in the order of $20 to $40 per acre.

Soil Association	36-inch Permeability Range (in/hr)
Mahoning-Ellsworth-Trumbull	0.063 to 0.63
Cardington-Bennington	0.2 to 2.0
Chili	2.0 to >12.0

Related field work and investigation, including soil borings and inspection of soils and fields in the Threee Rivers Basin and in Huron County, developed techniques of Farm Management specifically aimed at land treatment. These techniques included:

1. The Mini-Border Open Space System for rough grass/ winter cattle feed.
2. The Center-Pivot Drip Tube System for corn.
3. The Solid Set Sprinkler for hay and pasture.
4. The Alfalfa Border System for field storm runoff storage and infiltration.
5. Center Pivot Rig -- Flood Jet/Grass Strip
6. Center Pivot Rig -- Reed Canary Grass
7. Center Pivot Rig -- Slip Plow/Drip Tube
8. Center Pivot Rig -- Two Row Corn Strips
9. Center Pivot Rig -- ABC Method (Alternating Biennial Cropping Method)

Analyses indicated that these techniques were probably superior to the conventional spray irrigation methods using sandier soil, because of the superior renovative capabilities of the fine-grained soils.

Most significantly, it became evident that a wide variety of irrigation and drainage techniques could be employed on difficult soils.

The farm management techniques pointed towards dropping the sandier soils from further consideration. Thus, sandy Seneca and Sandusky County lands were bypassed in favor of the tighter Cardington-Bennington. The Chili soils were retained because of the proximity to small urban areas in the Upper Cuyahoga River Basin.

The irrigation techniques developed for the Mahoning-Ellsworth and the Cardington-Bennington soils are expected to vary from those chosen as additional testing and development takes place to optimize the procedures. In addition, consideration may be given to the Mahoning soils lying west of the Rocky River Basin, which would greatly reduce tunnel costs from the Cleveland lake front.

The three soil associations selected are listed below, with application rates related to cropping and renovative capability.

Association	Effluent	Application Rate	Crop*
1. Chili	M&I	60 in/yr	General
2. Mahoning-Ellsworth	M&I	90 in/yr	Grass
	Storm Runoff	150 in/yr	Grass
3. Cardington-Bennington	M&I	75 in/yr	Corn or Grass
	M&I	50 in/yr	Hay
	M&I	90 in/yr	Grass

*Research and development should be aimed at studying cultivation of crops such as onions, radishes, carrots, soy beans, and sugar beets, as well.

BIBLIOGRAPHY -- SECTION VIII

1. "An Evaluation of Cannery Waste Disposal by Overland Flow Spray Irrigation". Final report on a study project prepared for the Campbell Soup Company by C. W. Thornthwaite Associates. Publication in Climatology, Vol. XXII, No. 2, Elmer, New Jersey, September, 1969.

2. Telephone call from Ralph Toren, Wright-McLaughlin Engineers, to R. R. Cairns, Officer-in-Charge, Research Branch, Solonetzic Soil Substation, Canada Department of Atriculture in Vegreville, Alberta, on October 27, 1972. (Mr. Cairns stated that deep plowing (56 c.m.) could be accomplished for $10 to $15 per acre, using equipment already in common use on most farms.)

3. Melbourne and Metropolitan Board of Works, Melbourne and Metropolitan Board of Works Farm. Melbourne, Australia, 1971.

4. Parizek, R. R., and others. "Waste Water Renovation and Conservation". The Pennsylvania State University Studies No. 23, University Park, Pennsylvania: The Pennslyvania State University, 1967.

5. Wilson, C. W. and F. F. Beckett (eds.) Municipal Sewage Effluent for Irrigation. (Papers presented at the Louisiana Polytechnic Institute, July 30, 1968) Ruston, Louisiana: The Louisiana Tech Alumni Foundation, 1968.

SECTION IX

FARM MANAGEMENT OF LAND TREATMENT SITES

The success of land treatment areas for productive farming and ranching operations, coupled with efficient renovation of treated sewage effluent into good quality water, is dependent upon careful planning and proper farm management. The basis of this planning must include consideration of the right surface form, water application technique, soil preparation, and drainage system; this is the domain of the agricultural engineer. For example, soils with high silt content in the upper horizon might normally be suitable for treatment with limited amounts of effluent; however, given proper site preparation and irrigation techniques designed to optimize use of the soil in question, the land could be treated with 50 to 150 inches of water per year.

Tight, fine-grained soils have the greatest potential, if managed properly, for a high degree of sewage effluent renovation by land treatment. Sandier soils, with high permeability, suitable for conventional spray irrigation, might be selected when finer-grained soils are not readily available near a metropolitan area, or if farming operations and traditional practices tend to prevail. In Northern Ohio, both the sandy and the fine-grained soils are found.

The Lake Erie Basin of Northern Ohio has large areas of fine-textured soils, such as the Mahoning, Ellsworth, Cardington, and Bennington. The Upper Cuyahoga River Basin also has Chili soils underlain with permeable gravels. In Sandusky and Seneca Counties, the

permeable soil associations exist in large areas between Tiffin and Fremont, amounting to about 90,000 acres. Except for the Chili soils, the lighter and coarse-grained soils have generally been bypassed in the final selection process for those soils with a greater effluent renovation capability.

The reader is referred to Tables VIII-1, VIII-2, VIII-3, VIII-4, and VIII-5 for a summary of soil characteristics applicable to this study, and soils chosen for land treatment purposes for the Cleveland, Akron, Three Rivers Basin wastewater management study.

SOIL PROPERTIES

The soil properties of the five primary soils selected for land treatment purposes are briefly described below.

Mahoning. This soil is a silt to silty clay loam with a high percentage of silt and clay. The natural permeability decreases rapidly below one foot of depth, and the pH is quite acid. The cation exchange capacity is high. Land slope is generally from one to four per cent. The substratum begins at about three feet and is clay loam or silty clay loam till. Bedrock is greater than five feet deep. The wastewater renovative capacity is excellent.

Ellsworth. The similarity with Mahoning soils is quite close, though the Ellsworth is somewhat more permeable near the surface and at depth. The renovative capacity of the Ellsworth soil is excellent.

Chili. The Chili soils series in the Upper Cuyahoga Basin ranges from

silt loam to gravelly sandy loam, with a high silt content in the A Horizon. The natural permeability is high near the surface, and increases with depth. The pH indicates an acidic soil, and the cation exchange capacity is high. Land slope is quite variable, ranging from one to fifteen per cent. The substratum begins at about three and one-half feet and consists of gravel and sand. Bedrock is below five-foot depth. Renovative capacity for wastewater would be only somewhat less than that of the fine-textured soils, due to the coarser texture of the Chili soil.

Cardington. This soil ranges from silt loam to silty clay loam with a high percentage of silt. The permeability is moderate near the surface and somewhat less permeable below eight inches of depth. The pH is acidic. Land slope ranges up to about six per cent. The substratum is clay loam till at about three feet of depth, and bedrock is greater than five feet. Renovative capacity is excellent.

Bennington. The characteristics of the Cardington soil series are similar to those of the Bennington, except that the silt content is slightly higher in the B Horizon and the clay content slightly higher with depth for the Bennington. Other differences are given in the detailed tables. Renovative capacity is excellent.

The following table summarizes particular selection criteria, and presents a potential rating for each criterion based upon anticipated crops and farm management.

TABLE IX-1

	Chili	Mahoning Ellsworth	Cardington Bennington
1. Hydraulic Capacity[1]			
Inches/Hour (Equivalent Inches/ day)	2.0 to 6.3 (48 to 150)	0.06 to 0.2 (1.4 to 4.8)	0.2 to 0.63 (4.8 to 15)
2. Heavy Metal Removal[2]	99%	99%+	99%+
3. Nitrogen Removal[3]	85%+	95-99%	90-95%
4. Phosphorous Removal[4]	99%	99%+	99%+
5. Drainability[5]	Moderately Rapid	Slow	Moderately Slow

(1) See Table II-1 for Permeability.

(2) See Table II-1 for CEC, organic matter, and potential organic build-up.

(3) Based on reports at American Society of Agronomy and Soil Scientists of American, Joint Conference in Miami Beach, Florida on October 30, 1972.

(4) Parizek, R. R., and others. "Waste Water Renovation and Conservation" The Pennsylvania State University Studies, No. 23. University Park, Pennslyvania: The Pennsylvania State University, 1967.

(5) See Table II-1, County Soil Reports and "Definitions and Abbreviations for Soil Descriptions," (Form CF-123), U. S. Department of Agriculture, Soil Conservation Service, Berkeley, California, October 1966.

LAND TREATMENT OBJECTIVES

The objectives of land treatment are manyfold; however, they are summarized in three parts, as follows:

1. To renovate sewage effluent.
2. To recycle pollutants so that they become resources in our environment.
3. To create public economic and environmental benefits.

All three of the objectives received primary consideration in selecting land treatment areas. For instance, high level renovation of Akron wastewater may be accomplished on in-basin Mahoning soil land treatment areas, with the accompanying open space and greenbelt benefits, and a potential harvest of grass. The Chili soil areas provide for growing more typical agricultural crops; feed corn and other similar crops are suggested.

The western Ohio land treatment areas selected are aimed at creating a stronger and more viable irrigated agricultural economy using soils which presently have significant drainage handicaps. The recycling of nutrients, the drainage of land, and farm management efforts would help take this area into its rightful role as a major agricultural crop producing zone.[4]

The farm management techniques developed for this wastewater management study make it possible to meet the above-listed three objectives.

MAHONING-ELLSWORTH SOIL MANAGEMENT

A unique land management technique has been developed for the

Mahoning-Ellsworth soils which are very dominant in the Three Rivers Basin. Originally these soils were considered to be a major constraint to successful land treatment within the basin; however, detailed review of the technically-oriented soil properties, including test augering in the field and a study of topographic maps, has demonstrated that these soils actually provide a unique opportunity for widespread land treatment management.

The Overland Flow/Infiltration method has been developed to achieve the following specific goals:

1. Providing of massive blocks of perpetual open space in the Three Rivers Basin which would pre-empt continued and poorly planned urban sprawl for these areas.

2. Development of an irrigated grass crop for winter feeding of cattle.

3. Close-in land treatment sites for sewage effluent tertiary treatment where return flows will supplement recreational and esthetic stream flows, and provide supplemental water for water supply purposes.

Overland Flow/Infiltration System

Overland flow/infiltration, essentially a modified border irrigation method, is designed for tertiary treatment of significant quantities of treated sewage effluent on the Mahoning-Ellsworth soils. Narrow border strips having an average width of ten feet would be used. Widths would vary along their length to keep the borders running directly downhill. The purpose of this would be to prevent washing out of border dykes as a result of rodent activity or debris accumulation within the border.

Because these soils have low permeabilities in their lower horizons, they would be plowed to a depth of three and one -half feet on the approximate contour, which would be perpendicular to the borders. This would result in reduction of the density of the lower horizons and in placing more permeable soil at lower depths to facilitate better horizontal water movement. Drains would be placed at the depths of three to three and one-half feet under alternate border dykes, giving an average drain spacing of 20 feet.* Plowing would be accomplished prior to drain installation.

Individual risers would supply each mini-border. Several risers would be attached to a pipe manifold which would distribute the water from a valved outlet on the main buried pipeline. These valves would be operated by automatic controls which would sequence the irrigations. The advantage of this system over the use of solid sets for the same purpose would include a reduction in power costs, lower initial installation costs and lower maintenance costs than where risers and sprinkler heads would be exposed to damage by animals.

Renovation capacity, in terms of acre-inches per acre would be very high for this type of soil, particularly in the case of using this system for treatment of storm runoff. Large amounts of effluent could be treated close to its source, thereby greatly reducing water distribution costs.

Probably the most unique aspect of the system is that it combines the treatment processes of both the overland runoff method and the

*Drain spacing is based on soil permeability, required drain depth, crops, etc., and determined by tile spacing computations and agricultural engineering judgment.

infiltration-through-the-living-filter method to achieve some compounding of treatment efficiency. The treatment is accomplished by the water flowing horizontally across long stretches of dense grass, and then percolating through the soil zone for additional treatment. Irrigation application would be gaged so that there would be no surface flow left at the end of the mini-border run.

Runs of from 300 to 1,200 feet are contemplated on land which is deep-plowed at right angles to the runs to a depth of 3 to $3\frac{1}{2}$ feet. The 20-foot spacing of drains under the borders would permit application rates of 150 inches per year for storm runoff. An annual rate of 90 inches per year has been chosen for domestic and industrial effluent. The continuous grass cover would permit an irrigation season of forty weeks per year. Weekly application rates of four inches would be reasonable, though for the first few years, lower rates of no more than about $2\frac{1}{2}$ inches per week are recommended to allow the grass to establish a strong, dense root system and to give the soil structure a chance to undergo some re-structuring.

The crop would be a rough grass suitable for open-space greenbelt purposes, with harvesting potential as winter cattle feed. Layout of the system would contemplate adequate allowances for wildlife purposes. Design should be aimed at creating a bird and game refuge.

A diagram of Overland/Flow Infiltration methods are presented in Figure IX-1.

The vertical plowing to 3 or $3\frac{1}{2}$ feet would turn the soil on edge,

distribute the permeability more evenly by putting the A Horizon on edge, and result in a fairly permanent permeability increase. Surface preparation would follow deep plowing and tile installation and would consist of shaping the borders and planting of a rough grass mixture containing numerous varieties of seed. Early testing would show which seed mixture was best for the locality.

When antecedent moisture conditions preclude irrigation, water would be stored in the large winter reservoirs. Not all fields would be irrigated on the same day, which would reduce the problem associated with a heavy rainstorm. If a heavy rainfall occurred without warning, runoff from a wet field could be collected at the lower end and routed onto the next field downhill. Overall surplus runoff would be routed to conveniently-located storage areas for pumping back through the system for treatment.

Harvesting of the grass for feed purposes will remove nutrients from the area for recycling back to cattle, and then to the cities. Feed lots would be situated in appropriate locations in agricultural areas where feed lot wastes can be appropriately treated in a manner similar to that of municipal wastewater.

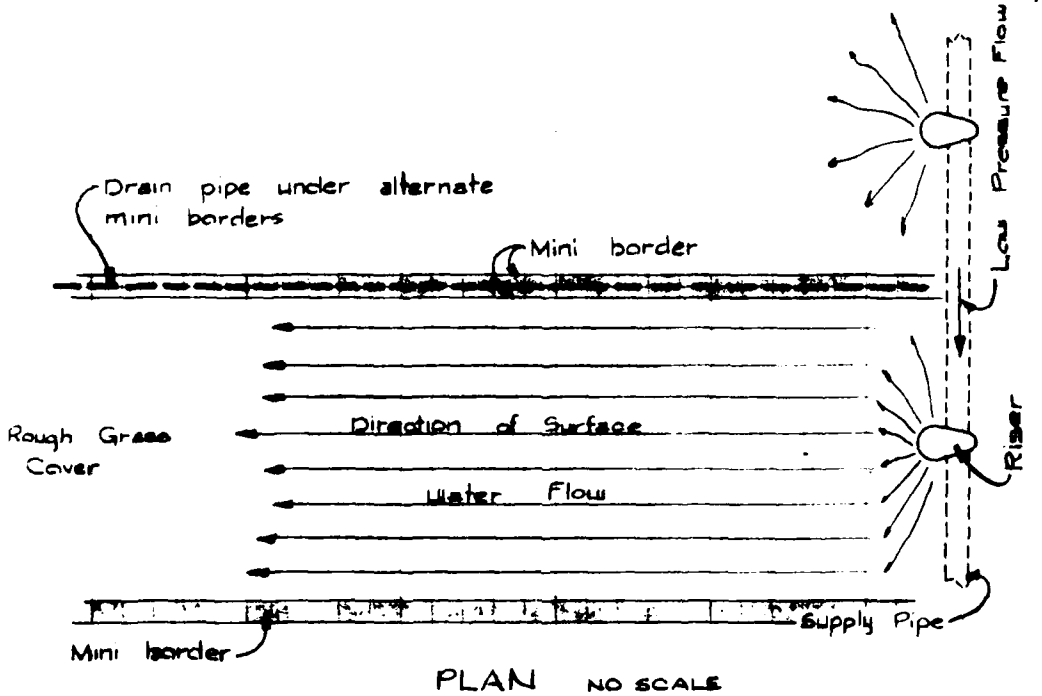
Initially, lower application rates would be used while techniques were being developed and refined to best manage the overall operation. Over a period of time, the rates would be optimized, consistent with the best renovation and farming efficiency.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

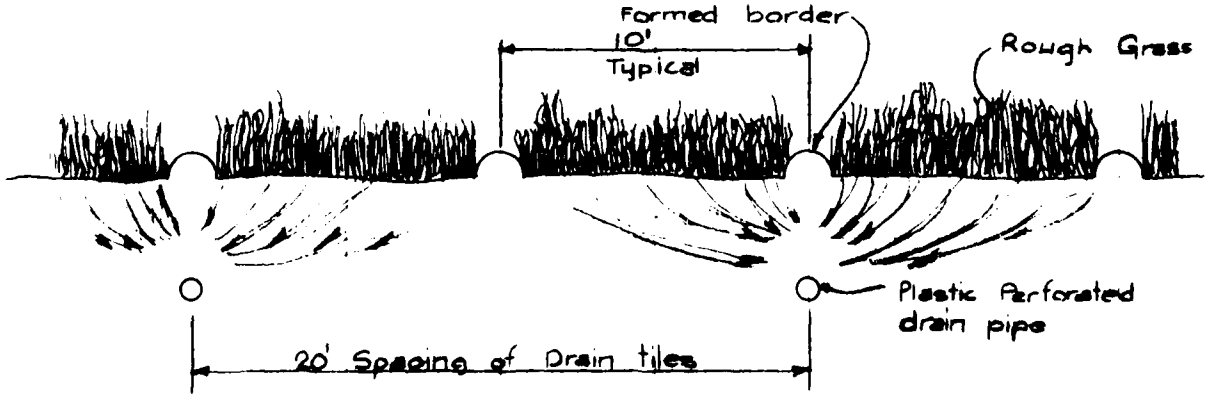
Land Treatment/Formulation Phase: III Sub - Item: Irrigation

Overland Flow/Infiltration Method
Manoning-Ellsworth Soils

SHEET NO. 1 OF 1
JOB NO. 712 - 70
BY KRW DATE 2/22/72



PLAN NO SCALE



CROSS SECTION
NO SCALE

Figure IX-1

CHILI SOIL MANAGEMENT

The Chili soil is more suited to normal agricultural management practices; however, the rather high silt content would indicate the desirability of deep plowing which would invert the soil profile. Both solid set and center pivot irrigation rigs would be used, and, in some areas, border irrigation and ridge and furrow practices might be employed.

Irrigation application rates of 2 to $2\frac{1}{2}$ inches per day might be used at a frequency of once per week.* The total application rate of 60 inches per year is about optimum to match the nitrogen uptake of the crop and soil. Rates might be increased after some experience with the system, coupled with monitoring of the return flow.

It is expected that a sub-drain system of tiling will not be needed except in selected areas. The high permeability of the substratum would provide good drainage. Groundwater mounds would be controlled with spaced water wells.

The Chili soils are particularly well-oriented towards groundwater recharge management and development of water well fields which can be used for municipal/industrial water supplies and low flow stream augmentation.

Crops grown on the Chili soils would most logically be for cattle feed purposes; however, where ridge and furrow irrigation was used, there is the opportunity of developing cash crop truck farming operations for vegetables of various types. In all probability, feed corn

*With solid set sprinklers. Each type of water application must meet specific hydraulic constraints.

would be the most likely major crop on this soil.

Potential runoff from heavy rainfalls would be managed with infiltration, storage, and recycling techniques.

CARDINGTON-BENNINGTON SOIL MANAGEMENT

The fine-grained soils of Seneca, Huron, Crawford, and Richland Counties have been selected rather than the sandier and more permeable soils between Tiffin and Fremont because of the present drainage problems in those tighter soils, good crop yield potential, and high effluent renovation capability.

These soils would provide for meeting the following goals:

1. Provide for increased and more viable agricultural production to help meet the region's future food needs.

2. High level wastewater renovation with return flows suitable for water supply purposes, and to help meet the objectives of the Northwest Ohio Water Plan.

3. Drainage of lands indicated by the Great Lakes Basin Commission as being of a high priority for drainage improvements.

The land management plans for the Cardington-Bennington soils would include consideration of the following:

1. Hay and pasture land covering an area up to 25 or 30 per cent of the total management area would be irrigated by solid set sprinklers at an application rate of 50 or more inches per year having underdrains at 30 feet spacing. Water would be delivered at 50 psi, with droplet size controlled to a fine size to overcome silt puddling on the surface. Hay would be for winter feeding of breeding cattle.

2. Rough grass land covering perhaps five per cent of the total management area using the Mini-Border System would be utilized to raise rough grass for winter

feeding of cattle. Drain spacing would be at 20 feet. (See Figure IX-1.)

3. Growing of a high-protein, low-fiber Reed Canary Grass for cattle feed purposes would provide for excellent land treatment. With high nitrogen applications, this crop can have an uptake of some 300 pounds of nitrogen per year per acre. Reed Canary Grass would be irrigated with conventional center pivot irrigation rigs and drain tile spacing would be at 20 feet. Odd shaped areas would be irrigated using solid set sprinklers. It is anticipated that effluent would be applied at a rate of 75 inches per year; however, farm operators might choose, after operating experience, to significantly increase the application rates so that more nitrogen can be applied to improve the type of grass harvested. (See Figure IX-2.)

4. A combination of feed corn and grass laid out in strips could be irrigated with water sprayed into the grassed area by a center-pivot irrigation rig side-mounted flood jet. Tile spacing would be at 20-foot centers and an annual application rate of 75 inches would be used. (See Figures IX-3 and IX-4.)

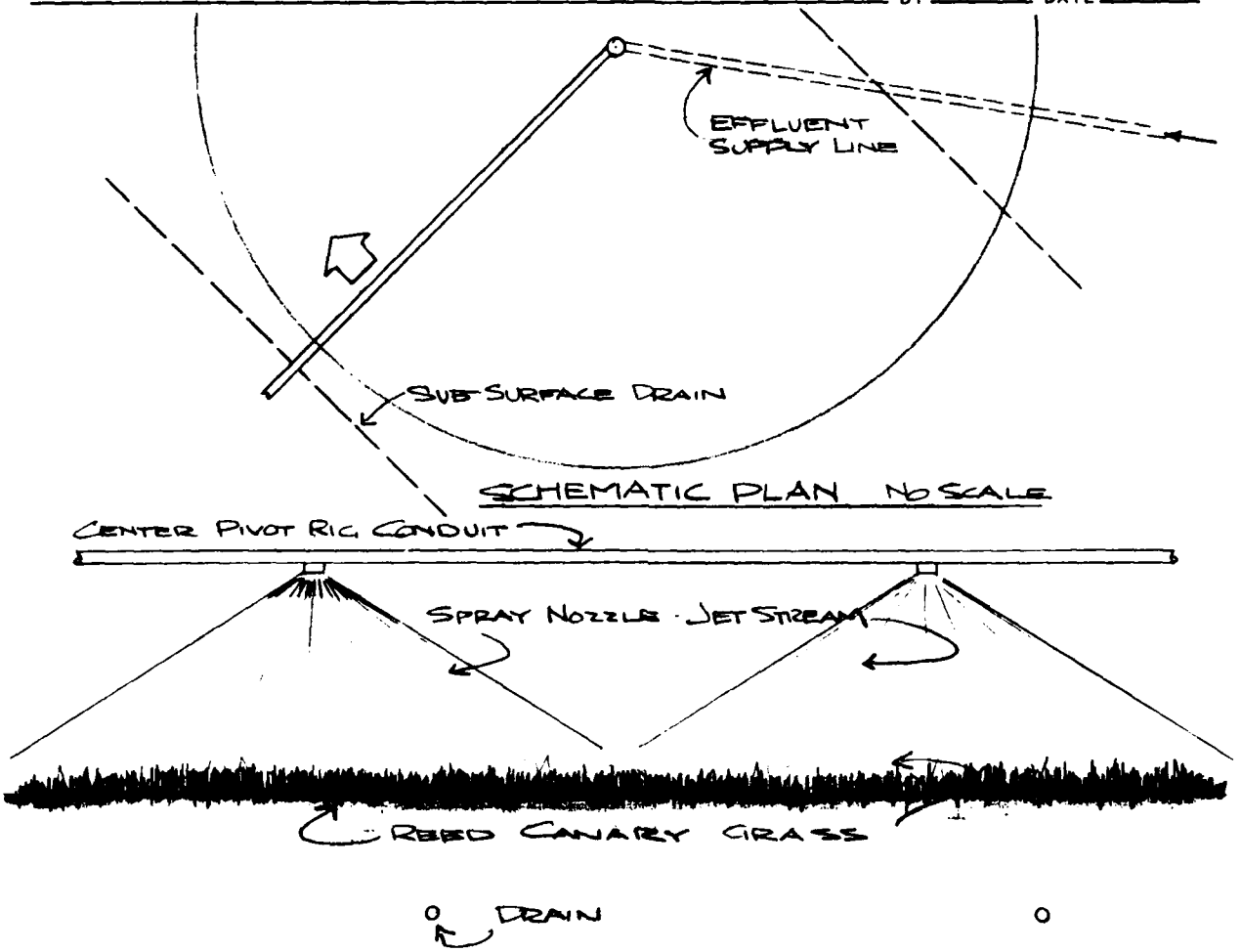
5. A corn crop laid out in double or triple rows, with each pair, or group, of rows separated by a trash-filled trough, receiving water applied by the center pivot-drip tube, is a potential land management technique for these soils. Drain tile spacing would be at 20 feet and an annual application rate of 75 inches per year would be used. (See Figure IX-5.)

6. Feed corn covering a portion of the land management area, using a center-pivot-drip tube method of applying water at the rate of about 75 inches per year. Drains would be installed approximately each 20 feet. The key to a successful program with corn on these soils is the drip-tube arrangement having a spacing of perhaps 14 feet; the water would be laid into a furrow having roughage (field trash), which, in turn, would provide for temporary water storage and high infiltration. Detailed planning of daily and weekly application rates to best manage the soil aerobic and anaerobic conditions for optimum renovation will be based upon field experimental work and further analyses. The drains could be laid out on straight lines, or in a circular fashion between the troughs. (See Figure IX-7.)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: III Sub - Item: IRRIGATION

CENTER PIVOT RIG – REED CANARY GRASS SHEET NO. ____ OF ____
CARDINGTON - BENNINGTON SOILS JOB NO. 712 - 70
BY KRW DATE 11-21-72



CROSS SECTION

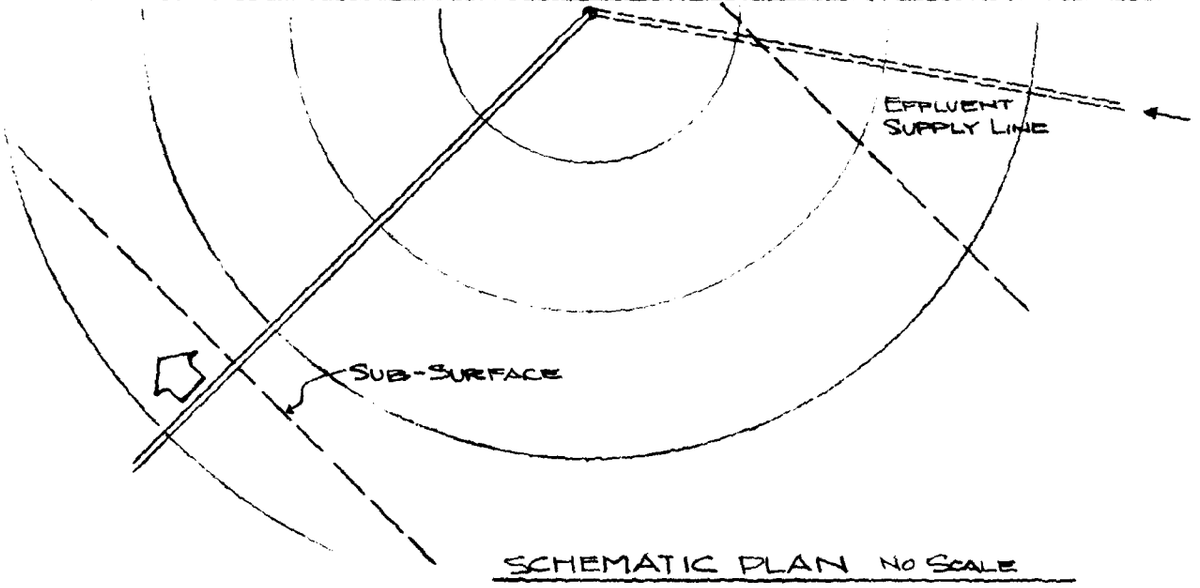
FIGURE IX-2

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

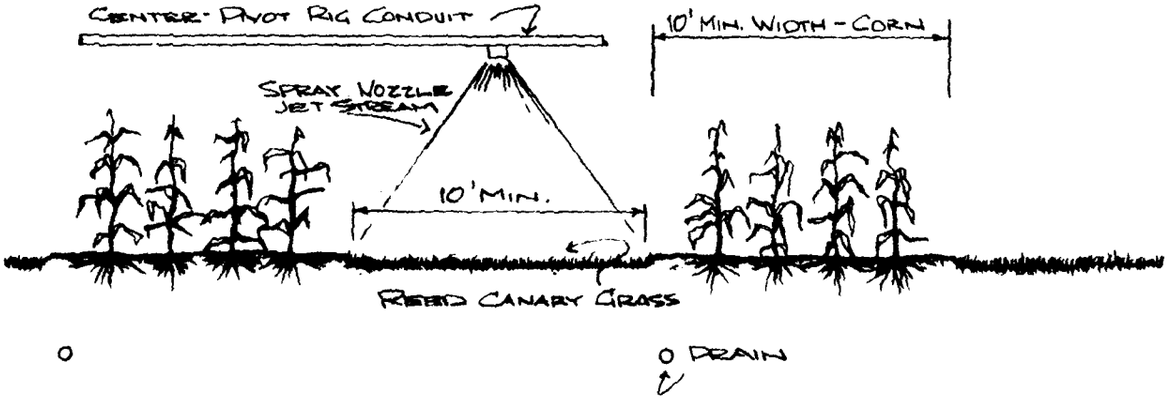
Land Treatment/Formulation Phase: III Sub - Item: IRRIGATION

CENTER-PIVOT RIG — FLOOD JET / GRASS STRIP
CARPINGTON - BENINGTON SOILS

SHEET NO. ____ OF ____
JOB NO. 71E-70
BY KRW DATE 11-21-72



SCHEMATIC PLAN NO SCALE



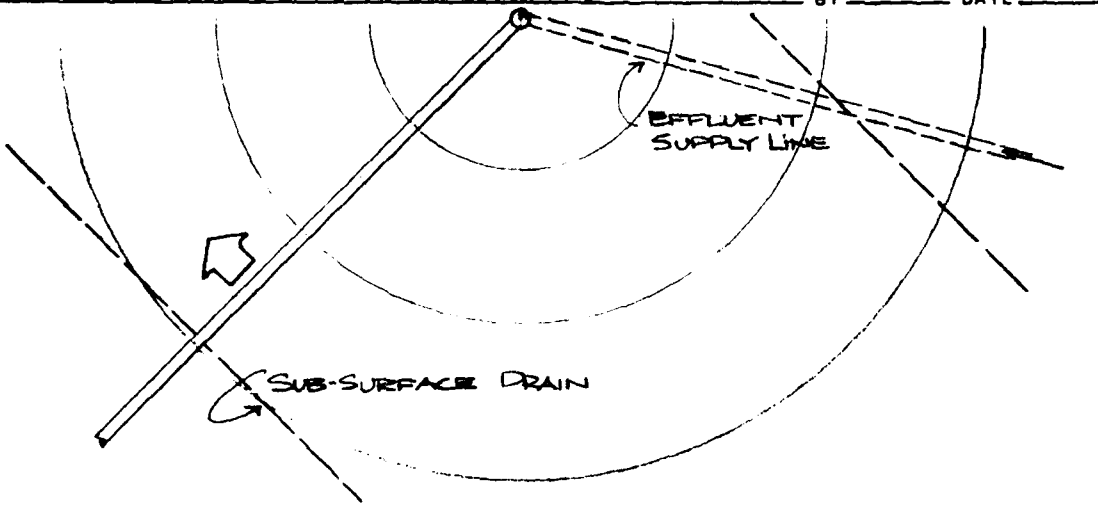
CROSS SECTION

FIGURE IX-3

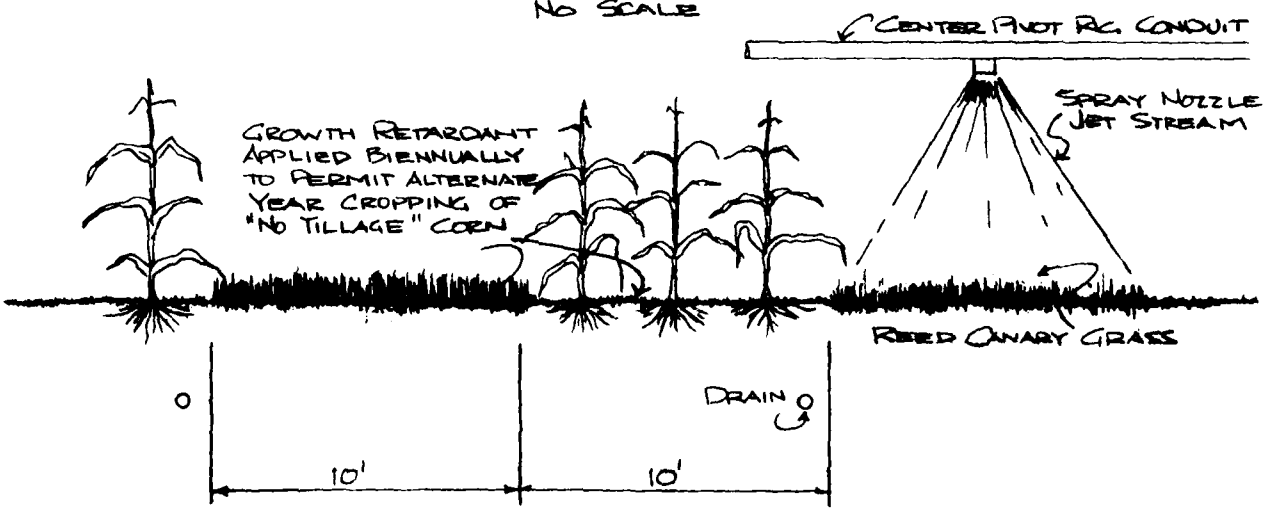
Land Treatment/Formulation Phase: III Sub - Item: IRRIGATION

CENTER PIVOT RIG - ABC METHOD (ALTERNATE BIENNUAL CROPPING METHOD) CARDINGTON - BENNINGTON SOILS

SHEET NO. ____ OF ____
JOB NO. 712-70
BY KRW DATE 11-21-72



SCHEMATIC PLAN
NO SCALE



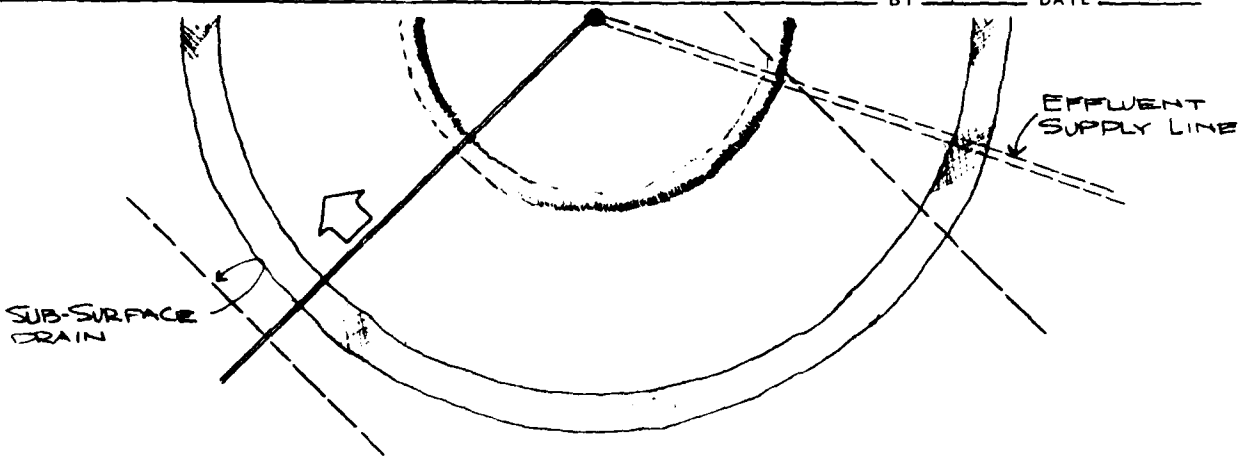
CROSS SECTION

FIGURE IX-4

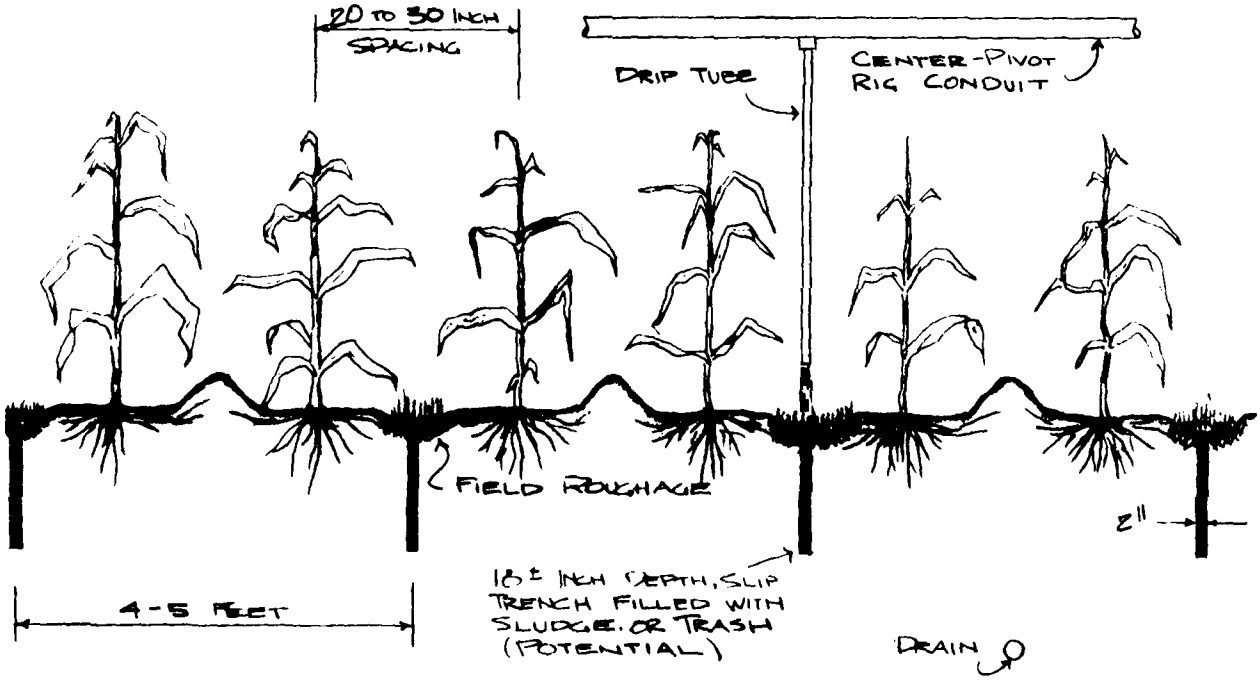
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: III Sub - Item: IRRIGATION

CENTER-PIVOT RIG - 2ROW CORN STRIPS SHEET NO. ____ OF ____
CARDINGTON-BENNINGTON SOILS JOB NO. 71Z-70
BY KRW DATE 11-21-72



SCHEMATIC PLAN No SCALE



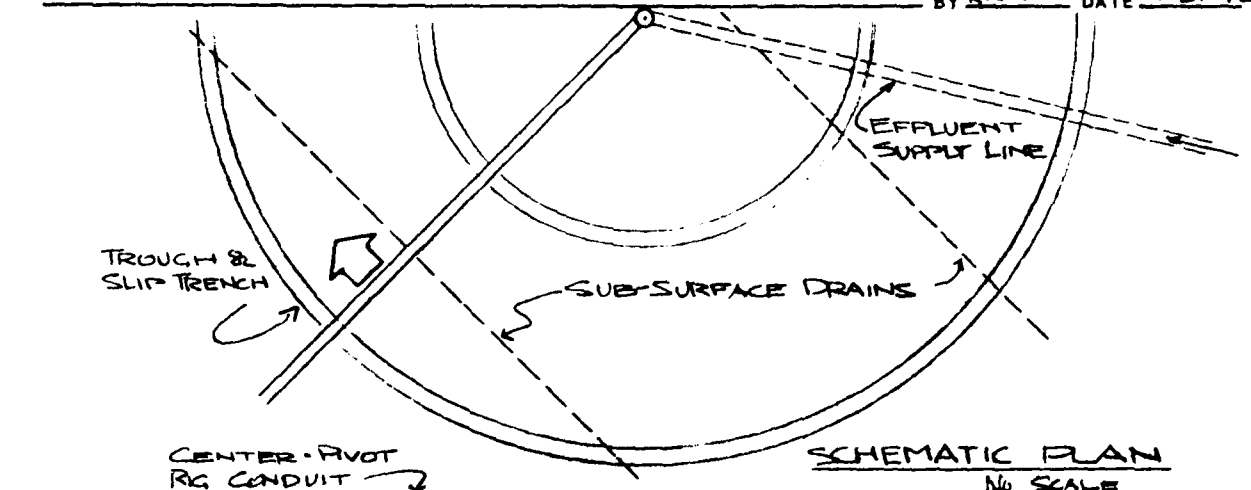
CROSS SECTION

FIGURE IX-5

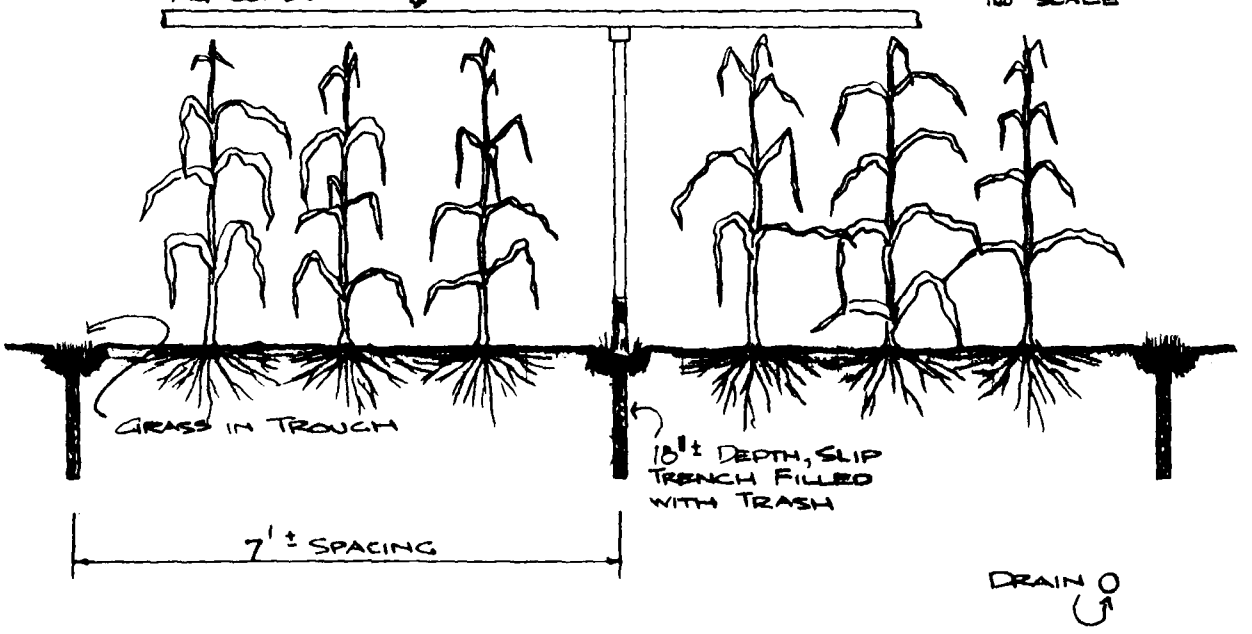
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: III Sub - Item: IRRIGATION

CENTER PIVOT RIG - SLIP PLOW/DRIP TUBE SHEET NO. ____ OF ____
CARDINGTON - BENINGTON SOILS JOB NO. 712 - 70
BY KRW DATE 11-21-72



SCHEMATIC PLAN
NO SCALE



CROSS SECTION

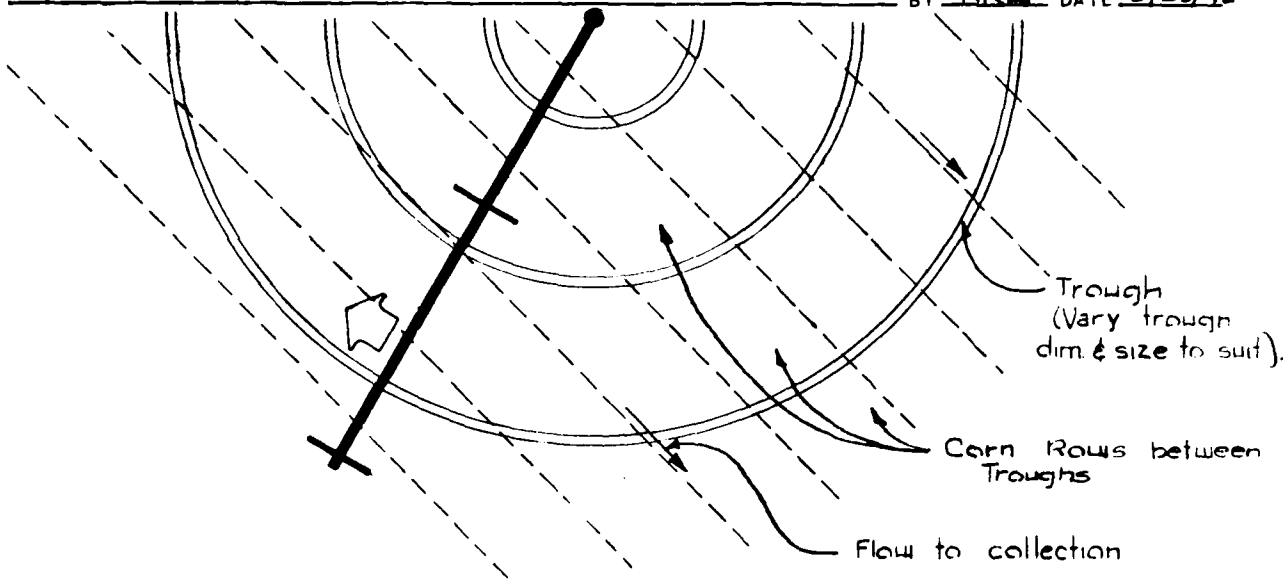
FIGURE IX-6

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

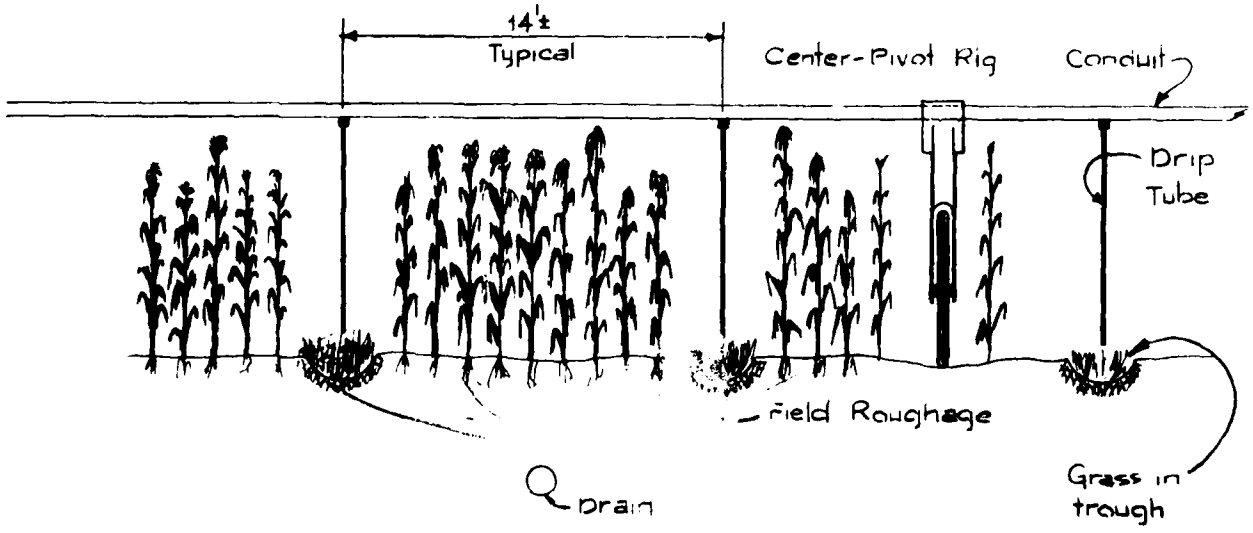
Land Treatment/Formulation Phase: III Sub - Item: Irrigation

Center Pivot 4" Drip Tube System
Cardington - Bennington Soils

SHEET NO. ____ OF ____
JOB NO. 712 - 70
BY KRW DATE 9/29/72



SCHEMATIC PLAN NO SCALE



CROSS SECTION
NO SCALE

Figure IX-7

It should be pointed out that a variety of farm management techniques can be developed specifically for the Cardington-Bennington soils. The Center Pivot-Drip Tube method is only one possibility. Furthermore, the buildup of organic soil material, the potential for modification of the soil surface through limited sludge application, the use of solid set sprinklers, the somewhat closer spacing of drains, the development of new type center-pivot irrigation rigs, and other possibilities makes the development of other techniques using present-day technology practical.

Low delivery pressure needs for the drip-tube and flood-jet method tend to significantly reduce pumping costs, as well as the initial construction costs of the pipe distribution system.

Early action installations, coupled with small-scale plot development initially, would be used to verify the proposed methods and to improve upon them. It is believed that such experimental work would lead to many additional variations of land management, besides providing demonstrations of the suitability of circular farming. Circular farming operations are preferred with center-pivot irrigation equipment. Rectangular farming can be practiced, but it is less efficient and less convenient.

Early action demonstrations will also provide further detailed information on nitrogen balance. This is discussed in the Land Treatment Phase II Report.

DEEP PLOWING

The matter of deep plowing is of interest to agriculturalists, and some concern has been expressed by eastern agronomists over the value of deep plowing. Vast deep plowing has been done in Canada.

The experiments have been conducted on solonetizic soils, which are salty soils but are not called saline. There are about 20,000,000 acres of this soil in Canada and extending into the northern United States, in states like North Dakota. The deep plowing is done 18 inches to 24 inches deep and an 18-inch plow width is pulled by a 130-horsepower tractor; the cost ranges from $10 to $15 per acre.[6]

The A Horizon is acidic, with a pH of 5.0 to 5.5; the B Horizon has a high clay content, is very tight, and is underlain with a lime salt consisting of gypsum and calcium carbonates. The lime layer is brought to the surface, bringing the pH to neutral conditions. The cost of deep plowing, about $10 to $15 per acre, is a cheaper method of liming than transporting the lime by train and applying it with machines.

The experiments have been conducted for three to thirteen years; to date, there is no sign of this land reverting to its original condition. The symbiotic fixation of nitrogen has been stimulated and generally the microorganism population has increased. These lands are generally dry-farmed.

In regard to sodium in the effluent, deep plowing would bring gypsum and calcium carbonates to the surface in sufficient quantities

to keep sodium from replacing the calcium and magnesium on the soil colloids. The sewage effluent would have an electrical conductivity of approximately 750 millimhos per cm and a reasonable sodium absorption ratio. Sufficient leaching is expected to occur through the soil column from both rainfall and irrigation applications to prevent sodium buildup.

As the effect of the calcareous material brought up from the C Horizon has dissipated, lime applications may be necessary to provide the calcium ions. This can be done by occasional applications of lime-conditioned sludge amounting to about 10 to 25 tons per acre. It is not anticipated that further deep plowing would be done to provide the lime because of the availability of lime deposits at a reasonable cost.

GENERAL

The discussion in this section of the Report has been presented primarily to demonstrate the variety of farm management techniques which might be developed to cope with constraints imposed by particular soil series which have limitations for utilization of more conventional irrigation and drainage methods. It is not meant to define a rigid limitation on choices of managment for these fine-grained soils.

It is anticipated that the agricultural fraternity would undertake mission-oriented research and development aimed at developing new techniques for particular soils and crops, with the age-old limit of agricultural economics being set in new dimensions on the basis that the

cropland can be synergistically utilized as a living filter for renovation of treated sewage effluent. Thus, the farmland would take on a new and additional vital role in serving the needs of society.

The potential of developing new methods for utilizing the soil to help in meeting the nation's need for clean water would hopefully lead to optimizing land use for agriculture and yet maximize the cleansing and purification potential as related to irrigation with wastewater.

BIBLIOGRAPHY -- SECTION IX

1. Joint Conference of the American Society of Agronomy, and Soil Scientists of America, Miami Beach, Florida, October 30, 1972.

2. Parizek, R. R. and others. "Waste Water Renovation and Conservation." The Pennsylvania State University Studies No. 23. University Park, Pennsylvania: The Pennsylvania State University, 1967.

3. "Definitions and Abbreviations for Soil Descriptions," (Form CF-123), U. S. Department of Agriculture, Soil Conservation Service, Berkeley, California, October, 1966.

4. Great Lakes Basin Framework Study, Appendix No. 16, "Drainage," Great Lakes Basin Commission, Draft No. 2, July, 1971.

5. The Northwest Ohio Water Development Plan, prepared for the Ohio Water Commission, Department of Natural Resources, (Principal Consultant, Burgess & Niple, Limited), Columbus, Ohio, January, 1967.

6. Telephone call from Ralph Toren, Wright-McLaughlin Engineers, to R. R. Cairns, Officer-in-Charge, Research Branch, Solonetzic Soil Substratum, Canada Department of Agriculture in Vegreville, Alberta, on October 27, 1972.

SECTION X

RENOVATIVE CHARACTERISTICS

The application of wastewater to agricultural land provides a natural means of treatment utilizing the living filter of the soil. Wastewater will have received secondary treatment prior to irrigation so that the characteristics of the irrigation water will be equivalent to treated wastewater presently discharged into rivers and lakes.

The capability of the soil to remove pollutants from the wastewater is termed the wastewater renovative capacity. This capacity is often substantial due to the large surface area of the soil particles, the microbiological activity in the soil, the cation exchange capacity, and the organic content of the soil either at its natural level or built up artificially. It has been estimated that one ounce of clay represents a total surface area of about six acres. "Even in a teaspoonful of soil from the temperate regions, there may be 5 billion bacteria, twenty million actinomycetes, a million protozoa, and 200,000 algae and fungi. These crowds of micro-organisms carry on such fierce activity on each acre that they expend an amount of energy equal to thousands of human beings living and working there." (Living Earth, p. 5)

EFFLUENT CHARACTER

The wastewater pollutants are in many instances resources for soil amendment. The non-beneficial constituents must be either stored or decomposed.

The irrigation water would have approximately the following concentrations of constituents:

TABLE X-1
IRRIGATION WATER QUALITY*

CONSTITUENT	MUNICIPAL - INDUSTRIAL AND COMBINED WASTEWATER (MG/L)	STORM RUNOFF (MG/L)	MUNICIPAL - INDUSTRIAL, COMBINED AND STORM RUNOFF (MG/L)
Suspended Solids (SS)	25	25	25
Biochemical Oxygen Demand (BOD)	15	15	15
Chemical Oxygen Demand (COD)	69	69	69
Total Dissolved Solids (TDS)	520	200	460
Nitrogen (N)	19.7	2.2	16.4
Phosphorous (P)	10.2	0.5	8.3
Heavy Metals	2.0	0.2	.7
Virus			
Bacteria			

* Based on the October, 1972 Contract Phase Report, Phase II - System Design and Estimate of Cost by Havens and Emerson, Ltd. and other communications with H. & E. Engineers. The 81% sewage effluent volume and 19% stormwater volume is representative of Plan 4 and Plan 12 for the Cleveland area plants. The average effluent concentrations are based on the use of biological systems without benefit of advanced wastewater treatment facilities.

RETURN FLOW QUALITY

The water undergoes renovation in the soil zone as it percolates through the living filter. Upon reaching the water table, or an artificial drain tile system, the water has had pollutants removed in varying amounts as indicated in the following tables for soils as selected in Section IX of this Appendix. The reader is referred to Land Treatment

Phase II Report for crop type and uptake and to Formulation Final Report for treatment goals.

TABLE X-2
RENOVATION OF EFFLUENT WITH CARDINGTON-BENNINGTON SOILS
BASED ON 75 INCHES/YEAR
MUNICIPAL/INDUSTRIAL/COMBINED EFFLUENT

CONSTITUENT	REMOVAL RATE (Percent)	RETURN FLOW (MG/L)
SS	99	< 0.3
BOD	99	< 0.2
COD	99	0.7
TDS	5-10	450-500 **
N	85-95*	< 1 to 2.5
P	99+	< 0.1
Metals	99+	Trace
Virus	99+	
Bacteria	99+	

TABLE X-3
RENOVATION OF EFFLUENT WITH MAHONING-ELLSWORTH SOILS
BASED ON 90 INCHES/YEAR
MUNICIPAL/INDUSTRIAL EFFLUENT

CONSTITUENT	REMOVAL RATE (Percent)	RETURN FLOW (MG/L)
SS	99	<0.3
BOD	99	< 0.2
COD	99	0.7
TDS	5-10	450-500 **
N	85-95*	1-3
P	99+	< 0.1
Metals	99	Trace
Virus	99	
Bacteria	99	

See references 3, 4, 5 and 6.

* The removal rate will depend on the crops grown, yields and product removal. Unexplained losses of up to 50% to the atmosphere may occur.[12]

** Average values are shown; lower and higher values are possible depending on rainfall and evapotranspiration rates.

TABLE X-4
RENOVATION OF EFFLUENT WITH MAHONING-ELLSWORTH SOILS
BASED ON 150 INCHES/YEAR
STORM RUNOFF

CONSTITUENT	REMOVAL RATE (Percent)	RETURN FLOW (MG/L)
SS	99	< 0.3
BOD	99	< 0.2
COD	99	0.7
TDS	5-10	150-200 **
N	99*	< 0.1
P	99+	< 0.01
Metals	99+	Trace
Virus	99+	
Bacteria	99+	

TABLE X-5
RENOVATION OF EFFLUENT WITH CHILI SOILS
BASED ON 60 INCHES/YEAR
MUNICIPAL EFFLUENT

CONSTITUENT	REMOVAL RATE (Percent)	RETURN FLOW (MG/L)
SS	99	< 0.3
BOD	95-99	< 0.8
COD	95-99	0.7-3.5
TDS	5-10	450-500 **
N	75-90*	2-5
P	98	< 0.2
Metals	95-99	Trace
Virus	99	
Bacteria	99	

See references 3, 4, 5 and 6.

* The removal rate will depend on the crops grown, yields and product removal. Unexplained losses of up to 50% to the atmosphere may occur. 12

** Average values are shown; lower or higher values are possible depending on rainfall and evapotranspiration rates.

RENOVATION

The degree of renovation of wastewater applied to agricultural land depends upon the type of soil used, farm management procedures, type of crop, and irrigation application rates. Literature describing renovation and accumulation of constituents in soils varies from one extreme to another in regard to application rates, concentrations of critical constituents, and soil types.

The reader is referred to Wastewater Management by Disposal in the Land, Corps of Engineers, U. S. Army; and Assessment of the Effectiveness and Effects of Land Disposal Methodologies of Wastewater Management, Russell F. Christman and others at the University of Washington, for two reports which speak directly to wastewater management using land treatment and resulting renovative capabilities of soils. For the specific soils in question in the Lake Erie basin of northern Ohio these reports, coupled with the data in Table II-1 and specific reports and reviews for particular constituents, were utilized to determine the removal effeciencies as tabulated in this Section of the Appendix.[3, 6, 9, 10]

Discussions of certain pollutant removals follow.

ORGANIC REMOVAL

The maximum allowable BOD concentration in return flows is 5 MG/L and the assumed concentration in the irrigation water is 20 MG/L, with some estimates of 30 MG/L. Thus, a minimum removal efficiency of 75 percent to 83 percent is required. All soils considered in this study

exceed these removal rates.

An application rate of 75 inches per year with an effluent having a BOD concentration of 20 MG/L would result in the application of about 340 pounds per acre per year.

According to the Washington report,[5] soils which have remained aerobic under loading rates of hundreds of pounds per acre per day removed 90 percent of the BOD.

The soil capability to remove biochemical oxygen demand (BOD) can depend on the vegetative cover, aerated surface area and infiltration capacity. Anything that adds surface area of the soil interface will increase biological decomposition whether it be litter or living plants. Net BOD removal efficiency has been observed to be high even in the coarsest soils and highest infiltration rates studies, even though the removal efficiency per unit soil column decreased under such conditions.

In essence, most soils have a satisfactory capacity to remove BOD both physically and biologically, but in the soils selected, the limiting process will likely be biological, i.e., the decomposition rate. The latter process will be governed by the environment favorable to microbial life such as bacteria, algae and fungi.

The University of Washington report, Assessment of the Effectiveness and Effects of Land Disposal Methodologies, (page 59), cites the authors McGauhey and Krone (1967) who reviewed the limited amount of knowledge on refractory materials most apt to resist removal in the soil mantle and reach the ground water. They concluded that "only 30 percent of the

organic carbon in secondary treatment effluent could be assigned to chemical groups (Painter, 1961; Bunch, et al., 1961). Whereas 50 percent of the soluble organics in settled sewage are carbohydrates, only 10 percent could be ascribed to this category following secondary treatment. Most compounds after that stage were considered to be soluble acids."[5]

McGauhey and Krone (1967) conclude from the results of several workers that simple sugars, starches, hemicelluloses, celluloses and proteins decompose rapidly in soil, whereas such groups as lignin, waxes, tannins, cutins and fats are more resistant to decomposition.

NUTRIENT UPTAKE

Interactions between organic and inorganic nutrients are of a dynamic nature in soil systems. Before becoming available for uptake by plants, organic nutrients must be microbially converted to available inorganic forms (mineralization). This release of applied organic nutrients to available forms is a slow process; thus it is important to have sufficient inorganic nutrients present to ensure adequate plant nutrition. These inorganic compounds will be supplied either directly from the sewage effluent or through mineralization of the organic compounds.

Plant residues, as well as any future organic matter applied through sludge or effluent irrigation, comprise the bulk of organic content in the soil. The most important organic nutrients in the soil are compounds of nitrogen, phosphorous and sulfur. These compounds must undergo microbial changes before they can be utilized by plants. Organic compounds incorporated in pesticides and herbicides are insignificant in their contribution to soil fertility. These compounds generally remain unchanged in the soil for varying periods of time before being decomposed microbially.

The application of sludge would increase the existing organic matter content of the soil to a much greater extent than irrigation with secondarily treated effluent. This increase in organic matter content would result in an increased cation exchange capacity (CEC) in the surface horizon of the soil. Thus a greater amount of exchange cations could be held in the surface horizon of the soil which would be available for plant uptake.

The inorganic nutrients which are essential to plants in large quantities (macronutrients) are N, P, S, K, Ca and Mg. Essential micronutrients in plant nutrition are Cu, Zn, B, Cl, Mo, Mn, and Fe. Generally, micronutrients are not limiting to plants in soils which are neutral to acid in pH. In acid soils Ca, Mg and K are sometimes leached and could become deficient for plant requirements. The application of sludge and/or effluent would tend to neutralize acid soils, thus providing a "liming" treatment to some degree. The most important inputs from secondary treated sewage effluent would be nitrogen and phosphorous in their inorganic forms, whereas with sludge applications these nutrients would be predominantly present in organic forms. Heavy metals such as Pb, Hg, etc., are not known to be essential to plant nutrition, and excessive quantities of these elements could be toxic to plants. Both K and NH_4 cations can be fixed within the lattices of 2:1 clays such as montmorillonite. Since kaolinite is the predominant clay (1:1) found in northern Ohio, this loss of available K and NH_4 to plants is not felt to be significant.

Nitrogen

Nitrogen is the major constituent of the soil organic matter with respect to plant nutrition. Organic nitrogen in the forms of amino acids, purines, etc., is slowly converted microbially to ammonium and nitrate, which can be utilized by the plant.

In addition to nutrient uptake by plants, nitrogen is lost to the atmosphere largely through denitrification and ammonia volatilization.

Denitrification is a microbial process and occurs optimumly from pH 7-8; however, it may occur to lesser extents in acid soils. Reduced soil aeration and fresh organic matter both are necessary for denitrification. Larger carbon-nitrogen (C:N) ratios favor denitrification while small C:N ratios reduce denitrification. Significant denitrification can be obtained in a soil-plant system by alternating periods of irrigating and drying, providing that the other conditions are favorable.

Nitrogen can be "fixed" from the air by either symbiotic or non-symbiotic microorganisms. Symbiotic nitrogen fixation occurs in the root nodules of legumes, and the amount symbiotically fixed is dependent on the amount of nitrogen available in the soil from other sources. Research has shown that nitrogen fixation by legumes will be depressed if sufficient commercial nitrogen is applied. Applying regular doses of nutrients from sewage effluent should produce similar results.

Nitrogen from non-symbiotic nitrogen fixation is associated with several different microbial groups and is not expected to contribute much to the nitrogen supply. Rainfall can add minor amounts of nitrogen, perhaps ten pounds per acre per year.

Generally, grass species will have a greater nutrient demand per acre than row crops. This is due to the greater density of grasses and the possibility that they can be grown for a longer season than most row crops.

The nitrogen uptake rate for the Lake Erie basin of northern Ohio will vary from crop to crop, and with farming and cropping practices.

For the application rates of effluent of 75 inches per year on the Cardington-Bennington Association, 90 inches per year on the Mahoning-Ellsworth-Trumbull Association and 60 inches per year on the Chili soils, the expected rate of nitrate-N in the tile effluent should be consistently less than the ppm maximum, perhaps as low as 0.1 ppm.

Nitrogen "losses" to the atmosphere can be expected prior to meeting crop uptake needs. With excess application of nitrogen, the loss to the atmosphere will increase, the crop uptake will increase, and fine-grained soils will accumulate nitrogen. Actually, some researchers have reported nitrogen efficiencies from applications to uptake of no greater than 50 percent.[12] See the Land Treatment Phase II Report for further discussion.

Phosphorous

Phosphorous is generally immobilized within the upper layer of soil by precipitation with certain cations as insoluble complexes. Thus, in a finer textured soil, phosphates will be removed to a great extent due to the high CEC. Some organic phosphates have been known to move with the soil water to a greater extent than the relatively immobile inorganic phosphates. Under increasingly acidic conditions inorganic phosphates will become more mobile in the soil.

Phosphorous is removed by plants in lesser amounts than is nitrogen. Legumes will remove from 10 to 20 lbs/acre during a growing season while tree crops remove slightly higher amounts. Generally phosphorous removal varies from one-tenth to one-third of the nitrogen consumption by plants.

Phosphorous is found in secondary effluent primarily in the inorganic forms orthophosphate ($H_2PO_4^-$, HPO_4^{-2}), polyphosphate ($P_3O_{10}^{-5}$), and metaphosphate ($P_4O_{12}^{-4}$). The latter two are converted to orthophosphate in the soil in a matter of days. Assuming the average amount of these materials in the effluent to be about 10 mg/l P, an application rate of 60 inches effluent per year would amount to about 135 lbs/acre/year.

Phosphate ions are strongly adsorbed on the surface of aluminum silicate and iron or aluminum hydroxide minerals in the soil. This is an almost instantaneous process, so that nearly all phosphate can be removed from solution if enough adsorption sites are available in the soil particles. The latter condition is enhanced by high clay content of the soil. As the surface of particles in the upper layers of the soil become saturated with adsorbed phosphate ions, the dissolved phosphate percolates further downward until it encounters unsaturated particles. Thus the depth of soil becomes an important parameter for long-term phosphate retention. After six years of use, a four-foot deep soil at Penn State still was capable of 99 percent phosphate retention, with a potential life of over 100 years.[9]

Since phosphate adsorbed on soil particles is readily available for plant uptake, the capacity of the soil for phosphate retention is greatly increased by heavy vegetative growth, especially in the upper layers where plant roots are most numerous.

Adsorbed phosphate which is not taken up by plants is subject to reaction with various soil constituents to form insoluble precipitates.

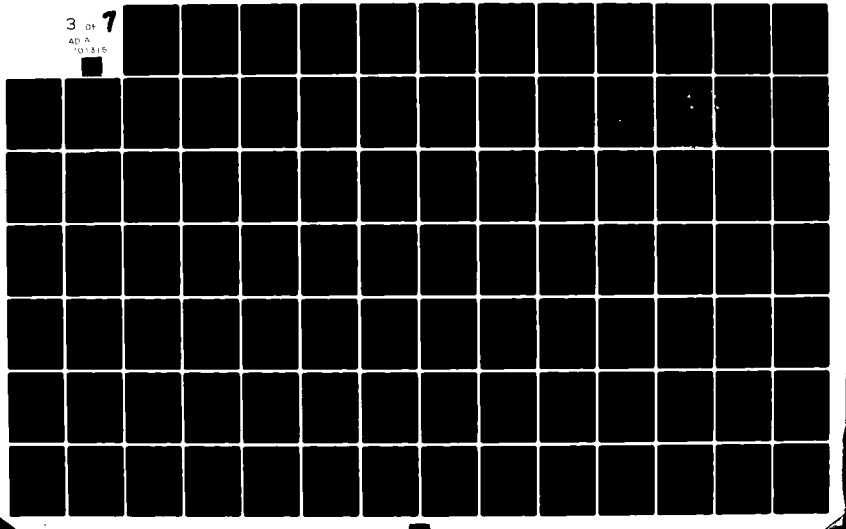
It can also be adsorbed by diffusion into the mass of the soil particles. These are both rather slow processes and result in phosphate in a form which is not easily available to plants and microorganisms. They do provide, however, additional mechanisms for long-term soil retention of phosphorous.

In acid soils (pH less than 6.0), the primary precipitates are believed to be strengite ($Fe(H_2PO_4)(OH)_2$) and variscite ($Al(H_2PO_4)(OH)_2$). These are formed by reactions with Fe^{+3} or Al^{+3} in the soil, which are found in extremely abundant quantities, but which are not available for reaction except at low pH values. In neutral and basic soils, the most common precipitates formed are octocalcium phosphate ($Ca_4H(PO_4)_3\ 3\ H_2O$) and fluoroapatite ($Ca_{10}(PO_4)_6F_2$). These are formed by reaction with calcium, which is nearly always found in adequate quantities in soils of higher pH.

Soils containing substantial amounts of clay minerals or iron and aluminum hydroxides thus provide a high possibility for both short-term (by adsorption) and long-term (by precipitation and diffusion) retention of phosphates. When we combine this capability with plant uptake from proper crop management, the soils of northeastern Ohio can be anticipated to provide virtually complete retention of dissolved phosphates from secondary effluent.

While there is some indication that an overabundance of phosphate can cause plant damage, this is unlikely to occur under the dispersed application used in spray irrigation of effluents. The more widespread

AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA, W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL



problem of phosphate deficiency can be reduced without disregarding possible future problems related to excess phosphate. In essence, "high" phosphate buildup would be related to time periods in excess of perhaps 100 to 150 years. During this period, the phosphate going to the stream will be minimal.

Potassium

Next to nitrogen, potassium is removed to the greatest extent from the soil by plants. Legumes can remove 50 to 100 lb. K/acre during a growing season while tree crops can remove well over 100 lb. K/acre. Leaching losses of potassium are small compared to the amount present in the soil. This is the result of the adsorption of potassium on the clay complex in soils. Potassium is found to be "fixed" within the lattice of certain 2:1-type clay minerals (illite). Since potassium is relatively immobile in soils and is taken up to a large extent by plants, it is felt that potassium would not be a significant source of environmental contamination under effluent or sludge applications.

TOTAL DISSOLVED SOLIDS

The soils of northern Ohio have been extensively leached, so that the additional water from irrigation would not result in larger additional concentrations in the drainage (tile) effluent. These soils are sufficiently acidic that the available calcium and magnesium would not be significant enough to precipitate bicarbonates. Under this environment, the tile effluent can be expected to contain the sulfates, chlorides and bicarbonates contained in the sewage effluent which constitute over

90 percent of the anions in the sewage effluent. The corresponding cations would consist mainly of calcium and magnesium and some sodium and potassium.

The accompanying table lists the average total dissolved solids (TDS) content for many of the streams which may receive treated wastewater from land treatment sites, either within or outside the Three Rivers Basin. The data in Table X-6 is for 1951-1952. Also shown are the periods of the year when the measured TDS is found to be higher, about equal to, or lower than the average figure. Table X-7 presents selected data for 1970.

A definite pattern exists in the data. During the winter and spring months (December to May, in general), the TDS is lower than average, while the period August to November generally shows higher TDS. During June and July, average TDS prevails. The variation is quite substantial, with a few exceptions which are noted below.

Downstream of the Cleveland Southerly Sewage Treatment Plant the TDS in the Cuyahoga River drops by more than 20 percent, and the seasonal variation is much less marked. This may be attributed to the infusion of a large (and relatively constant) amount of Lake Erie water.

Doan Brook shows the lowest TDS of all the streams flowing into the lake, with the exception of the Chagrin which also has a very constant TDS value.

The Chagrin and upper Cuyahoga Rivers have the lowest TDS of all, and also show only a slight seasonal variation in quality. These two

drainages contain by far the most natural vegetative patterns of all the streams considered. This tends to indicate that a fraction of the TDS, as well as variation in water quality, may be derived from the runoff from cleared agricultural lands.

The brackish Grand River has an extremely high content of calcium and sodium chlorides, apparently from natural sources, making it much different from any of the other rivers.

In view of the extremely high quality of most of the water supplies in the Three Rivers drainage, where nearly all of the water comes either from Lake Erie or the upper Cuyahoga River, indications are that the drainage of land-treated effluent into the streams of the area will not exceed the proposed 500 mg/l limit in TDS. The "use increments" of municipal use is on average about 250 ppm. The addition of this water may decrease the TDS of some of the streams into which the return drains during late summer and fall of the year.

Water management efforts need to be concentrated on the Grand River to determine if the total amount of dissolved solids flowing into Lake Erie from natural sources can be reduced. This is an area of study which would have a great effect on Lake Erie.

Table X-6 "Dissolved Solids Content in Lake Erie Tributaries for 1951-1952" and Table X-7 "Dissolved Solids in Selected Streams for 1970" follow.

TABLE X-6

DISSOLVED SOLIDS CONTENT IN LAKE ERIE TRIBUTARIES FOR 1951-1952

River	Avg. TDS (ppm)	Lower	Average	Higher
Portage	530	Dec.-June	July,Nov.	Aug.-Oct.
Sandusky	410	Dec.-May	June,July	Aug.-Dec.
Huron	380	Dec.-May	June-July	Aug.-Nov.
Vermilion	270	Dec.-May	June-July	Aug.-Nov.
Black	380	Dec.-May	May-July Nov.-Dec.	July-Nov.
Rocky	290	Jan.-May	June-July	Aug.-Dec.
Cuyahoga (Hiram Rapids)	158	Very little variation		
Cuyahoga (Independence)	500	Dec.-Apr.	May	June-Nov.
Cuyahoga (Cleveland)	390	Jan.-Apr.	May-July Nov.-Dec.	Aug.-Nov.
		(Much less variation than others)		
Doan Brook	260	No pattern in variation		
Chagrin	200	Jan.-Apr.	May-July	Aug.-Nov.
		(Less variation than others)		
Grand	4000	Nov.-May	-- (High Ca & Na Cl)	May-Nov.

TABLE X-7 *

DISSOLVED SOLIDS IN SELECTED STREAMS FOR 1970

River and Station	Dissolved Solids in MG/L		
	Average	High	Low
Sandusky River Below Fremont	410	706	196
Huron River Below Milan	430	580	146
Vermilion River Near Vermilion	340	440	254
Black River at Elyria	500	1010	172
Cuyahoga River at Independence	590	1010	314

* See reference 13.

HEAVY METALS

INTRODUCTION

For the purposes of this report, heavy metals can be defined as those metallic and other chemical elements which are not major constituents of most natural waters, and include the elements aluminum, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, chromium, iron, lead, manganese, mercury, molybdenum, nickel, silver, strontium, vanadium, and zinc. These metals are generally found in the natural waters in extremely minute quantities, but are added in much greater amounts as a result of man's activities, especially through manufacturing operations. If the concentrations of some of these metals reach a critical level, they can be toxic to man, or plants and animals. However, the metals can be monitored, crops can be rotated, and the fields managed to preclude the development of problems.

Treatment Considerations. The presence of heavy metals in irrigation water is of special concern because they:

1. Are conservative, that is, they are generally non-degradable,
2. Are in general quite actively involved in biological processes, and,
3. Tend to be concentrated in the food chain. Most of them are essential for growth but become toxic to microorganisms, plants or plant consumers at elevated levels.

The general situation presented by these non-degradables may be considered from a mass balance approach, which may lead to the following symbolic formulation:

$$T = Q_E - L - S$$

$$T = Q_E - L - S$$

All terms are in units of lb./day, element by element, where T represents the treatment required for heavy metal removal prior to irrigation, Q_E denotes the existing quality of the combined input wastewaters (domestic, industrial and storm), L represents the highest input that the most sensitive organism can tolerate and S relates to storage capacity of the soil. If impaction does not occur prior to the attainment of a steady state, S approaches zero and

$$T = Q_E - L$$

This rather ideal simplification is introduced because it serves to illustrate a number of crucial elements, how they interrelate, and thus the potential design and management alternatives.

To some extent, each term is manageable, i.e., can be varied, even considering real-system constraints. Most likely the major source of metals is industrial waste. If industries are required to treat their effluents prior to release, or pay for the treatment, some may find it feasible to alter processes, recycle waters, or recover metals in-house.

Thus, conceivably, Q_E might be improved, i.e., metal inputs to the system reduced. The present value of Q_E can be determined.

Obviously, many treatment alternatives, T, exist in either primary or secondary treatment with regard to type of treatment unit, degree of removal, and area location. Ideally, design of the required treatment would be based on:

$$Q_E - L - S$$

Of these, L and S are virtually unpredicatble at present in terms of special quantifiable numbers; therefore, optimal design a priori of the treatment system for heavy metal removal is impossible at this time.

By incorporating system flexibility, by close monitoring to determine L and S, by selecting crops with much higher L values, e.g., fibrous crops vs. food stuffs, and through operational and incremental design alterations, an optimal design may be approached in the future. Thus, future optimization can be built into the design and construction of the land treatment works.

As we have said, both L and S are to some extent manageable. For example, by liming the acidic soils, available storage may be increased and release to receiving streams decreased. Likewise L may be managed by agricultural technology, e.g., plant type or even species or alteration of soil pH (liming of acidic soils may decrease Cu, Zn, Mn, and Fe uptake while increasing anion uptake such as $MoO_4^{=}$).

Loading Limitations. The capacity of a particular soil to retain heavy metals could be limited by any one of four factors as generally discussed above; the first one of these to be exceeded determines the effective capacity of the soil. These factors are:

1. The physical capacity of the soil to retain metals, either mechanically or chemically. If this is exceeded, further metallic ions in solution will pass through the soil into receiving streams.

2. Damage to soil microorganisms. Metals which are toxic to these organisms could result in a reduced capacity of the soil to retain other constituents, degrade the applied BOD, or support plant growth.

3. Plant damage. Concentrations of metals toxic to plants could result in reduced yield or specific damage to some critical part of the plant's growth cycle.

4. Toxicity to animals consuming the plants. If the plants are to be consumed by animals or people, sufficiently high levels of certain metals could result in poisoning or illness of the animal consuming it, without obvious damage to the plant itself.

Most critical of all is the possibility for chronic human toxicity (versus the more obvious acute toxicity) due to metal recycled through the food chain. Relating cause and effect is extremely difficult because of numerous adverse influences from other sources which need control. Up to now, there has been little or no control (or even measurement) of the concentrations of these elements found in our air, surface and ground waters, sewage effluents discharged to streams and lakes, or in the food we consume.

The U. S. Bureau of Reclamation, which has been developing irrigation projects throughout the 17 western states since about 1902, has no official heavy metal standards, and they have not systematically measured such constituents. The U. S. Geological Water Supply Papers giving water quality records do not normally report heavy metals, except iron. This illustrates the lack of concern in the past relative to heavy metals. Land treatment with treated effluent is expected to stimulate more activity in this long ignored field, such activity probably falling upon the shoulders of

agronomists, health scientists, and animal specialists.

Little is known about damage to soil microorganisms, but its effect is most likely to be felt indirectly, in the form of plant damage. Toxicity to plants and animals is a complex function of many factors, including the type of plant grown; the concentration of a particular metal in the effluent; the amount of the same metal already in the soil before irrigation; the chemical form of the metal, which determines its availability to plants; and the effects of other chemical constituents, both in the soil and in the effluent. Little information is presently available in general regarding the chemical factors; however, biological factors (types of plants) can be easily controlled.

Applied Criteria for Classification of Soils. The soils under consideration are classified only according to their physical capacity to retain heavy metals in general. In the absence of specific trace metal analyses of the soils, this physical classification is based on the following factors:

1. Clay content. Since much of the adsorption of the heavy metals takes place on the surface of aluminosilicate particles, soils with higher clay contents have greater capacities for retention of metals.[4] CRREL Report, p. 49, 50.

2. Cation exchange capacity (CEC). Most of the clay content of soils in northeastern Ohio is in the form of kaolinite, which has a low CEC in comparison to other clay minerals. Therefore, this is a less important factor than the adsorptive capacity.[5] Washington Report, p. 77.

3. Organic content. Organic matter contributes both to adsorption and ion exchange mechanisms of heavy metal ion retention. Therefore, organic soils are more desirable than those with low organic contents. (High organic content could also increase metal uptake by plants through chelation.)[3,4,5]

4. pH. Neutral or alkaline conditions enhance both the adsorption and exchange mechanisms of metal ion retention. Therefore, higher pH's are generally more desirable. An exception to this rule is molybdenum, which is found in solution in an anionic state, as $MoO_4^{=}$, which is retained more easily at low pH.[5]
5. Depth. As surface layers of soil become saturated with heavy metals, the solution percolates downward. The deeper the soil, the greater the adsorptive capacity available.

[5] Washington Report, p. 95.

PROBLEMS WITH SPECIFIC METALS

If it is assumed that the secondary effluent contains average concentrations of dissolved metals, the concentrations of chromium, copper, iron manganese, nickel, lead, and zinc deposited in the soil, even after a century of application at a rate of 75 inches effluent per year, would be only a fraction of the naturally occurring amounts found in some soils. All of these ions would probably be retained almost completely. The major potential problem, concentration in the upper inch or so of the soil, will be alleviated by plowing of land.

Concentrations of boron in some effluents are high enough that the total accumulating after many years could approach the upper limits found naturally, barring plant uptake and removal. Boron, however, is an essential plant nutrient and could be expected to be removed by plants. The amount found in some effluent is high enough to cause damage in certain sensitive plants; therefore, the boron content of both the effluent and the plants grown on the land should be monitored and, if necessary, altered in order to produce maximum agricultural yields.

The recommended limit of cadmium in irrigation water is extremely

small (0.005 mg/l).[14] The U. S. Public Health Service, however, has set a recommended limit for cadmium in public drinking water supplies which is twice as much (0.01 mg/l) as for irrigation water.[14] This irrigation water value is based on the known toxicity of cadmium to man and the unproven, but potential, possibility that it might be concentrated in toxic quantities by certain food or forage plants. Until further investigations are performed to determine the cadmium cycle in plants, both effluent and plants should be carefully monitored. If a questionable situation should arise, means for the removal of most cadmium at its source (factories, etc.) should be considered. (See also reference 15.)

Mercury is toxic to man in very small quantities, and is known to be concentrated by certain organisms, such as swordfish. While the amount found in secondary effluent is likely to be much smaller than that which would be dangerous, this element should also be monitored in both effluent and plants.

The recommended limit of molybdenum in irrigation water is also quite small (0.005 mg/l).[14] There is serious question about the interpretation of experimental data which has led to this figure, however, and it appears far more likely that the molybdenum in the effluent will supply a need (Mo is an essential plant nutrient), than that it will contribute to molybdenosis in animals grazing on crops grown with spray irrigation of secondary effluent.

CLEVELAND HEAVY METALS

Studies by AWARE of the actual industries in Cleveland and

their anticipated discharge to municipal sewerage systems in the year 2020, using trend forecasting techniques and no major re-orienting of recycling philosophy, has resulted in projections of heavy metals loads.

The heavy metal discharges by industry, as estimated by AWARE, into the municipal sewage collection systems of Bedford, Cleveland Easterly, Cleveland Southerly, Cleveland Westerly, Summit, Twinsburg, and Willoughby were totalled for the year 2020 for the AWARE alternative 5A. Alternative 5A represents the least amount of in-house heavy metal control by industry of the treatment alternatives studied, and its objective is described by AWARE as follows:

> "Goal II modified to not require demineralization or removal of heavy metals except for direct discharge to waterways or where metals would interfere with biological treatment." (Aware Report, Phase II, p. 12)

Heavy metal concentrations in soil, assuming land treatment, were compared with four metal toxic levels as reported in the British Pollution Control Journal in 1972 on the basis of 50 and 100-year irrigation periods. The results are presented in Table X-8. Conclusions are as follows:

1. The copper, chromium, cadmium, nickel, zinc, and lead concentrations will still be within reasonable limits after 100 years of application to the same soil without deep plowing farm management.

2. The discharge levels assume no improvement in industry metal recycling efforts for the next 100 years over the present practices as indicated by AWARE studies, and no special effort by related industry to reclaim valuable metals which will become more scarce in the future.

3. Deep plowing would reduce the concentration levels of the heavy metals in the soil as indicated in Table X-8.

4. The soil provides a storage location for these metals where they can be controlled and managed.

The matter of heavy metal accumulation in the soil is a "guess" because the soils being considered are extremely efficient in removing and storing such metals contained in wastewater from metropolitan areas. The capacity for storage is huge, ranging up to 500 or 1000 years in many instances. Before this time, toxic levels of some metals would be reached. Thus, heavy metal accumulation management is mandatory.

Routing of heavy metals to land, rather than to water or air, provides an opportunity for management not found in the other mediums. The excellent field studies being conducted at the University of Illinois under an E.P.A. grant have confirmed that heavy metal accumulation in soil can be managed, and that the longer termed problem can be avoided by field monitoring and management. [17]

TABLE X-8
SOIL CONCENTRATIONS OF HEAVY METALS FROM LAND TREATMENT

Heavy Metal	Yr. 2020 Loads[1] (lb/day)	Yr. 2020 Loads with 62% Removal (lb/day)	Concentrations with 653.9 MGD (Incl. S.W.) (mg/l)	Irrigation Rate of 75"/Yr. Annual Loading (lbs/Ac.)	Irrigation Rate of 75"/Yr. Annual Concentration[2] (PPM/Ac.-12")
Silver	9.8	3.7	0.00068	0.0115	0.0029
Copper	1,797	682	0.125	2.12	0.53
Chromium	2,876	1,091	0.201	3.41	0.85
Cadmium	67	25.4	0.0047	0.075	0.019
Nickel	1,793	681	0.125	2.12	0.53
Lead	5.5	2.1	0.0039	0.066	0.016
Zinc	2,227	844	0.155	2.63	0.66
Iron	13,788	5,230	0.965	16.4	4.1

Heavy Metal	Irrigation Rates of 75"/Yr. - 90"/Yr. 50-Yr. Concentration in PPM 12" Layer	18" Layer	24" Layer	100-Yr. Concentration in PPM 12" Layer	18" Layer	24" Layer	Toxic Levels by British Paper[3]	Range of Natural Soil[4] (PPM -24")
Silver	0.14- 0.17	0.11- 0.13	0.07- 0.08	0.29- 0.35	0.21- 0.25	0.14- 0.17		0.1-1
Copper	26.50-31.80	19.90-23.90	13.25-15.90	53.00-63.60	39.80-47.80	26.50-31.80	100-200	2 -100
Chromium	42.50-51.00	31.90-38.30	21.25-25.50	85.00-102.00	63.80-76.60	42.50-51.00	400	5 -1000
Cadmium	0.95- 1.14	0.71- 0.85	0.47- 0.56	1.90- 2.28	1.43- 1.72	0.95- 1.14		---
Nickel	26.50-31.80	19.90-23.80	13.25-15.90	53.00-63.60	39.80-47.80	26.50-31.20	49-100	5 -500
Lead	0.80- 0.96	0.60- 0.72	0.40- 0.48	1.60- 1.92	1.20- 1.44	0.80- 0.96		2 -200
Zinc	33.00-39.60	24.80-29.80	16.50-19.80	66.00-79.30	49.50-59.40	33.00-39.60	125	10 -300
Iron	205.00-246.00	154.00-185.00	102.50-123.00	410.00-492.00	307.00-369.00	205.00-246.00		1.4-4.2%

Notes:
1. Loadings for Alternate 5A - Bedford, Cleveland Easterly, Cleveland Southerly, Cleveland Westerly, Summit Unsewered, Twinsburg and Willoughby -- As per AWARE Industrial Waste Study, October, 1972.
2. Weight of an acre of soil 12 inches deep = 4,000,000 lbs.
3. From 1972 paper of British Pollution Control Journal entitled, "Effects of Toxic Metals in Sewage on Crops."[11]
4. CRREL Report, page 58.

BIBLIOGRAPHY - SECTION X

1. Farb, Peter, Living Earth, New York: Harper Colophon Books, 1959, p. 5.

2. Havens and Emerson, Ltd., "Contract Phase Report, Phase II - System Design and Estimate of Cost," Cleveland, Ohio, October, 1972.

3. Letter from Dr. R. H. Miller, Professor of Agronomy, The Ohio State University, Columbus, Ohio, July 7, 1972.

4. Reed, S. C. (coordinator), Wastewater Management by Disposal on the Land, Corps of Engineers, U. S. Army, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, 1972 (referred to as the CRREL Report).

5. Christman, Russell F., and others at the University of Washington, Seattle, Washington, Assessment of the Effectiveness and Effects of Land Disposal Methodologies of Wastewater Management, Wastewater Management Report 72-1, Washington: United States Government Printing Office, 1972 (referred to as the Washington Report).

6. Memo from Dr. Norman Evans, Director, Environmental Resources Center Colorado State University, Fort Collins, Colorado, in response to inquiries regarding concentrations of certain constituents. July 31, 1972.

7. Report from Dr. Norman A. Evans, Director, Environmental Resources Center, Colorado State University (Data for Celma, Ohio sludge disposal fields and related topics).

8. "C-SELM" Wastewater Management Survey Study, Phase I, Soil Process, Task No. 15, Contract No. 1214.010 for the Chicago District of the U. S. Army Corps of Engineers, February, 1972.

9. Parizek, R. R. and others, "Waste Water Renovation and Conservation," The Pennsylvania State University Studies, No. 23, University Park, Pennsylvania: The Pennsylvania State University, 1967.

10. "An Evaluation of Cannery Waste Disposal by Overland Flow Spray Irrigation," Final report on a study project prepared for the Campbell Soup Company by C. W. Thornwaite Associates, Publications in Climatology, Vol. XXII, No. 2, Elmer, New Jersey, September, 1969.

11. Webber, J., Agricultural Development and Advisory Services, Leeds, England, "Effects of Toxic Metals in Sewage on Crops," presented at a meeting of the Metropolitan and Southern Branch held in London, June 17, 1971 (British Pollution Control Journal, 1972).

12. Joint conference of the American Society of Agronomy, and the Soil Scientists of America, Miami Beach, Florida, October 30, 1972. Technical session: "Land Application of Municipal Wastes."

13. 1970 Water Resources Data for Ohio Part 2, Water Quality Records, United States Department of the Interior, Geological Survey, Columbus, Ohio: U. S. Government Printing Office, 1971.

14. Report of the Committee on Water Quality Criteria, Federal Water Pollution Control Administration, Washington, D. C.: U. S. Government Printing Office, April 1, 1968.

15. Letter from Dr. Norman A. Evans, Director, Environmental Resources Center, Colorado State University, on the subject of cadmium levels in Cleveland waste water, July 31, 1972. (The letter was in response to the report, "Cadmium Uptake by Plants," Faz Haghiri, The Ohio State University; the letter stated that cadmium loading level should pose no problem.)

16. J. M. Koon and C. E. Adams, Associated Water and Air Resources Engineers, Inc., Alternatives for Managing Wastewater in the Three Rivers Watershed Area, Industrial Waste Study, Phase II - Design and Cost of Industrial Wastewater Treatment System, Nashville, Tennessee, October, 1972 (referred to as the Aware Report, Phase II).

17. Interview with Professor Tom Hinsley, Agronomy Department, University of Illinois (Office of the Chief Engineer, U. S. Army Corps of Engineers, temporary assignment) on October, 1972.

18. Millar, C. E., Soil Fertility, Wiley Publications, 1955.

19. Dean, L. A.,"Fixation of Soil Phosphorous," Advances in Agronomy, Vol. I, p. 391, 1949.

20. Midgley, A. R.,"Phosphate Fixation in Soils," Soil Science Society of America Proceedings, Vol. V, p. 24, 1940.

21. Reuss, John, "Nitrogen in Sugar Beet Production," Progress Report. Colorado State University, 1971.

SECTION XI

STRIP MINED LAND RECLAMATION

The major solids by-product of any wastewater treatment system is the sludge which is reclaimed from the water. This sludge is a mixture of the solid materials removed in the primary, secondary, and, in some cases, tertiary phases of the treatment. It contains both inorganic particulates and decayed organic matter. After suitable digestion and stabilization, the latter component has been stripped of volatile constituents and odor-producing matter, as well as most of the pathogens originally present. The final product is a thick slurry containing three to eight percent of finely divided solid particles. The organic content is very high, and the sludge contains substantial amounts of phosphorous and organic nitrogen, two vital plant nutrients. It also contains about 80 percent of the heavy metals present in the raw sewage, the total amount depending on the degree of pre-treatment before discharge of industrial wastes to the sewage system. The large quantities of sludge produced, coupled with the high content of organic matter and plant nutrients, make this a valuable resource which should be utilized to the maximum benefit.

A unique opportunity for doing this exists in the Cleveland-Akron area. To the south and east are vast areas of land which have been strip-mined for coal, more than 190,000 acres lying within a 150-mile radius of Cleveland. A county-by-county list of strip mine acreages for the entire state is shown in Table XI-1 . (Actual area must be reduced by about 25

per cent to account for lands which have been mined more than once). The data are also shown in Figure XI-1.

During the stripping process, the topsoil is generally buried beneath sterile, broken sandstone, some limestone, and some shale. Under the new Ohio reclamation law, however, the topsoil is removed from the land prior to mining. Reclamation results in approximately one foot of soil being returned as a cover.

Where sandstone is the major outcrop, there is often no runoff, with the rain percolating downward. Where shale is exposed at the surface, the raindrops pulverize the material, creating fine matter which is rich with sulfides, minerals, and oil. This is highly impervious to water and is toxic to plants. The shale residual is acid and high in iron, aluminum, and other metals. This latter condition leads to significant erosion.

Where sandstone is exposed, the water percolates through the sandstone, and the water and oxygen oxidize the various sulfides found in the sandstone, shale, and coal, with resulting sulfuric acid. The acid then solublizes other minerals containing heavy metals. Concentrations include the following:

Calcium	400 ppm
Magnesium	250 ppm
Manganese	500 ppm
Iron	500 ppm
Sulfates	2,500 ppm
Aluminum	100 ppm

Where the coal contained relatively high amounts of limestone, the alkilinity of the limestone completely neutralizes the acidity and

results in a percolating water pH of 7.5 to 8.0.

In all cases, the runoff water, or percolating water, is polluted, and this adversely affects downstream aquatic life. The characteristics of the mined land leads to a general arid condition.

Some of the recent reclamation work done on land high in limestone resulted in very good ground cover. Here Crown Vetch has been used because of its ability to tie up nitrogen from the air and grows under dry conditions. However, many other plant species, grass as well as legumes, are used in reclamation.

In areas of no reclamation, the decay of the sparse vegetation which grows on the spoil banks will slowly build up soil. However, this natural process period might take centuries. On the other hand, sincere efforts to reclaim the land have, in some cases, produced good range country where limestone is abundant. In areas high in sandstone, where no limestone is found, restoration of land has been found costly and difficult. It is necessary to provide a substance to the land to make it fertile, the addition being organic matter and needed nitrogen.

Restoration of strip-mined land requires, in addition to topsoil, several basic steps:

a. Provide a supply of nitrogen and phosphorous.
b. Increase the moisture-retention capacity of the soil.
c. Buffer the system to reduce acid conditions at depth.
d. Improve the physical characteristics of the soil.

In those cases where the land is covered with vegetation, and where reclamation is properly undertaken, the movement of air and water into

the spoil will be reduced, resulting in less acid production.

Much of the strip-mined land in Ohio has been left in very bad condition, but where the lands have already been leveled, land reclamation utilizing sludge can result in great benefits at low cost.

It is believed that much of the sludge should be first used on land having significant sandstone, which is the primary type of land now being mined in southeast Ohio.

The limestone land has a better natural restoration capacity. Sewage treatment plants producing lime sludges are quite suitable for lands containing little or no limestone, and where high acidity conditions exist.

Sludge would be removed from the digester as a liquid, concentrated to the desired degree if necessary, and transported via pipeline to the strip-mined areas. An existing abandoned coal slurry pipeline leads from Eastlake to Cadiz, in the heart of the strip-mined area, and could possibly be used with only slight modification. If its condition should prevent use directly, the existing right-of-way could still be utilized. This pipeline passes just a few miles east of an extensively mined area south of Canton, and could also be used for restoration of lands in this area.

At the end of the pipeline, a small reservoir would be constructed for storage purposes. From this storage site, the sludge would be transported via tank truck directly to the lands currently being restored, the tank trucks accompanying the applicator on its rounds. If necessary,

the pipeline could be extended every few years to reduce the distance to the lands then being treated.

Treatment of the strip-mined lands with sludge, coupled with appropriate planting and liming, where necessary, should permit immediate growth of numerous native species of plants. If the lands are permitted to revert, the soil-building process would then continue at a rapid rate. The land could be used for wildlife and recreation purposes, with some grazing permitted on areas seeded to grass instead of trees. After just a few decades, the natural restoration process will have proceeded to a degree that the land could then be used for any purpose, including agriculture.

Excellent research is being undertaken presently by personnel from Case Western University. The knowledge and results of their work should be used in the final planning and design of strip-mined land reclamation using sludge. Questions relating to optimum rates of application, plant species best suited, and frequency of application can best be answered by conducting additional field experiments as a part of final planning. These experiments can also help to answer questions related to the economics of large-scale sludge applications. However, in all of this work, an overriding consideration must be that our generation is trustee of the environment for future generations. This generation should look at the land use practices of today from the perspective of those living in Ohio during the next century.

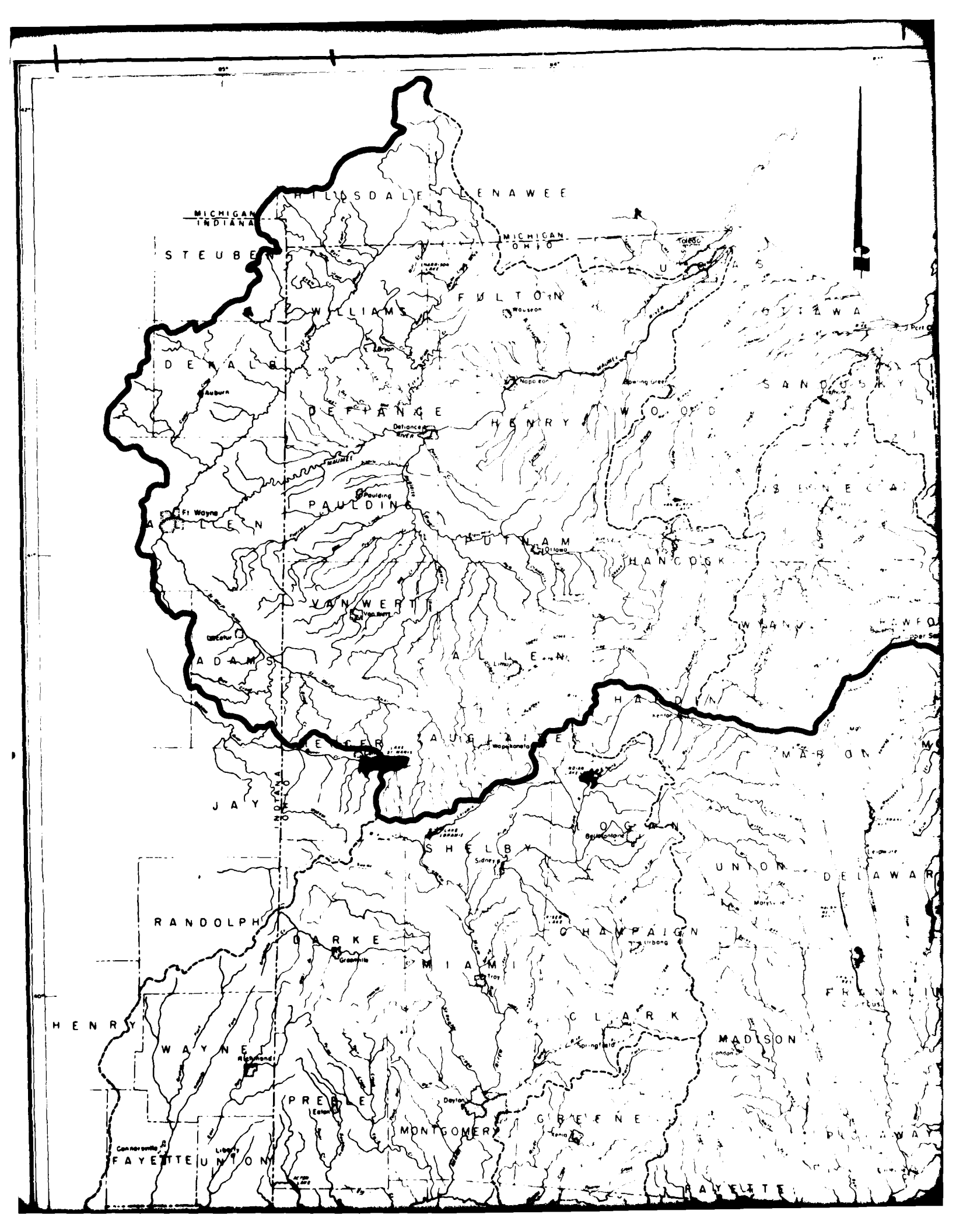
Table XI-1

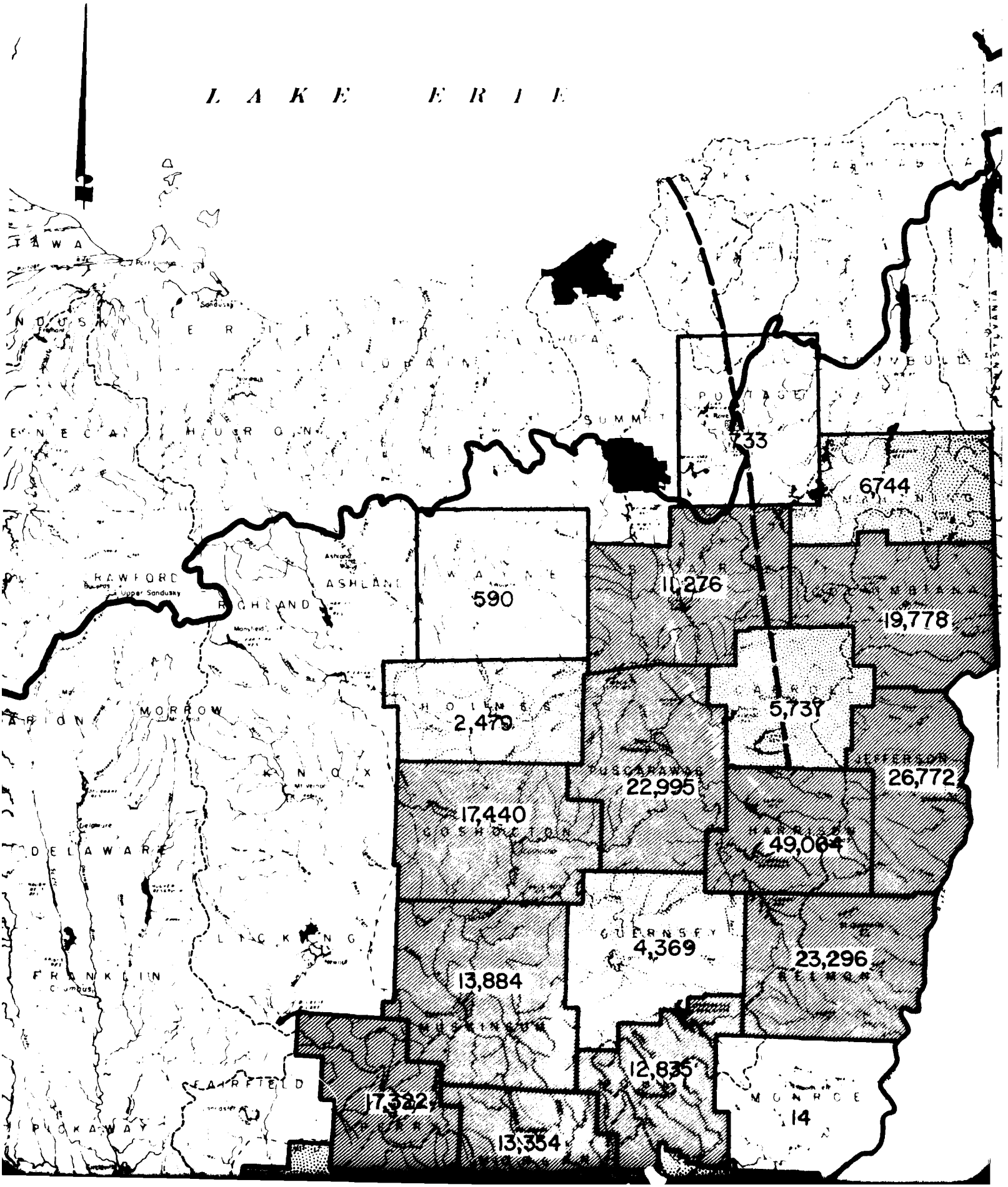
ACREAGE OF STRIP MINED LANDS IN OHIO

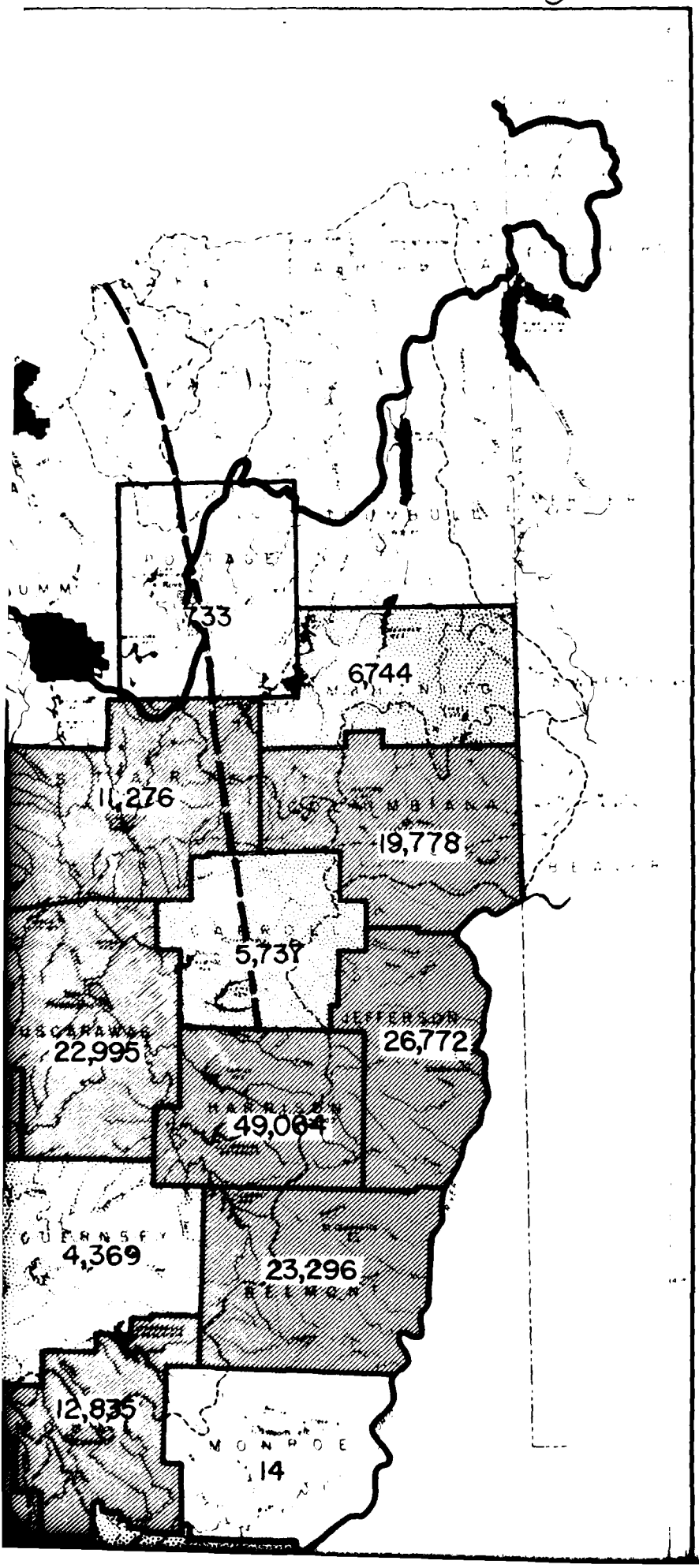
County	Acreage
Athens	2,563
Belmont	23,296
Carroll	5,737
Columbiana	19,778
Coshocton	17,440
Gallia	6,941
Guernsey	4,369
Harrison	49,064
Hocking	3,177
Holmes	2,479
Jackson	6,952
Jefferson	26,772
Lawrence	2,756
Mahoning	6,744
Meigs	5,402
Monroe	14
Morgan	13,354
Muskingum	13,884
Noble	12,835
Perry	17,322
Portage	733
Scioto	148
Stark	11,276
Tuscarawas	22,995
Vinton	4,207
Washington	1,864
Wayne	590

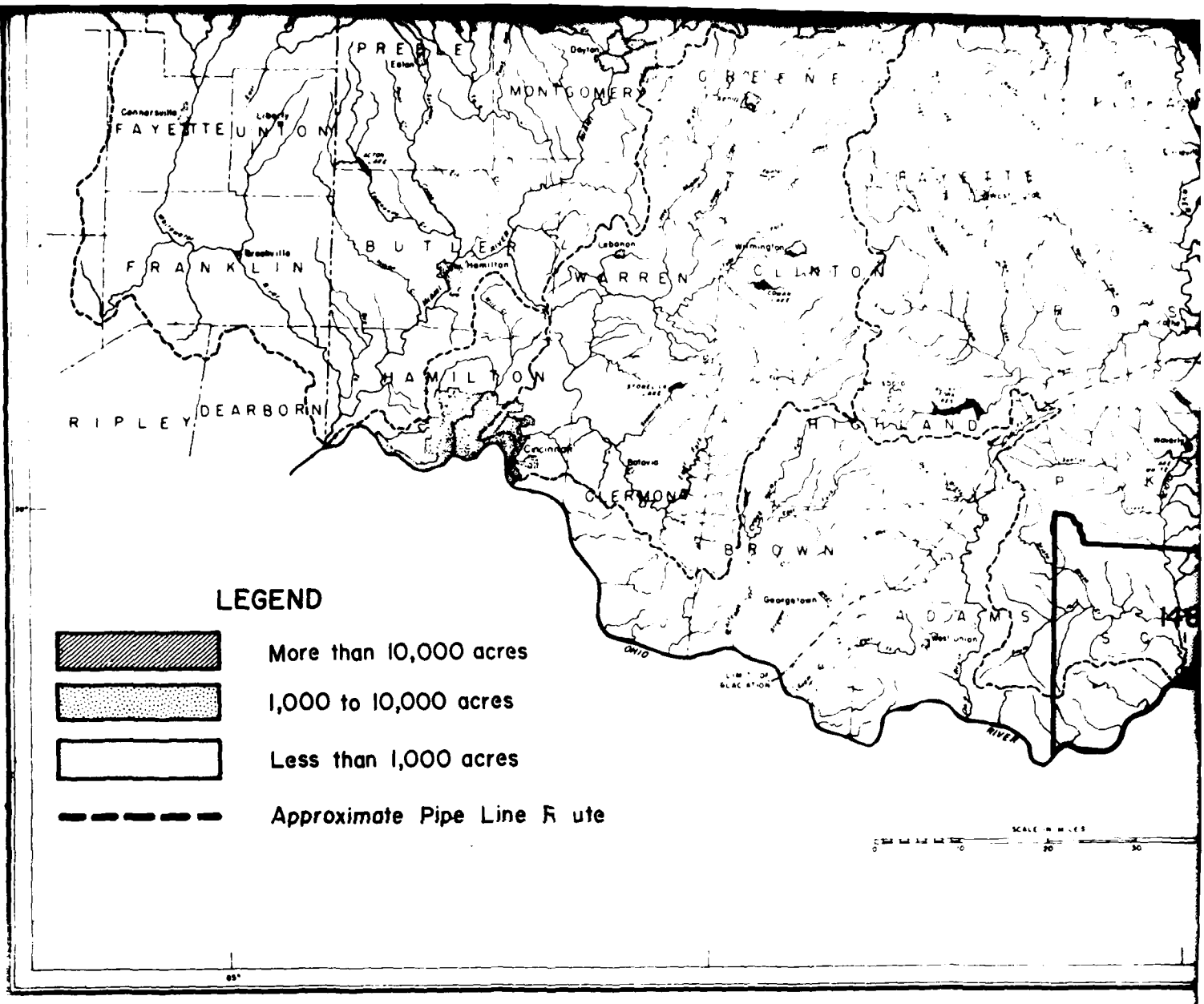
Total 282,692 acres

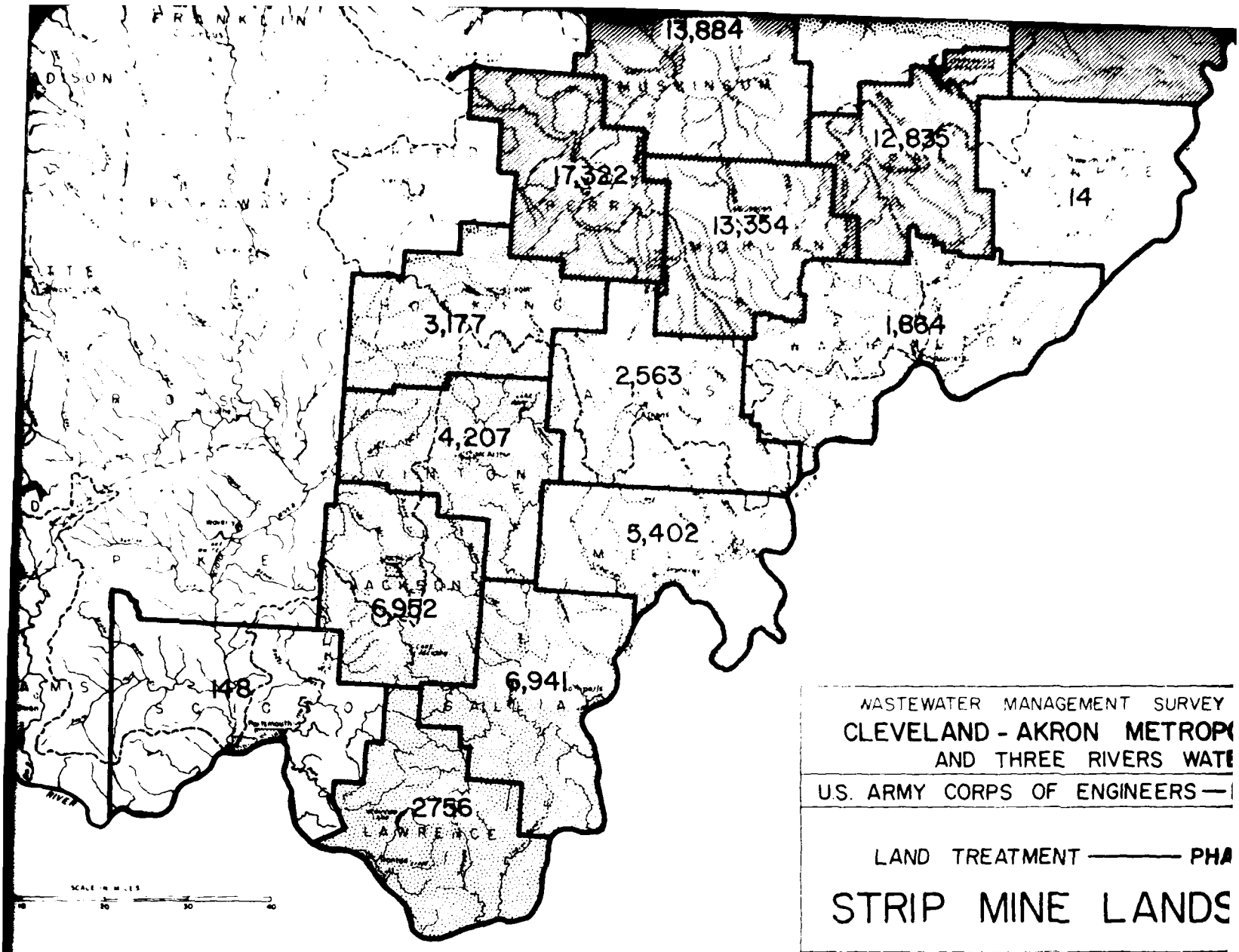
Less 25% = 210,000 acres


HILLSDALE
LENAWEE
MICHIGAN
INDIANA
MICHIGAN
OHIO
STEUBEN
FULTON
WILLIAMS
OTTAWA
DEKALB
SANDUSKY
DEFIANCE
HENRY
WOOD
SENECA
PAULDING
ALLEN
PUTNAM
HANCOCK
VANWERT
WYAND
ADAMS
ALLEN
HARDIN
WELLS
AUGLAIZE
MARION
JAY
SHELBY
UNION
DELAWAR
RANDOLPH
DARKE
CHAMPAIGN
MIAMI
FRANKLI
HENRY
WAYNE
CLARK
MADISON
PREBLE
GREENE
MONTGOMERY
FAYETTE
UNION
RAYETTE


LAKE ERIE
233
6744
590
10,276
19,778
2,479
5,737
22,995
26,772
17,440
49,064
4,369
23,296
13,884
12,835
17,382
14
13,354


733
6,744
11,276
19,778
5,739
26,772
22,995
49,064
4,369
23,296
12,835
14
MONROE


PREBLE
MONTGOMERY
GREENE
FAYETTE
UNION
FRANKLIN
BUTLER
WARREN
CLINTON
HAMILTON
RIPLEY
DEARBORN
HIGHLAND
CLERMONT
BROWN
ADAMS
LEGEND
More than 10,000 acres
1,000 to 10,000 acres
Less than 1,000 acres
Approximate Pipe Line Route

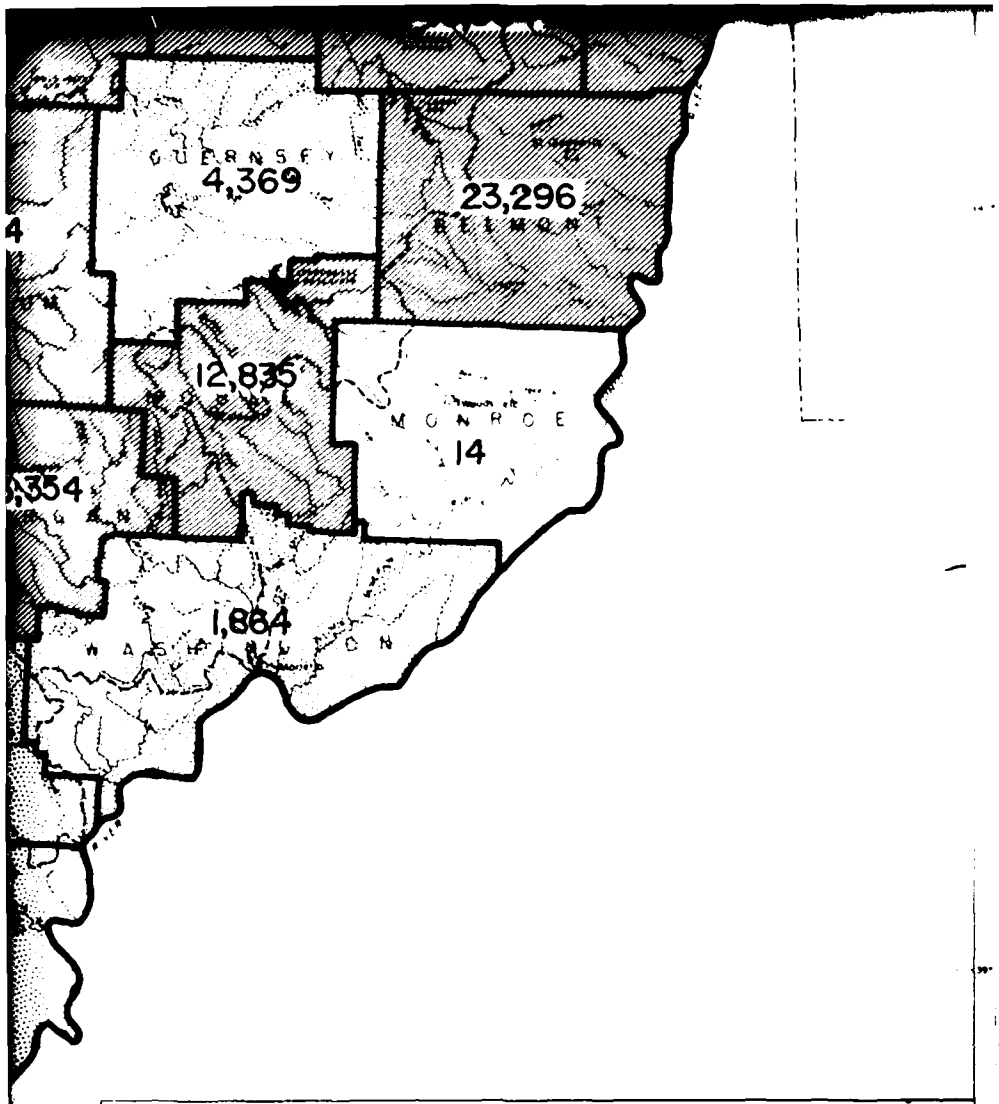


WASTEWATER MANAGEMENT SURVEY
CLEVELAND - AKRON METROP(
AND THREE RIVERS WATE
U.S. ARMY CORPS OF ENGINEERS —

LAND TREATMENT ——— PHA

STRIP MINE LANDS

15



WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

CLEVELAND - AKRON METROPOLITAN AREA
AND THREE RIVERS WATERSHED

U.S. ARMY CORPS OF ENGINEERS — BUFFALO DISTRICT

LAND TREATMENT ——— PHASE I REPORT

STRIP MINE LANDS IN OHIO

FIGURE XI-1

BIBLIOGRAPHY - SECTION XI

1. Brant, Russell A., 1964, "Geological Description and Effects of Strip Mining on Coal Overburden Material." The Ohio Journal Of Science 64(2): 68.

2. Anon., 1972, "Chicago Reclaiming Strip Mines with Sewage Sludge," Civil Engineering - ASCE, Vol. 42, No. 9, 98-102.

3. Hunt, C. F., W. E. Sopper, and L. T. Kardos, 1971, "Renovation of Treated Municipal Sewage Effluent and Digested Liquid Sludge Through Irrigation of Bituminous Coal Strip Mine Spoil." University Park, Pennsylvania: The Pennsylvania State University.

4. Bulk Transport of Waste Slurries to Inland and Ocean Disposal Sites, Vol. I, "The Waste Management Concept - Inland and Ocean Disposal of Selected Wastes," 1969, The Bechtel Corporation, San Francisco, Calif., for the Federal Water Pollution Control Administration, Waste Management Study.

5. Bulk Transport of Waste Slurries to Inland and Ocean Disposal Sites, Vol. II, "Criteria for Waste Management," 1969, (P. E. Snoek) The Bechtel Corporation, San Francisco, California, for the Federal Water Pollution Control Administration, Research Series Report DAST-16, Vol. 2.

6. Bulk Transport of Waste Slurries to Inland and Ocean Disposal Sites, Vol., III,"Technical Aspects of Pipelining of Waste Materials," 1969, The Bechtel Corporation, San Francisco, California, Federal Water Pollution Control Administration, Research Series Report DAST-16, Vol. 3.

7. Bulk Transport of Waste Slurries to Inland and Ocean Disposal Sites, A Summary Report, 1969, The Bechtel Corporation, San Francisco, Calif., for the Federal Water Pollution Control Administration, Contract No. 14-12-156.

8. Webber, J., Agricultural Development and Advisory Services, Leeds, England, "Effects of Toxic Metals in Sewage on Crops," presented at a meeting of the Metropolitan and Southern Branch held in London, June 17, 1971. (British Pollution Control Journal, 1972)

CLEVELAND-AKRON METROPOLITAN
AND THREE RIVERS WATERSHED AREA
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

LAND TREATMENT

PHASE II REPORT

PREPARED

FOR
U. S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

UNDER CONTRACT NO.: DACW49-72-C-0051

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO

DECEMBER 20, 1972

TABLE OF CONTENTS

		Page
LIST OF TABLES		v
LIST OF FIGURES AND CURVES		vi
SECTION I	INTRODUCTION	1
	Bibliography	4
SECTION II	TYPICAL PLANS	5
	Plan 12	5
	Sludge Treatment	9
	Storm Runoff from Outlying Urban Basins	10
	Storm Runoff from Central Urban Basins	11
	Combined Sewer Systems	13
	Low-Flow Augmentation	13
	Low-Flow Aspects of the Cuyahoga River below Lake Rockwell -- Present Conditions	13
	Water Inventory of the Cuyahoga and Chagrin River Basins	14
	Low-Flow Aspects of the Cuyahoga River -- Future Conditions	15
	Non-Structural Means of Wastewater Management	16
	Plan 4	17
	Plan 7	19
	Bibliography	21
SECTION III	SCHEMATIC DESIGN OF LAND TREATMENT COMPONENTS	22
	Introduction	22

TABLE OF CONTENTS (Continued)

		Page
SECTION III	Continued	
	Pumping Plants	24
	Design and Location	24
	Construction	25
	Transmission Tunnel, Drop and Lift Shafts	25
	Design	25
	Routing	26
	Appurtenances	27
	Construction	27
	Construction Timing	28
	Storage Reservoirs	29
	Design	29
	Construction	29
	Location	29
	Land Treatment Site	30
	Size and Location	30
	Special Considerations	30
	Irrigation System	31
	Description of Equipment, Design, and Operating Sequence	31
	Drainage System	33
	Description, Design, Installation and Operation	33
	Sludge Management	34

TABLE OF CONTENTS (Continued)

		Page
SECTION III	Continued	
	Miscellaneous	39
	Monitoring	39
	Administration Building	40
	Laboratories	40
SECTION IV	AERATED LAGOONS	41
	Process Description	41
	Aerated Lagoon Schematic Design	43
	Component Layouts	47
	Bibliography	49
SECTION V	WASTEWATER RENOVATION	50
	Typical Irrigation Management	54
	Irrigation Application, Solid-Set	56
	Aeration and Hydraulic Capacity	57
	Irrigation Application, Center-Pivot	63
	Nitrogen Applications	64
	Crop Utilization	65
	Bibliography	70
SECTION VI	COST ESTIMATION METHODOLOGY FOR RANGE OF ALTERNATIVES	72
	General	72
	Initial Costing for Comparability	72
	Capital Costs	75

TABLE OF CONTENTS (Continued)

		Page
SECTION VI	Continued	
	Operation and Maintenance Costs	76
	Land Costs	76
	Sources of Costing Information	77

LIST OF TABLES

		Page
TABLE IV-1	AERATED LAGOON NON-WINTER REMOVAL EFFICIENCIES	44
IV-2	AERATED LAGOON AND RESERVOIR: WINTER REMOVAL EFFICIENCIES	46
TABLE V-1	IRRIGATION WATER QUALITY	51
V-2	RENOVATION OF EFFLUENT WITH CARDINGTON-BENNINGTON SOILS BASED ON 75 INCHES/YEAR	52
V-3	RENOVATION OF EFFLUENT WITH MAHONING-ELLSWORTH SOILS BASED ON 90 INCHES/YEAR	52
V-4	RENOVATION OF EFFLUENT WITH MAHONING-ELLSWORTH SOILS BASED ON 150 INCHES/YEAR	53
V-5	RENOVATION OF EFFLUENT WITH CHILI SOILS BASED ON 60 INCHES/YEAR	54
V-6	DRAWDOWN AS AFFECTED BY TILE SPACING	59
V-7	DEPTH-FREQUENCY FOR SIX-HOUR DURATION RAINFALL	62
V-8	NUTRITIONAL ANALYSES OF SELECTED ANIMAL FEEDS	67
V-9	NUTRITIONAL AND CHEMICAL ANALYSIS OF REED CANARY HAY SAMPLES	68
TABLE VI-1	LAND TREATMENT: SUMMARY OF UNIT CAPITAL COSTS FOR FORMULATED PLANS	79
VI-2	LAND TREATMENT SUMMARY OF UNIT O & M COSTS FOR FORMULATED PLANS	82
VI-3	DETAILED CAPITAL COSTS FOR PLAN 7	97
VI-4	DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN 7	101
VI-5	DETAILED CAPITAL COSTS FOR PLAN 12	103
VI-6	DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN 12	113

LIST OF FIGURES AND CURVES

		Page
FIGURE II-1	LOW-FLOW CONDITIONS IN THE CUYAHOGA RIVER AND TRIBUTARIES	14-A
II-2	LOW-FLOW PROFILE OF THE CUYAHOGA RIVER BELOW LAKE ROCKWELL	14-B
FIGURE III-1	TUNNEL PROFILES TO WESTERN OHIO LAND TREATMENT AREAS	26-A
III-2	TYPICAL LAY-OUT: LAND TREATMENT SITE FOR A 4800-ACRE SITE	32-A
FIGURE IV-1	AERATED LAGOON SCHEMATIC FLOW DIAGRAM	43-A
FIGURE V-1	LAND AND RESERVOIR STORAGE REQUIREMENTS VS. APPLICATION RATES	57-A
V-2	REED CANARY GRASS COMMERCIAL FERTILIZER REQUIREMENTS VS. APPLICATION RATES	65-A
V-3	APPROXIMATION OF SOIL MOISTURE AND STORAGE CAPACITY FOR CARDINGTON-BENNINGTON SOILS	69-A
FIGURE VI-1	LAND TREATMENT SEQUENCE OF COST COMPONENTS OF FORMULATED PLANS - Initial Treatment In-Basin Final Treatment In-Basin	78-A
VI-2	LAND TREATMENT SEQUENCE OF COST COMPONENTS OF FORMULATED PLANS - Initial Treatment In-Basin Final Treatment Out-of-Basin	78-B
VI-3	LAND TREATMENT SEQUENCE OF COST COMPONENTS OF FORMULATED PLANS - Initial Treatment Out-of-Basin Final Treatment Out-of-Basin	78-C
CURVE A	CONSTRUCTION COSTS CONVERTED FROM O.C.E. CURVE	85
CURVE B	LINED MOLE TUNNEL CAPITAL COSTS	86
CURVE C	DROP SHAFT CAPACITY VS. TOTAL COST	87
CURVE D	FORCE MAIN CONSTRUCTION -- CAPITAL COSTS	88
CURVE E	CAPITAL COSTS FOR TUNNEL PUMPING STATIONS, UNTREATED SEWAGE	89

TABLE OF FIGURES AND CURVES (Continued)

		Page
CURVE F	STORAGE RESERVOIRS AND DETENTION PONDS CAPITAL COSTS	90
CURVE G	AERATED LAGOONS CAPITAL COSTS	91
CURVE H	CHLORINATION - CAPITAL COSTS	92
CURVE I	PUMPING STATIONS - IRRIGATION WATER	93
CURVE J	SEWER CONSTRUCTION - CAPITAL COSTS	94
CURVE K	SLUDGE MANAGEMENT, SLUDGE STORAGE (IN-BASIN) CAPITAL COSTS	95
CURVE L	SLUDGE MANAGEMENT, SLUDGE TO STRIP MINE AREA CAPITAL COSTS	96

ATTACHMENTS

ATTACHMENT A UNIT COST DEVELOPED BY LAND TREATMENT CONTRACTOR

SECTION I

INTRODUCTION

The planning and preliminary engineering of the land treatment components of the alternative plans developed during the Cleveland-Akron Metropolitan and Three Rivers Watershed Area Wastewater Management Survey Scope Study are presented in this technical appendix

The descriptions given relate to existing technology and agricultural practices found in various areas of the United States and the world None of the proposed components depends on new technological breakthroughs or future development.

Formerly it had been thought that the only thing new about the consideration of land treatment for the Three Rivers Basin, in terms of engineering, was the application of the technology on a massive scale for a major metropolitan area. However, study of the Melbourne, Australia, sewerage system has demonstrated that this belief was unfounded. Melbourne, Australia, uses land treatment for a population of 1.8 million people on an operating farm of some 27,000 acres. This sewage treatment facility has functioned successfully for more than 70 years.[1]

The layout of the land treatment components described in this appendix is based upon the particular hydrologic, geographic and topographic characteristics of northern Ohio. The results, however, are not far different from those which might be proposed for St. Louis, Detroit, Berlin, or other large metropolitan areas. This, of course, is not surprising because an advanced biological treatment plant in Cleveland would

---

[1] Due to limited farm size, a portion of the effluent receives only anaerobic/aerobic lagoon treatment before discharge to the bay.

bear considerable resemblance to such plants in other cities.

The development of present land treatment technology has included the detailed study and monitoring of three methodologies, which cover the full spectrum of soil types and application techniques.[2, 3] In addition, extremely wide ranges of pollutant loading have been used with consistently good renovation potential being demonstrated under proper management. For instance, the Paris, Texas, effluent loading included a biochemical oxygen demand (BOD) of from 550 to 900 ppm,[4] which is from 25 to 50 times the BOD concentration expected in normal municipal wastewater application. Yet 99 percent reduction in BOD has been experienced with annual application rates of more than 120 inches. At Paris, Texas, the overland flow method is used, which is considered to be the simplest and least sophisticated of the land treatment methods.

The three standard land treatment methods are given below:

Method	Characteristic Soil Type	Typical Soil Permeability Rates	Renovative Capacity
Overland Flow	Very Tight	0.1 in/day	High
Spray Irrigation	Moderate Permeability	2-5 in/day	High
Rapid Infiltration	Very Coarse	24-100 in/day	High

The overland flow method was discovered in Ohio in 1954 by accident by the Campbell Soup Company and used on a 300-acre site there. It is an effective substitute for conventional spray irrigation when the hydrological characteristics of the soil limit the movement of underground water.[4]

Rapid infiltration is practiced at Phoenix, Arizona, at the Flushing Meadows installation where rates of up to 24 inches per day are applied.[5] Spray irrigation was selected as one of six components in the 42+ MGD system designed for Muskegon, Michigan.[6]

The variations in soils and application rates are described here to demonstrate the wide range of conditions under which land treatment is feasible. Logic suggests that between the extreme soil types for which successful land treatment techniques have already been demonstrated, there is a vast number of soil and terrain conditions which can be used with combinations and modifications of the established techniques. Those chosen for the Survey Scope Study only scratch the surface. It is in this context that the reader should review this technical appendix.

Early-action projects, monitoring and research programs will bring to light new methods and refinements, which may be more economical, create greater benefits, and provide even more environmentally sound opportunities.

BIBLIOGRAPHY - SECTION I

1. Melbourne and Metropolitan Board of Works Farm, Melbourne and Metropolitan Board of Works, Melbourne, Australia, 1971

2. Christman, Russell F., and others at the University of Washington, Seattle, Washington, Assessment of the Effectiveness and Effects of Land Disposal Methodologies of Wastewater Management, Wastewater Management Report 72-1. Washington: United States Government Printing Office, 1972.

3. Reed, S. C. (coordinator), Wastewater Management by Disposal on the Land, Corps of Engineers, U. S. Army, Cold Regions Research and Engineering Laboratory. Hanover, New Hampshire, 1972.

4. "An Evaluation of Cannery Waste Disposal by Overland Flow Spray Irrigation," Final report on a study project prepared for the Campbell Soup Company by C. W. Thornwaite Associates, Publications in Climatology, Vol. XXII, No. 2, September, 1969.

5. Bouwer, Herman, Lance, J. C., and Rice, R. C. "Renovating Sewage Effluent by Groundwater Recharge." IN Proc., 16th Annual New Mexico Watershed Symp., Las Cruces, N. M., March, 1971, pp. 32-46. IN Hydrology and Water Resources of Arizona and the Southwest, Vol. 1, 1971, pp. 225-244. (Univ. of Ariz. Press, 1971). IN Proc., Land Spreading Conf., Orlando, Fla., July, 1971, Sect. 6.

6. Muskegon County Wastewater Management System Number One, "Cost and Performance Comparison for Alternative Treatment Systems, Aerated Lagoon--Spray Irrigation Facility Versus Two-stage Activated Sludge, Chemical Treatment and Filtration System." Bauer Engineering, Inc., Chicago, Illinois, April, 1971.

   See also: The Muskegon County Wastewater Management System, Bauer Engineering, Inc., Chicago, Illinois, July, 1971.

SECTION II

TYPICAL PLANS

The land treatment components which are described in the next section of this appendix are parts of an overall wastewater management system. Even though these components are described independently, one must relate each component to the system for proper perspective as to sizing, layout, and function.

The plans containing land treatment have been presented in detail in the Formulation Technical Appendix -- Development of Twelve Alternative Plans.[4] They are as follows:

Plan	Description	Per Cent Land Treatment
2	All Land, State Standards	100
4	All Land, NDCP Standards	100
5	Combination, State Standards	3.0
6	Combination, State Standards	49.4
7	Combination, NDCP Standards	3.2
8	Combination, NDCP Standards	75.5
9	Combination, NDCP Standards	41.5
12	All Land, NDCP Standards	100

To illustrate the roles and relationships of the various components, descriptions of three plans are presented below from the standpoint of land treatment. The other combination plans, which utilize treatment on land to varying degrees, include similar land treatment systems.

PLAN 12

This plan was developed around three basic design options: first,

land treatment of all municipal sewage and (design) storm runoff generated within the Three-Rivers Basin; second, aerated lagoons for secondary treatment prior to application on the land; and, third, the use of "in-basin" land treatment sites to the maximum practical extent, particularly including the treatment of all wastewaters generated by Akron within the Three-Rivers Basin.

The more densely urbanized areas along Lake Erie, where land treatment on a large scale is precluded by existing land use, would be served by collection and transmission facilities to carry the wastewaters to a land treatment site near the junction of Huron, Crawford, and Seneca Counties outside the Three-Rivers Basin. Preliminary treatment* would be given to sewage before it entered the Effluent Transmission Tunnel to the western treatment area, but secondary treatment, winter storage, disinfection, land application of the effluent, drainage of the irrigated lands, and recycling of sludge would all take place at the western area. The region of the Three Rivers Basin to be served in this manner would correspond fairly closely to Cuyahoga County and the portion of Lake County in the lower Rocky River Basin. The wastewaters to be transported to the west would include domestic sewage, compatible (pretreated) industrial wastes, separate storm runoff, and combined sewage from areas with combined sanitary and storm sewers.

The cities and new development which will exist in the upper reaches of the Rocky River, the Cuyahoga River, and the Chagrin River, would have their domestic and industrial wastewaters collected in conventional

---

*Consisting of screening and aeration.

manner, treated in aerated lagoons, and pumped to storage facilities for detention and subsequent application to irrigated land within the Three-Rivers Basin. The irrigated land would be tiled and the return flow collected for reuse.

Separate storm runoff would be collected, stored in detention basins, and then handled in one of two basic manners. The first method would be to pump from the detention basin directly to a winter storage reservoir, and then to adjacent land treatment areas for final treatment, collection, and reuse. The second method would include detention storage followed by release of the storm runoff at controlled rates into a sanitary sewer system outfall line or sanitary sewage aerated lagoon facility for secondary treatment during off-peak hours, combining the storm water with the domestic/industrial sewage for subsequent storage and land treatment as described above. The stabilized sludge from the aerated lagoons would be recycled to agricultural land situated in the general vicinity of the treatment works.

The wastewaters of the Three-Rivers Basin to be treated on western Ohio agricultural lands would have a system containing the following basic components.

a. A transmission tunnel with underground storage, the tunnel to be gravity flow to its terminus in the western Ohio land treatment area.

b. A pumping plant to lift the sewage out of the tunnel.

c. Aerated lagoons for secondary treatment at the western Ohio site.

d. Large reservoirs sized for winter storage and stabilization.

e. Irrigation land and facilities to apply the wastewater onto the land at controlled rates.

f. A renovation strata in the soil (living filter) where the secondary-treated effluent is given a high degree of treatment.

g. An underground artificial drainage system to collect the percolating waters and provide transportation of this collected water to appropriately selected points for subsequent reuse and/or discharge to surface water streams.

h. Stabilized sludge collection, transportation to appropriate lands for recycling and equipment to apply the sludge to the lands.

i. Pumps, pipelines, upground storage reservoirs, and recreational facilities related to taking advantage of reuse opportunities.

The secondary treatment would take place in biological treatment cells (aerated lagoons) which provide sufficient oxygen and mixing requirements for stabilization of the biochemical oxygen-demanding material in the raw wastewater. The effluent from these treatment cells would be similar in quality to that achieved by conventional secondary treatment.

Effluent from the biological treatment cells would flow to the storage lagoons, where the liquid would be stored for irrigation purposes. Storage lagoons provide flexibility in the system for periods of heavy rainfall or freezing. These storage facilities would provide additional treatment through waste stabilization. Wastewaters would be disinfected by chlorination before irrigation. Irrigation with the

effluent would follow the storage reservoirs. The wastewater and its constituents would be applied to the crops.

The aerobic soil zone provides advanced treatment for the wastewater. Organic matter is decomposed and utilized by the biological community living in the soil; suspended matter is filtered out by the soil particles; nutrients are utilized by the plants or precipitated out by the soil; and viruses are removed by oppositely-charged soil particles and are ultimately biologically decomposed. Significant nitrogen losses occur to the atmosphere.

The percolating water would be collected in pipes and channels, and reclaimed water then transmitted to appropriate points for reuse. The amount of water collected would essentially be that applied by irrigation plus rainfall, less total evapotranspiration.

Sludge Treatment. The sludge in the facultative cells of the aerated lagoon facilities would be removed periodically by specialized pumping equipment. The sludge in western Ohio would initially be applied to non-irrigated Cardington-Bennington soils in the general areas with deep plowing to improve the soil structure. In particular, the clay bulge in the B horizon would be treated with the sludge/deep plowing technique. It is anticipated that about 1,000 acres could be treated per year with the sludge generated in western Ohio land treatment area in the year 2020. However, some lands may be treated more than once, depending on the benefits as determined by further studies. It is anticipated that sludge would be made available to non-irrigated lands

in the vicinity on a pay-for-take basis from time to time once the benefits were fully demonstrated.

For the in-basin lands, the small amount of sludge generated outside of Akron will be applied to adjacent agricultural and open space lands by pressure injection with hauling paid for by the land treatment operator, unless a suitable market can be established for selling the sludge. Costs are based on the former assumption.

The sludge generated in Akron will be applied to lands to be irrigated in the future, but not initially irrigated, at a rate suitable to treat from 300 to 500 acres per year. By the year 2020, the Akron sludge would be used almost exclusively on recreational and non-irrigated farm lands in the Three-Rivers Basin and on agricultural lands adjacent to the land treatment site.

Storm Runoff from Outlying Urban Basins. Outlying basins slated for significant urbanization by the year 2020 will develop in a non-uniform density pattern, ranging from dense urban type clusters, growing incorporated communities, and some very light-density, single-family residences. The latter residences often may be at densities of one unit per one to ten acres.

Land planning and zoning will significantly diminish the present trend to urban sprawl because of the great expense of sewering and generally serving such low-density development, coupled with more stringent leaching field regulations.

Based on the above considerations, it can be assumed that urban storm runoff will be collected and treated from the truly urbanized areas. The light-density residential development of one unit per one to ten acres can be appropriately considered rural in nature, and storm runoff would not be collected and treated.

In cluster areas of development, where typical areas might be 50 to 100 acres in size, with densities of two to twenty units per acre surrounded by open space, storm runoff would be collected and treated locally, utilizing the adjacent open space in accordance with the general philosophy developed by the Chicago Metropolitan Sanitation District, which has been formalized in a regulation tied to issuance of sewer taps.

The storm runoff from the truly urbanized areas would be kept separate from normal stream flow from rural lands.

The "Mini-Border/Open Space" technique[3] would be used for storm runoff treatment in the separate storm water treatment facilities. Akron separate storm runoff would be collected and transported to the Summit County site. Land application would be at 150 inches per year over a forty-week period (280) days.

Storm Runoff from Central Urban Basins. While the urban runoff from outlying, and presently low-development, basins has been reduced from the annual runoff volumes, as presented in Haven & Emerson, Ltd's Phase I Report - Part B[2], the runoff volumes from metropolitan area basins such as in the Akron area (CU-48, 55, 56, 59, 62, 63, 66, 68, 69,

and 70) the Cleveland area, Medina area (R-34 and 35), and Kent (CU-51) have not been reduced from the H & E-computed figures. It is assumed that future development in these metropolitan areas would be sufficiently dense and uniformly distributed to require the collection of runoff from the entire areas. Thus, the full volume of storm runoff as computed is assumed to be collected and treated, even though significant reductions can be realized by institutional/political means.

Plan No. 12 has three patterns of storm water treatment, as follows:

1. Combined Storm Runoff. Detention is provided for release over a three-day period to the municipal sewage collection system during off-peak hours when capacity is available. Additional optimization would be appropriate for detention sizing.

2. Municipal STP-Treated Separate Storm Runoff. Detention is provided for a thirty-day period (0.16 x annual volume) before release to adjacent collector lines for conveyance to the central treatment facility. Here optimization is necessary to reduce detention storage to the one-year storm volume.

3. Separate Storm Runoff. Here, separate storm water facilities are provided. Storage in the basin is provided for the one-year design storm volume to be evacuated within three days to the winter storage reservoir prior to land treatment. There is no microstraining or other PCT plant-type treatment between detention and winter storage as with previous land treatment plans. The storm runoff designated as the average annual volume is fully treated in all instances.

Bottom deposits in the detention reservoirs would be treated as a "resource out of place" and provided at no charge to public and private interests for top soil and landfill purposes.

Combined Sewer Systems. There are many combined sewer overflows which discharge to the Cuyahoga River, Rocky River, and Lake Erie, which are significant sources of pollution. These overflows would be collected and stored at strategic locations in mined underground or covered surface storage for release at a selected rate into the combined sewer system or into new outfall lines to the transmission tunnel.

Low-Flow Augmentation. The total return flow from the western Ohio land treatment management areas would be of a large magnitude for the irrigation period. Depending upon the extent of reuse and transportation, this return flow would be distributed over numerous streams, primarily in the upper Huron and Sandusky River basins. Upground reservoirs may be provided where needed to equate supply to low-flow periods in the streams. Numerous recreational opportunities exist to be developed in conjunction with this reuse, including fishing, boating, swimming, and hunting. Wildlife refuge and bird habitats would also be included. Water supply potential for communities and industry would be enhanced.

Within the Three-Rivers Basin, the return flow from land treatment areas will beneficially raise the low flows of the upper Cuyahoga and the upper Rocky River.

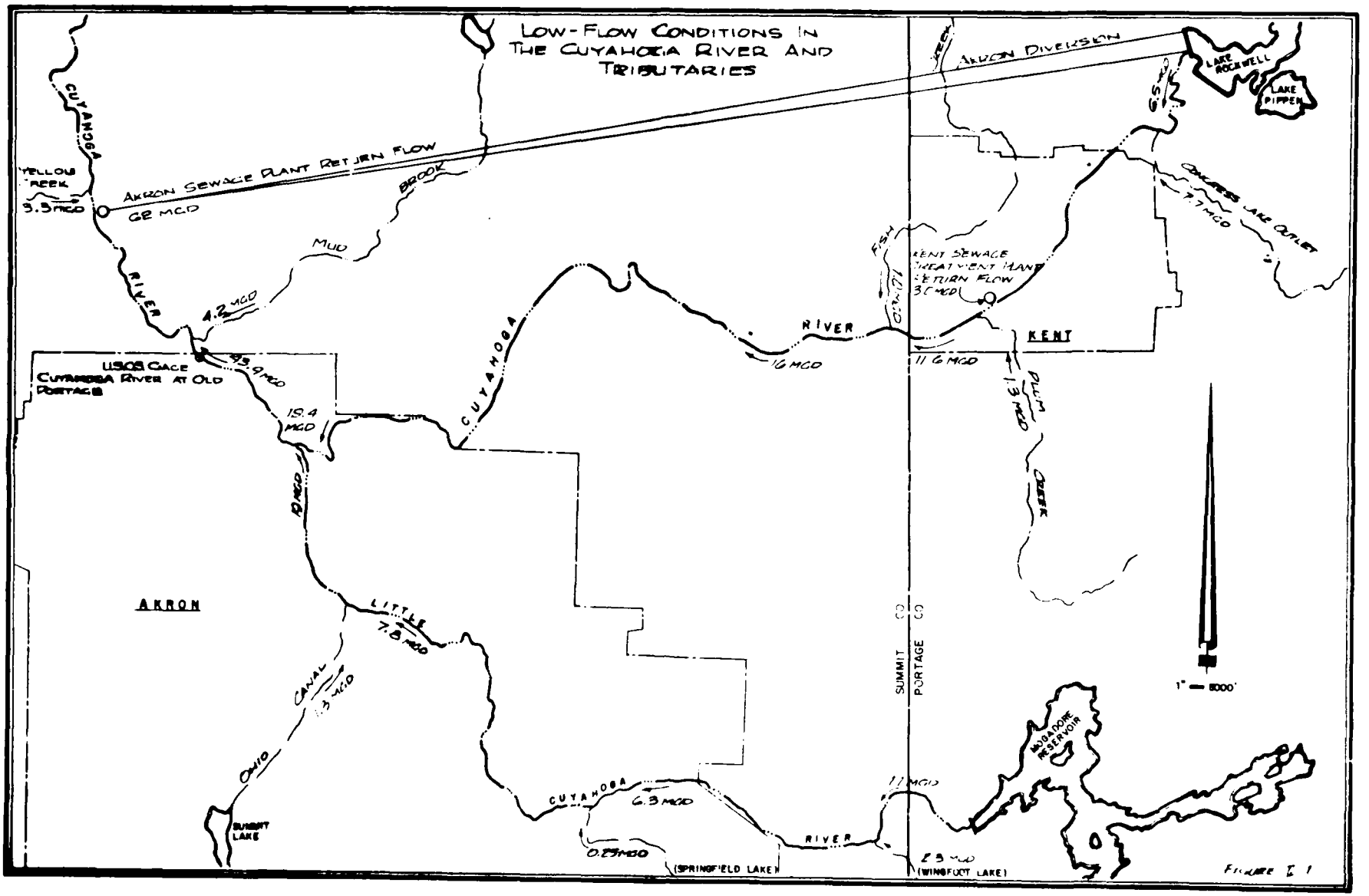
Low-Flow Aspects of the Cuyahoga River below Lake Rockwell -- Present Conditions. At present, the mainstem of the Cuyahoga River is subject to very low flows along the twenty-mile reach between Akron's principal water supply diversion at Lake Rockwell and the discharge point for the Akron Sewage Treatment Plant near the confluence of Yellow Creek with

the Cuyahoga River. Any sewage treatment plan which would affect either quantities or points of water withdrawal or return must give careful consideration to the effect upon the low-flow river regime within this critical reach.

The low-flow data are presented in map form in Figure No. II-1, attached. The basic source of these data was the Map Supplement to the Water Inventory of the Cuyahoga and Chagrin River Basins, published in 1959 by the Ohio Department of Natural Resources, Division of Water.[5] These data have, however, been updated to 1967 or 1968 in most cases, using a report prepared by H & E for the Three-Rivers Watershed District.[6]

Figure No. II-2 presents a low-flow profile of the mainstem of the Cuyahoga River from Lake Rockwell to its mouth. The reach of the river shown in Figure No. II-1 is indicated on the profile. This profile should be regarded as only illustrative of the general proportions of low-flow conditions and, in particular, of the impact of Akron's water supply and sewage facilities, but the absolute rates of discharge given should not be accepted as sufficiently defining particular low-flow problems.

The base flow or natural sustained dry-weather flow in the Cuyahoga below Lake Rockwell is relatively high for the size of the drainage basin as compared with other rivers in the Lake Erie Basin. This is due primarily to ground water discharge from extensive terrace deposits above Hiram and from highly permeable kames and kame terraces


LOW-FLOW CONDITIONS IN THE CUYAHOGA RIVER AND TRIBUTARIES
AKRON SEWAGE PLANT RETURN FLOW
6.2 MGD
AKRON DIVERSION
LAKE ROCKWELL
LAKE PIPPEN
6.5 MGD
YELLOW CREEK
5.5 MGD
CUYAHOGA RIVER
MUD BROOK
4.2 MGD
7.7 MGD
CUYAHOGA LAKE OUTLET
FISH CREEK
KENT SEWAGE TREATMENT PLANT RETURN FLOW
3.0 MGD
CUYAHOGA RIVER
16 MGD
KENT
11.6 MGD
13 MGD
PLUM CREEK
USGS GAGE CUYAHOGA RIVER AT OLD PORTAGE
19.9 MGD
19.4 MGD
BRIDGE
AKRON
LITTLE
7.8 MGD
OHIO CANAL
1.3 MGD
SUMMIT CO
PORTAGE CO
1" = 8000'
MOGADORE RESERVOIR
11 MGD
CUYAHOGA RIVER
6.3 MGD
0.25 MGD
SUMMIT LAKE
SPRINGFIELD LAKE
2.5 MGD
WINGFOOT LAKE
FIGURE I 1

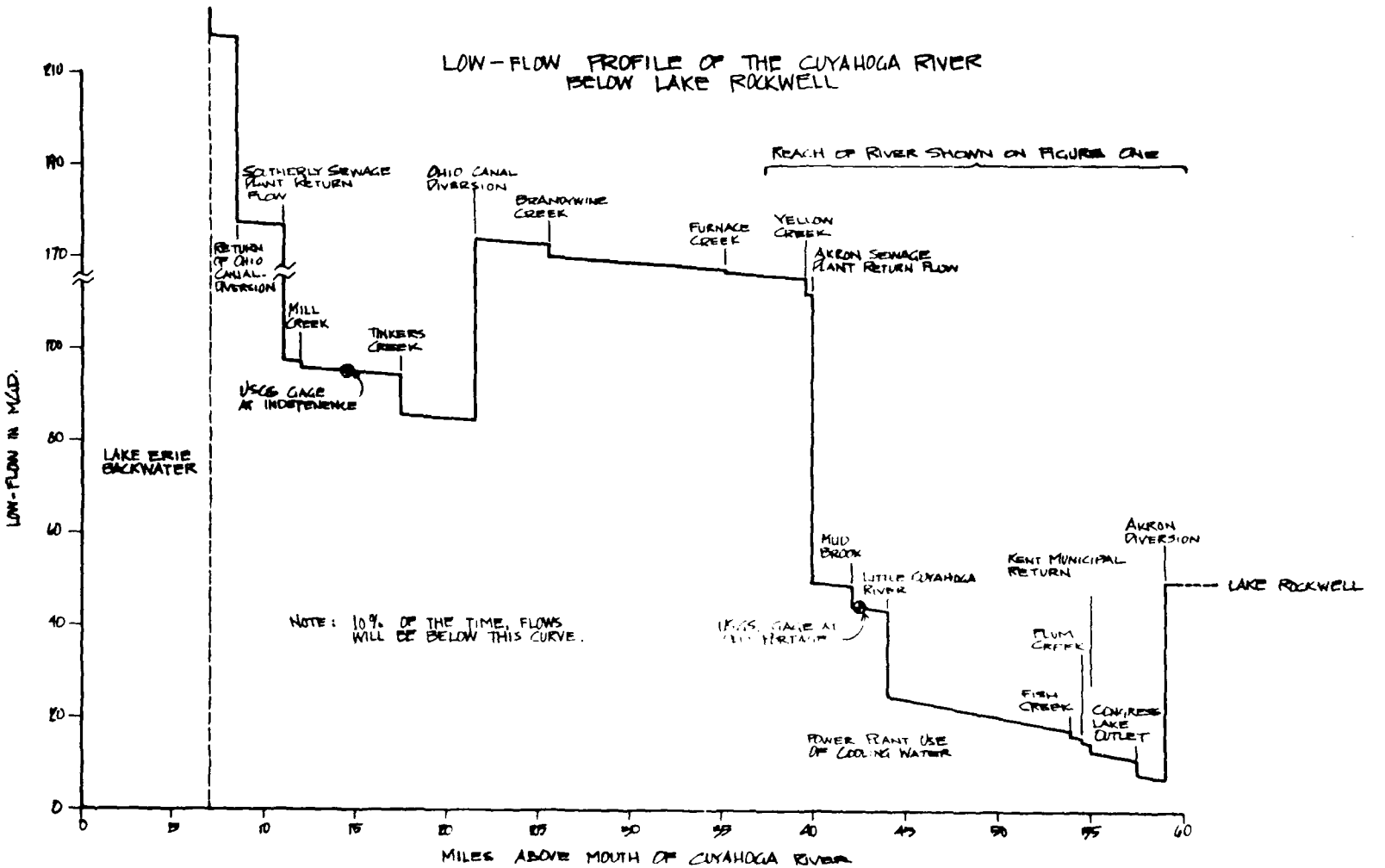

LOW-FLOW PROFILE OF THE CUYAHOGA RIVER
BELOW LAKE ROCKWELL
REACH OF RIVER SHOWN ON FIGURE ONE
LOW-FLOW IN M.G.D.
210
190
170
150
130
110
90
70
50
30
10
0
SOUTHERLY SEWAGE PLANT RETURN FLOW
OHIO CANAL DIVERSION
BRANDYWINE CREEK
FURNACE CREEK
YELLOW CREEK
AKRON SEWAGE PLANT RETURN FLOW
RETURN OF OHIO CANAL DIVERSION
MILL CREEK
TINKERS CREEK
USGS GAGE AT INDEPENDENCE
LAKE ERIE BACKWATER
MUD BROOK
LITTLE CUYAHOGA RIVER
AKRON DIVERSION
KENT MUNICIPAL RETURN
LAKE ROCKWELL
NOTE: 10% OF THE TIME, FLOWS WILL BE BELOW THIS CURVE.
USGS GAGE AT
PORTAGE
PLUM CREEK
FISH CREEK
CONGRESS LAKE OUTLET
POWER PLANT USE OF COOLING WATER
0
5
10
15
20
25
30
35
40
45
50
55
60
MILES ABOVE MOUTH OF CUYAHOGA RIVER

FIGURE II-2

drained by the Congress Lake Outlet.[7] This reach of the river, however, is now entirely regulated by upstream reservoirs and the diversion for Akron's water supply.

On frequent occasions, the withdrawal of water at Lake Rockwell curtails the passing of any water downstream, and the only flow in the river immediately below the dam is due to drainage from Twin Lakes, seepage from the reservoir, and the intermittent discharge of filter backwash water from the Akron intake, which may be operated from three to twenty times per day. During July and August of 1971, 28.6 and 32.3 million gallons, respectively, were relased from the backwash operation, giving an average of approximately one MGD flow from this source. In addition, effluent discharge from the new Twin Lakes Sewage Treatment Plant will shortly be contributing to the flow of the Cuyahoga at Ravenna Road a short distance below the dam.

Low-Flow Aspects of the Cuyahoga River -- Future Conditions. Increased water diversions by the City of Akron in the future will further deplete the flows of the Cuyahoga River. Thus, low-flow conditions in the reach of the river between Lake Rockwell and Yellow Creek, assuming that the current water management practices continue, will worsen.

Wastewater management in the Cuyahoga Basin needs to consider the ramifications of water supply to some extent, and comprehensive planning should incorporate all phases of water management and the hydrologic cycle.

Return flow of treated effluent upstream from Lake Rockwell will not improve low-flow conditions in the Cuyahoga River if Akron were to take the increased flows into its municipal water system as an additional supply. An agreement with Akron may be needed to forestall the diversion of new water intended for recreational purposes.

Non-Structural Means of Wastewater Management. Hand-in-hand with the physical works proposed in Plan D for wastewater management, non-structural measures would be employed. These include, but are not limited to, the following:

1. Roof-top ponding ordinances for Cleveland and Akron for storm runoff.
2. Flood plain regulation, basin-wide.
3. Upstream ponding regulations for new developments and urban renewal, including the "blue-green" technique of the Department of Housing and Urban Development.1
4. Cooling water recycling for power plants and industry.
5. Street cleaning ordinances and resolutions.
6. Reduction of use of de-icing chemicals.
7. Development of area-wide regulations on solid waste disposal management.
8. Land use regulations to limit and control unplanned urban sprawl.
9. Agricultural regulations related to winter fertilizer applications on frozen ground.

In general, the volumes of storm runoff which have been computed for the years 2020 and 1990 are high considering the likelihood of an

effective upstream ponding regulation being enacted within the next five years in the Three-Rivers Basin. Techniques of building and land development are available to reduce peak runoff to pre-development rates for the one-year frequency. Such ordinances are being adopted elsewhere with varying degrees of restrictiveness.

PLAN 4

This plan is similar to Plan 12 in that it proposes land treatment for all of the wastewaters, excepting particular industrial wastes, generated within the Three-Rivers Basin. Plan 4, however, differs from Plan 12 in the following respects: first, all secondary treatment would take place in activated sludge plants within the Three-Rivers Basin; second, to the maximum practical extent, sludges would be collected and piped to an area south of the Basin for reclamation of strip-mined lands; and, third, the secondary-treated effluent from a much larger area, including Akron, would be transported to the western Ohio land treatment area via the Effluent Transmission Tunnel.

In Plan 4, 87.2 per cent of the estimated flow of municipal sewage from the whole Three-Rivers Basin in the year 2020 would be transported to the western Ohio land treatment area. In addition, more than half of the storm water runoff which is projected to require treatment in 2020 would go to the western area. Detention storage would be provided in the basins-of-origin for this storm runoff with capacities of either 16 per cent of the annual runoff volume for separately storm-sewered areas, or equivalent to the one-year frequency

storm volume for combined storm/sanitary sewer systems. The stormwater would then be released at controlled rates to the secondary biological treatment plants, which, in turn, discharge to the Effluent Transmission Tunnel (E.T.T.).

These secondary treatment plants would discharge digested sludge through a network of pipelines to the strip-mined area in southeastern Ohio. The treated effluent from the plants would in most cases be dropped directly into the Effluent Transmission Tunnel, which traverses the Lake Erie shoreline, or into the southern spur tunnel, which extends from the E.T.T. up the Cuyahoga valley to the Akron treatment plant. In some cases, pump stations and short force mains would be needed to transport the plant effluent to a drop shaft into the E.T.T.

Once in the tunnel, the treated storm, sanitary, and compatible industrial wastewaters would flow by gravity to the terminus of the tunnel near the winter storage reservoir at the junction of Seneca, Crawford, and Huron Counties. A lift shaft and pumping plant at the lower end of the tunnel would raise the effluent to ground level. Operation of the winter storage reservoir and land treatment system would be similar to Plan 12.

In the upper reaches of the Three-Rivers Basin, where opportunities for land treatment are locally available, municipal sewage would be collected and given secondary treatment at 25 biological treatment plants before being pumped to storage reservoirs at the nearest land treatment sites. Sludge from these plants would be transported by

pipeline for strip-mined land reclamation where proximity to the trunk pipeline makes this practice feasible. Otherwise, sludge would be disposed of on adjacent agricultural lands within the Three-Rivers Basin.

Of the 77 storm runoff sub-basins which are not tributary to the E.T.T., 35 would be treated by releasing the storm water from detention storage basins to municipal sewage treatment plantsand thence to winter storage and land treatment within the Three-Rivers Basin. The remaining 42 sub-basins would be given screening and sedimentation and then pumped directly to separate winter storage reservoirs prior to disinfection and land treatment at higher application rates appropriate to the quality of the storm runoff.

PLAN 7

The overall wastewater management system proposed in this plan would make selective use of land treatment sub-systems for the smaller communities in the upper reaches of the Rocky, Cuyahoga, and Chagrin River basins. Sixteen municipal sewage treatment plants would provide secondary biological treatment prior to winter storage, disinfection, and application to nearby agricultural lands. Sludge from these plants would usually be applied to agricultural lands, although in two cases proximity to the main pipeline to the strip-mined area would make strip-mine reclamation the preferred means of sludge management.

Several of these sixteen municipal plants would be used for treatment of stormwater released from nearby detention storage reservoirs during periods of off-peak sanitary flows. This routing of stormwater

would be used in cases where the economic advantage lay with dual use of the treatment, transmission, and storage facilities provided for the municipal sewage. In addition, nine separate stormwater treatment plants, consisting of screening and sedimentation at the detention storage facilities, are proposed prior to direct transmission of the stormwater to winter storage reservoirs for subsequent disinfection and land treatment. These separate land treatment systems for storm runoff have been proposed to realize the joint benefits of lower transmission costs where municipal sewage treatment plants are distant, and of low-flow augmentation where the local availability of land treatment sites makes it possible to keep the renovated return flows high in the basins of origin. Bottom deposits from the separate stormwater detention storage reservoirs would be removed periodically with conventional machinery and made available for topsoil and landfill purposes.

The land treatment systems proposed in Plan 7 represent the simplest and most limited applications of this method. The components required are on a small scale, widely dispersed, and include only minor transmission facilities on or near the ground surface.

BIBLIOGRAPHY - SECTION II

1. Jones, D. Earl, "Urban Hydrology - a redirection," Civil Engineering-ASCE, August, 1967, pp. 58-67.

2. Survey Scope Study for Wastewater Management Program, Contract Phase Report, Phase I, Part B, Stormwater Runoff, Havens & Emerson, Ltd., Cleveland, Ohio, June, 1972.

3. Wastewater Management Survey Scope Study, Land Treatment Technical Appendix, Wright-McLaughlin Engineers, Denver, Colorado, November, 1972. (pp. 132-135)

4. Wastewater Management Survey Scope Study, Formulation Technical Appendix, Wright-McLaughlin Engineers, Denver, Colorado, Nov., 1972.

5. Water Inventory of the Cuyahoga and Chagrin River Basins, Ohio, Volume 2, Map Supplement. State of Ohio, Department of Natural Resources, Division of Water, Columbus, Ohio, January, 1959.

6. A Plan for Water Quality Management in the Central Cuyahoga Basin prepared for the Three Rivers Watershed District. Havens and Emerson, Ltd., Cleveland, Ohio, February, 1970.

7. Flow Duration of Ohio Streams, State of Ohio, Department of Natural Resources, Division of Water, Bulletin 31. Columbus, Ohio, January, 1959.

SECTION III

SCHEMATIC DESIGN OF LAND TREATMENT COMPONENTS

INTRODUCTION

This section contains a discussion of the design considerations for each component of the land treatment systems, whose overall relationships were described in the preceding section. The discussion of each component outlines the preliminary schematic design developed as a basis for cost estimates of the twelve alternative plans.

Each component of the system is discussed in the sequence in which it occurs as the wastewater being treated moves from its point of generation through pre-treatment in either conventional secondary sewage treatment plants or aerated lagoons on to a storage reservoir, and ultimately to the land treatment site. It will be noted that several of the components, such as force mains and pumping plants, are utilized at more than one place in the sequence. In the case of pumping plants, there is a variation in the actual type of plant used at a particular point in the sequence of components.

Sketches showing details of some of the components have been included. The basic planning components of the land treatment system are listed briefly below.

1. Secondary Treatment Facilities. (Prior to land application for tertiary treatment)
   - A. Using conventional sewage treatment plants
   - B. Using aerated lagoons.

2. Transmission Facilities.

   A. Pumping plant (where force main to tunnel is required).

   B. Force main and/or drop shaft and tunnel.

   C. Lift station secondary pumping plant at tunnel lift shaft.

   D. Force main to storage reservoir.

3. Storage Reservoir.

   A. Reservoir for winter storage.

   B. Reservoir aeration.

   C. Disinfection.

4. Land Treatment Site.

5. Irrigation System

   A. Pumping plant.

   B. Force mains.

   C. Application equipment and distribution piping.

6. Drainage System.

   A. Artificial subsurface drainage.

   B. Conduits and/or canals.

7. Sludge Management Facilities.

8. Miscellaneous (Monitoring, administration buildings, laboratories).

The components vary for each particular installation in this study; however, the basic functions and layout follow a pattern and have enough similarity so that the following component descriptions are generally applicable.

PUMPING PLANTS

Design and Location. Several types of pumping plants are utilized in connection with moving either treated effluent or raw sewage from conventional sewage treatment plants or collection points to successive treatment component process points enroute to final land treatment.

Conventional-type centrifugal pumping plants are utilized at the upstream ends of force mains to move the treated effluent into the tunnel or out to local storage facilities in-basin, as the case may be. To move raw sewage, a centrifugal, sewage/trash-type pump is utilized.

To move effluent or raw sewage out of the tunnel at its terminus, another type of vertical pump must be utilized to effect the lift to the surface. Here again, there are two types of pumping arrangements, one for effluent and the other for raw sewage, both with total lifts of up to 700 feet.

For the treated effluent, the tunnel would terminate in a concrete-lined basin at the elevation of the tunnel. Vertical turbine pumps would be placed in a lift shaft, or shafts, directly over the reservoir and used to lift the effluent to the surface and into the nearby storage reservoir. Another possibility would be to drill a series of wells through the top of the tunnel near its terminus at well-spaced intervals and to lift the effluent to the surface directly from the tunnel and thence into the nearby storage reservoir. The former was priced.

For the raw sewage, the tunnel would end in a concrete-lined clear well. From the clear well, suction pipes would take the raw sewage to

an underground dry well-type pumping plant. The pumps would be horizontal, centrifugal, sewage/trash-type and would pump the raw sewage to the aerated lagoons on the surface close to the tunnel terminus.

For finally pumping effluent from the storage reservoirs to the irrigation equipment which applies it to the land, a relatively low-head vertical turbine-type pump is utilized.

Construction. The physical facilities for housing the pumps for the latter type of service would be of typical farm-use design, and, in many cases, the entire facility would be pre-fabricated. The pumping plant at the tunnel terminus or the pumping plants feeding effluent or raw sewage through force mains into the tunnel, or those pumping directly from collection points or secondary treatment plants to in-basin land treatment storage reservoirs, would be of conventional sewerage industry design and construction.

TRANSMISSION TUNNEL, DROP AND LIFT SHAFTS

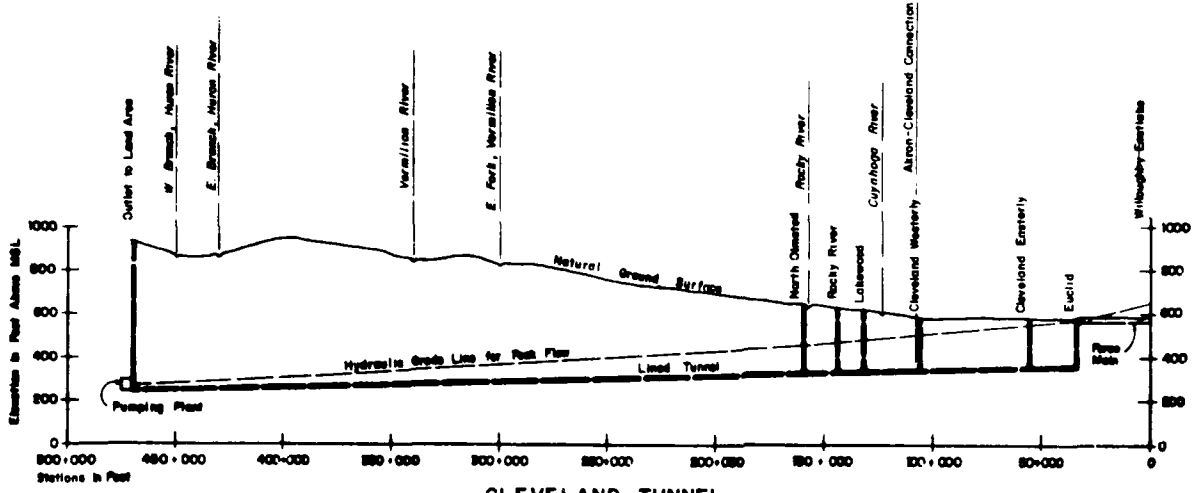
Design. The design of the tunnel portion of the conveyance system to the western land treatment site is based on projected 2020 total stormwater and municipal flows. The construction of two smaller tunnels, time-phased, may be selected in lieu of one larger tunnel. The tunnel is fully lined.

The tunnel has been sized to handle the cumulative peak sanitary flows from the various treatment plants connected to it; that is, about twice the average daily flow. Sufficient capacity is thus provided to absorb the daily maximum stormwater flows which may be anticipated under the stormwater flow design criteria.

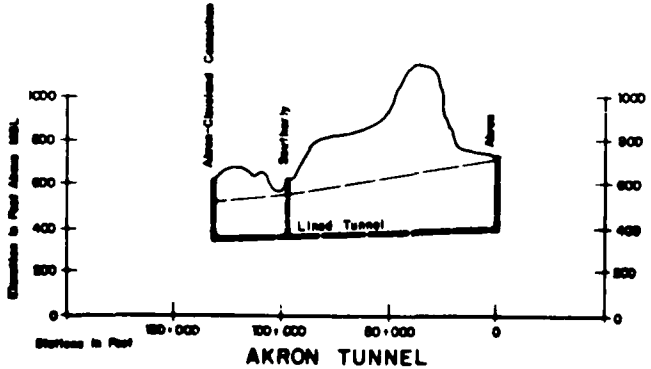
For main lines feeding into the tunnel proper from several treatment plants not directly on the tunnel route or beyond the starting point of the tunnel, force mains and pumping stations were utilized. In these cases, gravity-flow mains appeared uneconomical due to depth of excavation required for proper gradients.

Routing (As in Plan 12 for discussion purposes.) The tunnel starts at the Euclid Treatment Plant where raw sewage, after having received preliminary treatment, is routed by drop shaft into the tunnel. The flow, via force main, from the Willoughby-Eastlake Treatment Plant also enters the tunnel through the Euclid drop shaft. Following preliminary treatment, the flow from six other shoreline plants successively enters the tunnel route as it proceeds in a southwesterly direction toward the western Ohio land treatment area. The flow from the last three plants (Lakewood, Rocky River, North Olmsted) served by the tunnel is delivered through individual force mains to drop shafts into the tunnel, as in the case of Willoughby-Eastlake. See Figure III-1.

The tunnel, having collected the flows from the eight shoreline plants, then goes directly to the site of the large aerated lagoon complex which is centrally located within the western Ohio land treatment area. During the course of accumulating flows from the various plants along its route, the tunnel increases in size from an initial diameter of eight feet to a diameter of eighteen feet at the point where a twelve-foot diameter stub tunnel from the Southerly Treatment Plant enters the main tunnel route. The eighteen-foot diameter then continues



CLEVELAND TUNNEL



AKRON TUNNEL

Figure II-1
TUNNEL PROFILES
TO
WESTERN OHIO
LAND TREATMENT AREAS

to the western terminal point of the tunnel, as described above. At this point, the effluent is pumped out of the tunnel through a lift shaft.

Appurtenances. The force mains, drop shafts, and lift shafts appurtenant to the tunnel proper have already been mentioned in the discussion above. Aeration is provided in the tunnel at ten-mile stations.*

Final ingress of effluent to the tunnel is by means of a series of drop shafts sized to satisfy the flow requirements from the various treatment plants being served by the tunnel. Where plants are located in close proximity to the tunnel, flows can usually go directly into a drop shaft over the tunnel. Where plants are at some distance from the tunnel, it is then necessary to introduce the use of a force main through which the effluent from the treatment plant is pumped to a drop shaft located at the tunnel.

Construction. The tunnel construction would commence at a series of shafts so spaced along the alignment as to afford access to that number of work crews deemed essential for the completion of the tunnel within a reasonable length of time. One such possibility would be twenty-mile spacing of shafts, which would allow access for eight crews, each pair working simultaneously toward a meeting point ten miles distant. Once the access shafts had been driven to the required subterrannean elevations, actual excavation of the tunnel could be accomplished, using either conventional mining methods or by the use of mechanical moles. Some of the construction access shafts would revert

---

*For Plans 9 and 12 only.

to future-use aeration or drop shafts for the wastewater effluent or raw sewage to be conveyed, depending upon the sequence of the treatment method ultimately selected.

The tunnel affords gravity flow and can be surcharged if desired by means of underground storage chambers strategically located at points close to and at a higher elevation than the tunnel itself. The force mains referred to are pipelines under pressure located in available rights-of-way, either above ground or just below ground, following the general contour of the ground to be as inconspicuous as possible, consistent with engineering design requirements.

Construction Timing. Due to the magnitude of any construction effort necessary to install transmission tunnels of varying sizes, it is essential that the chronological date at which time a "no discharge of critical pollutants" or other wastewater standard is to be achieved, be compared with the lead-time required for construction of the tunnel facility. A preliminary analysis has indicated that a four-year lead-time would be required to construct a large diameter tunnel for a distance of some eighty miles, as is contemplated in at least one of the wastewater management plans now formulated.

This construction lead-time period will have a direct bearing on any phasing decisions to be made regarding phasing out of present treatment facilities, as well as the timing for bringing on-line new facilities designed to meet the higher effluent treatment standards.

STORAGE RESERVOIRS

Design. Storage reservoirs, required primarily for winter storage of effluent in the land treatment system, actually serve a three-fold purpose. The system must provide storage capacity for the treated effluent which continues to be generated between irrigation seasons when it cannot be utilized effectively. This storage capacity enables the reservoir to serve a second purpose as an equalizing reservoir should any situations arise during the growing season which restrict the flow of effluent for short periods of time. The third purpose served by the reservoirs is the further removal of suspended solids and reduction of BOD, thereby polishing the effluent prior to its final treatment on the land.

The reservoirs are designed as earth embankment structures, riprapped as needed, with concrete inlet and outlet structures, access roads, and fencing. Sites with relatively impervious sub-soil were preferred, in order to minimize the need for any lining of the reservoirs.

Construction. The volume of earth needed for the embankment is to be borrowed from the interior of the reservoir area. Dependent upon topography and availability of land area, storage facilities inside the Three-Rivers Basin area may be constructed in natural depressions or off-stream channels.

Location. The reservoirs are usually centrally located within the land treatment areas which they serve, in order to optimize piping and pumping

layouts, especially when large land areas are involved. For smaller areas inside the Three-Rivers Basin, the reservoir may be located at the periphery of the land area or close to the secondary treatment plants or aerated lagoon treatment facilities, depending upon the type of secondary treatment utilized prior to final land treatment.

LAND TREATMENT SITE

Size and Location. The size and the location of the land treatment site selected for use in the sequence of components comprising the land treatment system are interrelated variables. A comprehensive review of the necessary data presenting the parameters which relate to the suitability of a particular soil association for use in land treatment must first be undertaken. Once a soil association has been identified as having the necessary qualities suited to use for land treatment, it must also exist in sufficient acreage to support the treatment of the particular volume of wastewater ultimately to be generated in the immediate vicinity. Should this not be the case and land treatment is still desired, the wastewater will then have to be transmitted to another geographic location where land of suitable quality, and in sufficient acreage, does exist. Thus, the need arose, in several of the plans formulated for the study area, to transport the wastewater generated by the Lake Erie shoreline plants to a western Ohio land treatment area.

Special Considerations. Having generally located a suitable land treatment area geographically, the existing and projected land use must be considered. The net area available for land treatment must then be

determined, and it is this net area which must be able to support a selected wastewater application rate based on a number of parameters, including the average rainfall in the area under consideration.

It was generally observed that about 70 per cent of the rural land area comprising a particular land treatment area is usable for land treatment under the condition that existing residents and features are not relocated. Of the net area designated for land treatment purposes, it is estimated that 92 per cent will actually be irrigated, based on typical private farm operations in the west.

The land finally designated must then be acquired in fee simple, or some other acceptable arrangement must be made for its use for the intended purpose. The inhabitants of the land may or may not all have to be relocated, as the next step in the site preparation process, depending upon the configurations chosen for the irrigation system equipment and method of application of the nutrient-enriched wastewater.

The final step involving actual physical preparation of the site would now take place. This could include tree removal, grading, and installation of access roads. The land would then be ready for installation of the irrigation system component described in the next section.

IRRIGATION SYSTEM

Description of Equipment, Design, and Operating Sequence. Once the necessary land area suitable for land treatment by irrigation methods has been located and the right to its use acquired through a satisfactory method,* the irrigation system equipment and distribution piping would

---

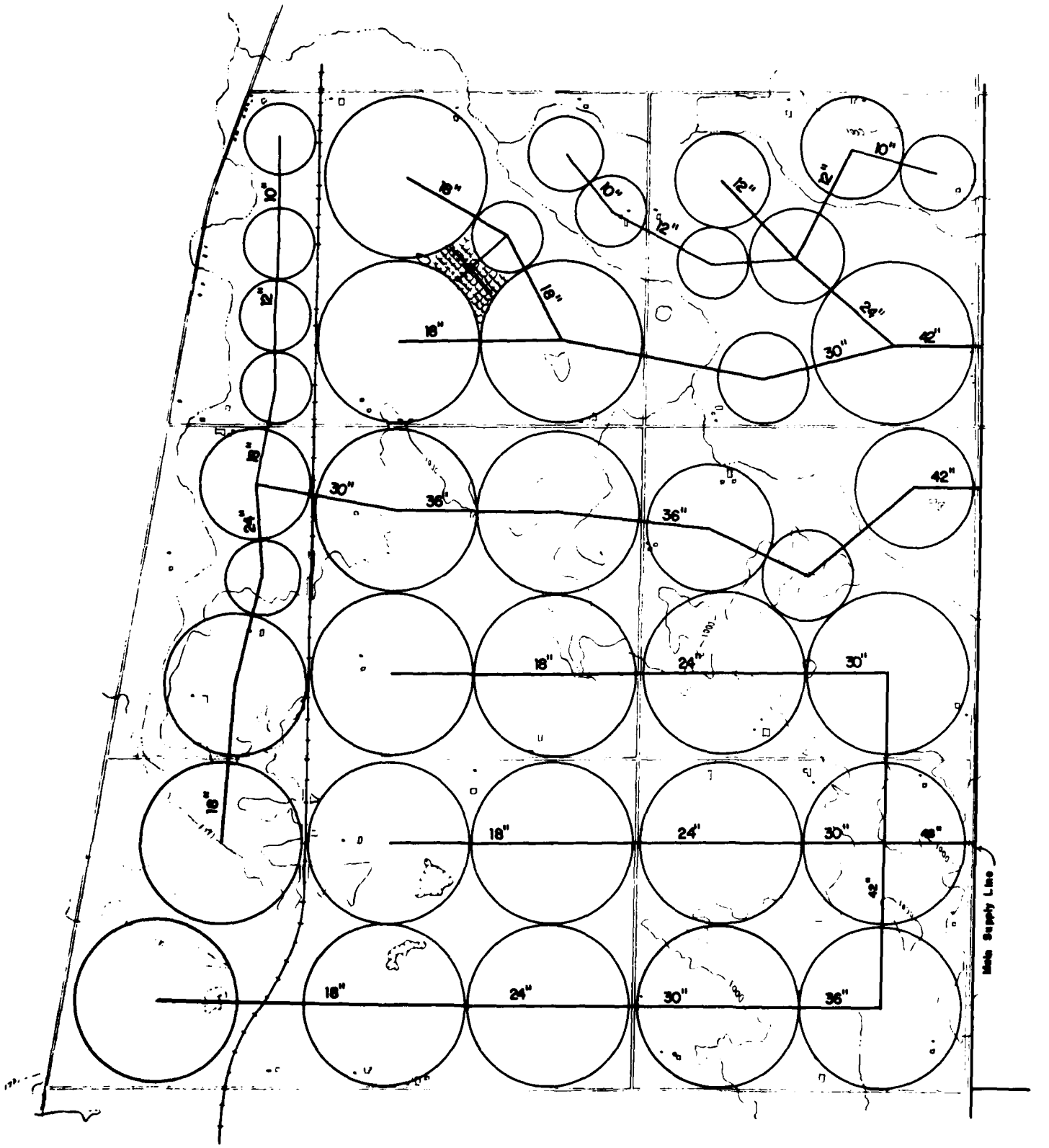
*Long-term lease, fee simple acquisition, or some combination, dependent upon institutional analyses.

be installed.

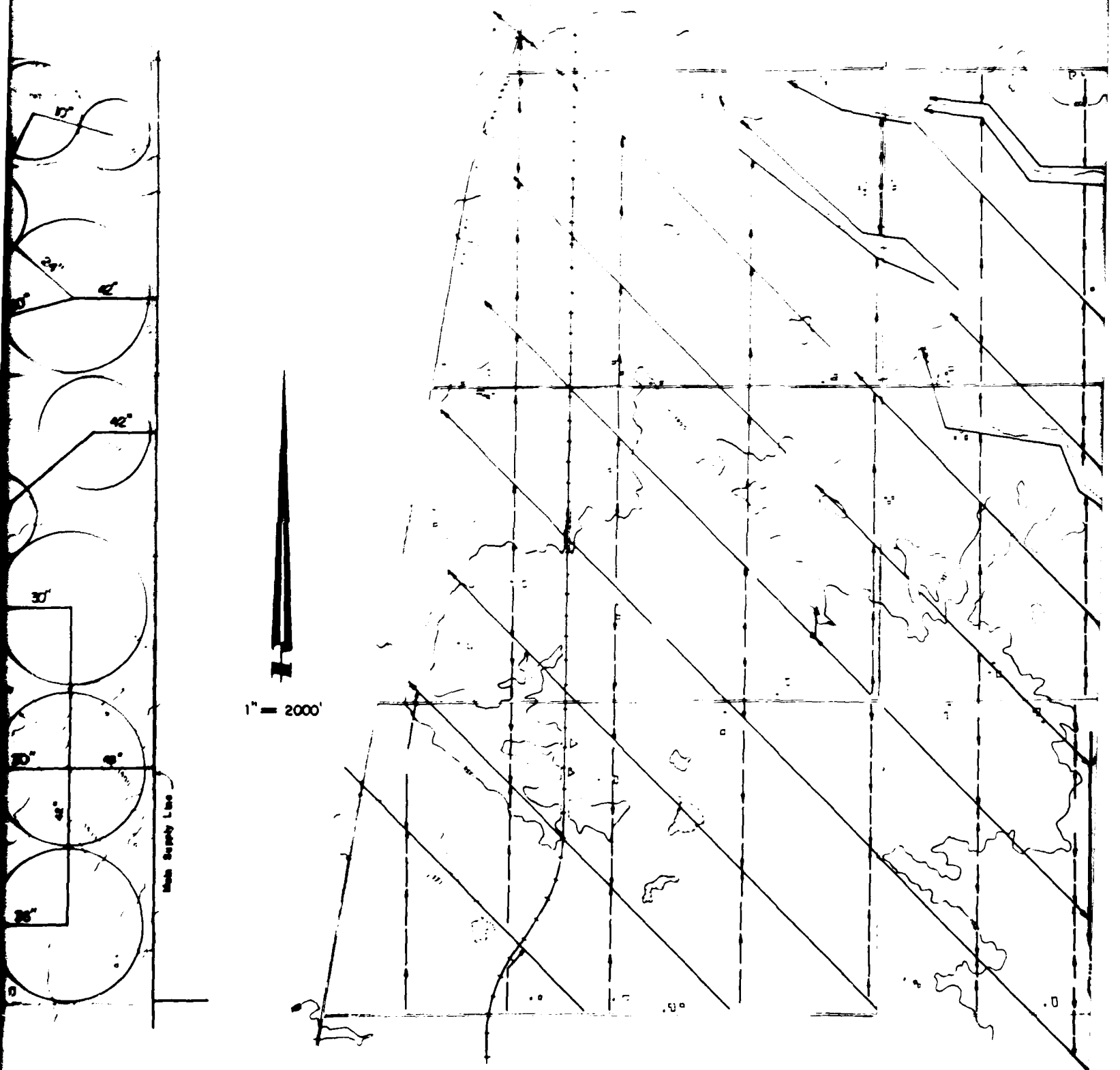
The principal type of irrigation equipment to be used can best be described as a center-pivot irrigation rig. This rig consists of a series of articulated truss spans extending from one central point called the pivot. Located at the outer end of the first span and at the end of each additional span is an electrically-driven wheel arrangement. The speed of rotation of the entire rig around its center pivot can be electrically controlled through the variable speed of the individually-controlled wheels. The outer end of the rig will be traveling at a greater circular speed than any point closer to the pivot. Each rig can cover increments of areas up to a total of 300 to 400 acres for the largest size rig.

The wastewater effluent from the storage reservoir is fed to the center pivots of those rigs being sequenced for use at any particular stage of the operating program for the entire area under irrigation. One or more pumps, depending upon the size of the system, take effluent from the storage reservoir and then pump it through a force main into the distribution piping network, terminating at the series of center pivots discussed above. See Figure III-2.

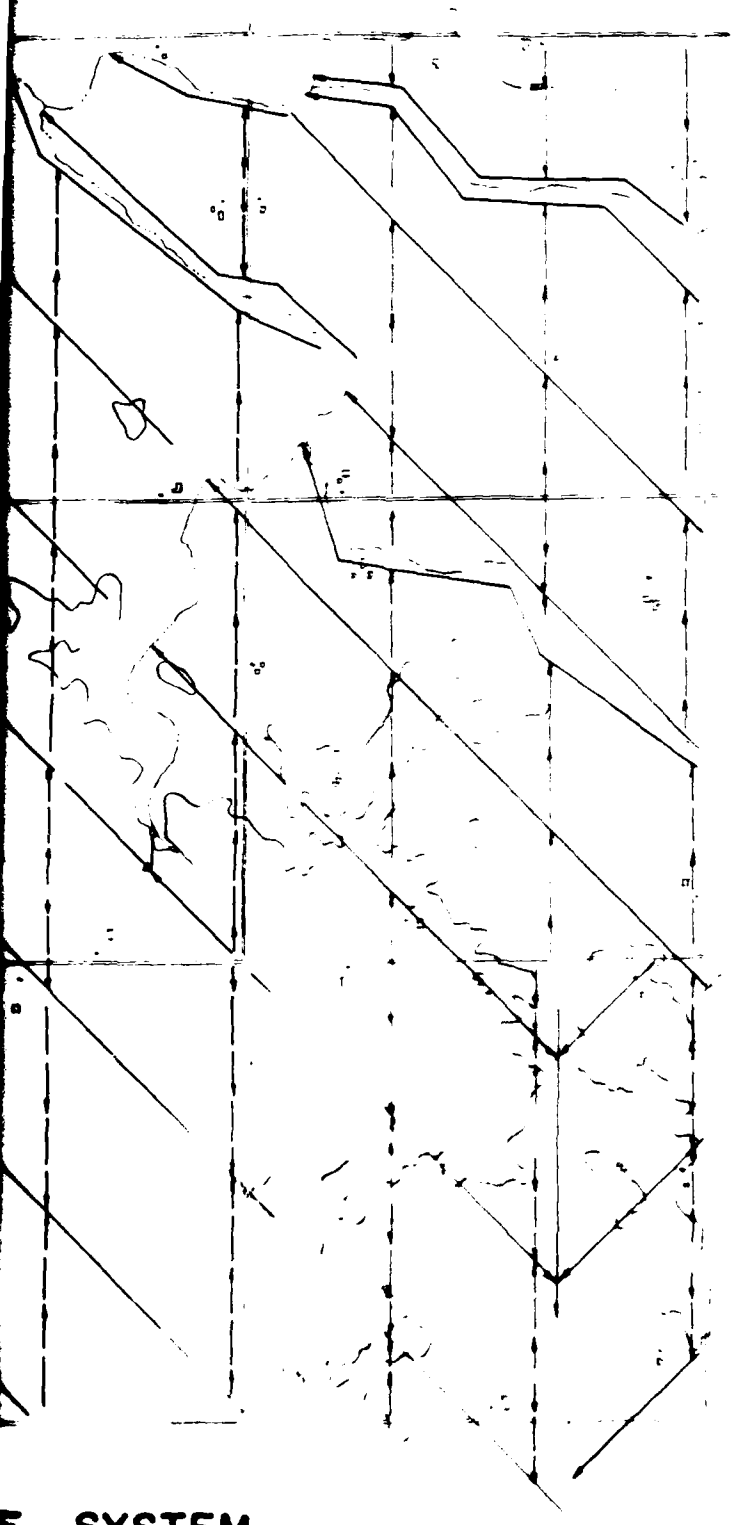
As the water issues from the center pivot, it flows radially through a properly-sized pipeline to individual spray nozzles, drip tubes, or other fixtures mounted at intervals along the trusses between the electrically-controlled drive wheels. The applicators are sized to produce a uniform application rate of effluent over the



IRRIGATION SYSTEM



DRAINAGE SYSTEM



NOTES:
Drain Laterals are spaced at 20-foot centers at depths varying from 36 to 42 inches and are made of 3-inch corrugated plastic pipe

LEGEND

- Pressure Pipe
- Pivot Irrigation Rig
- Solid-Set Sprinklers
- 3" Plastic Pipe
- Collectors or Mains
- Streams or Drainage Channels

Figure III-2

TYPICAL LAY-OUT

LAND TREATMENT SITE

FOR A
4800-ACRE SITE

E SYSTEM

entire area under command of the rig.

The effluent after leaving the applicators reaches the ground surface beneath the rig and percolates through the "living filter" of soil, nourishing the particular crop under cultivation. The volume of water in excess of the crop needs then finds its way into the artificial subsurface drainage network, to be described in the next section.

DRAINAGE SYSTEM

Description, Design, Installation, and Operation. Directly beneath the land area surface being irrigated, as described in the previous section, there is to be installed an artificial drainage system. The depth to the tile utilized in this system is determined by a number of factors, including the depth of the various soil horizons encountered, as well as the permeability of the soil.

The tile lines are sized according to the volume of flow anticipated. Tile lateral lines at spacings dictated by soil characteristics are connected to a series of headers and thence to main lines, all collecting the return flow of the effluent after it has passed through the soil filter, just as a network of lines had previously distributed the effluent to the irrigation equipment for application to the soil surface above.

Recent advances in technology should allow installation of inexpensive plastic pipe drain lines by means of laser-operated equipment to assure uniform depth. A nylon envelope has also been developed

for simultaneous installation with the plastic pipe, which enables good control of silting in the drain lines.

Once installed, the drain lines themselves will provide relatively trouble-free operation. The combined flow from the entire drainage system of any one land treatment area will require monitoring as to quality for possible re-cycling of some portion of the flow during certain periods of time, such as in the case of a tile line break.

It is proposed that the return flow be otherwise handled in one of several different ways, depending upon hydrologic conditions existing from one growing season to the next. The flow can be used to augment local stream flow directly; it can be stored in upland reservoirs and then released at strategic intervals for stream flow augmentation; it can be returned to its basin of origin via conduit if need be; or it can be sent directly to Lake Erie via conduit or canals should the volume of flow generated exceed the capacities of the streams in the immediate vicinity of the land treatment site.

SLUDGE MANAGEMENT

The disposal of the solid by-products of wastewater treatment is not, strictly speaking, an integral part of the various systems for the final treatment of the liquid effluent. Accordingly, the responsibility for design and costing of the sludge management subsystems was assigned to either the Domestic and Storm Runoff Contractor (Havens and Emerson, Ltd.) or the Land Treatment Contractor (Wright-McLaughlin Engineers), depending upon the method of disposal

determined for each case in the formulation of the twelve plans. Whenever sludge was to be disposed of by incineration, and subsequent landfill, the process was costed by Havens and Emerson, Ltd. Wright-McLaughlin designed and costed the sludge management components, wherever the choice was disposal on agricultural or strip-mined lands, regardless of whether the sludge was generated in plants or aerated lagoons preceding land treatment of the effluent, or whether the stabilized sludge was produced in the course of all water-based treatment.

The twelve formulated plans require a variable mix of three sludge management methods. (Use of traditional landfill methods using partially stabilized and concentrated sludge has been declining in popularity in recent decades in urban areas. The increasing amounts of sludge to be disposed of, coupled with the decreasing availability of "land to be consumed" at reasonable distances from the source, have contributed to this trend. Water pollution problems associated with landfill operations within the Three-Rivers watershed also militate against landfill with partially stabilized sludge.) Factors influencing the choice of sludge disposal include the individual sewage treatment plant size, location and method of secondary treatment selected for the influent wastewat as well as capital and operating costs, sludge characteristic., land availability, and possible uses as a soil conditioner or fertilizer.

Selection of a particular method of sludge disposal involves individual consideration of the various factors involved. Among these

are the existing eutrophication in Lake Erie, which would be further aggravated by disposal there; the environmental objections to disposal by discharge into streams; the humid continental climate of northeastern Ohio favorable to biological processes necessary in land disposal; the already existing high degree of urbanization of the area; the severity of existing air pollution; the domestic and/or industrial sludge characteristics; the relative proximity of strip-mine areas amenable to use for disposal.

With the above considerations in mind, the three methods of sludge management used in the formulated plans are briefly described below.

> Incineration. This method is generally less costly than traditional landfill, even with disposal of the resultant ash to landfill. During the incineration process, the temperature of the exhaust gases must be raised to about 1500 degrees Fahrenheit to eliminate noxious odors, toxic by-products, and vaporize the remaining water in the sludge. An additional fuel, such as natural gas, is required. Fly ash and sulfur dioxide are mostly removed by wet scrubbers, but other contaminant problems are solvable to varying degrees.
>
> At best, it is an inefficient, negative process requiring constant attention and practical only on a large scale. Economic advantages must be carefully weighed against the severe economic and environmental drawbacks when comparing incineration with alternative methods of disposal.
>
> Agricultural Application. This is an age-old method wherein organic matter and plant nutrients provide needed materials for current crops, while also helping to rebuild depleted soils. Optimum rates of sludge application must, however, be determined to avoid buildup on the soil of elements detrimental or toxic to plant life.

Sludge application crop land is likely to prove the best disposal method under amenable physical conditions and well-managed application for optimum results, including monitoring of key elements and crop rotation. A relatively small amount of land is involved for the annual volume of sludge produced and the time period in years between regulated applications could be in the magnitude of from ten to twenty years.

Strip-Mine Application. The desolate condition of 200,000 acres of strip-mined lands in south-eastern Ohio provides an opportunity not only for sludge disposal but also for rejuvenation of the land and its return to productive use. Enactment of new laws requiring some restoration of these lands may be necessary to facilitate and promote the application of heavy doses of matter with a high pH (to neutralize acid conditions), high organic content, and high content of plant nutrients, such as sewage sludge.

The existence of an abandoned coal slurry pipeline, with attendant right-of-way, already extending from the Cleveland area to the heart of the strip-mined lands, makes 75,000 acres accessible. Legal difficulties might well be minimized in the construction of necessary pipeline and distribution facilities.

Use of new methods of injecting sludge in depth could make possible sustained yield of heavy plant growth not possible by mere surface application. Surface application alone of 100 dry tons/acre of sludge would be to a virtually unlimited depository, especially if strip-mining continues.

Disadvantages of land disposal would become lost in the overwhelming acidity and metal content of the strip-mine soil, leading to many beneficial ecological results. Due to needs for land leveling and rock removal if used for agricultural purposes, the lands might best lend themselves to wildlife and recreational purposes wherein woodlands and numerous restored ponds would exist.

Agricultural Facilities. The stabilized sludge from the facultative lagoons would be dredged at two to ten year intervals. This would be an annual, though seasonal, operation in western Ohio.

Thence, sludge would be transmitted via pipeline to a central listribution point with about five miles of lagoons, where a sludge holding tank would provide one to two days storage. From there, sludge would be pumped in temporary lines to fields where tractors pulling pressure injection plows would place ten to forty tons per acre at the selected depth, generally about eighteen inches. Each plow would have from six to ten injectors. Supplying the sludge by tank truck would be an alternative to the temporary pipeline.

Stabilized sludge from the smaller in-basin facultative lagoons would be removed at infrequent intervals under contractual arrangements with local sludge handlers, who, in turn, would arrange for the lands to be treated. Transportation would generally be by truck because of the smaller volume involved.

Deposition in earthern storm drainage detention ponds, based upon existing practice, would be removed once each five to ten years for topsoil and landfill operations. Utility trench backfilling material can be expected to have a sale value of about 25 cents per cubic yard.

Strip-Mined Facilities. Sludge recycled to strip-mined lands are transported via permanent pipeline serviced with high-pressure pumps. Sludge is three to five per cent solids. The pipeline terminus is at a sludge holding facility sized to provide storage during inclement weather, and when ground freezing exceeds about three inches. Temporary pipelines from the storage facility deliver sludge to the current workings. The strip-mined lands are shaped, if necessary, and the sludge injected as with the agricultural tractors and plows. Application rates from 40 to 100 tons per acre are anticipated. A second application, using a "water winch" technique would be made about three years later if deemed necessary.

Harrison County Potential Farm Land. The upgrading of virgin, but nearly sterile, potential farm land is the sandstone area in and near Harrison County provides a large acreage needing sludge treatment.

> The sludge would be both injected and applied on the surface with a first-year application of about 40 tons per acre, with subsequent applications of perhaps from five to ten tons per acre. Land management would be aimed at building an organic soil content with suitable nutrients, which could maintain itself without regular sludge applications after about five years of initial treatment. Ideally, this land should be given the benefit of sewage effluent as well, so that the farmer would not need to depend upon artificial fertilizers following the end of sludge applications.

MISCELLANEOUS (Monitoring, Administration Buildings, Laboratories)

Monitoring. The nutrient-enriched wastewater effluent being dispatched to land treatment areas to be used for irrigated agriculture would be free of excessive concentrations of toxic or undesirable constituents. Also, to ensure proper knowledge of the concentrations of the various constituents, such as phosphates, nitrogen, and heavy metals, in the wastewater effluent being sent to the various land areas for treatment, it is essential that a system for monitoring specific constituents be established. The return flow from the artificial subsurface drainage system must also be similarly monitored to ensure that the quality of this flow will be compatible with the quality standards established for the receiving surface and ground water resources at all times.

Monitoring would be carried out by means of wells for ground water resources and by other suitable techniques for surface flows to existing water courses. A comprehensive monitoring system would enable accurate scientific analysis of early-action test plots to be made with regard to such parameters or application rates to achieve desired concentrations of various nutrients for optimum crop results.

Administration Buildings. In conjunction with the possible establishment of a regional authority to administer and coordinate the wastewater management program for the many constituent political entities within the study area, suitable office space facilities for headquarters and regional office personnel may have to be provided.

Laboratories. In order to carry out the necessary testing in conjunction with monitoring, test-plot programs, and any other needs of the wastewater management program as dictated from time to time, adequate laboratory facilities must be established and staffed. It is assumed that the location of such facilities would be coordinated with the location of regional offices and housed in the same building. It is assumed that the timing of and comprehensive needs for the laboratory facilities by the regional authority would be such as to preclude the use of existing private laboratories, though private labs are preferred.

SECTION IV

AERATED LAGOONS

Some of the plans include aerated lagoons for secondary treatment, rather than more conventional activated sludge or trickling filter wastewater treatment plants. A description of the aerated lagoon process is presented here with technical data to provide the reader with additional insight into these facilities.

Aerated lagoons are characterized by the relatively large volume of wastewater under treatment at any given time, introduction of air into the wastewater, and creation of a suitable environment for bacterial action. In many ways, it can be thought of as a slow activated sludge system, and as it parallels natural processes.

Process Description. Aerated lagoons are basins in which an active biological mass, oxygen, and wastewater are brought together. The resulting biological system is a variation of the activated sludge process. Wastewater organics, in the presence of oxygen, are utilized by the active mass. Therefore, the basic biological relationships pertinent to activated sludge apply to aerated lagoons.

The particular lagoon system proposed for the study area consists of two stages; the first stage, or aerobic lagoon, and the second stage, or facultative lagoon. The amount of mixing created by the aeration equipment is the distinguishing factor between the two lagoons. An aerobic lagoon is one in which mixing keeps the solids in suspension.

In the facultative lagoon, some solids deposition occurs, although dissolved oxygen is distributed throughout the basin. In both lagoons, oxygen requirements are satisfied.

The aerobic lagoon converts the incoming BOD of the wastewater to cell tissue. Normal operation will result in a lagoon effluent containing one-third to one-half the raw BOD.

The contents of the facultative lagoon are not completely mixed, allowing a portion of the incoming solids and the biological solids produced in the aerobic lagoon to settle to the bottom. These solids undergo anaerobic decomposition. This produces a stabilized lagoon effluent.

Consideration must be given to several design factors: BOD removal, effluent quality, oxygen requirements, temperature effects, mixing requirements, and sludge production.

> BOD Removal - The removal of BOD through an aerated lagoon is primarily a function of detention time, temperature, biological solids concentration, and the raw wastewater characteristics.
>
> Effluent Quality - Two effluent parameters are most important in an aerated lagoon design under present practices -- BOD and suspended solids (SS) concentrations. BOD conversion and removal have been previously discussed. Effluent SS contain portions of the influent SS, biological solids, and occasionally small amounts of algae.
>
> Oxygen Requirements - The oxygen required for bio-oxidation is dependent upon the BOD removed, quantity of bacterial solids and nutrient levels. Since aerated lagoons operate at low mixed liquor suspended solids concentrations, oxygen requirements are most directly related to BOD

removal. The ratio of oxygen: BOD removed varies in the range of 0.7 to 1.4.

Temperature Effects - Reduced temperature affects the performance of aerated lagoons by (1) reducing the biological activity and thus treatment efficiency, and (2) possible formation of ice cover. Added heat can overcome the efficiency drop in the larger western Ohio aerated lagoon system.

Mixing Requirements - Proper aerated lagoon operation depends on complete mixing of the liquid and uniform oxygen dispersion. Generally, the amount of aeration equipment required for mixing (solids kept in suspension) exceeds the amount needed to satisfy biological oxygen demands.

Sludge Production - The production of sludge is minimal in the aerated lagoon. The bacterial activity is nearly sufficient to destroy the cells created each day. The influent contains some non-oxidizable fraction and some non-oxidizable solids are produced within the system. Periodic removal of settled sludge may be required, perhaps once each two, five, or ten years.

Aerated lagoons provide an economical alternative in biological wastewater treatment. Low capital costs, simplicity of operation, and low operation and maintenance costs combine to offer a system which is capable of providing an effluent typical of conventional activated sludge plants,which is amenable to land treatment. (At Paris, Texas, wastewater has 500 to 900 mg/l of BOD applied to land, with resulting 99 per cent removal.)[5]

Aerated Lagoon Schematic Design. The aerated lagoons proposed for the Cleveland/Akron/Three Rivers Basin are shown schematically in Figure No. IV-1. This Figure represents the design considerations

FIGURE IV-1

AERATED LAGOON SCHEMATIC FLOW DIAGRAM

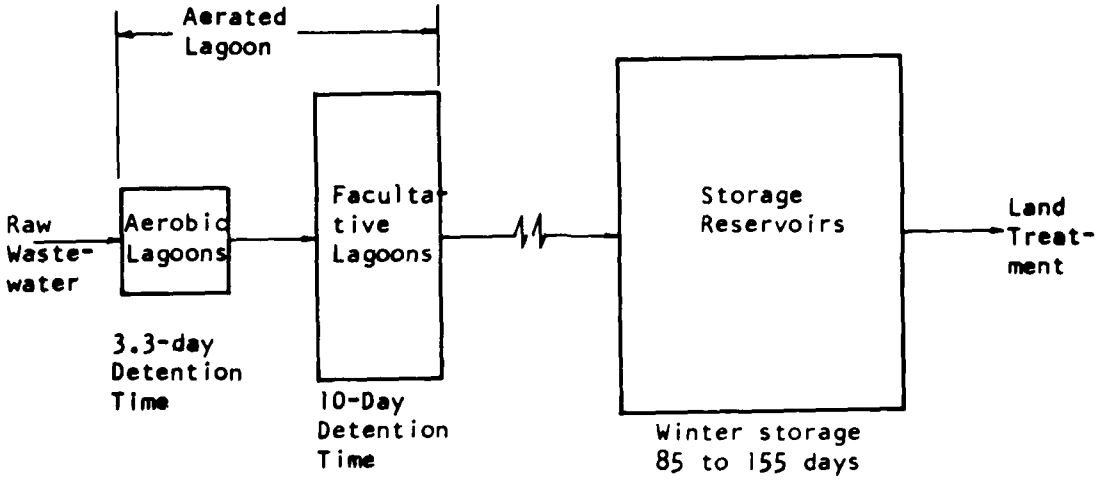
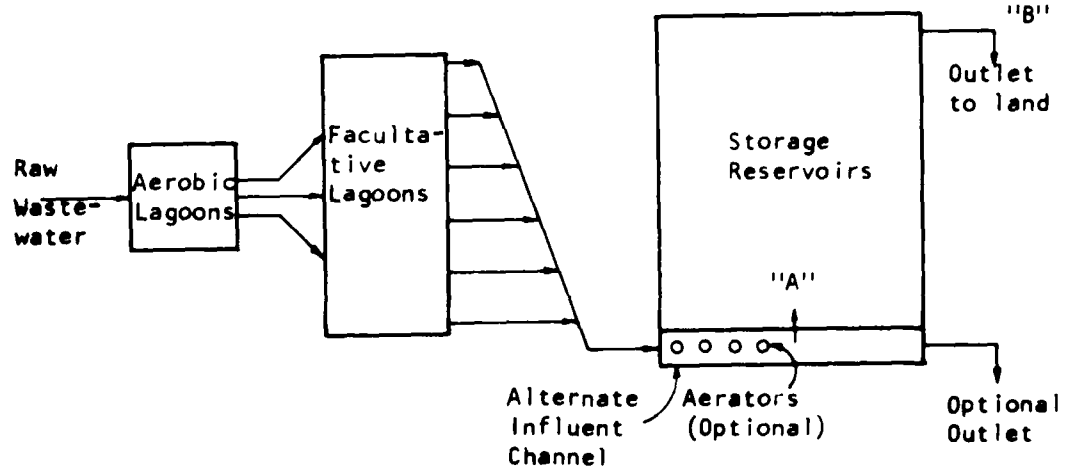


FIGURE IV-2

OPTIONAL AERATION AND ROUTING FEATURES



presently employed and reflects recent developments by manufacturers of aeration equipment.

Design criteria and efficiencies for aerated lagoons are summarized in the following table.

TABLE IV-1

AERATED LAGOON NON-WINTER REMOVAL EFFICIENCIES
(Without benefit of reservoir storage)

Treatment Unit	Influent BOD (mg/l)	Effluent BOD (mg/l)	Per Cent BOD Removed	Influent SS (mg/l)	Effluent SS (mg/l)	Per Cent SS Removed
Aerobic Lagoon	178[1]	78[2]	56	182[1]	111[2]	39
Facultative Lagoon	78	22[2]	72	111	50[2]	55
Aerated Lagoon[3]	178	22	87	182[1]	50	73

1. Havens & Emerson, Cleveland, Ohio
2. Lightnin-Mixing Equipment Co., Inc. Rochester, New York
3. Aerated Lagoon = Aerobic + Facultative Lagoon.

Winter operation of aerated lagoons will affect removal efficiencies. Ten to twenty per cent reductions could be expected, although the lower range can be used when temperature changes are gradual and allow sufficient time for the bacterial acclimation. For the Cleveland-Akron Study Area, a twelve per cent reduction in removal efficiency was assumed. Any heat added to the process from power plants would increase the winter removal efficiency.

The previous discussion centered around the aerated lagoon as a treatment system. However, for complete treatment prior to land

application, the effect of the storage reservoirs should be considered. These reservoirs form an integral part of the treatment process by providing an environment for biological activity and settling, in addition to winter storage. This is particularly important, as the aerated lagoon winter operation produces the lowest seasonal treatment efficiency.

Sizing economics indicate storage reservoir depths of fifteen to twenty feet. Reservoirs equipped with aeration devices may be considered facultative ponds. Aeration provides enough oxygen to maintain aerobic conditions in the surface zone. However, incomplete mixing allows accumulation of solids in the bottom anaeorbic zone. An intermediate zone, partly aerobic and partly anaerobic, exists between the two.

Three storage reservoirs are not equipped with aeration devices and should be considered anaerobic ponds.* (A shallow surface zone can be considered aerobic.) Stabilization is by precipitation and anaaerobic conversion of organic matter to CO_2, CH_4, gaseous end products, organic acids, and cell tissues.

Removal efficiencies during winter storage in these reservoirs should range from 75 to 95 per cent. An average of 85 per cent was assumed. (Heat added to the western Ohio winter reservoir would increase the stabilization.) Design criteria and efficiencies for aerated lagoons and storage reservoirs are summarized in the accompanying table. These values apply to winter operation, without aeration, and without heat added.

---

*During wintertime, minimal treatment periods; however, effluent BOD per acre of surface area loading to reservoirs is considerably lower than normal design loadings to oxidation ponds, such as in North Dakota.

TABLE IV-2

AERATED LAGOON AND RESERVOIR: WINTER REMOVAL EFFICIENCIES

Treatment Unit	Influent BOD (mg/l)	Effluent BOD (mg/l)	Per Cent BOD Removed	Influent SS (mg/l)	Effluent SS (mg/l)	Per Cent SS Removed
Aerated Lagoons	178[1]	45	75	182[1]	71	61
Storage Reservoir	45	7	85	71	11	85
Overall Treatment[4]	178	7	96	182	11	94

1. Havens & Emerson, Cleveland Ohio
4. Overall treatment = Reduced aerated lagoon treatment due to winter operation + storage reservoir treatment during winter storage.

To further increase the removal efficiencies of the aerated lagoon treatment, reservoir channel aeration is an option. This appears schematically in Figure No. IV-2. Aeration is supplied to a potential channel between the facultative lagoon and the storage reservoir. This would also be beneficial during summer operation when residence time in the reservoirs could approach zero.

During winter operation "B" is closed and the reservoir is allowed to fill. For the irrigation season, open "B" and allow facultative lagoon effluent and stored water to mix prior to land treatment.

The effluent produced by aerated lagoons is comparable with other basic biological treatment plants. It is highly stabilized, contains low concentrations of BOD and SS; it is most amenable to land treatment and crop irrigation.

Component Layouts. The aerated lagoon systems, including the reservoir, will have an overall winter treatment efficiency of:

BOD : 96 per cent
SS : 95 per cent

without considering use of waste heat or aeration of the winter reservoirs.

The winter reservoirs all are planned for aeration in this preliminary design, except where several miles of open buffer land is indicated as surrounding the particular system. Aeration of the reservoir would increase the treatment removal efficiency. For final design considerations, aeration should be considered optional for all reservoirs.

Waste heat from the proposed western power plant will be routed to the western aerobic lagoons during winter, as well as to the adjacent facultative lagoons. This will increase the removal efficiency during the winter period through the two steps of aerated lagoon treatment to near the summer efficiency.

It is planned that all wastewater will be routed through the reservoir during the entire year, and, therefore, the reservoir will always serve as a third step in the effluent stabilization process, bringing overall system treatment efficiencies for BOD to approximately 98 per cent during the non-winter period. The aerated channel alternate would not be utilized unless found to be desirable for winter operation efficiency improvement. This would be a final design option.

The aerobic lagoon cells vary in design layout from location to

location, and in accordance with the loadings. For instance, the western Ohio lagoon cell is twenty feet deep, with average dimensions of 875 feet by 420 feet. Eight aerators are planned at 75-horsepower each. There would be forty such cells. The facultative lagoons would be twenty feet deep, with average dimensions of 1,050 feet by 350 feet. Each cell would have three aerators at 100-horsepower each. There would be 120 such cells. The total surface area of aerobic cells is 440 acres, and the total surface area of facultative cells is 1,320 acres.

The smaller aerobic lagoon cells and facultative cells are fifteen feet deep, with moderate sized facilities at eighteen feet of depth. The areas are commensurate with the rate of flow, providing a total of 13.3 days of detention for the full winter period of twelve to sixteen weeks.

Dikes are constructed with impervious linings and sealed bottoms. The inside side slopes are at 4:1, with a fifteen-foot to twenty-foot top width. All dikes are suitably riprapped to protect against erosion.

The capability of the land to treat irrigation water with organic loadings of over 500 mg/l to 99 per cent removal efficiencies has been documented at Paris, Texas with the overland flow method.[5] Thus, removals as indicated herein are greater than considered necessary. The layout as proposed has significant safety factors included.

BIBLIOGRAPHY - SECTION IV

1. Survey Scope Study for Wastewater Management Program, Contract Phase Report, Phase II, Systems Design and Estimates of Cost, Havens & Emerson, Ltd., Cleveland, Ohio, October, 1972.

2. Data from Lightnin-Mixing Equipment Co., Inc., Rochester, New York, 1972.

5. "An Evaluation of Cannery Waste Disposal by Overland Flow Spray Irrigation," Final report on a study project prepared for the Campbell Soup Company by C. W. Thornwaite Associates, Publications in Climatology, Vol. XXII, No. 2, September, 1969.

SECTION V

WASTEWATER RENOVATION

The renovative capacity and efficiency of the land treatment systems varies from soil to soil, with crops grown, with the character of irrigation and drainage, and with the quality of the effluent being applied as irrigation water.

The land treatment methods developed during the Cleveland-Akron and Three-Rivers Watershed Areas Wastewater Management Study include:

1. On Chili Soils
   a. Center-pivot irrigation techniques.
   b. Corn, hay, and pasture crops.
   c. Application rate of 60 inches per year.
2. On Cardington-Bennington Soils
   a. Center-pivot and/or solid-set irrigation techniques.
   b. Reed canary grass, hay, pasture, and corn crops.
   c. Application rates of 50, 75, and 90 inches per year.*
3. On Mahoning-Ellsworth Soils
   a. Overland runoff/infiltration techniques.
   b. Reed canary grass or other grasses.
   c. Application rates of 90 inches per year,* and 150 inches per year for separate storm runoff.

The renovation of the wastewaters by these methods will exceed the proposed NDCP standards.[1]

---

*Rates which were used for purposes of preliminary schematic design and costing. Early-action testing and monitoring are expected to demonstrate that optimum rates may approximate 120 inches per year.

The following table presents the projected quality of the irrigation water following secondary biological treatment and assuming a mix 81 per cent municipal-industrial sewage and 19 per cent storm water. The concentrations shown are conservatively high for computational purposes.

TABLE V-1

IRRIGATION WATER QUALITY

Constituent	Municipal-Industrial and Combined Wastewater (mg/l)	Storm Runoff (mg/l)	Municipal-Industrial Combined and Storm Runoff (mg/l)
Suspended Solids (SS)	25	25	25
Biochemical Oxygen Demand (BOD)	15	15	15
Chemical Oxygen Demand (COD)	69	69	69
Total Dissolved Solids (TDS)	520	200	460
Nitrogen (N)	19.7	2.2	16.4
Phosphorous (P)	10.2	0.5	8.3
Heavy Metals	2.0	0.2	1.7
Virus			
Bacteria			

The quality of the drain tile effluent, after land treatment, is represented in the following tables for each of the methodologies employed.

TABLE V-5

RENOVATION OF EFFLUENT WITH CHILI SOILS
BASED ON 60 INCHES/YEAR
MUNICIPAL EFFLUENT

Constituent	Removal Rate (Per Cent)	Return Flow (mg/l)
SS	99	<0.3
BOD	95-99	<0.8
COD	95-99	0.7-3.5
TDS	5-10	450-500***
N	75-90*	2-5
P	98	<0.2
Metals	95-99	Trace
Virus	99	
Bacteria	99	

* The removal rate will depend on the crops grown, yields, and product removal. Unexplained losses of up to 50 per cent to the atmosphere may occur.

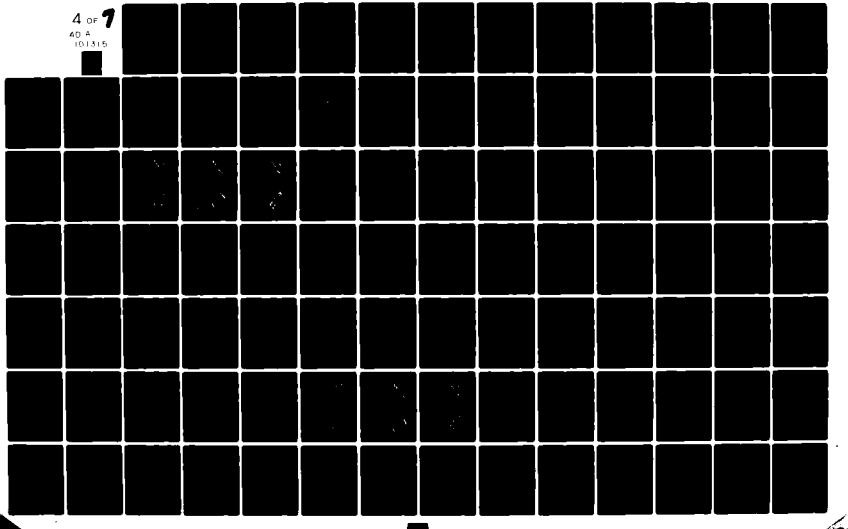
***Average values are shown; lower or higher values are possible, depending on rainfall and evapotranspiration rates.

TYPICAL IRRIGATION MANAGEMENT

A typical irrigation and drainage management opportunity involving Reed canary grass has been investigated for utilization with the Cardington-Bennington soils. The approach was twofold; first, to review a wide range of irrigation application rates from the operational feasibility point of view; and, secondly, to identify optimum application rates conjunctively with the nitrogen, aeration, and hydraulic

AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA, W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL

4 OF 7
AD A
101315



capacity constraints. The heavy metal and organic loading impacts have been discussed in the Land Treatment Phase I Report, with the conclusion that metals can be properly and safely managed, and that the potential for the soil to decompose organic material is high.

Two methods of application are proposed. Wherever the shape and size of fields are optimum, center-pivot machines would apply the effluent through spray nozzles. The corners between these units and other odd-shaped areas would be irrigated, using permanent-type solid-set sprinkler systems. Center-pivot units are recommended wherever practical because of their lower initial cost and operating pressure, though solid sets offer more refined control. However, solid sets could be selected for use in place of center-pivots, as desired.

The recommended drainage system would be installed first, followed by the irrigation system. No unusual or expensive land preparation would be required.

Soil preparation would begin with plowing approximately seven inches deep with a conventional moldboard plow. In the case of the center-pivot, the plowing should be done in such a way as to move the soil toward the future wheel track. To do this, the machine is operated without irrigating for one revolution to locate the wheel tracks. Plowing is then begun by plowing soil onto the wheel track from each side. The plowing is then completed, leaving the dead furrow midway between the wheel tracks. The result is a slightly elevated area for the wheels to run on which avoids potential traction problems. The surface between the tracks should then be smoothed using a landplane.

The grass seed should be planted with a drill. Until the grass is fully established, water applications should be limited to only that amount which is needed to keep the soil moist. Water application should then be gradually increased, taking about two years to reach the design capacity.

The proposed irrigation season is 36 weeks, of which no irrigation would take place during six weeks which would be reserved for harvesting the hay and for temporary shutdown during very excessive rainfall. The resulting weekly rate would be two inches per week for 60 inches per year, three inches per week for 90 inches per year, and four inches for 120 inches per year. See Figure V-1.

Irrigation Application, Solid-Set. The Ohio Irrigation Guide suggests a maximum application rate of 0.4 inches per hour for these soils. It is further stated that with adequate ground cover this rate can be doubled (0.8 iph).[3] However, with solid-set sprinklers, there is no need to maximize rates. Therefore, the proposed rate is 1/3 iph, which is well below the maximum suggested. Two inches of effluent would be applied during each irrigation requiring one irrigation per week for 60 inches per year, three irrigations each two weeks for 90 inches per year, and two irrigations per week for 120 inches per year for the solid-set sprinklers.

The resulting application time would be six hours per irrigation, which is the same as for the Campbell Soup operation at Paris, Texas during the cool months.[4] However, at Paris, the resting time between irrigations was only eighteen hours. This proposal would provide

resting periods of 162, 106, and 78 hours for annual applications of 60, 90, and 120 inches, respectively. Automated permanent solid-set sprinkler systems provide great flexibility so, if for any reason it is desired to use a resting period of only eighteen hours as at Paris, application times could be reduced to two-thirds, one, and one and one-third hours for annual applications of 60, 90, and 120 inches respectively.

Aeration and Hydraulic Capacity. Three potential alternative irrigation plans, which would be fully tested and monitored during the early-action program, propose annual applications of (1) 60 inches per year, (2) 90 inches per year, and (3) 120 inches per year. Each irrigation will be six hours, or less, in duration, applying water at 0.33 inches per hour* Respective irrigation schedules will be: (1) one per week, (2) two every three weeks, and (3) two per week. Weekly applications are therefore: (1) two inches, (2) three inches, and (3) four inches. Time intervals between irrigation (from end of an irrigation to beginning of next) are: (1) 162 hours = 6.75 days, (2) 106 hours = 4.4 days, and (3) 78 hours = 3.25 days.

There are two approaches available to estimate the performance of tile drains: one would apply an analytical method, treating the system as a non-steady one, such as is used in design of drains for irrigated lands.[6]

However, for this case, a better approach is available because of the tile drain experiments in Ohio on soils very similar in texture

*For solid-set applications.

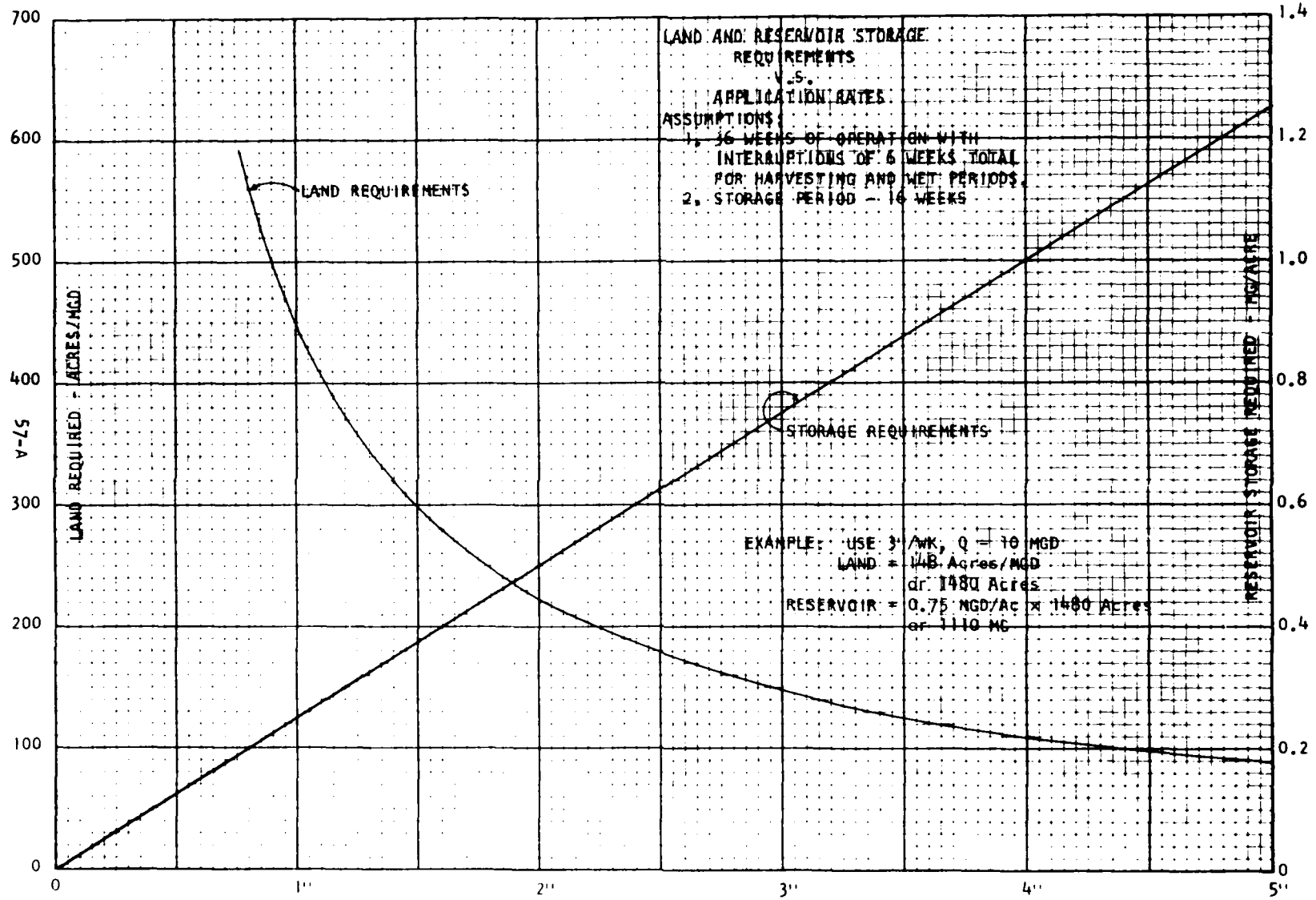


FIGURE V-1 APPLICATION RATE - INCHES/WEEK

and other characteristics to the soils in question.[7, 8] The experience from these installations should be excellent guides to estimating tile drain performance and are preferred over the analytical approach, which depends on idealizing the system.

There are two questions to be answered in evaluating a drainage system:

1. Will the water table decline following irrigation be rapid enough?
2. Will aeration requirements of the crop be met?

In regard to water table reaction, Reference No. 8, Figure No. 6, gives water table drawdown at mid-point between tile as a function of tile spacing. The experimental system happens to have tile at 36-inch depth, and impermeable material occurs at 36 inches below the tile. This is nearly identical to the system required for the Cardington-Bennington soils, with the possible exception that impermeable material may in some cases be nearer the tile. The reader is referred to Table II-1 of the Land Treatment Phase I Report.[1] However, the theoretical effect of this variation is known to be small (<10 per cent); so it can be neglected without harm to the spacing estimates.

Assuming as an initial condition that the water table is at or near the surface, a condition to be expected immediately following irrigation in the extreme case, the question is, what rate of water table decline can be expected for a given drain spacing.

The following tabulation summarizes tile performance expected

for three spacings and the three levels of annual application.

TABLE V-6

DRAWDOWN AS AFFECTED BY TILE SPACING

Tile Spacing (feet)	Rate of Drawdown (ft/day)	Total drawdown in feet between irrigations* for Annual Applications of: 60 Inches	90 Inches	120 Inches
40	0.3	2.0	1.3	0.9
35	0.4	2.7	1.8	1.3
30	0.6	3.0	2.6	1.9

*Based on solid-set sprinkler applications.

Oxygen requirements (aeration) within a root zone are met by diffusion of air, provided continuous channels through the soil exist. At moisture content near saturation, water fills pores to an extent that channels are blocked. However, at saturation of about 0.8 (80 per cent of total pore volume occupied by water) continuous channels are open for air diffusion. Therefore, the saturation at any point to which aeration is desired must be examined in order to determine if that point (and the soil above it) can be aerated.

Aeration need not be continuous with time within the root zone, but various plants have critical lengths of time, beyond which, without aeration, the plant suffers adverse effects (growth reduction). In general, most standard field crops can tolerate three days without aeration; many can tolerate four or five days. Grasses are among the most tolerant.

Reference No. 7, Figure No. 7, provides an excellent estimate of moisture content at a depth of six inches as a function of water table

depth. If saturation at six inches can be shown less than 0.8 after four days, aeration should be adequate for all grasses. Water table drop in four days, based on daily rates given in Table V-6 for tile spacings of 40, 35, and 30 feet are, respectively: 1.2 feet, 1.6 feet, and 2.4 feet at the ground water table high point midway between tiles.

The data of Reference No. 7 are soil moisture per cent on a weight basis, which must be converted to volume basis as follows:

$$\theta = \theta_w \frac{\rho_s'}{\rho_w}$$

Where θ = Volumetric moisture content, per cent

θ_w = Moisture content, weight basis, per cent

ρ_s' = Bulk density of soil

ρ_w = Density of water = 1.0

Then saturation can be calculated as:

$$S = \frac{\theta}{\Phi}$$

Where S = Saturation, $0 \leq S \leq 1.0$

θ = Volumetric Moisture Content

Φ = Total porosity

Total porosity in the "A" horizon soil, according to Reference No. 7, is found from θ_w at saturation given as 43 per cent (approximate). Bulk density of "A" horizon is estimated as 1.3. Total porosity is:

$$\Phi = \theta_{sat} = (.43)\left(\frac{1.3}{1.0}\right)$$

Φ = .56 ("A" horizon, 0 - 12")

Reference No. 7, Figure No. 7, gives moisture content θ_w at six inches depth with water table at 1.2 feet (= 14 inches) as θ_w = 32.5 per cent. Converting θ_w to volume basis,

$$\theta = (32.5)\ (\frac{1.3}{1.0})$$

$$\theta = 42.3 \text{ per cent}$$

Then saturation at six-inch depth is:

$$S = \frac{\theta}{\Phi} = \frac{42.3}{56}$$

$$S = 0.75$$

It may be concluded that saturation at six-inch depth after four days or less will be less than the critical limit for aeration of S = 0.8. Therefore, adequate aeration for grass production is assured under all three tile spacings and for the three levels of annual irrigation under consideration. (The only question would be forty-foot spacing with an application rate of 120 inches per year where drawdown at midpoint in 3.25 days (78 hours) is only 0.9 feet (= eleven inches). By Figure No. 7, θ_w = 34 per cent, and calculation as before shows S = 0.79. Therefore, adequate aeration is expected at six-inch depth in less than four days.)

However, rainfall is expected to occur at times when the profile is draining after irrigation and, thus, to prolong the time of inadequate aeration. Fortunately, evapotranspiration through the grass crop will ameliorate this problem. Estimated evapotranspiration is

0.2 inches per day much of the summer. Between irrigations of 3.25 days (120 inches per year), evapotranspiration will extract 0.65 inches of water, enough to aerate the top six inches.

During rain storms, irrigation would cease. Operationally, a forecast of rainfall by a weather observer would dictate the stopping of irrigation from four to twenty-four hours ahead of precipitation, though the timing is not critical. Following is a tabulation of six-hour rainfall amounts as related to frequency of occurrence.

TABLE V-7

DEPTH-FREQUENCY FOR SIX-HOUR DURATION RAINFALL[9, 10]

Frequency in Years	2	5	10	25	50	100
Depth in Inches*	1.8	2.3	2.8	3.1	3.4	3.8

A drain system with tile at 36-inch depth and spaced forty feet apart will serve the drainage needs of a grass crop on the Cardington-Bennington soils for each of the three annual application rates under consideration, as demonstrated by this solid-set sprinkler example.

This recommendation is based on actual field experience on soils of similar drainage characteristics. The estimates made on this basis should be conservative for Cardington-Bennington sites because these soils are slightly lighter in texture with higher permeability.

In addition, however, all planning and costing for drainage design is based on 70 per cent of the Cardington-Bennington soils having tile spacing of twenty feet, with the remaining 30 per cent of the land having a spacing of thirty feet. This closer spacing would

*It should be noted that the soil moisture storage capacity approximates 0.15-0.2 inches/ inch of depth (2 inches/foot). Infiltration capacity with continuous vegetation exceeds two inches/hour. (Figure V-3)

provide an additional drainage reliability factor, though in the early action field testing the need for this closer spacing should be thoroughly investigated to determine whether or not the forty-foot spacing would be preferable in the interest of further cost reduction.

Irrigation Application, Center-Pivot. The center-pivot rig irrigation application varies from the solid-set rate because of hydraulic constraints in the rig concept and design. The center-pivot rig would irrigate continuously during its revolutions, and would continuously rotate, except during rainy periods or emergencies. The rig would travel at a rate of three revolutions per day, laying down either approximately 0.1, 0.15, or 0.2 inches per revolution to provide two, three, or four inches per week of water, respectively.

A slower-moving rig, perhaps at two revolutions per day, would lay down 0.15, 0.22, 0.3 inches per revolution. Testing would determine the most suitable rate and optimum design of the equipment.

The light application of water to any one acre in a given eight or twelve-hour period, coupled with the low daily rates and resting periods between applications, would provide a constantly aerated zone and a water table close to the artificial drain tile level for the two, three, and four-inch weekly rates.

The storage capacity of 0.15 to 0.2 inch per inch would provide for protection against rainstorm runoff to a degree, because the fields would not be saturated from irrigation. In addition, the continuous vegetative covering provides high detention characteristics

and surface storage. This, coupled with border areas designed for overland flow land treatment, is expected to prevent surface runoff for six-hour storms having a frequency of occurrence of approximately once in 25 years. See Figure V-3.

The balance between the use of center-pivot rigs and solid-set sprinklers is flexible, and would be selected after significant early-action testing.

Nitrogen Applications. Nitrogen requirements for production of high-quality Reed canary grass hay having a protein content of above 20 per cent are large.[5] An annual rate of effluent application of 120 inches would be needed to supply the nitrogen requirements, assuming a total N of 16.4 mg/l is available in the municipal/industrial, combined and separate storm runoff. Smaller amounts would require supplemental N. Greater applications could be made without causing excessive nitrate levels in the drainage water.

With a 16.4 mg/l concentration of N (Table V-1), applications of 60, 90, and 120 inches of effluent per year would contain 223, 334, and 446 pounds of N per acre, respectively. The Campbell Soup Report indicated a nitrogen content of high protein Reed canary grass hay as 62 pounds per ton.[4] A yield of four tons per acre would remove 248 pounds of N per acre. Assuming 60 per cent nitrogen uptake efficiency (probably high for such high N levels), the total nitrogen requirement would be 413 pounds per acre. Application of 120 inches of effluent per year would supply the requirement. A supplement of 79 pounds per

acre of N would be needed at 90 inches per year. A supplement of 190 pounds per acre of N would be needed for 60 inches per year. (Figure V-2)

The application of 120 inches of effluent per year would be the optimum rate for recycling nitrogen. The drainage outflow would be of better quality than required. The drainage outflow would be of better quality than required. Considerably higher rates could be more cost-efficient under a disposal concept in which renovation of the effluent is the prime concern.

Crop Utilization. An investigation of the meat packing industry in Sandusky, Ohio and environs indicated two hog meat packing plants and one cattle meat packing company. The Routh Packing Company has a throughput of 10,000 hogs a week, or about 520,000 per year. According to Mr. Richard Kurt of the plant, approximately 35 per cent come from Ohio, 20 to 30 per cent from Indiana, and the rest from Illinois, Iowa, and Missouri. Mr. Kurt did indicate a trend for packing houses to be close to the highest concentrations of production. In other words, most of the hogs are killed in Iowa and Nebraska where they are produced, because of shipping costs. Northern Ohio is a meat importer, and this is reflected in Cleveland area meat prices.[11]

Another company in Sandusky, the Waldock Packing Company, kills approximately 10,000 to 20,000 hogs a day, the livestock coming from local sources which are limited.[12]

The Sandusky Dressed Beef Company is a cattle processor with a kill rate of about 300 head per day, or about 110,000 per year. About

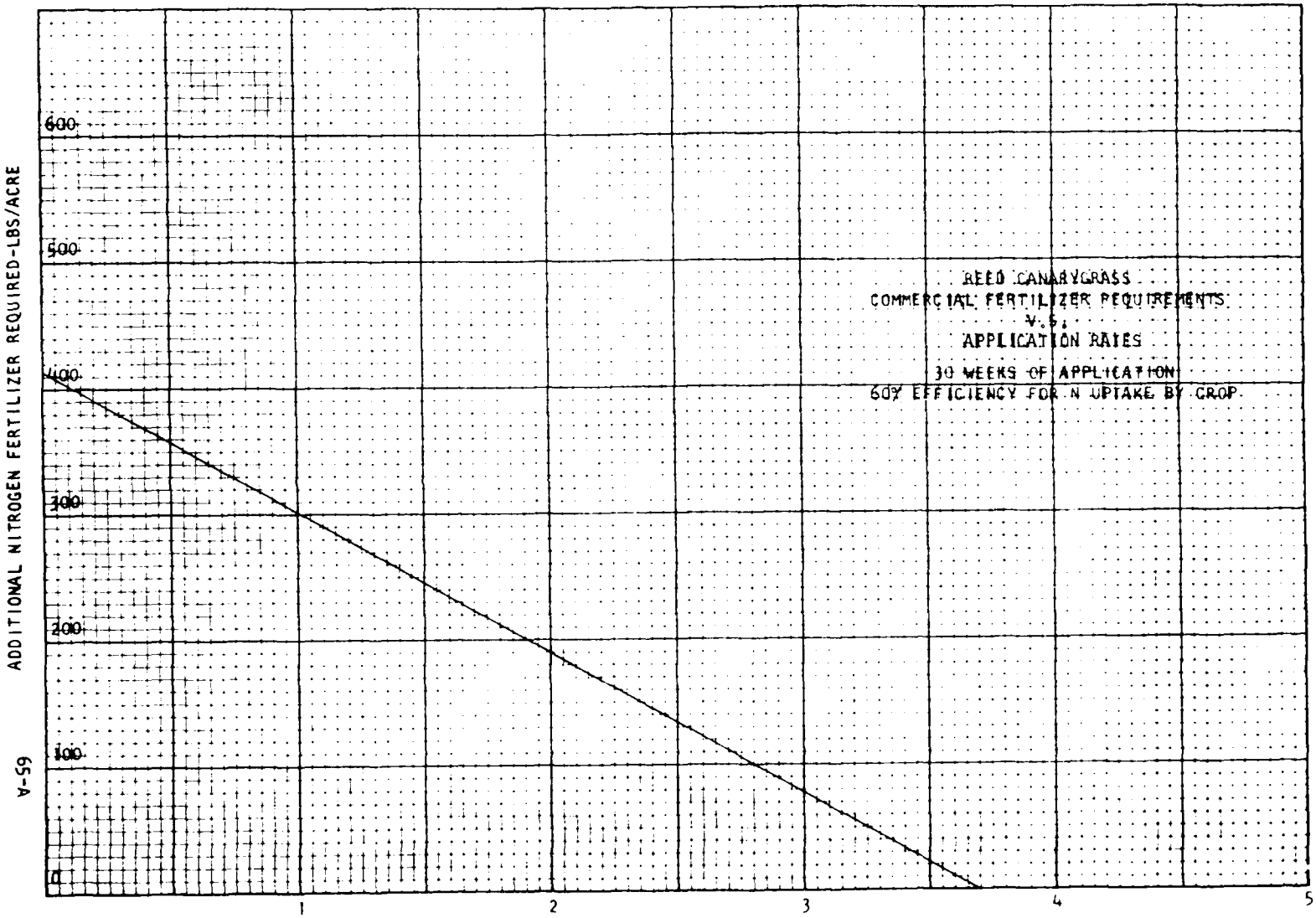

REED CANARYGRASS
COMMERCIAL FERTILIZER REQUIREMENTS
VS.
APPLICATION RATES
30 WEEKS OF APPLICATION
60% EFFICIENCY FOR N UPTAKE BY CROP
ADDITIONAL NITROGEN FERTILIZER REQUIRED-LBS/ACRE
600
500
400
300
200
100
0
1
2
3
4
5
APPLICATION RATE - INCHES/WEEK

FIGURE V-2

60 per cent of the cattle come from Ohio and the rest from nearby states. Shipping c sts affect the plant economics.[13]

Mr. Dean Triplett of Weisbart and Company, of Brush, Colorado, indicated the following typical ration for hogs:

> 70 per cent corn (wheat and milo can be substituted depending on price).
>
> 15 per cent soybean oil and meat scraps consisting of one-fourth meat scraps.
>
> 10 per cent other grains.
>
> 5 per cent minerals and additives.

Experiments for hogs have been made pelletizing roughages such as Reed canary grass with varying degrees of success. However, the pelletized roughages are best for cattle or other animals with similar digestive systems. The value of the feed is, in essence, a matter of cost per calorie, thus the energy per pound of feed would be an important consideration.[14] Calories are related to protein content.

The nutritional quality of Reed canary grass varies widely, depending upon the nitrogen availability in the soil where it is grown. Studies show that Reed canary grass grown on land treatment sites can have exceptional nutritional value, ranging up to 23 per cent crude protein. The mineral content is also high, nearly double the quantity found in other good quality hay. Cattle have exhibited a definite preference for hay grown on land treatment sites.[4]

The following table presents contents of various plant nutrients and digestible constituents for different varieties of animal feed.[4]

TABLE V-8

NUTRITIONAL ANALYSES OF SELECTED ANIMAL FEEDS

(Reference No. 4, Page 15)

Dry Roughage	Protein %	Fiber %	TDN* %	Phos. %	Nit. %	Dry Matter %
Alfalfa hay	14.7	29.0	50.3	.21	2.35	90.4
Bermuda grass hay	7.3	25.6	43.0	.20	1.17	90.7
Clover hay	12.0	27.1	49.0	.23	1.92	89.0
Johnson grass hay	6.5	20.4	50.3	.26	1.04	90.1
Prairie hay	5.7	30.3	49.2	.10	.91	90.4
Reed canary hay	7.5	29.1	46.6	.23	1.20	90.8
Timothy hay	6.2	30.1	46.9	.16	.99	88.7

*Total digestible nutrients

Studies indicate that Reed canary hay can equal or exceed the nutritional value of alfalfa and clover hay, and feeding tests indicate a superior potential market value when compared with other good quality hay.

In the table below, the fodder analysis data from the Paris, Texas land treatment area are presented for comparison with information in Table V-8.

TABLE V-9

NUTRITIONAL AND CHEMICAL ANALYSIS
OF
REED CANARY HAY SAMPLES
(Reference No. 4, Page 17)

Harvest Date	Sample No.	Growth Units	Protein %	Fiber %	TDN* %	Phos. %	Nit. %	Dry Matter %
5/ 2/68	S- 1	1122	21.6	24.4	61.7	0.5	3.7	89.8
5/ 9/68	S- 2	1300	14.7	28.7	54.1	0.6	2.4	89.5
5/16/68	S- 3	1549	16.6	27.4	57.3	0.5	2.7	90.6
5/23/68	S- 4	1721	19.8	29.3	55.7	0.6	3.1	90.2
7/ 1/68	S- 6	3508	22.2	27.7	61.6	0.4	3.6	93.4
7/22/68	S- 9	4615	16.4	30.3	56.5	0.4	2.6	93.5
8/12/68	S-12	5786	16.3	27.6	59.6	0.3	2.6	93.6
9/ 3/68	S-15	6844	18.1	27.0	60.5	0.5	2.9	93.1
9/23/68	S-18	7505	18.8	28.3	59.0	0.6	3.1	92.7
10/ 7/68	S-19	7845	22.0	25.0	64.2	0.5	3.6	93.2
10/28/68	S-22	8270	23.0	24.2	65.5	0.6	3.7	93.2

*Total Digestible Nutrients

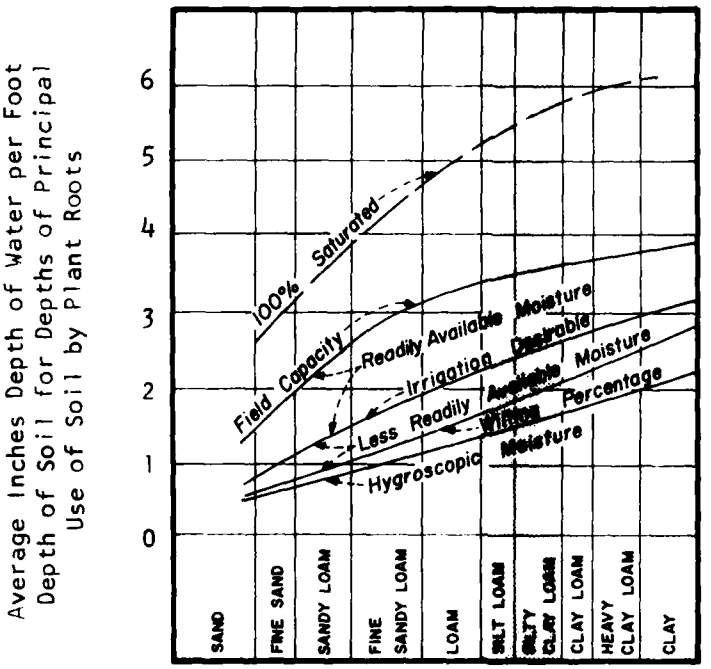
"It is a well-established agricultural fact that when an excess of nutrient elements are present in the soil, plants will uptake in greater quantity than normal. In wastewater disposal, this phenomenon is of special significance in that those plant nutrients removed in the hay are totally unavailable for algae growth in the receiving stream. The phosphorus thus removed amounts to ten pounds of P per ton of hay, or 8,000 pounds removed in a single cutting of 32,000 bales in Paris in 1968 (24,000 lbs. of PO_4). Even more impressive is the uptake of nitrogen which averages 3.1 per cent of dry weight of the Reed Canary hay or 62 lbs. per ton -- nearly 50,000 lbs. of N removed in the single harvest of 1968."[4] (Page 17)

The growing of Reed canary grass on the western land treatment site could form the basis for the development of a major local industry related to cattle feeding and slaughtering. Waste products (manure) from the cattle could be returned to the agricultural land, helping to make up the nitrogen demands of the hay crop. Waste from the slaughtering operations would also lend itself to land treatment. Thus, recycling potential could be compounded significantly by subsystem nutrient uses.

With hogs and cattle being shipped in from other states at present, a local cattle-raising industry could reduce the national and regional transportation demands somewhat, and tend to reduce meat prices for those who are economically disadvantaged in the Cleveland area.

This sample description of irrigation management on the Cardington-Bennington soils for application rates of from 60 to 120 inches per year provides for a wide range of choices in hydraulic loading. Costing of land treatment in western Ohio is based on 70 per cent of the land being irrigated at 75 inches per year, 25 per cent at 50 inches, and five per cent at 90 inches per year. Furtner analyses are expected to point towards the use of higher application rates; however, this can be a decision made at a later time in the project development.

FIGURE V-3
APPROXIMATION OF SOIL MOISTURE AND STORAGE CAPACITY
FOR CARDINGTON - BENNINGTON SOILS



The above figure corresponds to Figure No. 2 on Page 19 of Reference No. 15, except for the dashed line representing saturated conditions, which was calculated using an equation and values given by the same author for different soils.

SATURATED CONDITIONS

	Vm (Per Cent Moisture by Volume)	Inches of Water per Foot of Soil (Equal to 0.12 Vm)
Sandy Soil	20	2.4
Most Cultivated Soils	30 - 50	3.6 - 6.0
Clay	> 50	> 6.0

Before irrigation, the "A" horizon would normally have a moisture content of less than field capacity. If it is assumed that the available moisture (the difference between the wilting point and field capacity) is 25 per cent depleted prior to irrigation, the available storage for a

silty clay loam, such as a Cardington or Bennington soil, can be estimated, using Figure No. V-3 as follows:

	Inches of Water per Foot of Cardington-Bennington Soil
At 100 per cent saturation	5.5 inches/foot
At 75 per cent field capacity	3.4 inches/foot
Available Storage Capacity	2.1 inches/foot (0.175 inches/inch)

BIBLIOGRAPHY - SECTION V

1. Wastewater Management Survey Scope Study, Land Treatment Technical Appendix, Wright-McLaughlin Engineers, Denver, Colorado, November, 1972.

2. Survey Scope Study for Wastewater Management Program, Contract Phase Report, Phase II, Systems Design and Estimates of Cost, Havens & Emerson, Ltd., Cleveland, Ohio, October, 1972.

3. Ohio Drainage Guide, U. S. D. A., Soil Conservation Service; Ohio Agricultural Experiment Station; Cooperative Extension Service, The Ohio State University; Ohio Dept. of Natural Resources, Division of Lands and Soil. 1965.

4. "An Evaluation of Cannery Waste Disposal by Overland Flow Spray Irrigation," Final report on a study project prepared for the Campbell Soup Company by C. W. Thornwaite Associates, Publications in Climatology, Vol. XXII, No. 2, Elmer, New Jersey, September, 1969.

5. Reed, S. C. (coordinator), Wastewater Management by Disposal on the Land, Corps of Engineers, U. S. Army, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, 1972.

6. Dumm, Lee D., "Subsurface drainage by transient-flow theory," Paper 6315, Jour. of Irrig. and Drain. Div., Proc. ASCE Vol. 94, No. IR4, Dec. 1968. Also, Trans ASCE, Vol. 135, 1970, p. 931.

7. Taylor, G. S., Truman Goins, and N. Holowaychuk,"Drainage Characteristics of Toledo and Hoytville Soils," Ohio Agricultural Experiment Station. Research Bulletin 876, May, 1961.

8. Hoffman, G. J. and G. O. Schwab, "Tile spacing prediction based on drain outflow," Tran. A. S. A. E., Vol. 7, No. 4, pp. 444-447, 1964.

9. "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," U. S. Department of Commerce, Weather Bureau, Technical Paper No. 40, 1963.

10. "Two-to-Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States," United States Dept. of Commerce, Weather Bureau Technical Report No. 49, 1964.

11. Telephone call from Ralph Toren, Wright-McLaughlin Engineers, to Mr. Richard Kurt, Routh Packing Co., Sandusky, Ohio, on December 5, 1972.

BIBLIOGRAPHY - SECTION V (cont.)

12. Telephone call from Ralph Toren, Wright-McLaughlin Engineers, to Waldock Packing Company, Sandusky, Ohio on December 5, 1972.

13. Telephone call from Ralph Toren, Wright-McLaughlin Engineers, to Sandusky Dressed Beef, Sandusky, Ohio, on December 5, 1972.

14. Telephone call from Ralph Toren, Wright-McLaughlin Engineers, to Dean Triplett, Weisbart & Co., Brush, Colorado, on December 5, 1972.

15. Etcheverry, B. A. and S. T. Harding, Irrigation Practice and Engineering, Volume 1, Use of Irrigation Water and Irrigation Practice, McGraw-Hill Book Company, Inc., New York, 1933.

16. Joint conference of the American Society of Agronomy, and the Soil Scientists of America, Miami Beach, Florida, October 30, 1972. Technical session: "Land Application of Municipal Wastes."

SECTION VI

COST ESTIMATION METHODOLOGY FOR RANGE OF ALTERNATIVES

GENERAL

An essential task of the Survey Scope Study was to provide the basis for a cost comparison of the numerous alternative plans developed during the earlier stages of the study. In addition, the final alternatives have been construction-phased and fully costed, as described under that portion of the report dealing with final alternatives.

The cost estimates were to be prepared and presented in such a way as to permit not only comparisons among the plans, but also identification of the costs of the various major components of each plan, e. g., sewers, treatment plants, pumps, and reservoirs, and a separation of the costs related to treating stormwater from the costs of treating municipal and industrial wastewaters in each plan. The cost figures to be used for these three purposes were to incorporate both construction costs (capital costs) and the costs of operating and maintaining the systems after construction (O & M costs).

INITIAL COSTING FOR COMPARABILITY

The need for an initial cost comparability among plans led to the adoption of a standardized procedure for design work and cost estimation for this early work. First, each plan was laid out to meet projected wastewater loads for the year 2020. Second, the

costing procedure assumed that the 2020 facilities would be built at one time using current (1972) costs. Third, the total capital cost for each component of the wastewater treatment system would be converted to an annual payment based on a 7 per cent interest rate amortized over the estimated useful life of the particular component. The replacement cost for each component was incorporated in this annual capital cost payment by use of a capital recovery factor related to the component's estimated useful life. Finally, the annual capital cost for each component of the plan was added to the annual operation and maintenance (O & M) cost and this total represents the "annual comparable cost" for that particular component of the plan.

In order to facilitate comparisons among plans, a single "annual comparable cost" for each plan was needed. This was accomplished by totaling separately the capital costs and the O & M costs of the individual components and then adding a uniform contingency factor of 30 per cent (including 5 per cent for engineering and design and 5 per cent for supervision and administration) to the total annual capital cost, and a 20 per cent contingency factor to the total annual O & M cost for each plan. The sum of these two figures was the plan's annual comparable cost.

Finally, it was desired to isolate the costs of treating stormwater. Where actual facilities for transmission, storage, and treatment of stormwater were completely separate from the municipal-industrial sewage treatment systems, the costs could be totaled

directly. However, many of the facilities in the twelve plans were designed to combine stormwater and municipal wastewater at varying points in the treatment system, and in these cases, it was necessary to subtract an increment of cost from each component in proportion to the additional capacity required for the inclusion of stormwater.

This "stormwater increment" for both Capital and O & M costs was then added to the costs for the separate stormwater facilities, to obtain a total annual comparable cost for stormwater treatment in each plan. These computations all are shown in Tables 1-C through 12-C in the Formulation Technical Appendix - Development of Twelve Alternative Plans.

The development of annual comparable costs described above assumes that the wastewater treatment systems in each plan can be broken down into separate components or cost items, for which capital and O & M costs can be calculated. Since the same general components are used in all plans, but in varying combinations and sizes, it was possible to set up a standardized table for detailed cost computations, in which each column represented a separate cost item. Samples of these land treatment cost computations for Plans 12 and 7, including both capital and O & M costs, are presented at the end of this section, and three schematic diagrams are included to illustrate the cost items corresponding to each column. In these tables and diagrams, Item Nos. 7 through 11 correspond to collection and conventional in-plant treatment facilities and were designed and cost estimated by

Havens and Emerson, Ltd. of Cleveland. However, where aerated lagoons are utilized in land treatment they are also assigned a column (plant) number and the cost figures for the aerated lagoon component are shown in this column when and where applicable. The remaining components, 13 through 29, are related only to systems incorporating land treatment and were designed and costed by Wright-McLaughlin Engineers of Denver. It should be noted that Sludge Management, except by incineration, was also costed by Wright-McLaughlin and used in those plans which are otherwise full or partially water-based treatment as costed by Havens and Emerson, Ltd.

CAPITAL COSTS

The basic element in this costing system is the cost per unit of measurement, or the unit cost. After each plan was broken down into a number of components (i. e., Storage Reservoirs), each component was then analyzed and the cost of its construction was expressed in terms of a unit of measurement related to that component (i. e., the cost per million gallons of storage capacity in a Storage Reservoir). Thus, the estimated total cost of a component within a particular plan might be obtained by multiplying the cost determined for each unit by the number of units called for in that plan.

It is important to note that the unit of measurement is common to components performing the same function in any plan (i. e., million gallons of storage); however, the cost per unit of measurement (cost per million gallons of storage) could vary widely, depending upon the

relative size of a particular component as utilized in a particular plan, according to economies of scale. These relationships are expressed in cost curves presented at the end of this section, and a table entitled Summary of Unit Capital Costs relates the use of these curves to the calculation of the capital cost for each component.

This system enables planners to compare the costs of the components, or groups of components, performing similar functions. It also allows them to estimate the total cost of performing any one function in a given plan. Finally, it makes possible a cost comparison for performing similar functions with different plans.

OPERATION AND MAINTENANCE COSTS

Operation and maintenance unit costs in some cases were based on the computed capital costs for land treatment components, and in other cases, were directly related to design units such as acres or million gallons, etc., rather than to capital costs.

To establish a particular O & M unit cost, a composite labor and materials estimate was made with a separate estimate being made for power, where applicable.

LAND COSTS

Costs for land acquisition were based on information provided by the Real Estate Division of the North Central Divisional Office, Corps of Engineers, Chicago, Illinois. With an acquisition cost of $16,000 for one unit of farm buildings, and an average relocation cost of $5,000 per family, the total cost per acre, including the cost of the land,

averaged $600. The 15 per cent variation allowance previously added by the Real Estate Division in their calculation was included in the overall 30 per cent contingency applied to the capital costs. While the resultant average cost of $780 per acre is slightly higher than the $700 indicated by the Real Estate Division, the new cost appears to be a reasonable estimate in view of the wide variations in land cost by counties and the generally rising trends in the real estate market.

The Real Estate Division office specifically requested that the following limiting condition be set forth in any report incorporating their land cost estimate: "The estimate listed herein is not based upon appraisals; therefore, the prices are estimates only. In addition, the cost for farm buildings to be acquired can vary greatly, depending upon the areas selected, and until a firm plan is available, no definite amounts can be given."

SOURCES OF COSTING INFORMATION

In addition to the accumulated costing experience of Wright-McLaughlin, Havens and Emerson, and AWARE, a number of other organizations were consulted to obtain as broad a base as possible for costing the twelve alternative wastewater management plans. Cost data from actual contract bids is, of course, the preferred source of costing information, and such actual unit costs were used as a basis wherever practical. Governmental agencies, such as the U. S. Bureau of Reclamation, played an important role in providing information. The Corps of Engineers supplied special research material prepared under

contract, such as the "CRREL Report", and compiled resource material and cost curves for consultants engaged in pilot studies currently underway. The Environmental Protection Agency, and other agencies directly concerned with wastewater management, prepared background studies and prototype environmental impact statements. Other sources of information included the consulting firms of Bauer Engineering, Inc. and Woodward-Clevenger Associates, Inc., university personnel, and manufacturers.

The specific references for each land treatment unit cost are contained in a technical submittal entitled "Unit Costs", submitted on September 22, 1972 and revised on October 6, 1972. (See Attachment A)

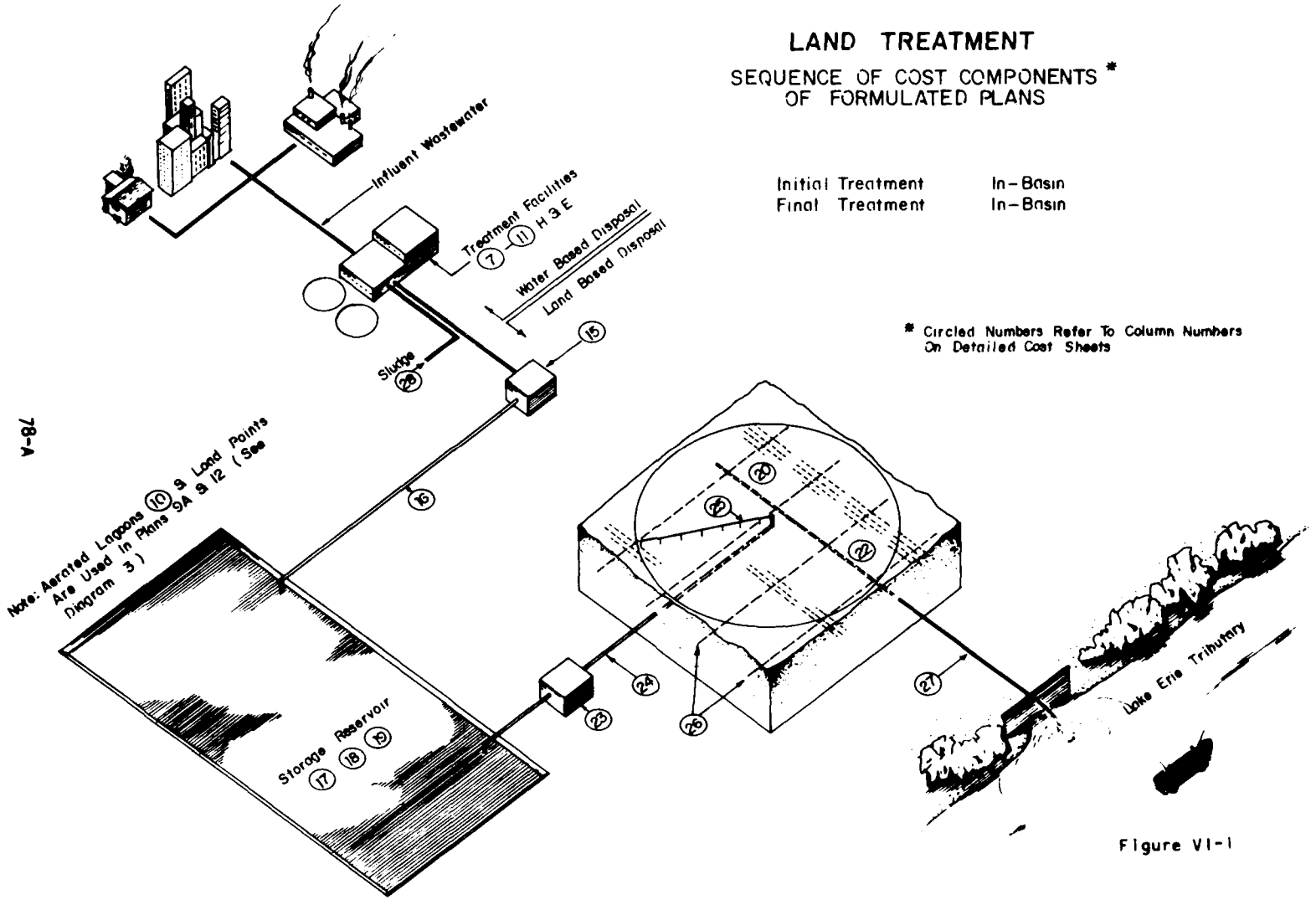

LAND TREATMENT
SEQUENCE OF COST COMPONENTS *
OF FORMULATED PLANS
Initial Treatment In-Basin
Final Treatment In-Basin
* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets
Influent Wastewater
Treatment Facilities
7 - 11 H 3 E
Water Based Disposal
Land Based Disposal
15
Sludge
29
Note: Aerated Lagoons 10 & Land Points 9A & 12 (See Are Used In Plans Diagram 3)
16
20
28
22
24
23
26
27
Storage Reservoir
17 18 19
Lake Erie Tributary

Figure VI-1

LAND TREATMENT

SEQUENCE OF COST COMPONENTS *
OF FORMULATED PLANS

Initial Treatment — In-Basin
Final Treatment — Out-of-Basin

* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

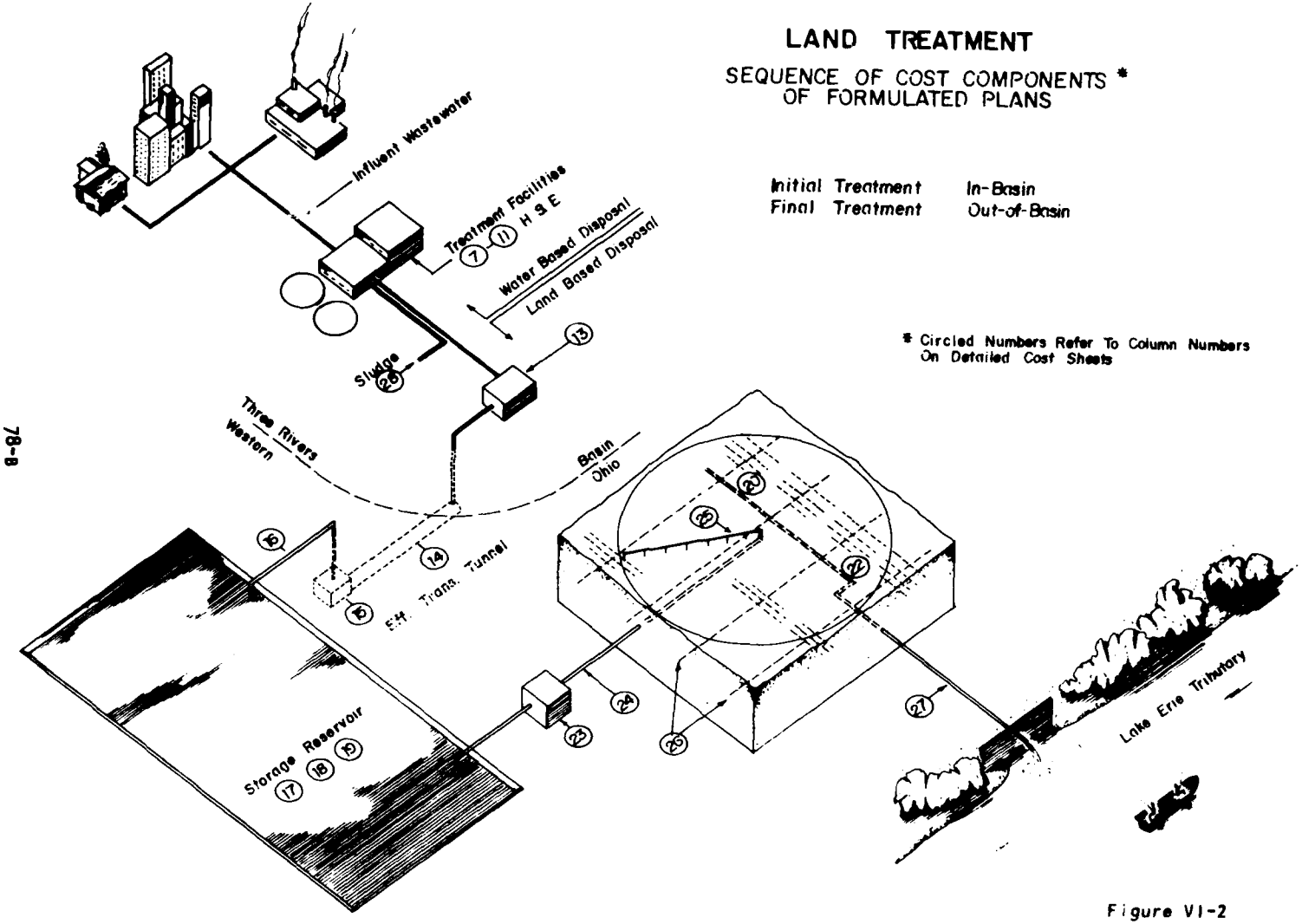


Figure VI-2

LAND TREATMENT
SEQUENCE OF COST COMPONENTS*
OF FORMULATED PLANS

Initial Treatment — Out-of-Basin
Final Treatment — Out-of-Basin

* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

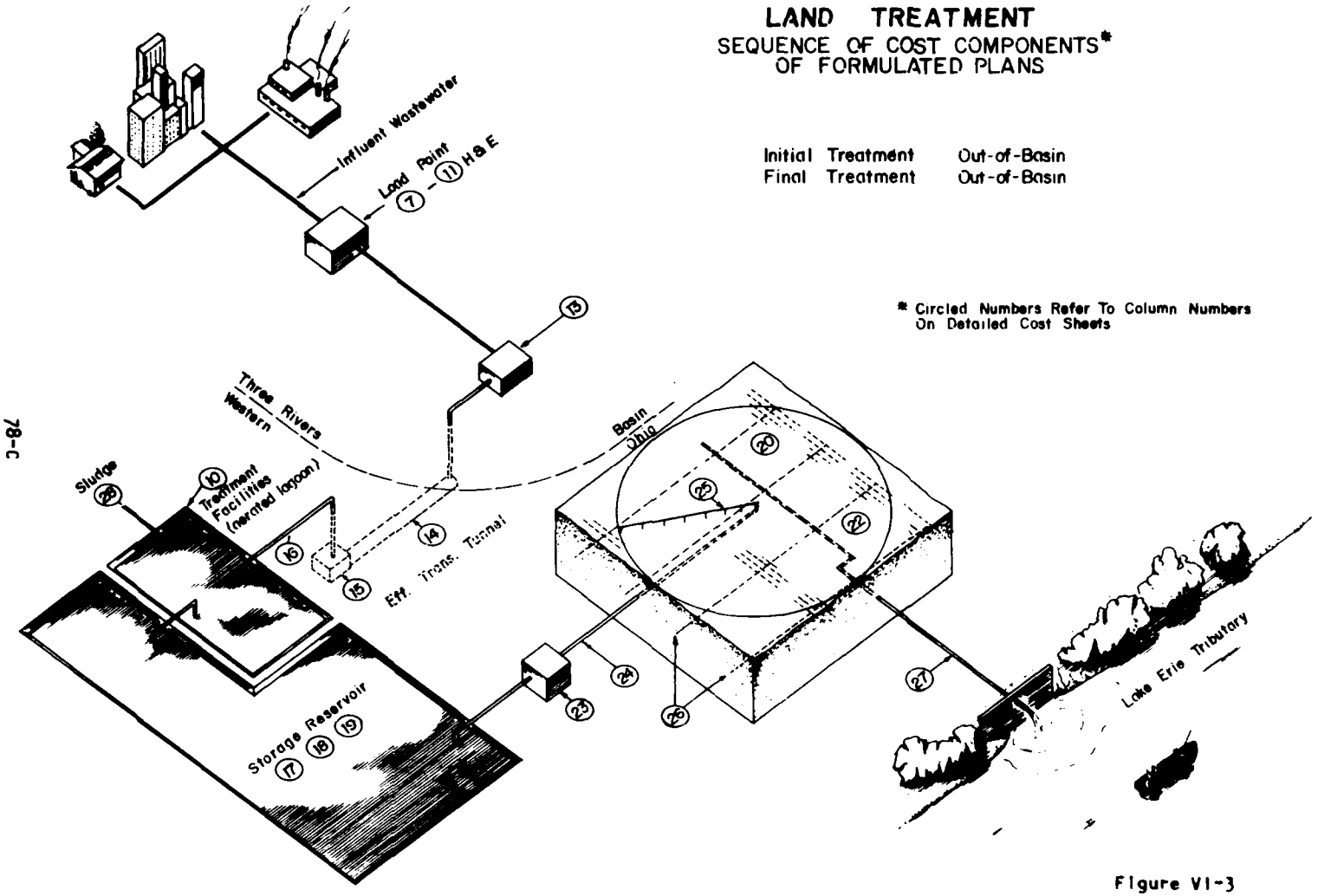


Figure VI-3

TABLE VI-1
LAND TREATMENT
SUMMARY OF UNIT CAPITAL COSTS
FOR FORMULATED PLANS

DETAILED COST SHEET COL. NO.	ITEM OR COST COMPONENT	UNIT USED	COST PER UNIT	REMARKS
1	Plant Name	--	--	
BASIC DESIGN DATA				
2	Detention Storage	MG	Data Used in Component Costing	
3	Plant Capacity	MGD	Data Used in Component Costing	
4	Raw Sludge	TPD	Data Used in Component Costing	
5	Winter Storage	MG	Data Used in Component Costing	
6	Land Treatment Site	Acre	Data Used in Component Costing	
PRE-TREATMENT FACILITIES				
7	Detention Storage	(H&E)	(Costed by H&E)	
8	Sewers	(H&E)	(Costed by H&E)	
9	Pump Station	(H&E)	(Costed by H&E)	
10	Plant: Conventional Secondary Aerated Lagoon	(H&E)	(Costed by H&E)	
10A	Prelim. Treatment	(H&E)	(Costed by H&E)	
10B	Lagoon System	MGD	Varies - Use W-ME Curve G	
10C	Disinfection	MGD	Varies - Use W-ME Curve H	Use Total ADF
11	Sludge	(H&E)	(Costed by H&E)	
12	Total Columns 7-11	--	--	
TRANSMISSION FACILITIES				
13	Pump Plant (Force Main to Tunnel)	MGD	Varies - Use W-ME Curve A	Use Plant Factor to Adjust ADF for Peak Flows
14	Tunnel Complex:			
	Force Main (To Drop Shaft)	Foot	Varies - Use W-ME Curve D	Sized for Peak Flows
	Drop Shaft	Foot	Varies - Use W-ME Curve C	Sized for Peak Flows
	Tunnel	Foot	Varies - Use W-ME Curve B	Sized for Peak Flows
	Lift Shaft	Foot	Varies - Use W-ME Curve C	Sized for Peak Flows

TABLE VI-1 (Continued)
LAND TREATMENT
SUMMARY OF UNIT CAPITAL COSTS
FOR FORMULATED PLANS

DETAILED COST SHEET COL. NO.	ITEM OR COST COMPONENT	UNIT USED	COST PER UNIT	REMARKS
TRANSMISSION FACILITIES (Continued)				
15	Secondary Pump Plant (To Storage Reservoir)			
	From Plant	MGD	Varies - Use W-ME Curve A	Use Plant Factor to Adjust ADF for Peak Flows
	Out of Tunnel	MGD	Varies - Use W-ME Curve E	Use Average Max. Daily Sanitary + Average Daily Stormwater Flow
16	Force Main (To Storage Res.)	Foot	Varies - Use W-ME Curve D	Sized for Peak Flows
STORAGE RESERVOIR				
17	Reservoir	MG	Varies - Use W-ME Curve F	Length of Application Period Determines Storage Capacity
18	Aeration	MG	$700	
19	Disinfection	MGD	Varies - Use W-ME Curve H	Length of Application Period Determines Daily Flow
LAND TREATMENT SITE				
20	Purchase & Relocation	Acre	$600	
21	--	--	--	
22	Site Preparation	Acre	$65	Specialized Preparation Included in Irrigation Equipment
IRRIGATION SYSTEM				
23	Pump Station	MGD	Varies - Use W-ME Curve I	Capacity 1.5 x Application Period Daily Average Flow for Peaking
24	Force Main (Reservoir to Site)	Foot	Varies - Use W-ME Curve D	Sized for Peak Flows
25	Equipment & Distribution Piping	Acre	Varies from $175 to $475	According to Soil Association Being Irrigated

TABLE VI-1 (Continued)
LAND TREATMENT
SUMMARY OF UNIT CAPITAL COSTS
FOR FORMULATED PLANS

DETAILED COST SHEET COL. NO.	ITEM OR COST COMPONENT	UNIT USED	COST PER UNIT	REMARKS
DRAINAGE SYSTEM				
26	Tile	Acre	Varies from $350 to $495	According to Soil Association Being Drained
27	Conduits & Canals	Acre	$25	As Needed to Convey Return Flow to Suitable Discharge Points
SLUDGE MANAGEMENT FACILITIES				
28	Sludge Management			
	Aer. Lagoons to Agric.Land	Ton	$120	
	Conv. Plants to Agric.Land	Gallon	Varies - Use W-ME Curve K	
	Plants & Lagoons to Strip Mine Land	Ton	Varies - Use W-ME Curve L	
MISCELLANEOUS				
29	Monitoring, Admin. Buildings & Laboratories	Percent	5 Percent of Irrigation System + Drainage System Total Capital Costs	

TABLE VI-2
LAND TREATMENT
SUMMARY OF UNIT O & M COSTS
FOR FORMULATED PLANS

DETAILED COST SHEET COL. NO.	ITEM OR COST COMPONENT	UNIT USED	COST PER UNIT	REMARKS
1	Plant Name	--	--	
BASIC DESIGN DATA				
2	Detention Storage	MG	Data Used In Component Costing	
3	Plant Capacity	MGD	Data Used in Component Costing	
4	Raw Sludge	TPD	Data Used In Component Costing	
5	Winter Storage	MG	Data Used In Component Costing	
6	Land Treatment Site	Acre	Data Used In Component Costing	
PRE-TREATMENT FACILITIES				
7	Detention Storage	(H&E)	(Costed by H&E)	
8	Sewers	(H&E)	(Costed by H&E)	
9	Pump Station	(H&E)	(Costed by H&E)	
10	Plant: Conventional Secondary Aerated Lagoon	(H&E)	(Costed by H&E)	
10A	Prelim. Treatment	(H&E)	(Costed by H&E)	
10B	Power (Aeration)	MGD	$7,550/year	Use Total ADF
10C	Maint. & Labor	Percent	3 Percent of Lagoon System Capital Cost	
10D	Disinfection			
	(Maint.&Labor)(In-Basin)	MGD	$3,650/year	Use Total ADF. Power Assumed Negligible.
	(Maint.&Labor)(Out-of-Basin)	MGD	$2,500/year	Use Total ADF. Power Assumed Negligible.
11	Sludge	(H&E)	(Costed by H&E)	
12	Total Columns 7-11	--	--	
TRANSMISSION FACILITIES				
13	Pump Plant (Force Main to Tunnel)			
13A	Power	MGD	$2,100/year	Use Total ADF As Adjusted
13B	Maint. & Labor	Percent	5 Percent of Capital Cost	

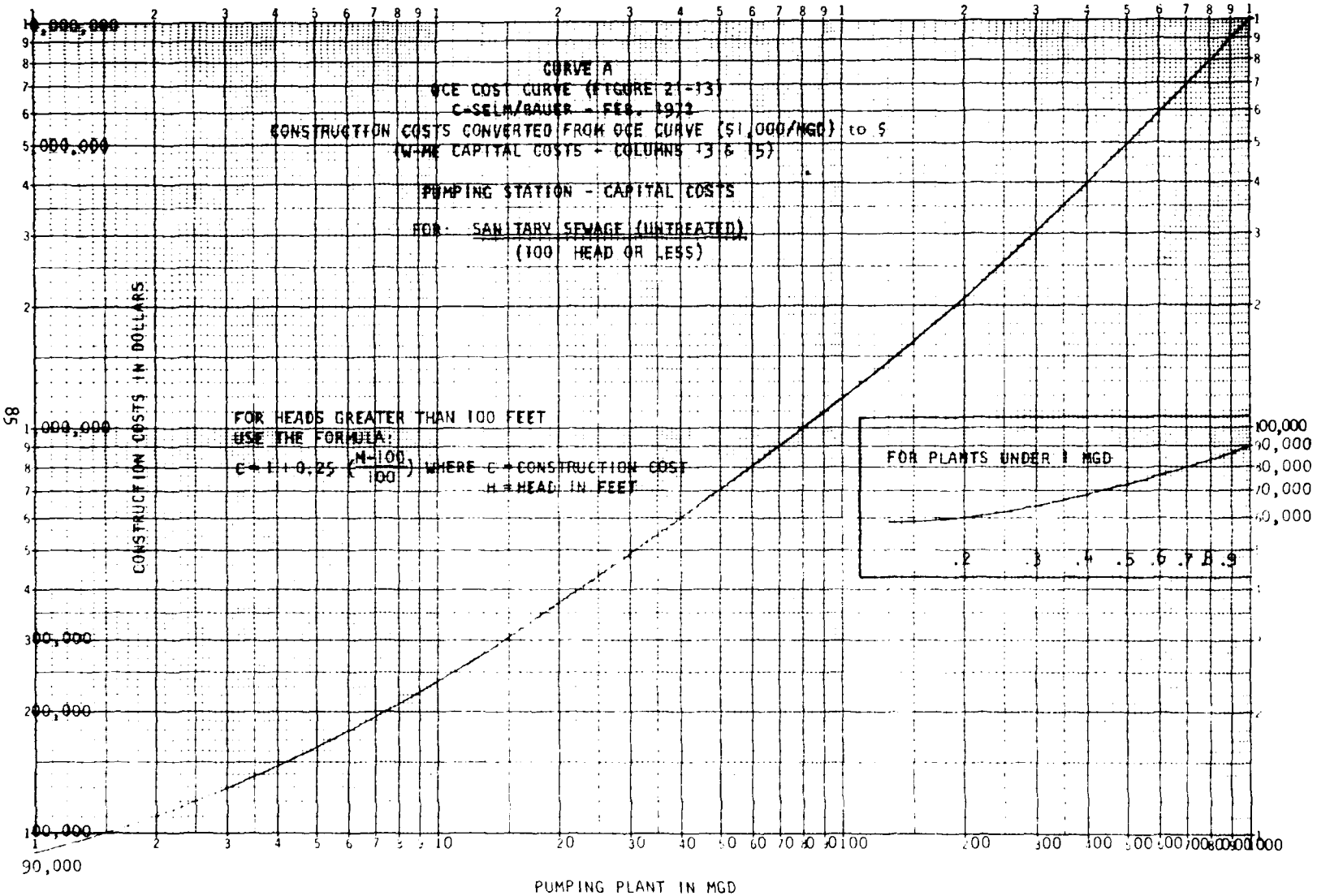
TABLE VI-2 (Continued)
LAND TREATMENT
SUMMARY OF UNIT O & M COSTS
FOR FORMULATED PLANS

DETAILED COST SHEET COL. NO.	ITEM OR COST COMPONENT	UNIT USED	COST PER UNIT	REMARKS
TRANSMISSION FACILITIES (Continued)				
14	Force Main, Drop Shaft, Tunnel, Lift Shaft			
	Maint. & Labor	Percent	1/2 Percent of Capital Cost	
15	Secondary Pump Plant (To Stor. Reservoir)			
15A	Power (From Plant)	MGD	$5,550/year	Use Total ADF As Adjusted
15A	Power (Out of Tunnel)	MGD	$15,000/year	Use Total ADF As Adjusted
15B	Maint.&Labor (From Plant)	Percent	5 Percent of Capital Cost	
15B	Maint.&Labor (Out of Tunnel)	Percent	3 Percent of Capital Cost	
16	Force Main (To Stor. Res.)			
	Maint. & Labor	Percent	1/2 Percent of Capital Cost	
STORAGE RESERVOIR				
17	Reservoir - Maint. & Labor	Percent	1/2 Percent of Capital Cost	
18A	Aeration - Power	MG	$20	Use Storage Reservoir Volume
18B	Aeration - Maint. & Labor	MG	$20	Use Storage Reservoir Volume
19A	Disinfection - Power	MGD		Power Assumed Negligible
19B	Disinfection - Maint. & Labor	MGD	$1,825/year	Length of Application Determines Daily Flow
LAND TREATMENT SITE				
20	Purchase & Relocation	--	--	No O & M Cost Incurred
21	--	--	--	--
22	Site Preparation	--	--	No O & M Cost Incurred
IRRIGATION SYSTEM				
23	Pump Station			
23A	Power (In-Basin Wastewater)	Acre	$18/year	
	(In-Basin Stormwater)	Acre	$36/year	
	(Out-of-Basin)	Acre	$16/year	

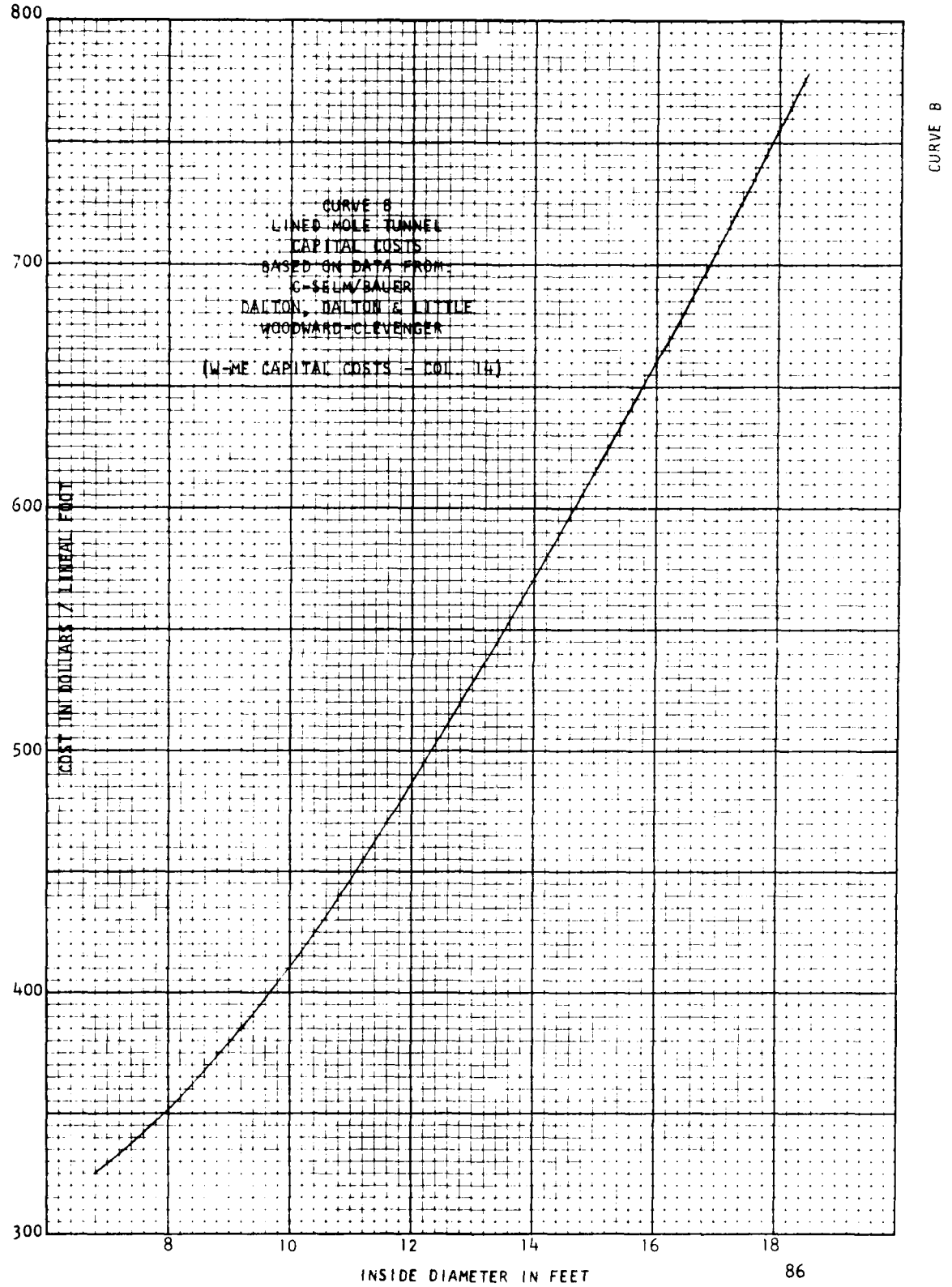
TABLE VI-2 (Continued)
LAND TREATMENT
SUMMARY OF UNIT O & M COSTS
FOR FORMULATED PLANS

DETAILED COST SHEET COL. NO.	ITEM OR COST COMPONENT	UNIT USED	COST PER UNIT	REMARKS
IRRIGATION SYSTEM (Continued)				
	Pump Station			
23B	Maint. & Labor (In-Basin)	Percent	5 Percent of Capital Cost	
	(Out-of-Basin)	Percent	3 Percent of Capital Cost	
24	Force Main - Maint. & Labor	Percent	1/2 Percent of Capital Cost	
25	Equipment & Distribution Piping			
	Maint. & Labor	Acre	$10/year	Using Center Pivot Type Sprinklers
	Maint. & Labor	Acre	$ 4/year	Using Solid Set Sprinklers
DRAINAGE SYSTEM				
26	Tile - Maint. & Labor (In-Basin)	Acre	$ 4/year	
	(Out-of-Basin)	Acre	$ 4.50/year	
27	Conduits & Canals - Maint.&Labor	Acre	$ 2/year	
SLUDGE MANAGEMENT FACILITIES				
28	Sludge Management			Includes Both Power and Maint. & Labor Costs
	Conv.Plant/Agric.Land (In-Basin)	Ton	$40	
	Aer.Lagoons/Agric.Land (In-Basin)	Ton	$16	
	Aer.Lagoons/Agric.Land(Out-of-Basin)	Ton	$16	
	Conv. Plant/Strip Mine Land	Ton	$16	
	Aer. Lagoons/ Strip Mine Land	Ton	$16	
MISCELLANEOUS				
29	Monitoring, Admin. Buildings & Laboratories	Percent	10 Percent of Capital Cost as Computed for Miscellaneous	

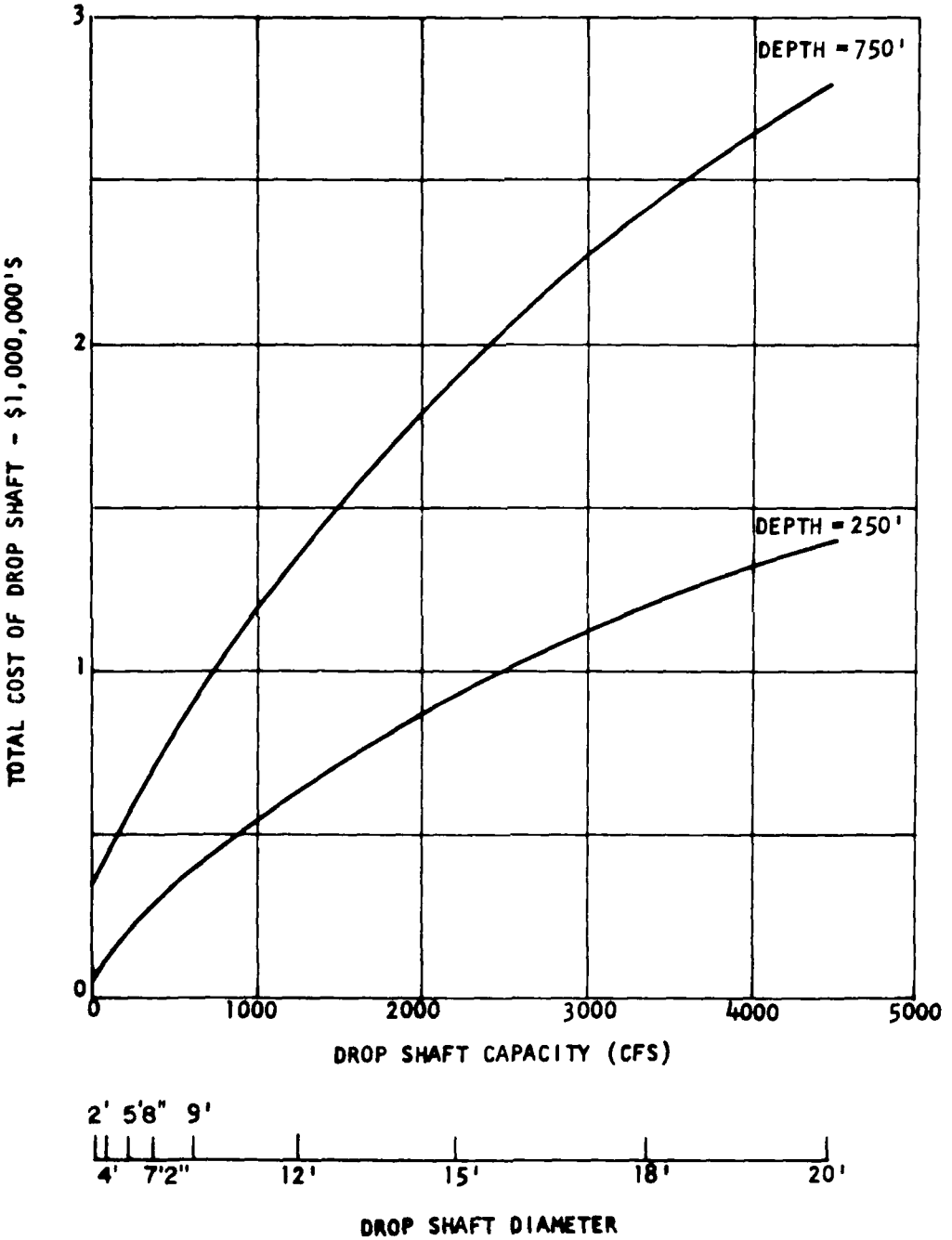
K-E LOGARITHMIC 46 7323
KEUFFEL & ESSER CO.



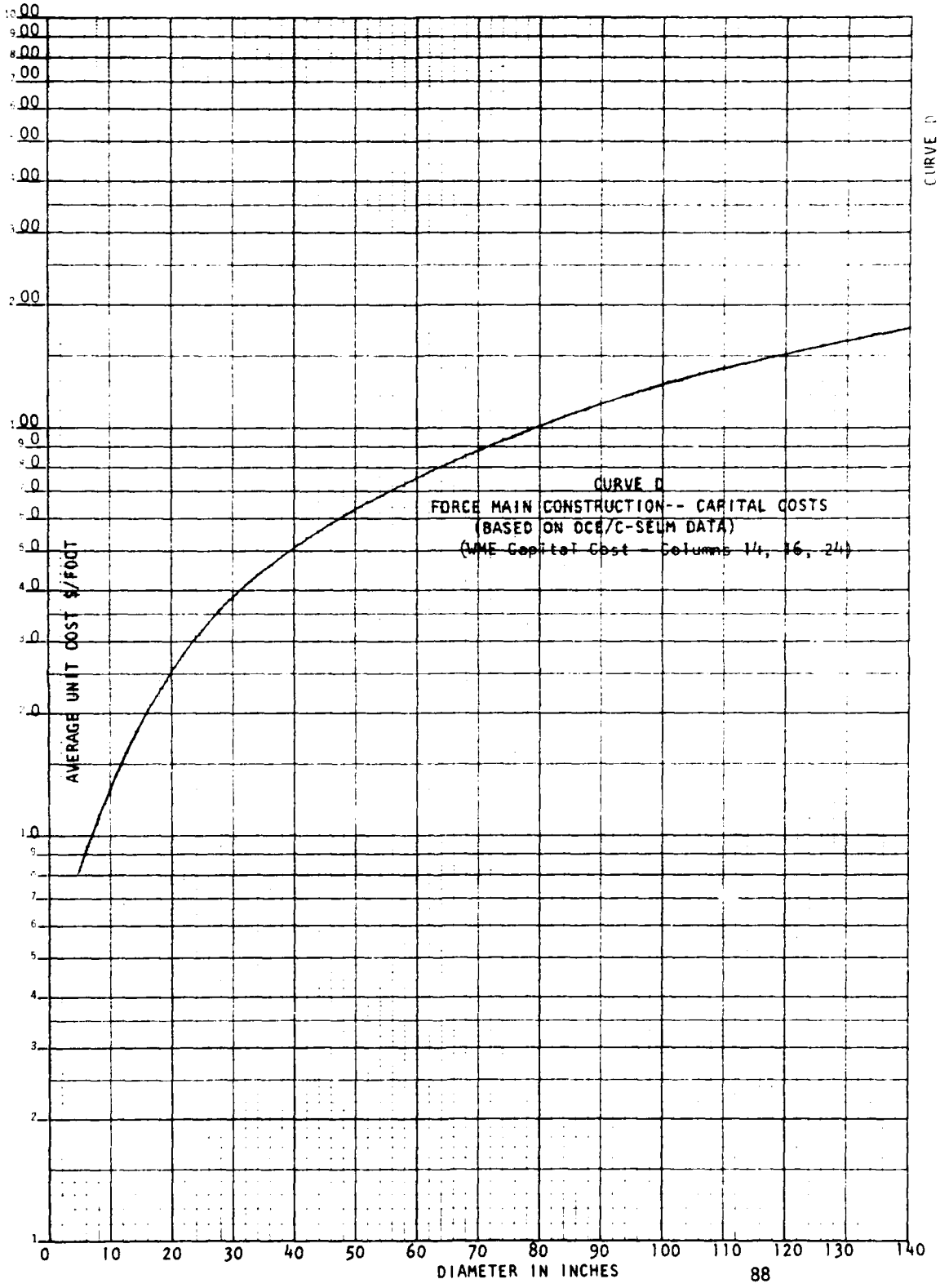
CURVE A


CURVE B
CURVE B
LINED MOLE TUNNEL
CAPITAL COSTS
BASED ON DATA FROM:
G-S&LM/BAUER
DALTON, DALTON & LITTLE
WOODWARD-CLEVENGER
(W-ME CAPITAL COSTS = COL. 14)
COST IN DOLLARS / LINEAL FOOT
800
700
600
500
400
300
8
10
12
14
16
18
INSIDE DIAMETER IN FEET
10 X 10 TO THE INCH 46 0703
7 X 10 INCHES
KEUFFEL & ESSER CO.

CURVE C
OCE, FIGURE 21-14
C-SELM, BAUER
(WME CAPITAL COSTS - COLS. 14 & 15)
DROP SHAFT CAPACITY VS. TOTAL COST

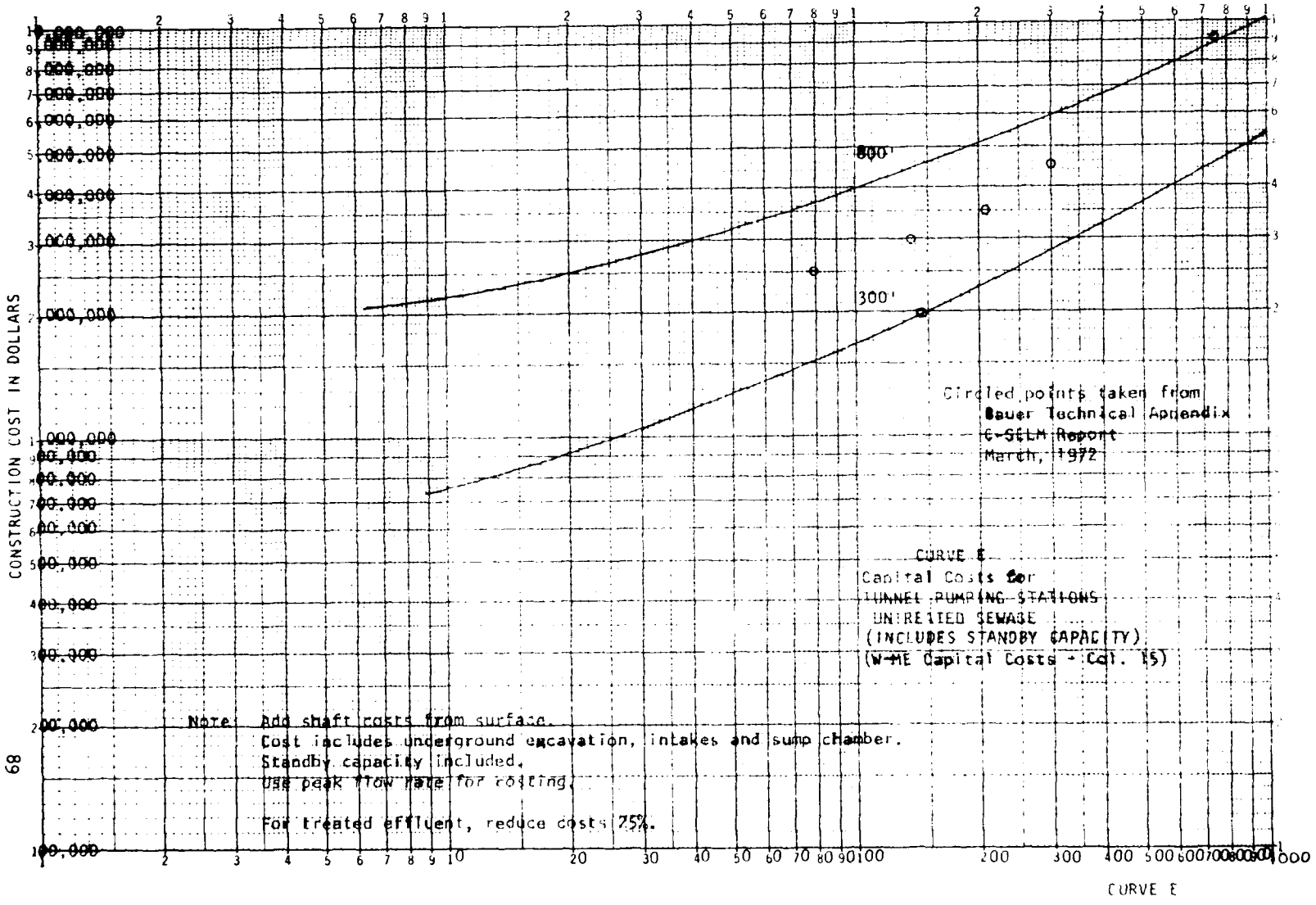


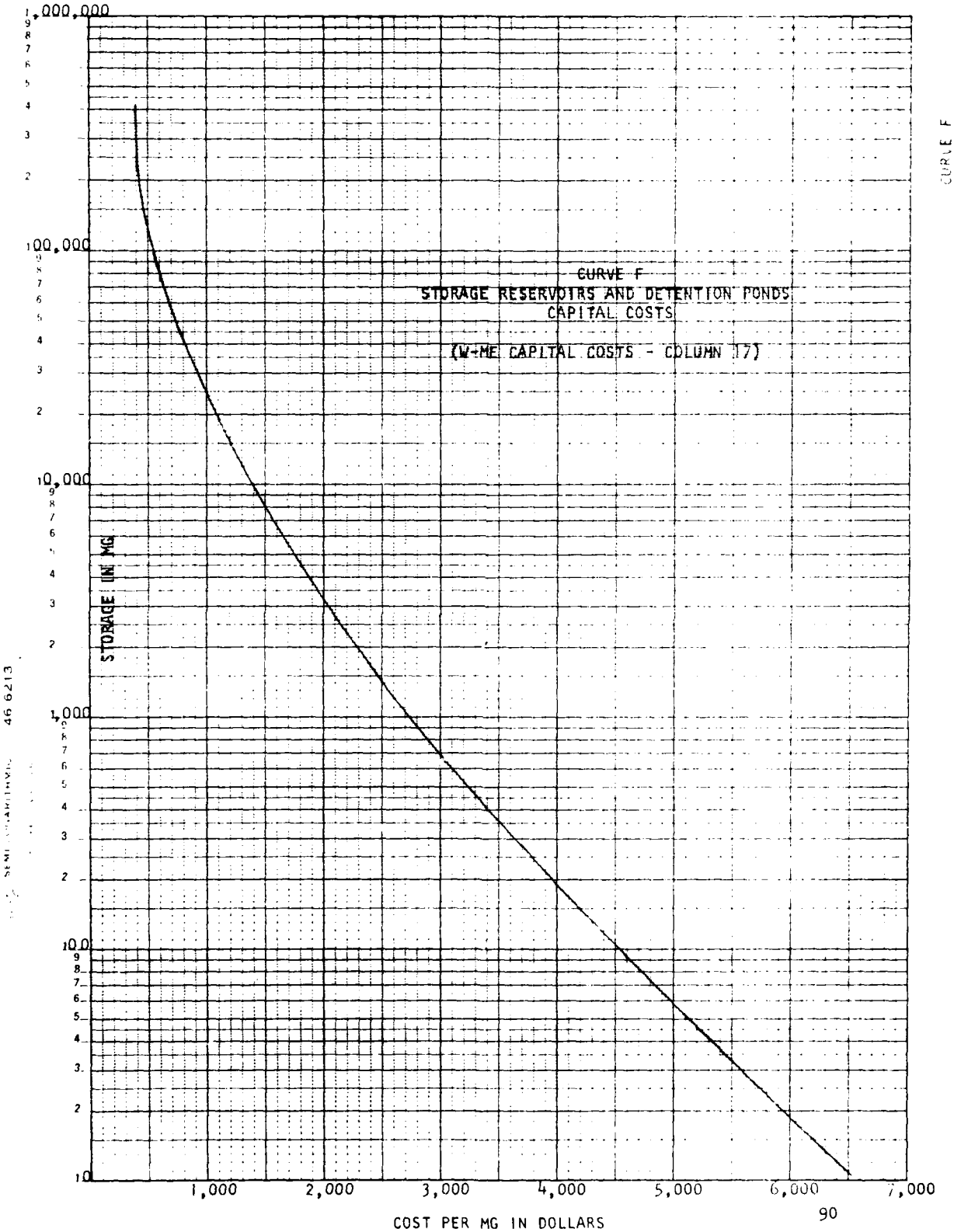
CURVE C

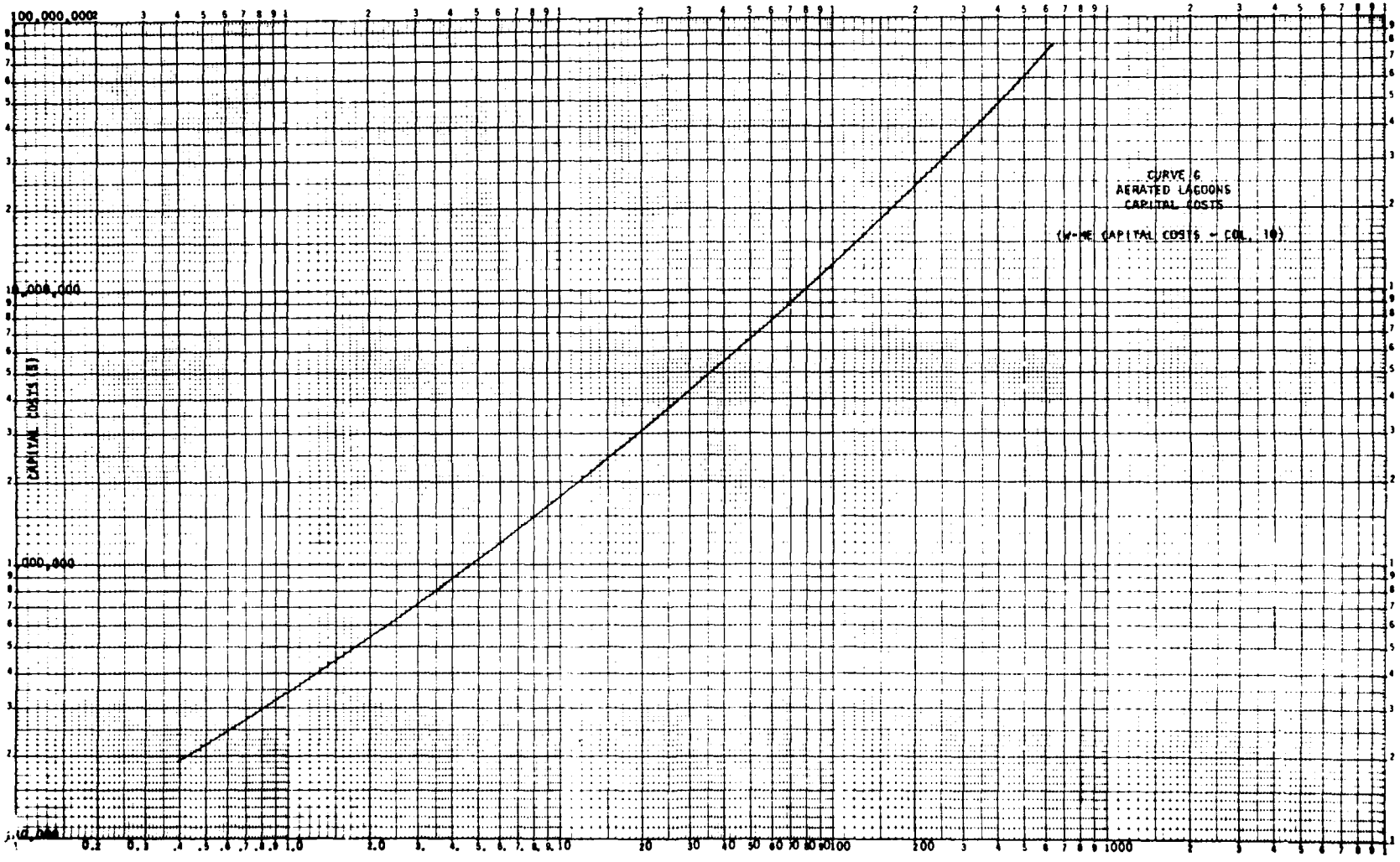

CURVE D
FORCE MAIN CONSTRUCTION-- CAPITAL COSTS
(BASED ON OCE/C-SELM DATA)
(WME Capital Cost - Columns 14, 16, 24)
AVERAGE UNIT COST $/FOOT
DIAMETER IN INCHES
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1
2
3
4
5
6
7
8
9
10
100
200
300
400
500
600
700
800
900
1000

CURVE D

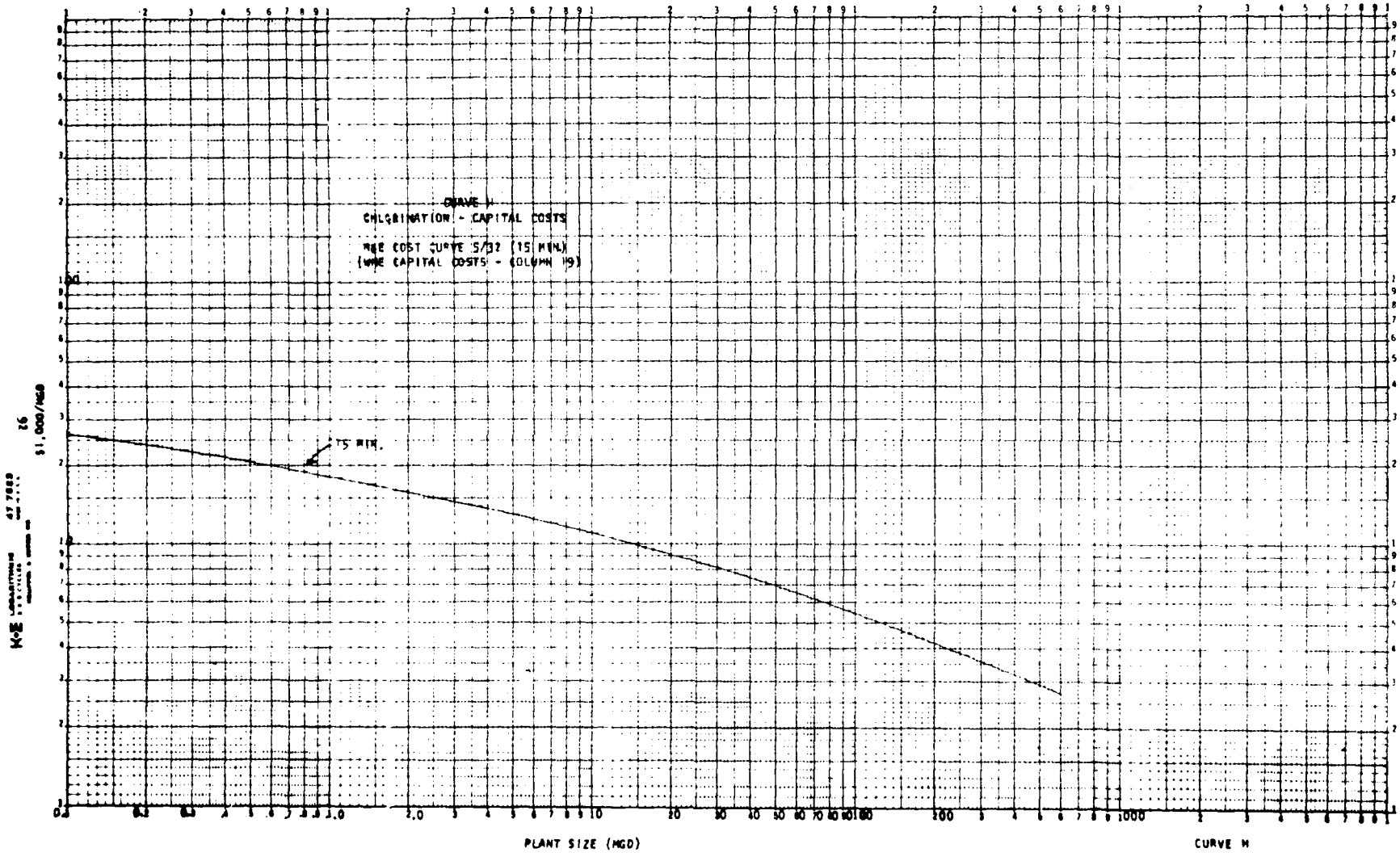
K&E LOGARITHMIC 46 7323
KEUFFEL & ESSER CO



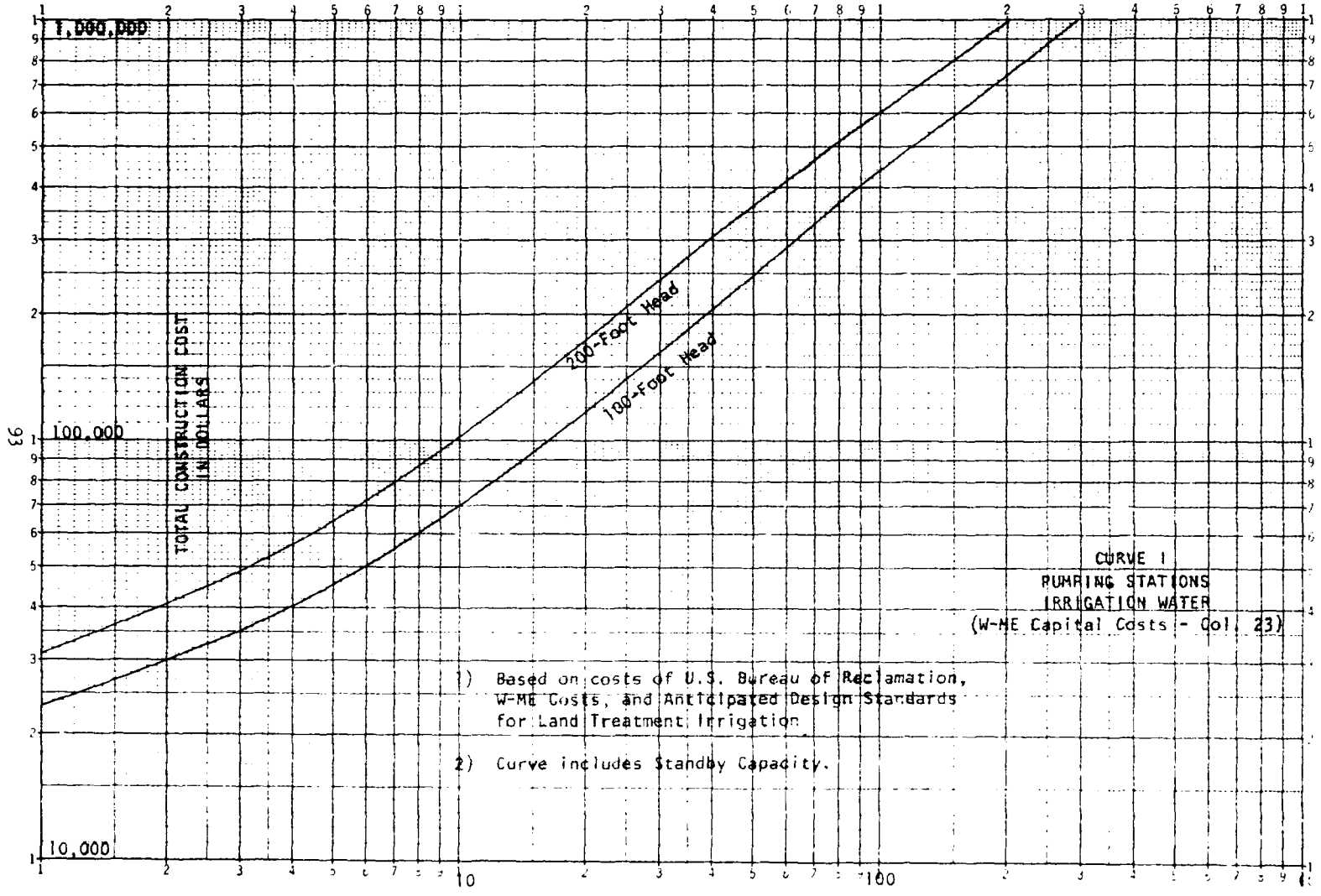

CURVE F
STORAGE RESERVOIRS AND DETENTION PONDS
CAPITAL COSTS
(W-ME CAPITAL COSTS - COLUMN 17)
STORAGE IN MG
1,000,000
100,000
10,000
1,000
100
10
1,000
2,000
3,000
4,000
5,000
6,000
7,000
COST PER MG IN DOLLARS
46 6213


CURVE G
AERATED LAGOONS
CAPITAL COSTS
(W-ME CAPITAL COSTS - COL. 10)
CAPITAL COSTS ($)
AERATED LAGOON - TREATMENT CAPACITY (MGD)

CURVE G


CURVE H
CHLORINATION - CAPITAL COSTS
WPCF COST CURVE 5/32 (15 MIN.)
(WPCF CAPITAL COSTS - COLUMN 19)
15 MIN.
$1,000/MGD
PLANT SIZE (MGD)
CURVE H

LOGARITHMIC 7323



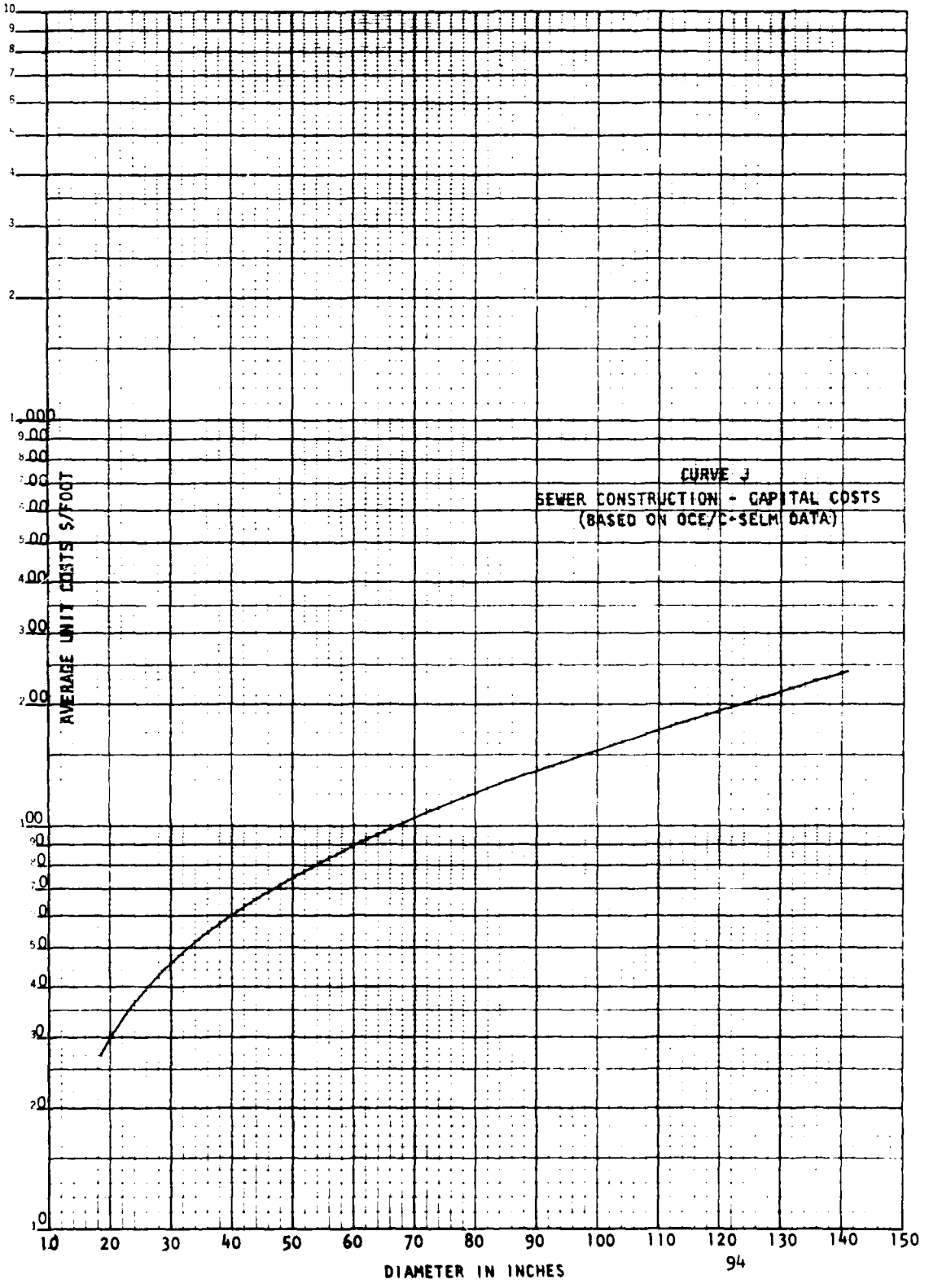
CURVE I
PUMPING STATIONS
IRRIGATION WATER
(W-ME Capital Costs - Col. 23)

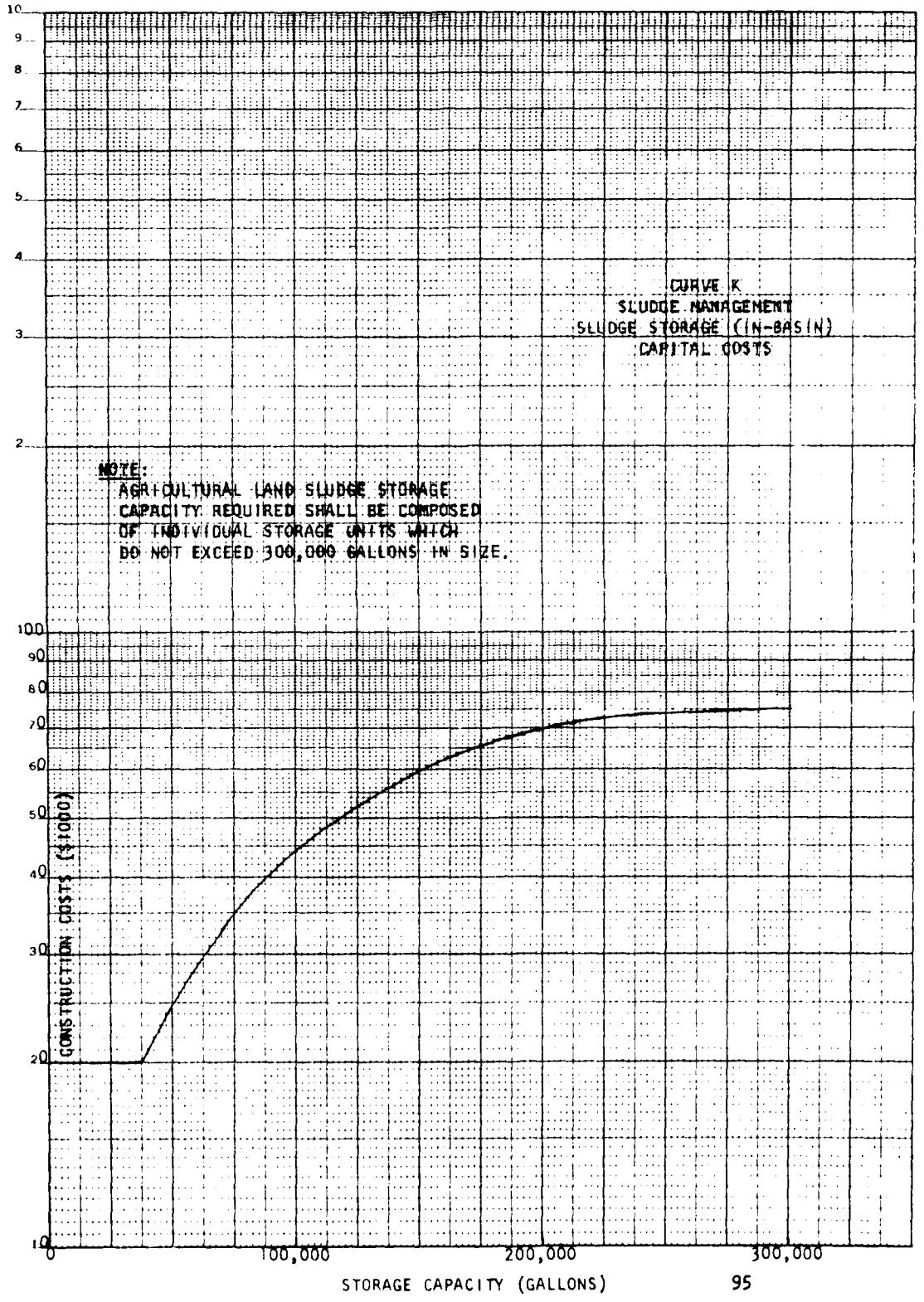
1) Based on costs of U.S. Bureau of Reclamation, W-ME Costs, and Anticipated Design Standards for Land Treatment Irrigation.

2) Curve includes Standby Capacity.

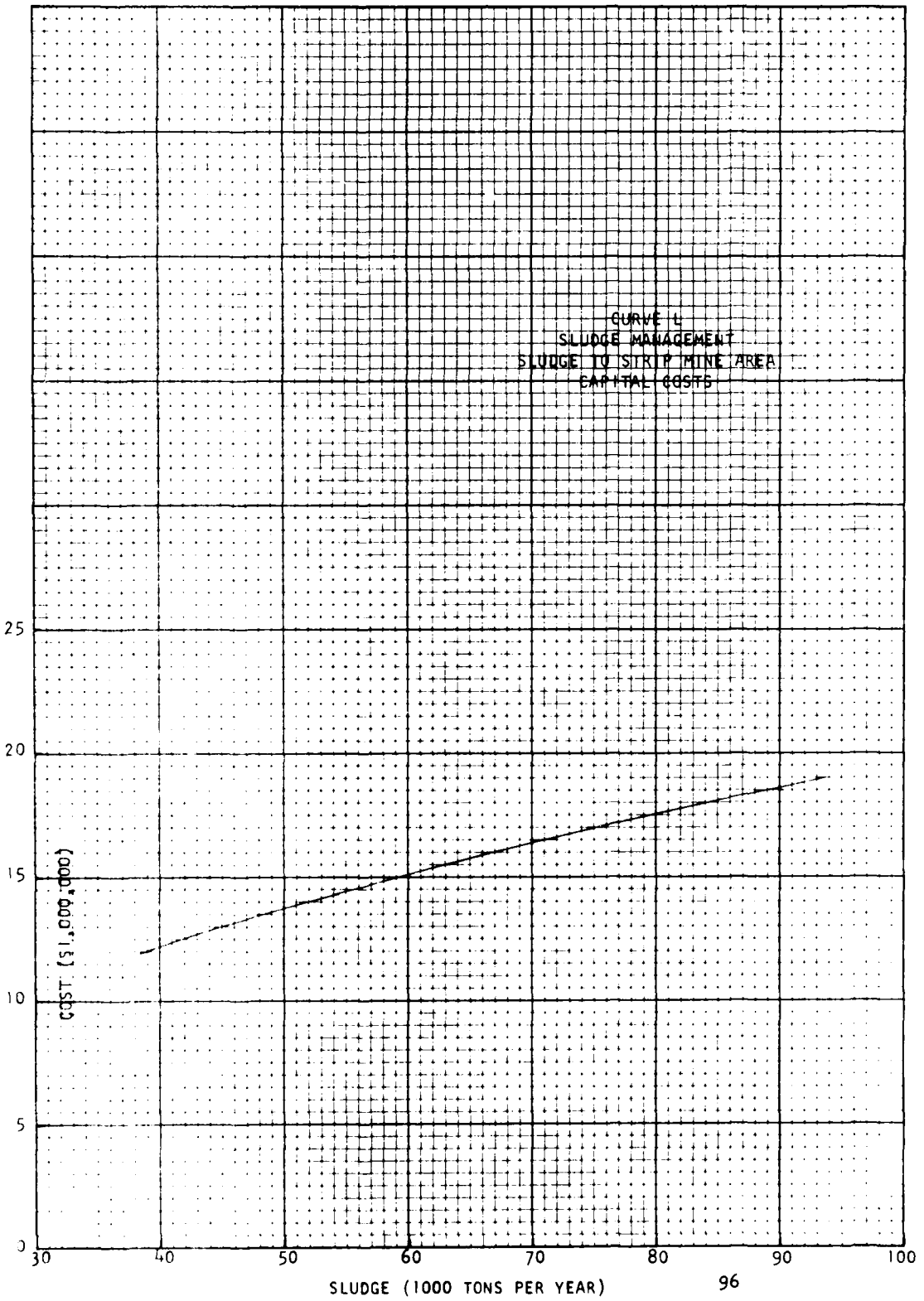
CURVE I

CURVE J


CURVE J
SEWER CONSTRUCTION - CAPITAL COSTS
(BASED ON OCE/C-SELM DATA)
AVERAGE UNIT COSTS $/FOOT
DIAMETER IN INCHES
10
9
8
7
6
4
3
2
1,000
900
800
700
600
500
400
300
200
100
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


CURVE K
SLUDGE MANAGEMENT
SLUDGE STORAGE (IN-BASIN)
CAPITAL COSTS
NOTE:
AGRICULTURAL LAND SLUDGE STORAGE CAPACITY REQUIRED SHALL BE COMPOSED OF INDIVIDUAL STORAGE UNITS WHICH DO NOT EXCEED 300,000 GALLONS IN SIZE.
CONSTRUCTION COSTS ($1000)
STORAGE CAPACITY (GALLONS)
0
100,000
200,000
300,000
10
9
8
7
6
5
4
3
2
100
90
80
70
60
50
40
30
20
10
SEMI-LOGARITHMIC
46 5133
KEUFFEL & ESSER CO.

CURVE K



CURVE L

K&E 10 X 10 TO THE INCH 46 0703
KEUFFEL & ESSER CO

TABLE VI-3

DETAILED CAPITAL COSTS FOR PLAN 7

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . .

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . %
Combined and Separately-Sewered S.R.O. %

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
IN BASIN															
ROCKY RIVER															
Upper E. Branch	--	1.11	0.72	172	250									135	195
Hinckley	55	1.72	1.11	405	1,550									170	330
Mallet Creek	--	0.60	0.39	93	135									110	44
Sub-Totals	55	3.43	2.22	670	1,935									415	569
CHAGRIN RIVER															
Newbury Twp.	--	1.54	0.97	238	345									160	105
Fowler's Mill	--	2.00	1.28	310	450									180	130
Silver Cr. (Fairmount Road)	70	3.40	2.19	702	1,032									250	480
Aurora Central	45	2.98	.92	575	845									500	990
Chagrin E. Branch	--	1.95	1.26	302	440									180	88
Sub-Totals	115	11.87	7.62	2,127	3,112									1,270	1,793
CUYAHOGA RIVER															
E. Claridon	--	0.48	0.31	74	250									100	220
Butternut Creek	--	1.17	0.75	181	265									140	240
Burton	95	3.61	2.33	798	1,175									125	104
Auburn Twp.	--	0.84	0.54	129	190									120	52
Troy Twp.	--	0.47	0.30	73	106									100	110
Mantua	13	0.86	0.56	227	239									120	234
Shalersboro	--	2.00	1.29	310	450									180	110
Randolph	--	0.75	0.48	116	170									120	52
Sub-Totals	108	10.18	6.56	1,908	2,845									1,005	1,122
In-Basin Totals	278	25.48	16.40	4,705	7,892									2,690	3,484

TABLE VI-3 (Continued)

DETAILED CAPITAL COSTS FOR PLAN 7

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . ___

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
IN BASIN														
ROCKY RIVER														
Upper E. Branch	676	146	21	103		11	60	13	77	46	4	45	10	
Hinckley	1,310	345	72	644		70	105	90	483	284	27	60	50	
Mallet Creek	407	79	10	56		6	30	26	42	26	2	25	6	
Sub-Totals	2,393	570	103	803		87	195	129	602	366	33	130	66	
CHAGRIN RIVER														
Newbury Twp.	860	202	25	143		15	50	15	107	62	6	55	12	
Fowler's Mill	1,080	263	32	186		20	95	65	139	82	8	65	19	
Silver Cr. (Falmount Road	1,970	600	96	427		47	120	45	321	188	18	To Strip Mine Land	35	
Aurora Central	1,690	490	82	351		38	110	90	264	155	15	To Strip Mine Land	32	
Chagrin E. Branch	1,040	256	48	187		20	80	22	137	81	8	63	16	
Sub-Totals	6,640	1,811	283	1,294		140	455	237	968	568	55	183	114	
CUYAHOGA RIVER														
E. Claridon	336	63	18	103		11	135	30	78	46	4	22	15	
Butternut Creek	697	154	33	110		12	48	13	83	48	5	45	10	
Burton	2,168	680	105	488		53	130	45	365	214	20	85	38	
Auburn Twp.	1,027	250	40	79		8	68	22	59	35	3	35	9	
Troy Twp.	336	63	15	44		5	45	13	33	20	2	22	6	
Mantua	838	193	30	99		11	60	30	75	44	4	35	11	
Shalersboro	1,080	255	49	186		20	80	22	140	83	8	65	16	
Randolph	490	98	22	71		7	52	15	53	31	3	28	8	
Sub-Totals	6,972	1,756	312	1,180		127	618	190	886	521	49	337	113	
In-Basin Totals	16,005	4,137	698	3,277		354	1,268	556	2,456	1,455	137	650	293	
							Sludge via Pipeline to Strip-Mined Areas (For 6 Plants Including Silver Creek & Aurora Central)					20,000		
							Sludge Management Total (9 Other Plants to Incineration Costed by M&E)					20,650		

TABLE VI-3 (Continued
DETAILED CAPITAL COSTS FOR PLAN 7

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only X

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
IN BASIN															
CHAGRIN RIVER															
CHN-12 (SWTP #15)	19.8			48	73									83	91
CHN-13 (SWTP #15)	34.4			86	107									100	150
CHN-25 (SWTP #20)	25.4			64	104									91	52
CHN-31 (SWTP #31)	16.6			42	64									80	104
CHN-35 (SWTP #48)	18.9			47	73									83	60
CHN-36 (SWTP #48)	26.4			67	103									91	60
Sub-Total	141.5			354	524									528	517
ROCKY RIVER															
R-29 (SWTP #7)	27.0			68	104									92	165
CUYAHOGA RIVER															
CU-53 (SWTP #27)	124.0			310	1,100									170	900
CU-67 (SWTP #32)	55.0			137	211									115	418
CU-73 (SWTP #33)	11.2			28	54									71	90
CU-74 (SWTP #33)	19.7			49	75									84	75
CU-75 (SWTP #34)	28.0			70	107									90	70
CU-76 (SWTP #34)	13.6			34	52									75	50
Sub-Total	251.5			628	1,599									605	1,603
In-Basin Totals	420.0			1,050	2,227									1,225	2,285

TABLE VI-3 (Continued)
DETAILED CAPITAL COSTS FOR PLAN 7

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only X

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
IN BASIN														
CHAGRIN RIVER														
CHN-12 (SWTP #15)	244		13	18		2	34	5	14	8	1		3	
CHN-13 (SWTP #15)	387		18	26		3	42	8	21	11	1		4	
CHN-25 (SWTP #20)	310		16	25		3	38	6	20	11	1		4	
CHN-31 (SWTP #31)	217		12	15		2	33	3	12	7	1		3	
CHN-35 (SWTP #48)	239		11	18		2	39	9	14	8	1		4	
CHN-36 (SWTP #48)	325		15	25		1	44	10	20	11	1		4	
Sub-Total	1,722		85	129		13	230	41	101	56	6		22	
ROCKY RIVER														
R-29 (SWTP #7)	324		17	25		3	38	7	20	11	1		4	
CUYAHOGA RIVER														
CU-53 (SWTP #27)	1,110		57	273		32	71	38	213	118	9		22	
CU-67 (SWTP #32)	577		27	53		6	49	12	41	22	2		6	
CU-73 (SWTP #33)	153		7	13		1	32	7	10	6	1		3	
CU-74 (SWTP #33)	247		11	19		2	40	9	14	8	1		4	
CU-75 (SWTP #34)	333		8	13		1	35	8	10	5	1		3	
CU-76 (SWTP #34)	182		12	20		2	41	9	15	9	1		4	
Sub-Total	2,602		122	391		44	268	83	303	168	15		42	
In-Basin Totals	4,648		224	545		60	536	131	424	235	22		68	

100

TABLE VI-4

DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN 7

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only X

PERCENT OF GRAND TOTAL FOR O. & M. COSTS: Municipal and Industrial . . . . . %
Combined and Separately-Sewered S.R.O. %

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES					
1	2	3	4	5	6	7	8	9	10	11	12	13		14	15		16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant		Force Main Drop Shaft Tunnel	Secondary Pump Plant		Force Main
												13A	13B	14	15A	15B	16
												Power	Maint & Labor	Maintenance & Labor	Power	Maint & Labor	Maintenance & Labor
IN BASIN																	
Combined		25.48	16.40	4,705	5,462										141	134	17
Separate Stormwater		7.16			919										40	61	11

TABLE VI-4 (Continued)

DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN 7

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only X

All Costs In $1,000

	STORAGE RESERVOIR					LAND TREATMENT SITE			IRRIGATION SYSTEM				DRAINAGE SYSTEM				MISC.	
	17	18		19		20	21	22	23		24	25	26	27	28		29	30
PLANT NAME	Reservoir	Aeration		Chlorination		Purchase and Relocation		Site Preparation	Pump Station		Force Main	Equipment & Distribution Piping	Tile	Conduits & Canals	Sludge Management		Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
	17	18A	18B	19A	19B				23A	23B					28A	28B		
	Maintenance & Labor	Power	Maint. & Labor	Power	Maint. & Labor	No O & M		No O & M	Power	Maint. & Labor	Maintenance & Labor	Maint. & Labor	Maintenance & Labor	Maint. & Labor	Power	Maint. & Labor	Maint. & Labor	
IN BASIN																		
Combined	80	94	94	46					98	63	3	22	22	11	1910		29	
Separate Stormwater	23			13					33	27	1	4	4	2			7	

TABLE VI-5

DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . ____

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
								10A	10B	10C					
								Preliminary Treatment	Aerated Lagoons	Disinfection					
IN BASIN															
ROCKY RIVER															
Upper E. Branch	61	1.11	0.72	183	402			34	560	19				90	195
Hinkley	55	1.72	1.11	226	472			34	660	28				110	330
Medina County	--	5.00	3.22	425	900			70	1,050	65				165	180
New Medina	--	9.49	6.12	807	1,275			101	1,700	110				230	450
Mallet Creek	--	0.60	0.39	51	90			27	250	12				76	44
Liverpool	--	5.00	3.22	425	750			70	1,050	65				165	240
Sub-Totals	116	22.92	14.78	2,117	3,889			336	5,270	299				836	1,439
CHAGRIN RIVER															
Haven Road (Newbury)	--	3.54	2.25	550	785			54	800	50				140	210
Silver Cr. (Fairmount Road)	57	3.40	2.19	678	988			54	940	48				140	480
Aurora Central	33	2.98	1.92	561	842			51	840	45				130	990
McFarland Creek	51	4.29	2.76	803	1,169			63	1,050	60				150	1,020
Chagrin Falls	96	3.58	2.31	788	1,166			56	1,050	50				140	420
Chagrin E. Branch	--	1.95	1.26	302	440			40	540	31				110	88
Sub-Totals	237	19.74	12.69	3,682	5,390			318	5,220	284				810	3,208
								Included in H&E Costs							

TABLE VI-5 (Continued)

DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . .

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
IN BASIN														
ROCKY RIVER														
Upper E. Branch	740	128	42	120		26	41	15	86	171	10	8	16	
Hinckley	880	158	49	142		31	47	60	100	201	12	13	21	
Medina County	1,440	298	80	270		59	70	40	194	382	23	39	35	
New Medina	2,340	565	130	382		83	110	60	274	541	32	72	51	
Mallet Creek	260	36	15	27		6	25	22	19	38	2	5	5	
Liverpool	1,440	298	80	225		49	70	40	161	319	19	39	31	
Sub-Totals	7,100	1,483	396	1,166		254	363	237	834	1,652	98	176	159	
CHAGRIN RIVER														
Haven Road (Newbury)	1,750	385	85	235		51	87	81	350	196	20	27	37	
Silver Cr. (Fairmount Road)	2,030	474	90	296		64	76	45	470	247	25	26	43	
Aurora Central				252		54			400	210	21	23		
McFarland Creek	4,830	1,510	245	350		76	230	180	555	292	29	33	140	
Chagrin Falls				350		76			554	291	29	27		
Chagrin E. Branch	1,100	211	48	132		29	56	22	209	110	11	15	20	
Sub-Totals	9,710	2,580	468	1,615		350	449	328	2,538	1,346	135	151	240	

TABLE VI-5 (Continued)

DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . ____

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
								10A	10B	10C					
								Preliminary Treatment	Aerated Lagoons	Disinfection					
IN BASIN															
CUYAHOGA RIVER															
Chardon Windsor	--	0.20	0.13	36	30			27	125	5				60	63
East Claridon	--	0.48	0.31	87	110			27	215	10				72	220
Butternut Creek	--	1.17	0.75	181	260			29	380	21				90	240
Middlefield	54	2.70	1.74	561	817			48	820	41				125	300
Burton	36	0.91	0.59	236	337			27	450	16				88	104
Auburn Twp.	37	0.84	0.54	229	324			27	440	15				84	52
Troy Twp.	--	0.47	0.30	73	106			27	215	10				72	110
Mantua	12	0.86	0.56	164	235			27	355	15				84	234
Shalersboro	--	2.00	1.29	310	450			40	540	32				110	110
Ravenna	--	12.34	7.95	1,910	2,770			130	2,050	130				270	1,720
Randolph	--	0.75	0.48	116	170			27	285	14				82	52
New Kent	177	28.95	18.30	4,960	7,191			190	4,600	240				480	3,088
Tinkers Creek	235	7.20	4.65	1,743	2,500			90	1,900	86				200	1,850
Sub-Totals	551	58.87	37.59	12,706	15,300			716	12,375	635				1,817	8,143
AKRON															
Area "A"		(88.8)		7,530	13,250			320	10,400	440				1,100	5,715
Area "B"		(65.0)		5,500	9,750			230	7,600	400				860	6,750
Sub-Totals		146.9	80.94	13,030	23,000			550	18,000	840				1,960	12,465
In-Basin Totals		248.43	146.00	31,535	47,579			1,920	40,865	2,058				5,423	25,255
								Included in Sewer Costs							

501

TABLE VI-5 (Continued)
DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . ____

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
IN BASIN														
CUYAHOGA RIVER														
Chardon Windsor	195	25	8	9		2	20	9	6	13	1	1	2	
East Claridon	404	61	15	33		7	26	13	52	28	3	4	6	
Butternut Creek	734	127	32	78		17	36	15	123	65	7	9	12	
Middlefield	1,780	393	79	245		53	78	30	388	204	20	21	36	
Burton	910	165	40	101		22	40	22	160	84	8	7	16	
Auburn Twp.	880	160	40	97		21	40	22	154	81	8	6	15	
Troy Twp.	350	51	15	32		7	25	13	50	26	3	4	6	
Mantua	677	115	30	70		15	34	30	111	59	6	7	12	
Shalersboro	1,120	217	49	135		29	47	22	214	112	11	15	20	
Ravenna	5,290	1,340	178	830		180	152	120	1,315	693	69	96	118	
Randolph	510	81	22	51		11	30	15	81	42	4	6	9	
New Kent	8,680	3,470	374	2,150		467	408	398	3,420	1,798	180	221	305	
Tinkers Creek	4,360	1,220	180	750		163	160	90	1,190	625	62	56	106	
Sub-Totals	25,890	7,425	1,062	4,581		994	1,096	699	7,264	3,830	382	453	663	
AKRON														
Area "A"	11,300		610	7,950		860	480	4,560	2,840	5,620	331	652	691	
Area "B"	9,350		493	5,850		635	380	4,110	2,100	4,150	244	478	549	
Sub-Totals	20,650		1,103	13,800		1,495	860	8,670	4,940	9,770	575	1,130	1,240	
In-Basin Totals	63,350	11,488	3,029	21,162		3,093	2,768	9,934	15,576	16,598	1,190	1,910	2,302	

TABLE VI-5 (Continued)
DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . ____

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
								10A	10B	10C					
								Preliminary Treatment	Aerated Lagoons	Disinfection					
OUT-OF-BASIN (Cleveland Shoreline Tunnel)															
North Olmsted	698	37.00	23.8					260				1,300	1,670		
Rocky River	298	22.05	14.2					180				860	15,280		
Lakewood	166	21.00	13.5					180				800	10,860		
Westerly	1,070	41.70	29.2					280					4,545		
Southerly	1,582	178.20	119.0					620					32,800		
Easterly	1,054	172.00	111.0					600					30,735		
Euclid	306	37.34	24.1					240					8,899		
Willoughby-East Lake	463	22.27	14.3					180				910	2,500		
Sub-Total (Shoreline)	5,637	531.56	349.1	98,700	133,500			2,540	83,000	1,700		3,870	340,539	26,560	-
Sub-Total (In-Basin)		248.43	146.0	31,535	47,579			1,920	40,865	2,058		-	-	7,931	25,255
GRAND TOTAL		779.99	495.1	130,235	181,079			4,460	123,865	3,758		3,870	340,539	34,491	25,255

Included in H&E costs

TABLE VI-5 (Continued)
DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only . . . . . ____

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
OUT-OF-BASIN (Cleveland Shoreline Tunnel)														
North Olmsted														
Rocky River														
Lakewood														
Westerly														
Southerly														
Easterly														
Euclid														
Willoughby-East Lake														
Sub-Total (Shoreline	54,285	-	2,224	77,000		8,340	5,800	54,000	46,250	57,200	3,210	4,090	8,320	
Sub-Total (In-Basin)	63,350	11,488	3,029	21,162		3,093	2,768	9,934	15,576	16,598	1,190	1,910	2,302	
GRAND TOTAL	117,635	11,488	5,253	98,162		11,433	8,568	63,934	61,826	73,798	4,400	6,000	10,622	

TABLE VI-5 (Continued)
DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only X

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
ROCKY RIVER															
SWTP #13 (LE-12)	44			146	154									300	380
#11 (R-11)	29			80	85									235	600
#12 (R-12)	59			203	503									365	765
#10 (R-19)	18			59	62									180	220
# 9 (R-20)	27			86	226									225	240
# 8 (R-23,25)	51			165	173									330	645
# 7 (R-26)	4			12	12									100	75
# 6 (R-27)	15			51	53									165	264
# 2 (R-28)	64			210	220									380	152
# 1 (R-29)	12			40	104									150	220
# 3 (R-30,33)	9			34	34									130	105
# 5 (R-31,32)	24			84	87									210	176
# 4 (R-34,35)	33			110	117									255	90
Sub-Total	389			1,280	1,830									3,025	3,932
CHAGRIN RIVER															
SWTP #37 (CHN-7)	4			26	15									95	45
#36 (CHN-8)	5			31	18									105	135
#39 (CHN-9)	11			67	39									140	40
#38 (CHN-10)	32			195	112									250	150
#34 (CHN-12)	9			51	29									130	120
#35 (CHN-13)	16			91	53									170	220
#30 (CHN-18)	3			17	10									90	90
#31 (CHN-19)	3			20	12									90	105
#29 (CHN-25)	12			68	39									150	88
#28 (CHN-31)	7			44	26									115	140
#33 (CHN-35,36)	21			120	71									195	210
#27 (CHN-29)	3			11	26									90	30
Sub-Total	126			741	450									1,620	1,373

TABLE VI-5 (Continued)
DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only X

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
ROCKY RIVER														
SWTP #13 (LE-12)	620		34	92		10	37	40	33	65	4		9	
#11 (R-11)	380		22	51		5	29	30	18	36	2		6	
#12 (R-12)	810		46	302		33	44	40	113	214	12		21	
#10 (R-19)	295		16	38		4	26	30	13	26	1		5	
# 9 (R-20)	395		22	136		15	29	30	48	96	6		10	
# 8 (R-23,25)	725		41	108		11	41	40	37	74	4		8	
# 7 (R-26)				7		1			3	5	1		1	
# 6 (R-27)	260		15	30		3	25	30	11	22	1		4	
# 2 (R-28)	820		47	132		14	45	40	47	93	5		12	
# 1 (R-29)	212		12	62		7	23	18	22	44	3		6	
# 3 (R-30,33)	185		10	20		2	20	18	7	14	1		3	
# 5 (R-31,32)	395		22	52		6	29	30	18	37	2		6	
# 4 (R-34,35)	490		28	70		7	33	30	25	50	3		7	
Sub-Total	5,029		315	1,100		118	381	376	395	776	45		98	
CHAGRIN RIVER														
SWTP #37 (CHN-7)	148		7	9		1	15	18	7	4	1		2	
#36 (CHN-8)	172		8	11		1	15	18	9	5	1		2	
#39 (CHN-9)	320		14	23		3	24	18	19	10	1		4	
#38 (CHN-10)	780		33	67		7	36	30	53	28	3		8	
#34 (CHN-12)	260		11	17		2	22	18	14	7	1		3	
#35 (CHN-13)	420		18	32		3	27	30	25	13	1		5	
#30 (CHN-18)	105		5	6		1	10	18	5	3	--		2	
#31 (CHN-19)	120		5	7		1	10	18	6	3	--		2	
#29 (CHN-25)	330		14	23		3	24	18	19	10	1		4	
#28 (CHN-31)	230		10	16		2	20	18	12	7	1		3	
#33 (CHN-35,36)	530		24	43		5	30	30	34	18	2		6	
#27 (CHN-29)	72		3	16		2	8	18	12	7	1		2	
Sub-Total	2,875		152	270		31	241	234	215	115	13		43	

TABLE VI-5 (Continued)

DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only X

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial. . . . . ____%
Combined and Separately-Sewered S.R.O. ____%

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant	Force Main Drop Shaft Tunnel	Secondary Pump Plant	Force Main
CUYAHOGA RIVER															
SWTP #26 (CU-34)	14			81	117									160	550
#25 (CU-40)	4			25	14									95	105
#24 (CU-41)	5			32	18									105	150
#23 (CU-42)	8			46	27									125	240
#18 (CU-51)	60			365	526									350	675
#17 (CU-53)	45			330	190									300	1,350
#21 (CU-57)	18			130	75									180	132
#19 (CU-58)	45			250	145									300	295
#20 (CU-67,71)	41			246	142									290	720
#15 (CU-73,74)	14			82	48									160	110
#14 (CU-82)	3			15	9									90	135
#40 (CU-43,44,45	47													320	810
#41 (CU-46)	10													135	260
#42 (CU-47)	50													330	450
#43 (CU-48,55,56)	78													440	790
#44 (CU-54)	39													280	90
#45 (CU-62)	38			1,866	1,960									275	600
#46 (CU-66)	37													275	120
#47 (CU-68)	25													215	2,870
#48 (CU-69,70)	103													545	900
#49 (CU-59)	30													240	760
#50 (CU-63)	18													180	675
Sub-Total	732			3,468	3,271									5,390	12,787
In-Basin Totals	1,247			5,489	5,551									10,035	18,092

TABLE VI-5 (Continued)

DETAILED CAPITAL COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. ____
Separately Treated S.R.O. Only X

All costs in $1,000

	STORAGE RESERVOIR			LAND TREATMENT SITE			IRRIGATION SYSTEM			DRAINAGE SYSTEM			MISC.	
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PLANT NAME	Reservoir	Aeration	Chlorination	Purchase and Relocation		Site Preparation	Pump Station	Force Main	Equipment and Distribution Piping	Tile	Conduits and Canals	Sludge Management	Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
CUYAHOGA RIVER														
SWTP #26 (CU-34)	372		17	70		8	26	30	56	29	3		7	
#25 (CU-40)	143		6	8		1	15	18	7	4	1		2	
#24 (CU-41)	176		8	11		1	15	18	9	5	1		2	
#23 (CU-42)	240		10	16		2	20	18	13	7	1		3	
#18 (CU-51)	1,280		56	316		34	50	44	250	131	13		24	
#17 (CU-53)	1,170		52	114		12	48	44	90	48	5		12	
#21 (CU-57)	560		25	45		5	32	30	36	19	2		6	
#19 (CU-58)	950		40	87		9	41	44	69	36	4		10	
#20 (CU-67,71)	950		40	85		9	40	44	67	35	3		9	
#15 (CU-73,74)	375		17	29		3	26	30	24	12	1		5	
#14 (CU-82)	93		4	5		1	10	18	4	2	--		2	
#40 (CU-43,44,45)														
#41 (CU-46)														
#42 (CU-47)														
#43 (CU-48,55,56)														
#44 (CU-54)														
#45 (CU-62)	4,350		250	1,180		127	225	422	422	833	83		91	
#46 (CU-66)														
#47 (CU-68)														
#48 (CU-69,70)														
#49 (CU-59)														
#50 (CU-63)														
Sub-Totals	10,659		525	1,966		212	548	588	1,047	1,161	117		173	
In-Basin Totals	18,563		992	3,366		361	1,170	1,198	1,657	2,052	175		314	

TABLE VI-6

DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal+Industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only. X

PERCENT OF GRAND TOTAL FOR O. & M. COSTS: Municipal and Industrial . . . . . %
Combined and Separately-Sewered S.R.O. %

All costs in $1,000

	BASIC DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES					
1	2	3	4	5	6	7	8	9	10	11	12	13		14	15		16
PLANT NAME	Detention Storage (MG)	Plant Capacity (MGD)	Raw Sludge (TPD)	Winter Storage (MG)	Acres	Detention Storage	Sewers	Pump Station	Plant	Sludge	Total Columns 7-11	Pump Plant		Force Main Drop Shaft Tunnel	Secondary Pump Plant		Force Main
												13A	13B	14	15A	15B	16
												Power	Maint & Labor	Maintenance & Labor	Power	Maint & Labor	Maintenance & Labor
								10A Preliminary Treatment	10B 10C Aerated Lagoons Power Maint & Labor	10D Disinfection							
IN BASIN																	
Combined: Includes 25.4 ADF (S.W.)		273.83	146.0	31,535	47,579				2067 2043	999					1519	271	126
Separate Stormwater		77.5			5,551			Included in H&E Costs							430	50	90
OUT-OF-BASIN																	
Combined: Includes 22.0 ADF (S.W.)		653.6	349.1	98,700	133,500				4935 4277	1634		1372	193	1703	9804	797	

TABLE VI-6 (Continued)

DETAILED OPERATION AND MAINTENANCE COSTS FOR PLAN 12

FOR FACILITIES RECEIVING: Municipal-industrial/Combined S.R.O./Municipal S.T.P. Treated S.R.O. X
Separately Treated S.R.O. Only X

All Costs in $1,000

	STORAGE RESERVOIR					LAND TREATMENT SITE			IRRIGATION SYSTEM				DRAINAGE SYSTEM				MISC.	
	17	18		19		20	21	22	23		24	25	26	27	28		29	30
PLANT NAME	Reservoir	Aeration		Chlorination		Purchase and Relocation		Site Preparation	Pump Station		Force Main	Equipment & Distribution Piping	Tile	Conduits & Canals	Sludge Management		Monitoring, Admin. & Labs., Elec.	Total Columns 7-29
	17	18A	18B	19A	19B				23A	23B					28A	28B		
	Maintenance & Labor	Power	Maint. & Labor	Power	Maint. & Labor	No O & M		No O & M	Power	Maint. & Labor	Maintenance & Labor	Maint. & Labor	Maintenance & Labor	Maint. & Labor	Power	Maint. & Labor	Maint. & Labor	
IN BASIN																		
Combined	316	370	370	500					856	138	50	190	190	95	236		230	
Separate Stormwater	92			141					200	58	6	22	22	11			31	
OUT-OF-BASIN																		
Combined	271			1193					2136	174	270	133	601	267	564		832	

ATTACHMENT A

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN
AND THREE RIVERS WATERSHED AREA

U N I T C O S T S

DEVELOPED BY LAND TREATMENT CONTRACTOR
PHASE II

PREPARED
FOR
U. S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

UNDER CONTRACT NO.: DACW49-72-C-0051

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO
SEPTEMBER 22, 1972
REVISED OCTOBER 6, 1972

UNIT COSTS

Table of Contents

Section

1. Abbreviations

2. Costing Sequence Diagrams - Showing the Cost Components of the Formulated Plans - The Numbers Shown are Keyed to Those Used for the Detailed Cost Sheet Component Columns (See Section 4 for Samples of Detailed Cost Sheets)

3. Unit Costs

A. Capital Costs - Details of Unit Cost Determinations

Cost Component	Detailed Cost Sheet Column Number
(Basic Data)	(1-6)
Treatment Facilities (In Plants or Aerated Lagoons) . . .	7-11
Transmission Facilities	
Pump Plant.	13
Force Main)	
Drop Shaft)	14
Tunnel)	
Secondary Pump Plant.	15
Force Main.	16 (See Col 14)
Storage Reservoir	
Reservoir	17
Aeration	18
Chlorination.	19
Land Treatment Site	
Purchase & Relocation	20
Site Preparation.	22
Irrigation System	
Pump Station.	23
Force Main.	24 (See Col. 14)
Equipment & Distribution Piping .	25
Drainage System	
Tile.	26
Conduits & Canals	27
Sludge Management.	28
Miscellaneous (Monitoring, Admin. Bldgs., Labs.) .	29

CURVES USED FOR COSTING OF COMPONENTS . . .(See Separate List)

CAPITAL COSTS
LIST OF CURVES
USED FOR COSTING

Cost Component	Curve	Detailed Cost Sheet Column Number
Pump Plant (Station)	A	13 & 15
Force Main	D	14, 16, 24
Drop Shaft	C	14
Tunnel (Lined Mole)	B	14
Secondary Pump Plant	E	15
Lift Shaft	C	15
Aerated Lagoons	G	10
Storage Reservoir or Det'n. Pond	F	17
Chlorination	H	19
Irrigation Pump	I	23
Sludge Storage (In Basin)	K	28
Sludge to Strip Mine Areas	L	28
Sewer	J	

UNIT COSTS

Table of Contents (Cont'd.)

Section

3. Unit Costs

B. Operation & Maintenance Costs - Details of Unit Cost Determinations

Cost Component	Detailed Cost Sheet Column Number
(Basic Data)(See A. Capital Costs) .	(1-6)
Treatment Facilities (In Plants or Aerated Lagoons) . . .	7-11
Aerated Lagoons - Power	10A
- Maint. & Labor	10B
- Chlorination. .	10C
Transmission Facilities	
Pump Plant - Power.	13A
- Maint. & Labor . . .	13B
Force Main)	
Drop Shaft)- Maint. & Labor . . .	14
Tunnel)	
Secondary Pump Plant - Power. . . .	15A
- Maint.& Labor	15B
Force Main - Maint. & Labor . . .	16 (See Col. 14)
Storage Reservoir	
Reservoir - Maint. & Labor. . . .	17
Aeration - Power.	18A
- Maint. & Labor	18B
Chlorination - Power.	19A
- Maint & Labor . .	19B
Land Treatment Site.	No O&M for Cols. 20 & 22
Irrigation System	
Pump Station - Power.	23A
- Maint. & Labor . .	23B
Force Main - Maint. & Labor . . .	24 (See Col. 14)
Equipment & Distribution Piping - Maint. & Labor.	25
Drainage System	
Tile - Maint. & Labor	26
Conduits & Canals - Maint. & Labor	27
Sludge Management - Power.	28A
- Maint. & Labor .	28B
Miscellaneous - Maint. & Labor . . .	29

C. Contingencies - Percentage Applied to Capital Costs
- Percentage Applied to O&M Costs

UNIT COSTS

Table of Contents (Cont'd.)

Section

4. Sample Cost Compilation & Summary Forms Used in Costing
-Detailed Capital Costs - Sheets A & B
-Detailed O&M Costs - Sheets A & B
-Comparable Annual Cost Index - Year 2020 - Sheets A & B (Cost Summaries)

ABBREVIATIONS

ADF = Average Daily Flow

AR = Annual Runoff

MDF = Maximum Daily Flow

MF = Peak Hourly Flow

MGD = Million Gallons Per Day

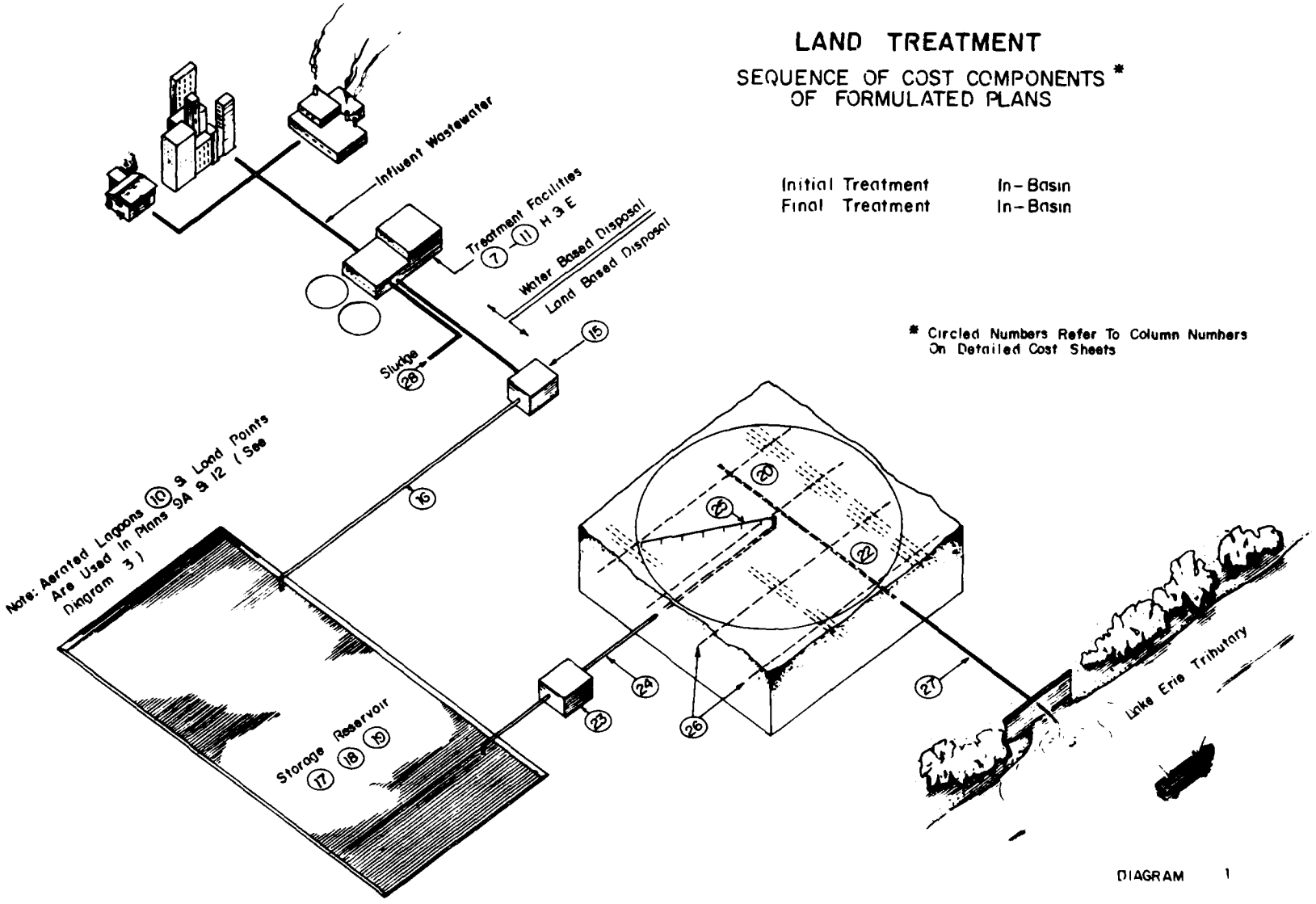
TDH = Total Dynamic Head

TPD = Tons Per Day

LAND TREATMENT

SEQUENCE OF COST COMPONENTS * OF FORMULATED PLANS

Initial Treatment	In-Basin
Final Treatment	In-Basin



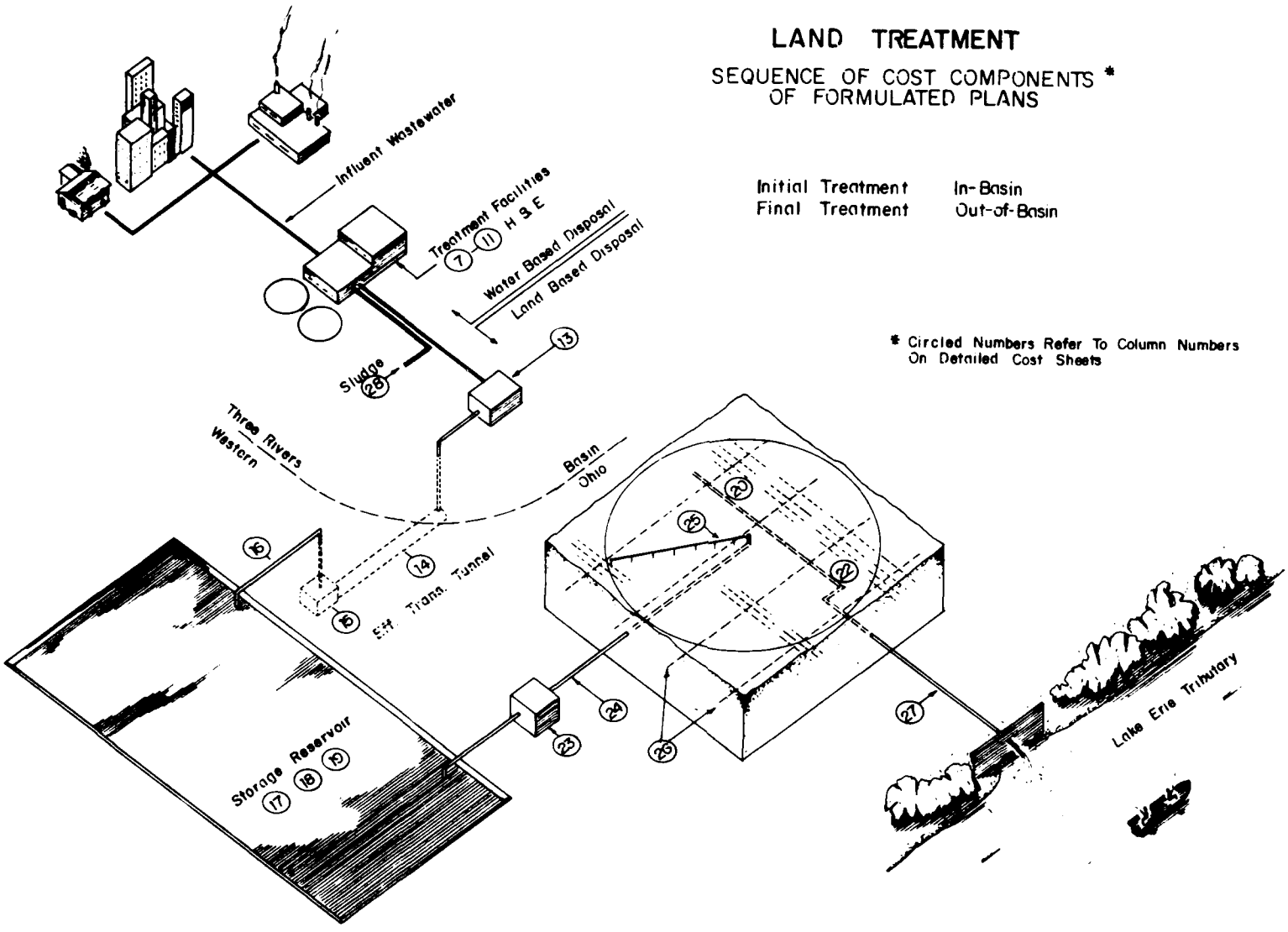
* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

DIAGRAM 1

LAND TREATMENT

SEQUENCE OF COST COMPONENTS * OF FORMULATED PLANS

Initial Treatment — In-Basin
Final Treatment — Out-of-Basin



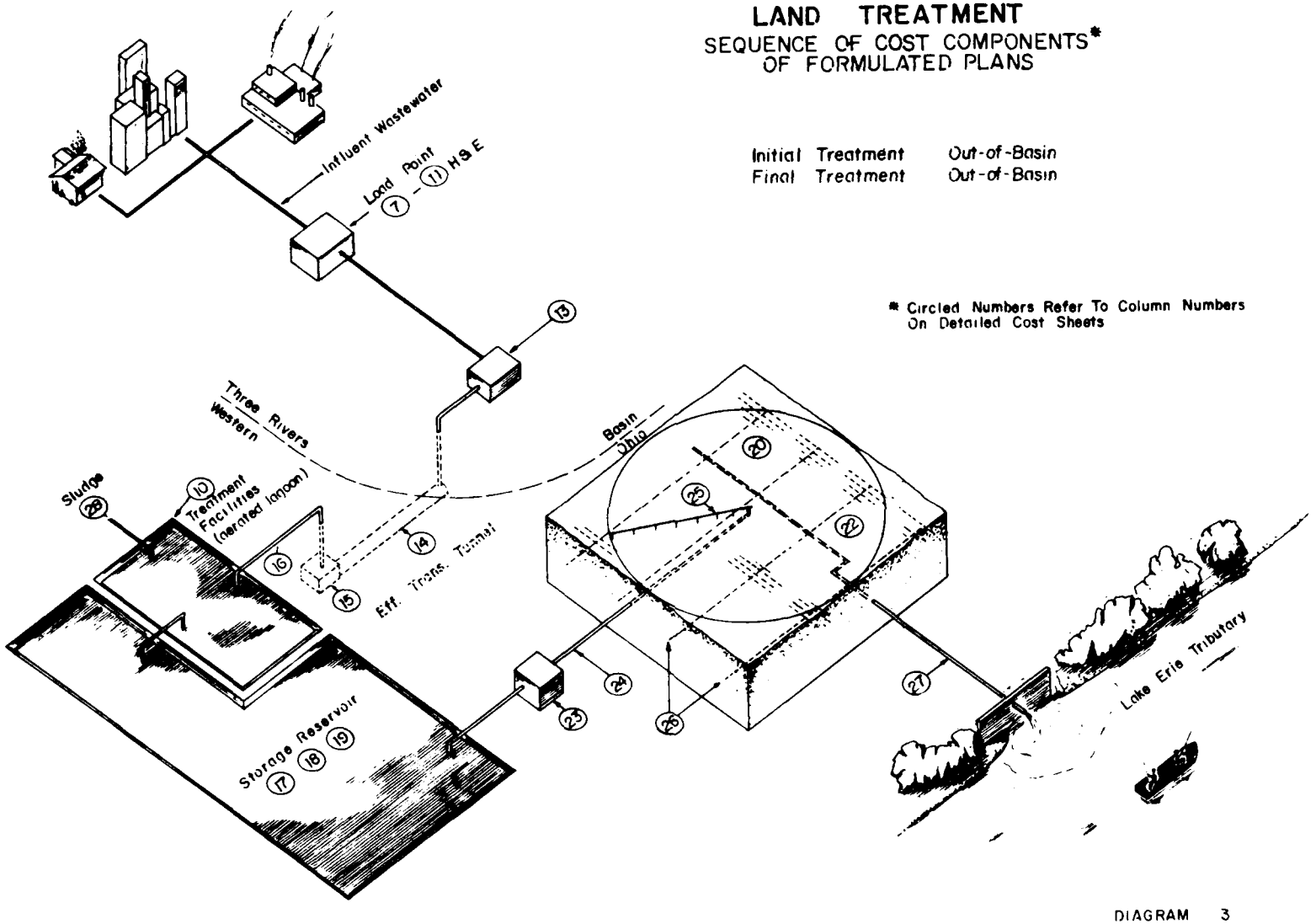
* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

DIAGRAM 2

LAND TREATMENT

SEQUENCE OF COST COMPONENTS* OF FORMULATED PLANS

Initial Treatment — Out-of-Basin
Final Treatment — Out-of-Basin



* Circled Numbers Refer To Column Numbers On Detailed Cost Sheets

DIAGRAM 3

CAPITAL COSTS

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 1-6 JOB NO. 712 - 70

ITEM: Basic Data BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) X

B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Basic Data (Used in Costing) Column: 1-6
Name

Column No.	Item w/Source of Data and/or Explanation
1	Plant Name
2	Detention Storage (MG) A&E Phase I Report - Part B
3	Plant Capacity (MGD) Wastewater: Municipal Wastewater Flow - A&E Projections Phase I Report, Part A Industrial: AWARE Projections Stormwater: A&E Projections Phase I Report, Part B Conceptualized Plants: W-ME Projections
4	Raw Sludge - A&E (TPD)
5	Winter Storage (MG) a. Sanitary Plant No. of Days x (ADF) = MG Storage b. Sanitary Plant with Stormwater Sanitary + Stormwater = MG Storage No. of Days x (ADF) + ½(AR) = MG Storage c. Stormwater Plant (two most widely used %'s are shown as examples) $\frac{155}{365}$ x Annual Runoff = MG Storage or $\frac{85}{365}$ x Annual Runoff = MG Storage
6	Acres Needed for Treatment a. Sanitary Plant (ADF) x 365 x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate = Acres b. Sanitary Plant with Stormwater Sanitary Acres + Stormwater Acres (ADF) x 365 x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate + AR x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate = Acres c. Stormwater Plant AR x 3.07 $\frac{\text{Acre-ft.}}{\text{MG}}$ / App. Rate = Acres

Note: The number of days used to determine the Winter Storage equals 365 days less the number of days of estimated application of wastewater. This can vary depending on the soil type being used for treatment.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item.

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 7-11 JOB NO. 71-2-70
ITEM: Treatment (In Plants) (Aerated Lagoon - Col. 10) BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____
B. General Component Heading:
Treatment Facilities X Irrigation System ____
Transmission Facilities ____ Drainage ____
Storage Reservoirs ____ Miscellaneous ____
Land Treatment Site ____

C. Cost Item Treatment (In Plants or Aerated Lagoon) (Name) Column: 7-11

COMPUTATION:

All costs for sewage treatment plants are supplied by Havens & Emerson. For Plan 9A, 3 plants were costed using aerated lagoons rather than secondary treatment in sewage treatment plants. The costs for these aerated lagoons are included in land treatment costs. For Plan 12 all plants were costed using aerated lagoons.

Column 10 in the detailed cost sheets shows aerated lagoon costs and this component cost is shown under the Land Treatment Site heading rather than under Treatment in Plants on the plan cost summary sheets.

Curve G has been plotted to show the capital cost for a wide range of aerated lagoon treatment capacities. The costs shown in column 10 of the detailed cost sheets were selected from Curve G.

EXPLANATION:

REFERENCES:

Havens & Emerson - Secondary, Tertiary and Advanced Wastewater Treatment Plant Costs.
W-ME - Aerated Lagoon Costs

FINAL UNIT COST USED: All costs supplied by Havens & Emerson except as in Plans 9A & 12.

3

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 13 JOB NO. 71-2 - 70
ITEM: Pumping Plant to Tunnel/ Force Main BY W-iE DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities	X	Irrigation System	____
Storage Reservoirs	____	Drainage	____
Land Treatment Site	____	Miscellaneous	____

C. Cost Item Pumping Plant (Name) Column: 13

COMPUTATION:

Curve A plots the costs of various size pumping plants as used in the C-SELM project. The costs are based on actual contract experience as well as designs built up from component labor and material costs.

EXPLANATION:

REFERENCES:

OCE Cost Curve - Figure 21-13 as shown in
Bauer, C-SELM Report
(Feb. 1972)

FINAL UNIT COST USED: Curve A Used to Determine Individual Plant Costs

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 14, 16 and 24 JOB NO. 712 - 70
ITEM: Force Main BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)

B. General Component Heading:

Transmission Facilities	X	Irrigation System	X
Storage Reservoirs		Drainage	
Land Treatment Site		Miscellaneous	

C. Cost Item: Force Main (Name) Column: 14, 16 and 24

COMPUTATION:

Curve D was plotted from data in the referenced report. Costs of some sizes smaller as well as larger than those shown in the table were then determined by extrapolation

EXPLANATION:

REFERENCES:

OCE Cost Table 21-3 as shown in
Bauer, C-SELM Report
(Feb. 1972)

FINAL UNIT COST USED: Use Curve D to Determine Cost of Various Size Lines

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 14 and 15 JOB NO. 71-2 - 70

ITEM: Drop Shaft (Lift Shaft) BY GGR DATE 9-14-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) _____

B. General Component Heading:

Transmission Facilities	X	Irrigation System	
Storage Reservoirs		Drainage	
Land Treatment Site		Miscellaneous	

C. Cost Item: Drop Shaft (Lift Shaft) (Name) Column: 14 and 15

COMPUTATION:

Curve C, which is Figure 21-14 from the OCE publication (Task No. 21) of the unit costs developed in the C-SELM, Bauer Engineering Study, is the source of drop shaft and lift shaft unit costs.

EXPLANATION:

REFERENCES:

OCE Cost Figure 21-14 as shown in
Bauer, C-SELM Report
(Feb. 1972)

FINAL UNIT COST USED: Use Curve C to Determine Costs of Various Diameter Shafts

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 14 JOB NO. 712 - 70

ITEM: Tunnel BY GGR DATE 9-14-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) _____

B. General Component Heading:
- Transmission Facilities X
- Storage Reservoirs _____
- Land Treatment Site _____
- Irrigation System _____
- Drainage _____
- Miscellaneous _____

C. Cost Item Tunnel (Name) Column: 14

COMPUTATION:

COST PER LINEAL FOOT (Constr. Cost Only)

The ENR Sept. 1970	Finish Dia.	Adjusted '72 (Cleve) (Rpt) D-D&L	'72 (Ltr) W-C	'72 (C-Selm Rpt) BAUER	AVERAGE	ADJUSTED
Engr. Construction Cost	8'	280	400	310	330	350
Index = 1752 (Cleveland)	10'	360	450	380	400	400
(used by Dalton-Dalton-Little) On 6-72 the	12'	460	500	440	470	500
Index = 2025 (Cleveland)	14'	570	600	530	570	600
$\frac{2025}{1752} = 1.16$ (Used to adjust D-D&L costs from 1970 → 1972)	16'	660	650	640	650	650
	18'	780	800	750	780	750

All tunnels are lined:

EXPLANATION:

Based on above average costs, it is felt that tunnel costs in "adjusted" column are reasonable to use. This means W-C costs as used before can be reduced $50/ft for the 8', 10', and 18' tunnels. (The 18' tunnel is adjusted to a slightly below the average figure since the original $800 cost was not in the C letter and was subsequently extrapolated at what is now felt to be e more on the high side - $750 probably would have been a more reasonable extrapolation).

REFERENCES: September 1970 - Dalton, Dalton & Little Cleveland Tunnel Report
February 1972 - C-Selm (Bauer) costs as Published by Corps
June 1972 - Woodward-Clevenger & Assoc. Inc. letter to W-ME

USED: See "Adjusted" column. (Curve B was plotted from the costs shown above)
(Revision as of 9-14- 2)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 15 JOB NO. 712 - 70
ITEM: Secondary Pump Plant BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) _____
B. General Component Heading:
Transmission Facilities _____ Irrigation System _____
Storage Reservoirs _____ Drainage _____
Land Treatment Site _____ Miscellaneous _____

C. Cost Item: Secondary Pump Plant (Name) Column: 15

COMPUTATION:

Curves A and E both plot the costs of various size pumping plants as used in the C-SELM project. The costs are based on actual contract experience as well as designs built up for specific applications.

Use Curve A for pumping into tunnel or pumping from plant to storage reservoirs.

Use Curve E for pumping out of tunnel.

EXPLANATION:

REFERENCES:

Pumping Station Construction Cost as shown in
Cost Data Annex to Technical Appendix
C-SELM, Bauer Engineering Report
(March, 1972)

Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curves A and E to Determine Individual Plant Costs

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

SHEET NO. 1 OF 1

FOR COLUMN #: 17

JOB NO. 71-2-70

ITEM: Storage Reservoirs

BY GGR DATE 9-15-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities	____	Irrigation System	____
Storage Reservoirs	X	Drainage	____
Land Treatment Site	____	Miscellaneous	____

C. Cost Item Storage Reservoirs (Name) Column: 17

COMPUTATION:

	STORAGE VOLUME	COST/MG	ADJUSTED COST/MG (25% contingency Removed)	
Based on sample designs and costing	10 MG	$8,200 x 0.8 =	$6,560	
	540 MG	4,000 x 0.8 =	3,200	
	12,500 MG	1,275 x 0.8 =	1,020	use $1,000/MG min
	50,000 MG (4 cells)	1,230 x 0.8 =	985	
	100,000 (8 cells)		700	) Estimated based on Bauer cost experience
	150,000 (12 cells)		500	)

Land costs and site preparation included in above. Tight soils should not require lining.

EXPLANATION: NOTE: Costing is to be done so that any contingency factor which is applied is added at the very end and to the total cost rather than to individual items comprising the composite estimate.

Storage reservoirs had a 25% contingency added in as used in previous estimates -- this 25% is now removed!

Chicago-Selm Reservoir cost of $363/MG based on adjusted bidding experience at Muskegon (C-Selm Res. is 369,000 MG) (In 8 cells @ 46,000 MG per cell)

REFERENCES:
Wright-McLaughlin Engineers - cost comps.
Bauer Engineering - costs based on Muskegon and other data.

FINAL UNIT COST USED: As shown in adjusted col. above and as plotted for W-ME curve titled "Storage Reservoirs & Detn Ponds - Capital Costs".

(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 18 JOB NO. 712 - 70

ITEM: AERATION BY RMcL DATE 8-11-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)

B. General Component Heading:

Transmission Facilities	Irrigation System
Storage Reservoirs X	Drainage
Land Treatment Site	Miscellaneous

C. Cost Item: Aeration (Name) Column: 18

COMPUTATION:

For emergency - supplemental storage aeration. Prototype 5 MG module @ 20' Depth (avg)
Area = 31,400 s.f. or R = 100' (ok for area of influence)

Avg BOD_5 = 12 mg/l or BOD_u = 20 mg/l

Say satisfy by feed @ 2 mg/l/day maximum rate

#/day for 5 MG = 40 #/day/unit =<2.0 #O_2/hr

Way low: Mixing intensity will govern. Normal for D. O. mix = 6-8 HP/MG
With small units, reasonable D.O. mix (at surface only) can be done w/about 1.0 HP/MG.
5 HP unit w/cables & elect. = $3,500
$3,500/5 MG = $700/MG

EXPLANATION:

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $700/MG

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item.

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 19 JOB NO. 712 - 70
ITEM: Chlorination BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities ____	Irrigation System ____
Storage Reservoirs X	Drainage ____
Land Treatment Site ____	Miscellaneous ____

C. Cost Item Chlorination (Name) Column: 19

COMPUTATION:

Curve H is as supplied by Havens and Emerson.

EXPLANATION:

REFERENCES:

Havens & Emerson

FINAL UNIT COST USED: Use Curve H to determine Chlorination cost for Various Plant Sizes.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

SHEET NO. 1 OF 1

FOR COLUMN #: 20

JOB NO. 712 - 70

ITEM: Purchase & Relocation

BY KRW DATE 9-14-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities ____	Irrigation System ____
Storage Reservoirs ____	Drainage ____
Land Treatment Site X	Miscellaneous ____

C. Cost Item: Purchase & Relocation (Name) Column: 20

COMPUTATION:

Purchase Land Cost - Average $334.00/Acre (page 3 of letter from Dept. of Army - see reference below)

Family Relocation Cost:

Average Farm = 80 acres - based on listed averages
Cost for 1 unit of farm buildings = $16,000
Relocation Cost - $5,000

Total Relocation Cost for One Family	Relocation Cost Per Acre	Total Purchase & Relocation Cost Per Acre:
$16,000	= $21,000/80 acres	$334/Ac. Raw purchase
5,000	= $262.50/Ac.	$262/Ac. Relocation
$21,000		$596/Ac.

EXPLANATION:

Method: Each County priced by township ($/acre)
Cost ($/acre) averaged for each county
Average cost ($/acre) for all counties = $334/acre - See resume, page 3 of letter
Average relocation cost = $262.50/acre - see above or page 4 of letter
Total Estimated Cost Per Acre = $600/acre
(With 15% variation allowance = $700/acre - page 4 of letter)

REFERENCES: Dept. of The Army
North Central Division, Corps of Engineers
536 S. Clark Street
Chicago, Illinois 60605
By letter - July 24, 1972/Management & Disposal Branch, Real Estate Div.

FINAL UNIT COST USED: $600/Acre (does not include any contingency)
Revision as of 9-14-72

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 21 JOB NO. 712 - 70

ITEM: Revision - Farm Equipment BY W-ME DATE 9-14-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site X Miscellaneous ____

C. Cost Item Farm Equipment (Name) Column: 21

COMPUTATION:

Do not include this in cost summary. This item originally estimated at $100/ac. is a cost of doing business. It more appropriately should be considered as a deduct from farm income, along with labor, chemicals, gas, oil, and vehicles.

Net farm income estimates can be more readily referenced to by leaving out of estimate.

EXPLANATION:

Land management has been investigated in detail with regard to specific crops, type of application, type of drainage, etc. Costs of irrigation equipment and drainage reflect land management techniques required initially such as surface preparation and specialized deep plowing.

REFERENCES: Wright McLaughlin Engineers

FINAL UNIT COST USED: Drop Farm Equipment Cost (Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 22 JOB NO. 712 - 70

ITEM: Site Preparation (Revised) BY W-ME DATE 9-14-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities	____	Irrigation System	____
Storage Reservoirs	____	Drainage	____
Land Treatment Site	X	Miscellaneous	____

C. Cost Item Site Preparation (Name) Column: 22

COMPUTATION:

1)	Woodland clearing	$35/acre
2)	Miscellaneous site preparation such as fences, removals, site work	20/acre
3)	Access roads	5/acre
4)	Miscellaneous grading for operation	5/acre
		$65/acre

$65/acre is basic site preparation. Specialized site preparation to be included in irrigation equipment.

Note: Relocation costs and purchase of farm buildings included in cost of land at $700/acre (includes 15% contingency factor included by Chicago Division). Thus, use $600/acre in computations for land purchase and relocation. Families not moved from site would tend to lower land costs.

EXPLANATION:

1) Woodland clearing computed at 10% of total area at $350/acre. Much of woodland will not be cleared, however.
2) Includes removal of buildings which would conflict with operations.
3) Access roads would be in addition to existing roads, for access to operational points of irrigation and drainage facilities.
4) This includes grading for irrigation facilities, access roads, etc.. For specialized irrigation and application techniques, additional site preparation will be included under irrigation equipment.

REFERENCES: Reservoir clearing experience in Colorado - Wright - McLaughlin Engineers
"Cost Summary for Land Treatment" ($82/acre)
"Muskegon Contract No. 1"
C - SEEM Report - Technical Appendix (Cost Data Annex)
March, 1972

FINAL UNIT COST USED: $65/acre
(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

SHEET NO. 1 OF 1

FOR COLUMN #: 23

JOB NO. 71-2-70

ITEM: Pump Station

BY W-ME DATE 9-20-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) _____

B. General Component Heading:

Transmission Facilities _____	Irrigation System X
Storage Reservoirs _____	Drainage _____
Land Treatment Site _____	Miscellaneous _____

C. Cost Item Pump Station (Name) Column: 23

COMPUTATION:

Curve I is based on construction cost experience.

EXPLANATION:

REFERENCES:

U. S. Bureau of Reclamation
Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curve I to Determine Individual Plant Costs

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 6
FOR COLUMN #: 25 JOB NO. 71-2 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - MAHONING SOILS MINI-BORDER SYSTEM BY W-ME DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)

B. General Component Heading:
Transmission Facilities Irrigation System X
Storage Reservoirs Drainage
Land Treatment Site Miscellaneous

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) Column: 25

COMPUTATION: MAHONING SOILS - MINI-BORDER SYSTEM

For application rates of 90 inches/year (municipal effluent) or 150 inches/year (separate storm runoff).

Automated farm distribution equipment (25-year life) . .	$150/acre
Site Preparation:	
Forming	$ 10/acre
Soil preparation and seeding	$ 15/acre
Deep plowing on contour	$ 40/acre
	$215/acre

EXPLANATION:

REFERENCES:
Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept. Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $215/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 6
FOR COLUMN #: 25 JOB NO. 712 - 70
ITEM: EQUIPMENT DISTRIBUTION PIPING-CHILI & RELATED SOILS IN-BASIN BY W-ME DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)
B. General Component Heading:
Transmission Facilities Irrigation System X
Storage Reservoirs Drainage
Land Treatment Site Miscellaneous

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING Column: 25
Name

COMPUTATION: CHILI AND RELATED SOILS IN-BASIN

For application rate of 60 inches/year.

Use solid-set system.

Sprinklers . . . . . $ 300/acre
Distribution System . . . . . $ 175/acre

$475/acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept.
Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $ 475/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 3 OF 6
FOR COLUMN #: 25 JOB NO 712 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS (COMPOSITE) BY W-ME DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)
B. General Component Heading:
Transmission Facilities Irrigation System X
Storage Reservoirs Drainage
Land Treatment Site Miscellaneous

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING Column: 25
Name

COMPUTATION: CARDINGTON - BENNINGTON SOILS
(COMPOSITE OF WESTERN AREAS)

Mini-Border	5%	0.05	(175) =	9
Hay & Pasture	30%	0.30	(475) =	142
Corn (Pivot Rigs)	65%	0.65	(320) =	208
				359

USE $360/Acre

EXPLANATION:

REFERENCES: Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept. Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $360/Acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 4 OF 6
FOR COLUMN #: 25 JOB NO. 71-2 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS BY RLT DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) Column: 25

COMPUTATION:

CARDINGTON-BENNINGTON SOILS

For application rate of 75 inches/year on corn with drip tubes on rigs. On 160 acres one large rig irrigates 122 acres.

Cost of Pivot Rig: $23,000

Cost per acre: $23,000/122 acres = $190/acre Use: $200/acre

Cost of Piping $100/acre

Circular Plowing with roads and gully crossing . . . $ 20/acre

$320/acre

EXPLANATION:

REFERENCES:
Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept., Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $320/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 5 OF 6
FOR COLUMN #: 25 JOB NO. 712 - 70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS BY RLT DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) Column: 25

COMPUTATION: CARDINGTON-BENNINGTON SOILS

For application rate of 50 inches/year using solid-set system.

Cost of Sprinklers $300/acre
Cost of Distribution System. $175/acre
$475/acre

EXPLANATION:

REFERENCES:
Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept., Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $475/acre

AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA. W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL

5 OF 7
AD A
101 315

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 6 OF 6
FOR COLUMN #: 25 JOB NO. 71-2-70
ITEM: EQUIPMENT & DISTRIBUTION PIPING - CARDINGTON-BENNINGTON SOILS - MINI BORDER BY RLT DATE 9/18/72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: EQUIPMENT & DISTRIBUTION PIPING (Name) Column: 25

COMPUTATION:

CARDINGTON-BENNINGTON SOILS - MINI-BORDER SYSTEM

Automated Farm Distribution	$150/acre
Site Preparation	
Forming	$ 10/acre
Soil Preparation and Seeding	$ 15/acre
	$175/acre

EXPLANATION:

REFERENCES:
Donald L. Miles, Irrigation Specialist, Agricultural Engineering Dept., Colorado State University
Wright-McLaughlin Engineers
Valmont Industries, Inc., Valley, Nebraska
IRECO Industries, Inc., Eugene, Oregon
ENRESCO, Colorado Springs, Colorado
Rain Bird Sprinkler Manufacturing Corp., Glendora, California

FINAL UNIT COST USED: $175/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 6
FOR COLUMN #: 26 JOB NO. 71-2-70
ITEM: Tile - Mahoning Soils - Mini-Border BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Tile - Mahoning Soils (Name) Column: 26

COMPUTATION:

MAHONING SOILS: MINI-BORDER SYSTEM

For stormwater use 150"/yr. application rate.
For sanitary sewage use 90"/yr. application rate.

Spacing = 70'
Total length = 2180'

Total cost of tile (2180') = $328/acre
Collectors and structures = $ 95/acre
$423/acre

Use $425/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $425/acre (MAHONING SOILS: MINI-BORDER SYSTEM)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 6
FOR COLUMN #: 26 JOB NO. 71-2-70
ITEM: Tile - Cardington-Bennington Soils BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Tile - Cardington-Bennington Soils (Name) Column: 26

COMPUTATION:

CARDINGTON-BENNINGTON SOILS -- CORN

Use application rate of 75"/yr.

Spacing = 20'

Total length = $\frac{209}{20}$ (209) = 2180 l.f.

Total cost of tile (2180')	=	$480/acre
Add $70/acre for collectors, structures, etc.	=	$ 70/acre
		$550/acre
Deduct 10% for existing tiles	=	- 55/acre
		$495/acre

Net cost/acre = $495/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $495/acre (CARDINGTON-BENNINGTON SOILS--CORN)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 3 OF 6
FOR COLUMN #: 26 JOB NO. 712 - 70
ITEM: Tile - Cardington-Bennington Soils--Hay & Pasture BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Tile - Cardington-Bennington Soils (Name) Column: 26

COMPUTATION:

CARDINGTON-BENNINGTON SOILS--HAY & PASTURE

Use application rate of 50"/yr.

Spacing = 30'

Length = $\frac{209}{30}$ (.09) = 1450 l.f.

Total cost of tile (1450')	=	$320/acre
Add $70/acre for collectors, structures, etc.	=	$ 70/acre
		$390/acre
Deduct 10% for existing tiles	=	- 40/acre
Net cost/acre	=	$350/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $350/acre (CARDINGTON-BENNINGTON SOILS--HAY & PASTURE)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 4 OF 6
FOR COLUMN #: 26 JOB NO. 712 - 70
ITEM: Tile - Cardington-Bennington Soils--Composite Out-of-Basin BY RIT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)
B. General Component Heading:
Transmission Facilities Irrigation System
Storage Reservoirs Drainage X
Land Treatment Site Miscellaneous

C. Cost Item: Tile - Cardington-Bennington Soils (Name) Column: 26

COMPUTATION:

CARDINGTON-BENNINGTON SOILS--COMPOSITE OF WESTERN LAND AREAS

Mini-border	5%	= .05(350)	=	$ 18/acre
Hay & Pasture	30%	= .30(350)	=	$105/acre
Corn (pivot rigs)	65%	= .65(495)	=	$322/acre
			TOTAL	$445/acre

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $445/acre (CARDINGTON-BENNINGTON SOILS--COMPOSITE)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 5 OF 6
FOR COLUMN #: 26 JOB NO. 712 - 70
ITEM: Tile - Cardington-Bennington Soils--Mini-Border System BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)
B. General Component Heading:
Transmission Facilities Irrigation System
Storage Reservoirs Drainage X
Land Treatment Site Miscellaneous

C. Cost Item: Tile - Cardington-Bennington Soils (Name) Column: 26

COMPUTATION:

CARDINGTON-BENNINGTON SOILS--MINI-BORDER CONCEPT

Use 30' spacing.
Same as Hay & Pasture.

EXPLANATION:

See above: Tile costs are based on agricultural costs in 1972 as determined by survey and major checking w/Agricultural Engineers, including several at Ohio State University.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $350/acre (CARDINGTON-BENNINGTON SOILS--MINI-BORDER CONCEPT)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 6 OF 6
FOR COLUMN #: 26 JOB NO. 712 - 70
ITEM: Tile - Chill Soils BY RLT DATE 9-18-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) _____
B. General Component Heading:
Transmission Facilities _____ Irrigation System _____
Storage Reservoirs _____ Drainage X
Land Treatment Site _____ Miscellaneous _____

C. Cost Item: Tile - Chill Soils (Name) Column: 26

COMPUTATION:

CHILI SOILS

Use application rate of 60"/yr.

Use spacing of 60' @ 5½-foot depth

Length = $\frac{43,560}{60}$ = 726 ft.

Cost of 4" Tile (726') = $290/acre
Add $90/acre for collectors, structures, etc. = $ 90/acre
TOTAL $380/acre

EXPLANATION:

All of the Chili soils may not require tile drainage, depending on the topography. For example, on steep terrain tile drainage may be limited to the low-lying lands.

REFERENCES:

Table III, Practical Installation of Clay, Concrete and Corrugated Plastic Subsurface Drains, by Lyman S. Willardson. Also conversation with Dr. Willardson.

FINAL UNIT COST USED: $380/acre (CHILI SOILS)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 27 JOB NO. 71 - 70

ITEM: Conduits and Canals BY KRW DATE 9-16-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities	____	Irrigation System	____
Storage Reservoirs	____	Drainage	X
Land Treatment Site	____	Miscellaneous	____

C. Cost Item Conduits and Canals (Name) Column: 27

COMPUTATION:

Cost of construction will be an average of $25/acre over and above drainage unit costs.

EXPLANATION:

Conduits will be required to convey return flow to suitable discharge points. Canals will be used where volumes are large. Hydrological studies in western Ohio show stream regimes to be generally suitable.

REFERENCES:

Based on evaluation of typical units and topographical maps, and on hydrological study of streams.

FINAL UNIT COST USED CAPITAL COST: $25/acre

(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

FOR COLUMN #: 28 SHEET NO. 1 OF 2

ITEM: Sludge Management (In-Basin) JOB NO. 712 - 70

BY LAL DATE 9-21-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities ____	Irrigation System ____
Storage Reservoirs ____	Drainage ____
Land Treatment Site ____	Miscellaneous ____

C. Cost Item Sludge Management (In-Basin) (Name) Column: 28

COMPUTATION:

Costs based upon the storage capacity needed for winter months.
(No costs were included for land or equipment as they are included under land acquisition and treatment costs.)

EXPLANATION:

Sludge produced was converted to gallonage. Use Curve K to obtain cost at that volume.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curve K to Determine Costs of Sludge Management Facilities In-Basin.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 2

FOR COLUMN #: 28 JOB NO. 71-2 - 70

ITEM: Sludge Management (Strip Mined Areas) BY LAL DATE 9-21-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M) ____

B. General Component Heading:

Transmission Facilities	____	Irrigation System	____
Storage Reservoirs	____	Drainage	____
Land Treatment Site	____	Miscellaneous	____

C. Cost Item Sludge Management (Strip M. Areas) Column: 28
Name

COMPUTATION:

EXPLANATION:

Capital Cost for sludge management to STRIP MINED AREAS based on:

1. Pipeline Easement
2. Pipeline
3. Pump Stations
4. Storage Reservoirs
5. Distribution Piping
6. Trucks
7. Application Equipment

REFERENCES:

"Bulk Transport of Waste Slurries to Inland and Ocean Disposal Sites,"
Bechtel Corporation, Sept. 1969
Wright-McLaughlin Engineers

FINAL UNIT COST USED: Use Curve L to Determine Cost of Facilities for Sending Sludge to Strip Mined Areas.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item.

UNIT COST CONTAINED IN DETAILED COSTING SHEETS

SHEET NO. 1 OF 1

FOR COLUMN #: 29

JOB NO. 712 - 70

ITEM: Miscellaneous

BY KRW DATE 9-16-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)

B. General Component Heading:

Transmission Facilities		Irrigation System	
Storage Reservoirs		Drainage	
Land Treatment Site		Miscellaneous	X

C. Cost Item Miscellaneous (Name) Column: 29

COMPUTATION:

Computed at 5 percent of irrigation & drainage capital costs. (Cols. 23 thru 27)

EXPLANATION:

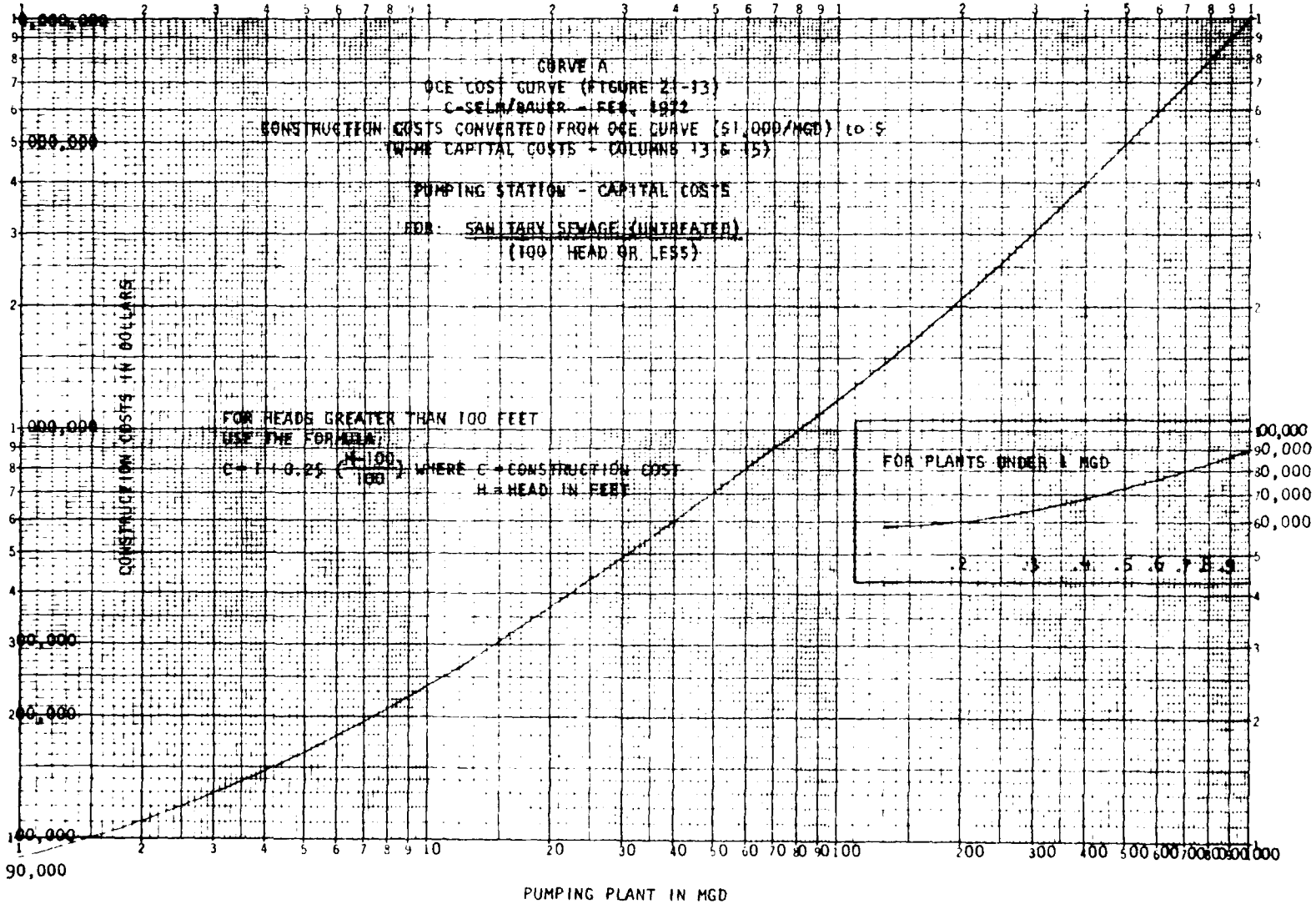
Miscellaneous includes capital cost for administration building, monitoring holes for ground water, also outside electrical costs not already included in other major components and laboratories.

REFERENCES:

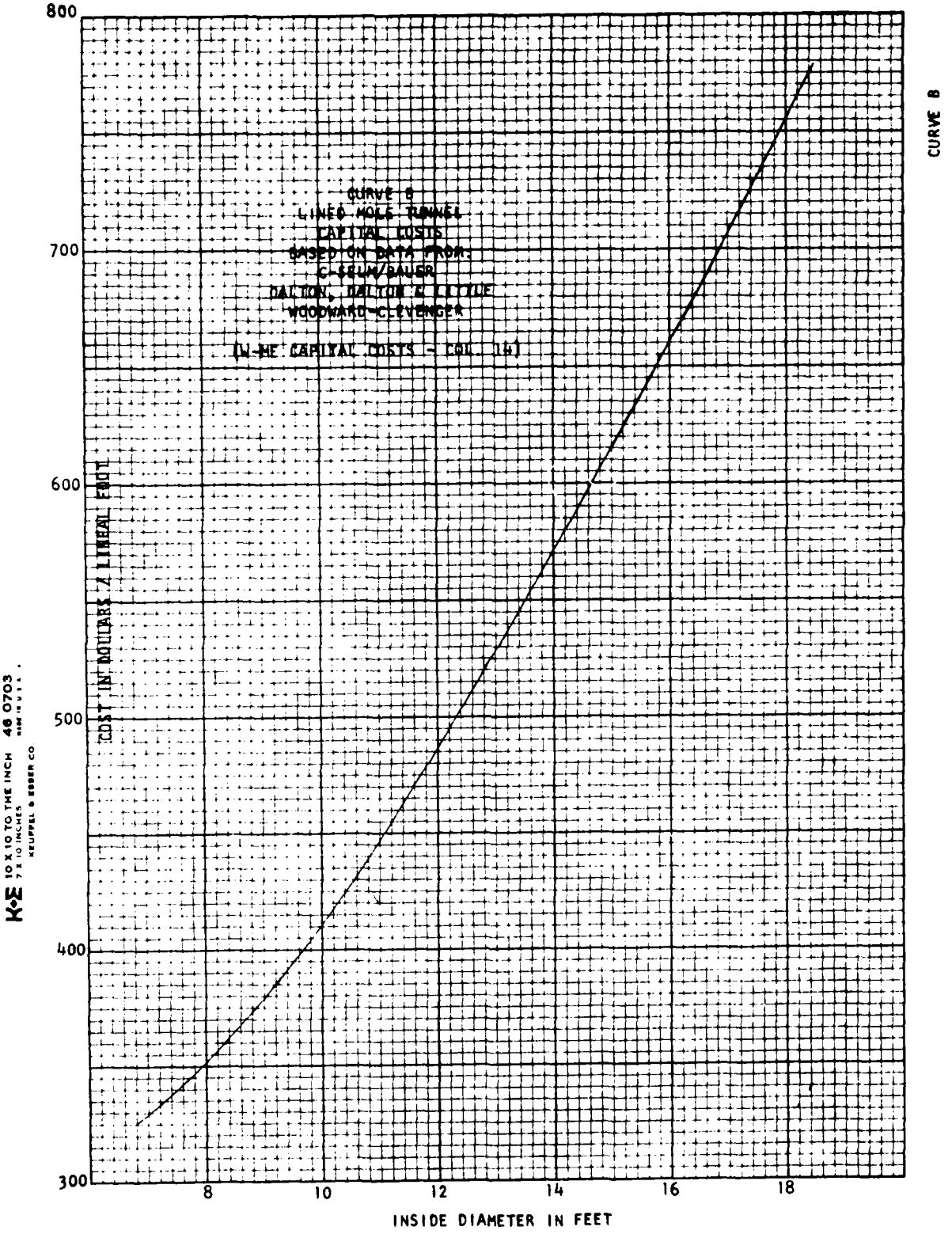
Wright-McLaughlin Engineers
Bauer Engineering

FINAL UNIT COST USED: 5 percent of Irrigation & Drainage Cost (Cols. 23 thru 27)

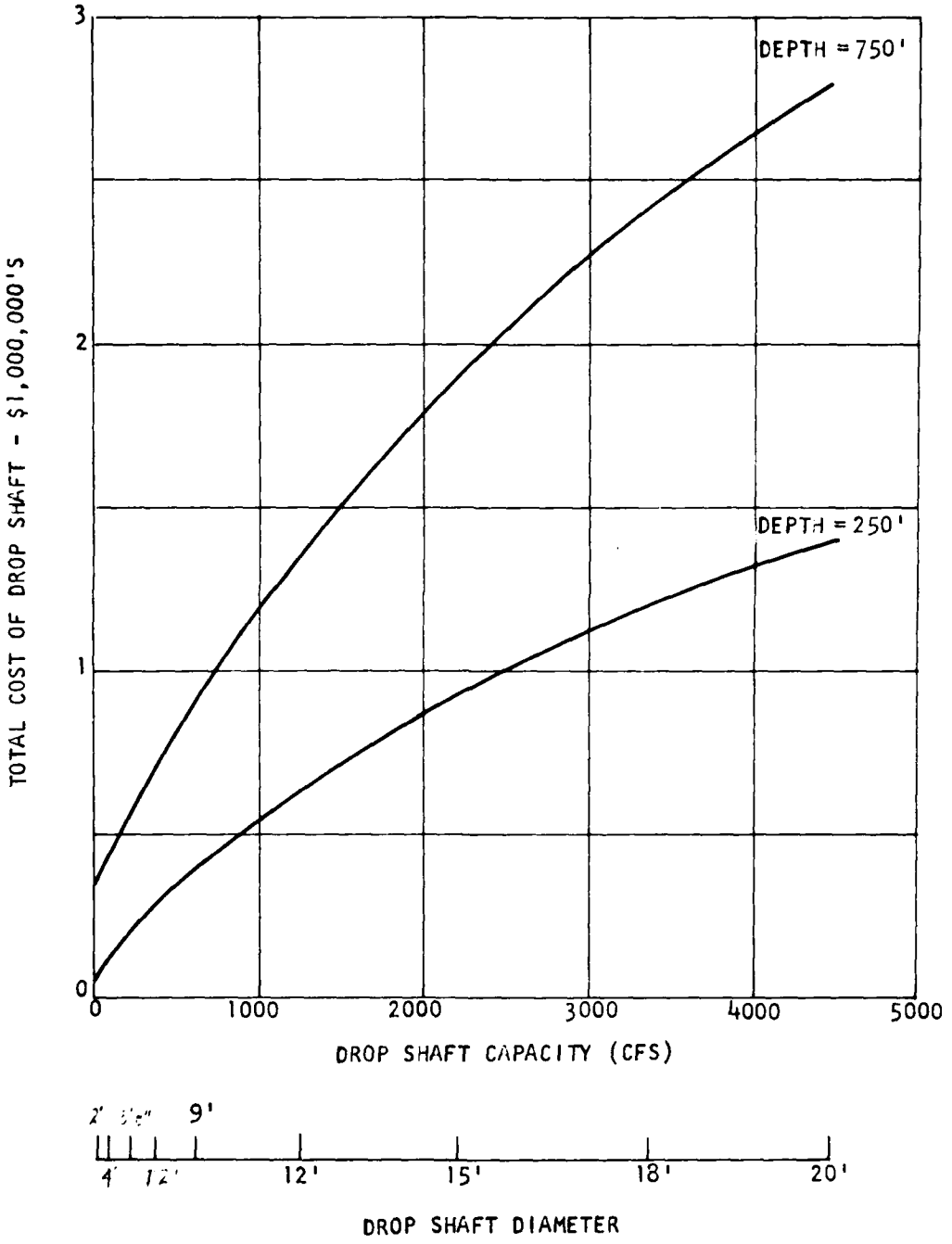
K&E LOGARITHMIC 2 x 3 CYCLE KEUFFEL & ESSER CO. 46 7323



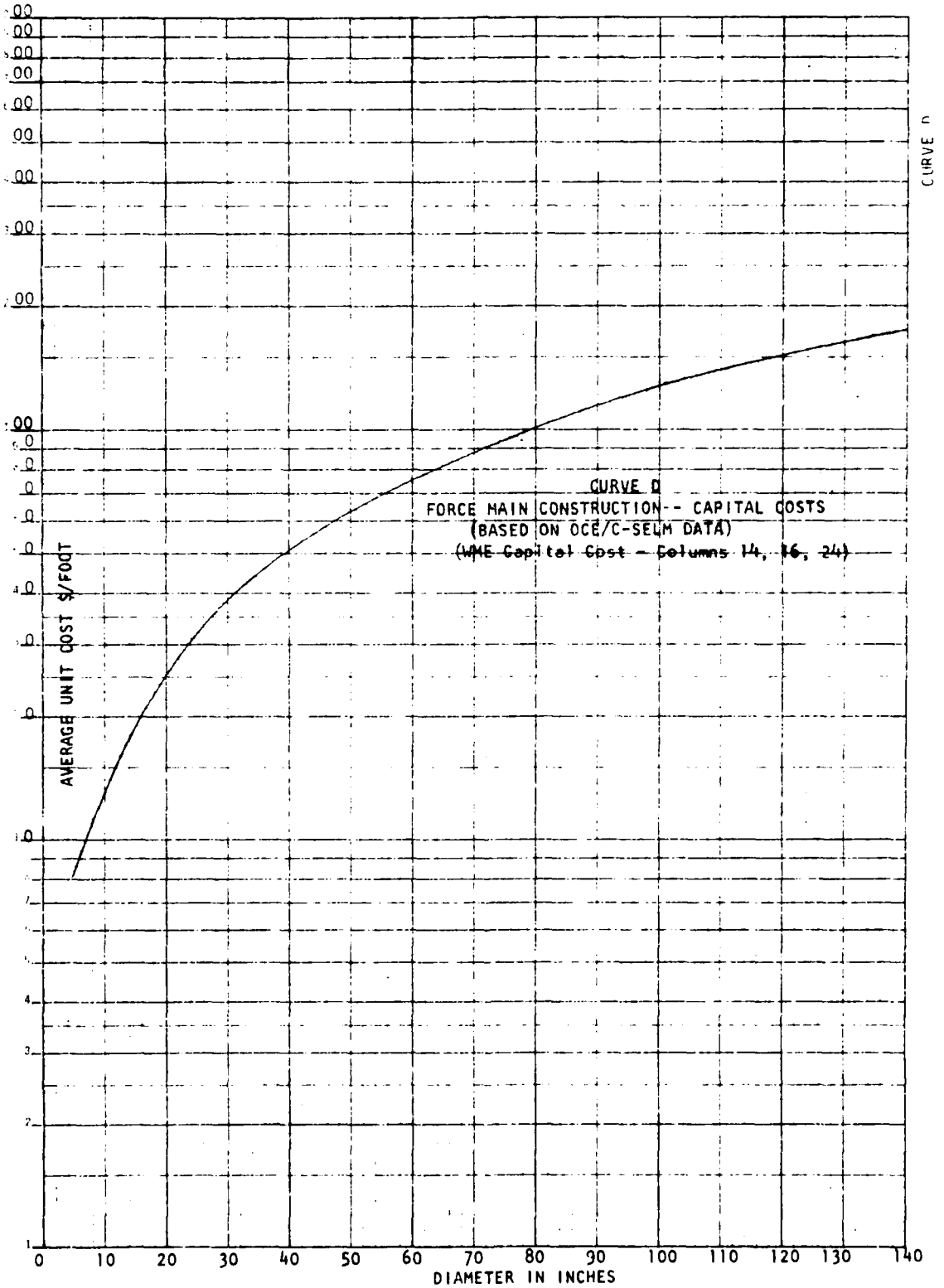
CURVE A


CURVE B
CURVE B
LINED MOLE TUNNEL
CAPITAL COSTS
BASED ON DATA FROM:
C-SELUM/BAUER
DALTON, DALTON & LITTLE
WOODWARD-CLEVENGER
[W-HE CAPITAL COSTS - COL 14]
COST IN DOLLARS / LINEAL FOOT
800
700
600
500
400
300
8
10
12
14
16
18
INSIDE DIAMETER IN FEET
K+E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES
KEUFFEL & ESSER CO

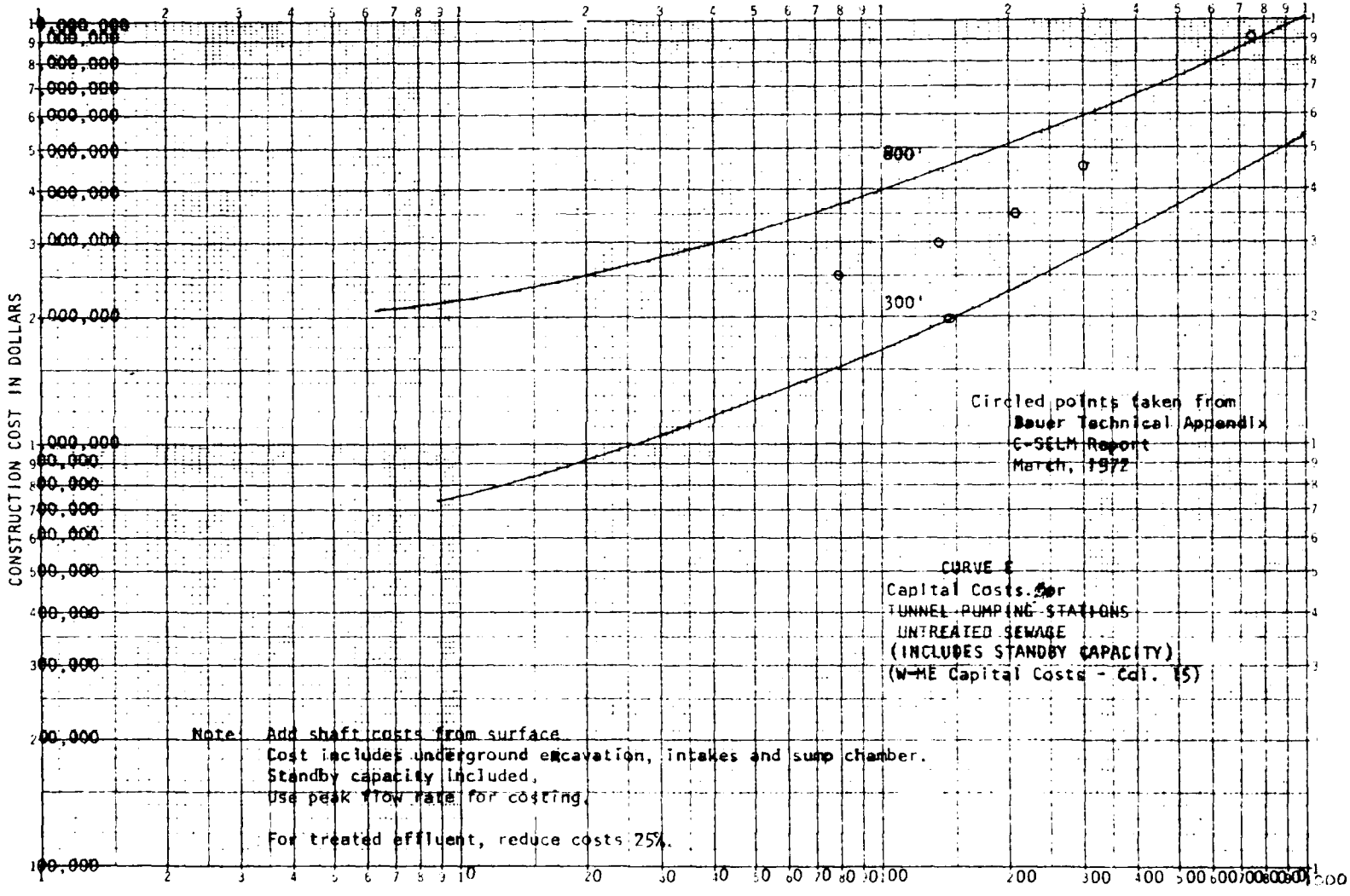
CURVE C
OCE, FIGURE 21-14
C-SELM, BAUER
(WME CAPITAL COSTS - COLS. 14 & 15)



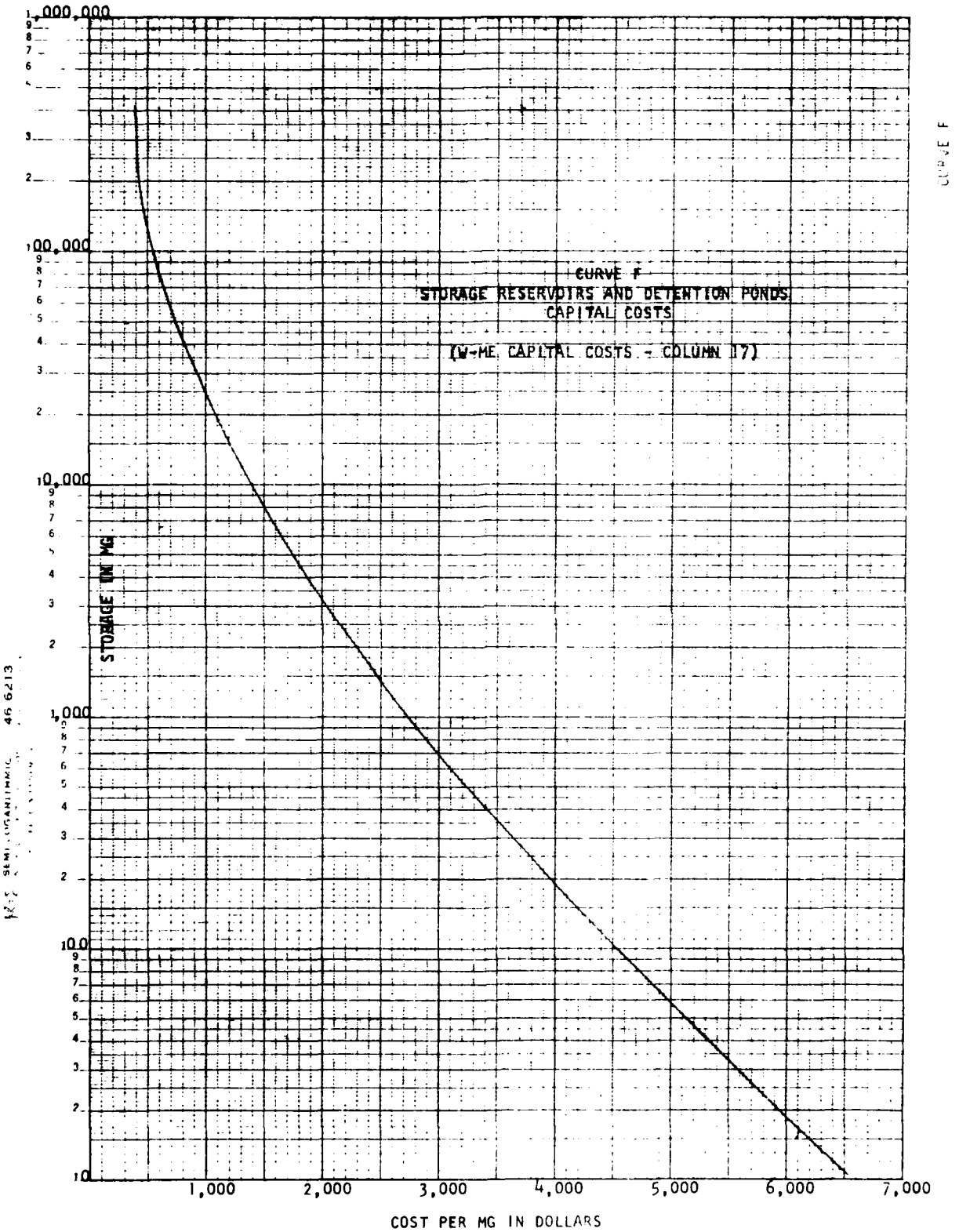
CURVE C

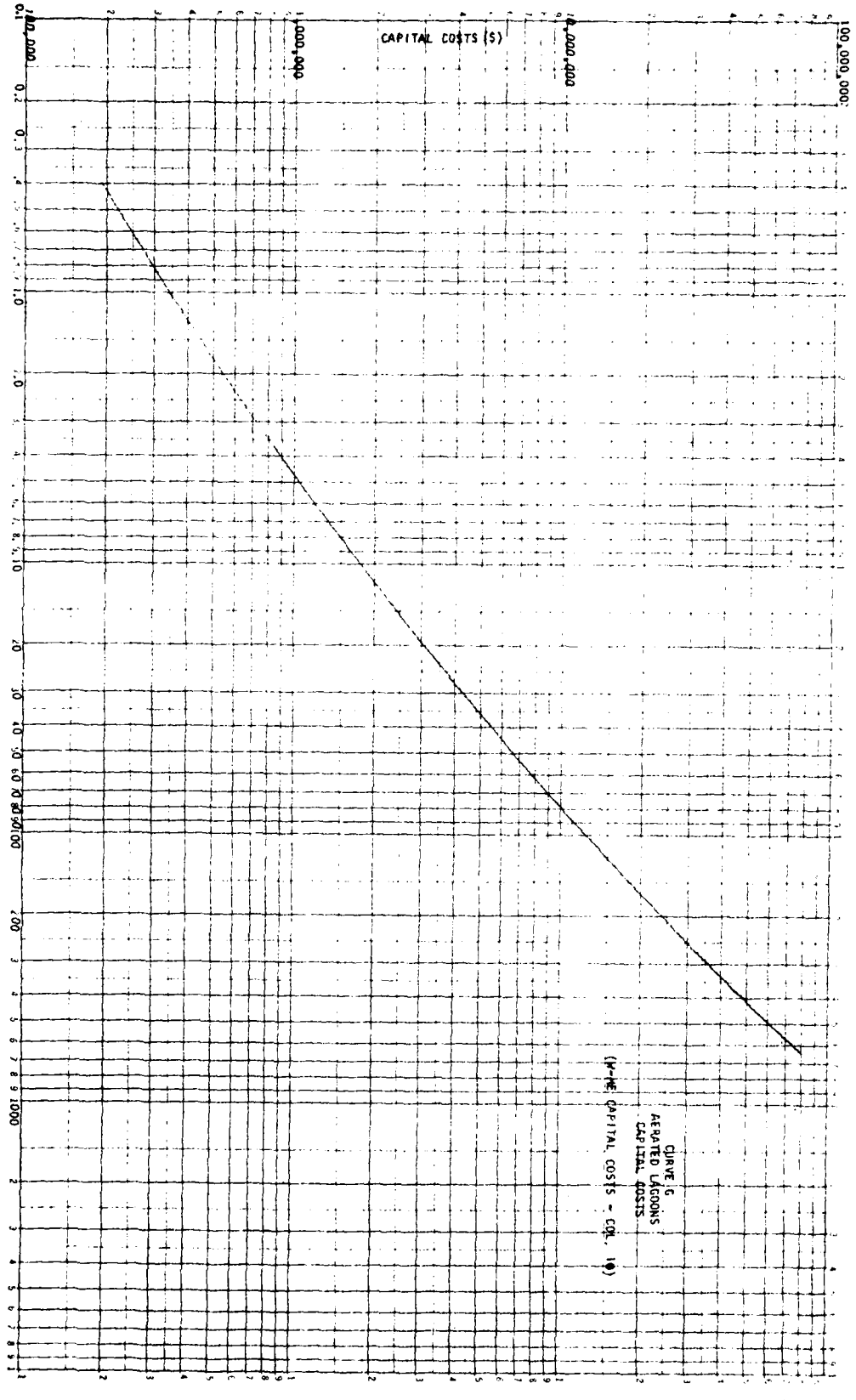

CURVE D
FORCE MAIN CONSTRUCTION-- CAPITAL COSTS
(BASED ON OCE/C-SELM DATA)
(WME Capital Cost – Columns 14, 16, 24)
AVERAGE UNIT COST $/FOOT
DIAMETER IN INCHES
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1
2
3
4
7

K&E LOGARITHMIC 46 7323
KEUFFEL & ESSER

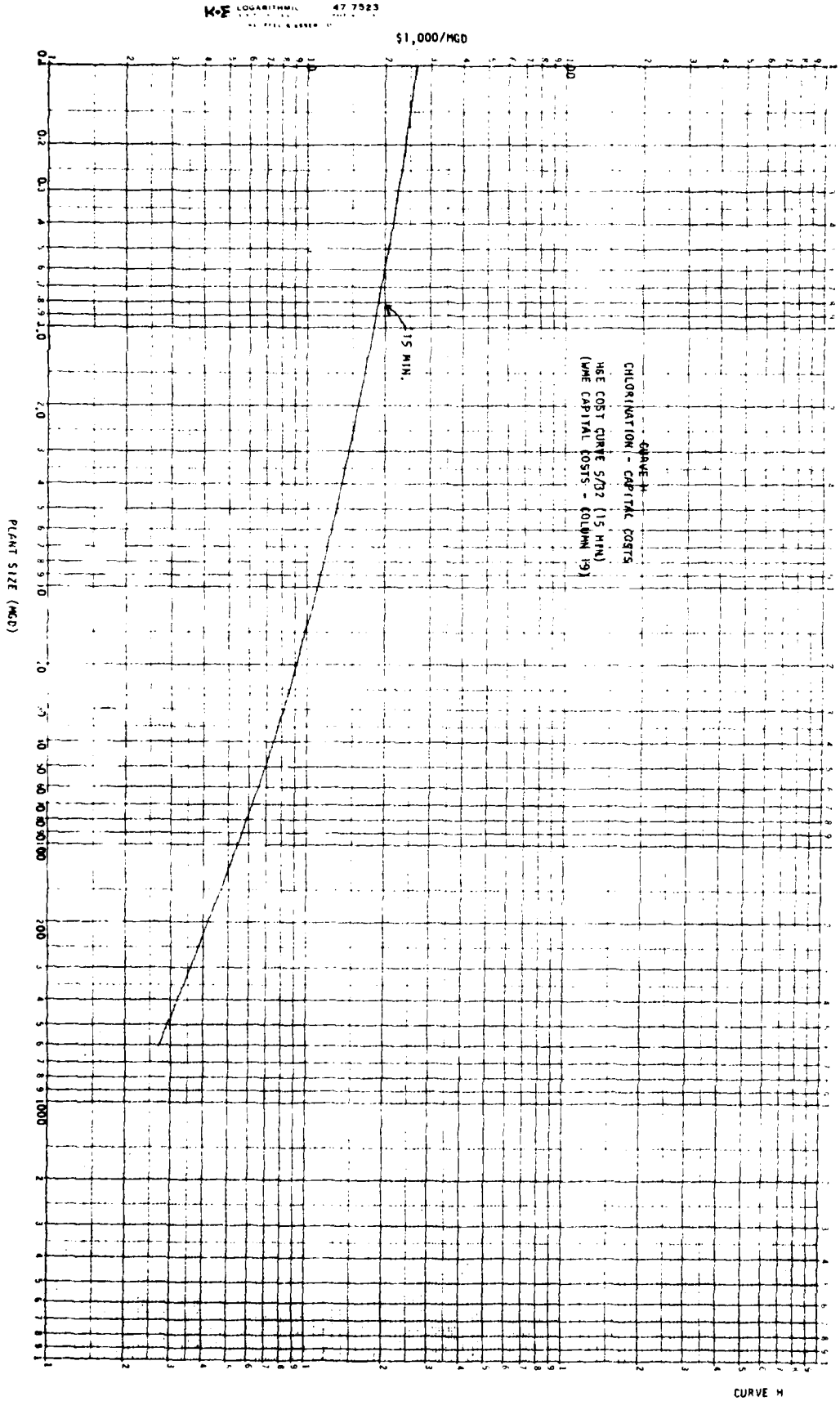


CURVE E


CURVE F
STORAGE RESERVOIRS AND DETENTION PONDS
CAPITAL COSTS
(W-ME CAPITAL COSTS - COLUMN 17)
STORAGE IN MG
1,000,000
100,000
10,000
1,000
100
10
1,000
2,000
3,000
4,000
5,000
6,000
7,000
COST PER MG IN DOLLARS
CURVE F

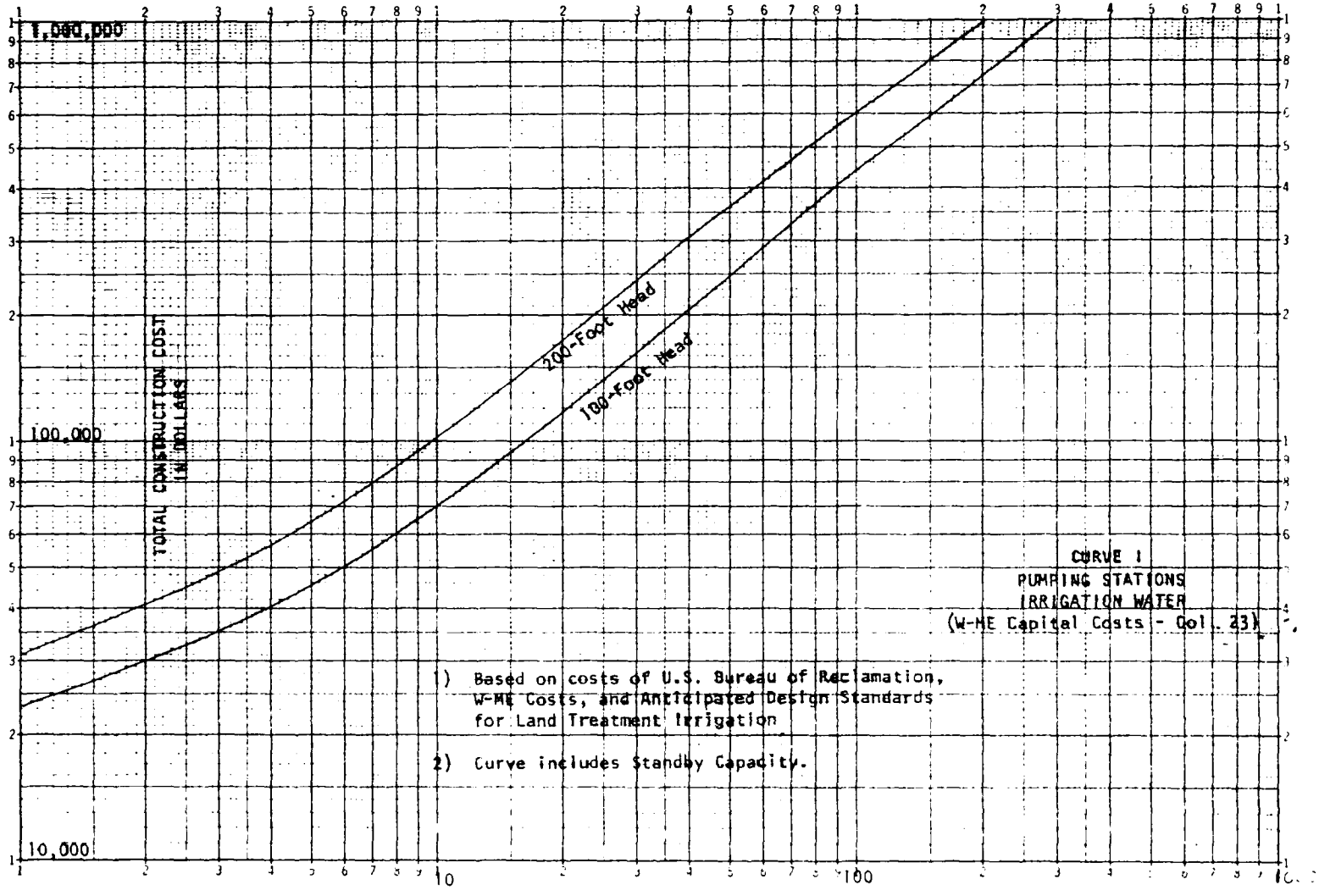

CAPITAL COSTS ($)
AERATED LAGOON - TREATMENT CAPACITY (MGD)
CURVE G
AERATED LAGOONS
CAPITAL COSTS
(W-ME CAPITAL COSTS - COL. 10)

CURVE G


K+E LOGARITHMIC 47 7523
$1,000/MGD
PLANT SIZE (MGD)
15 MIN.
CHLORINATION - CAPITAL COSTS
CURVE H
HGE COST CURVE 5/32 (15 MIN)
(WWE CAPITAL COSTS - COLUMN 19)

CURVE H

W-E LOGARITHMIC 46 7323
KEUFFEL & ESSER CO.

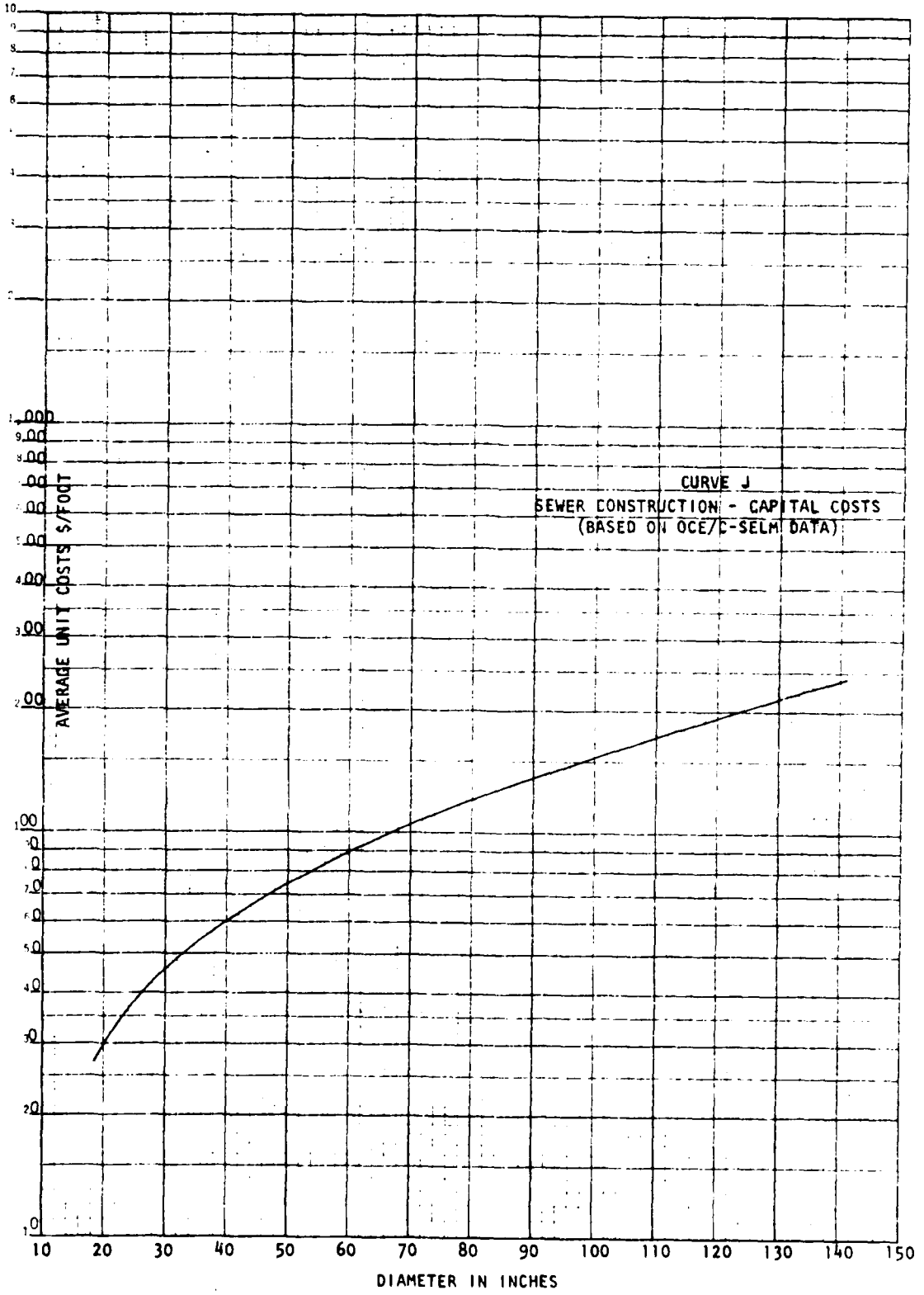


CURVE 1
PUMPING STATIONS
IRRIGATION WATER
(W-ME Capital Costs - Col. 23)

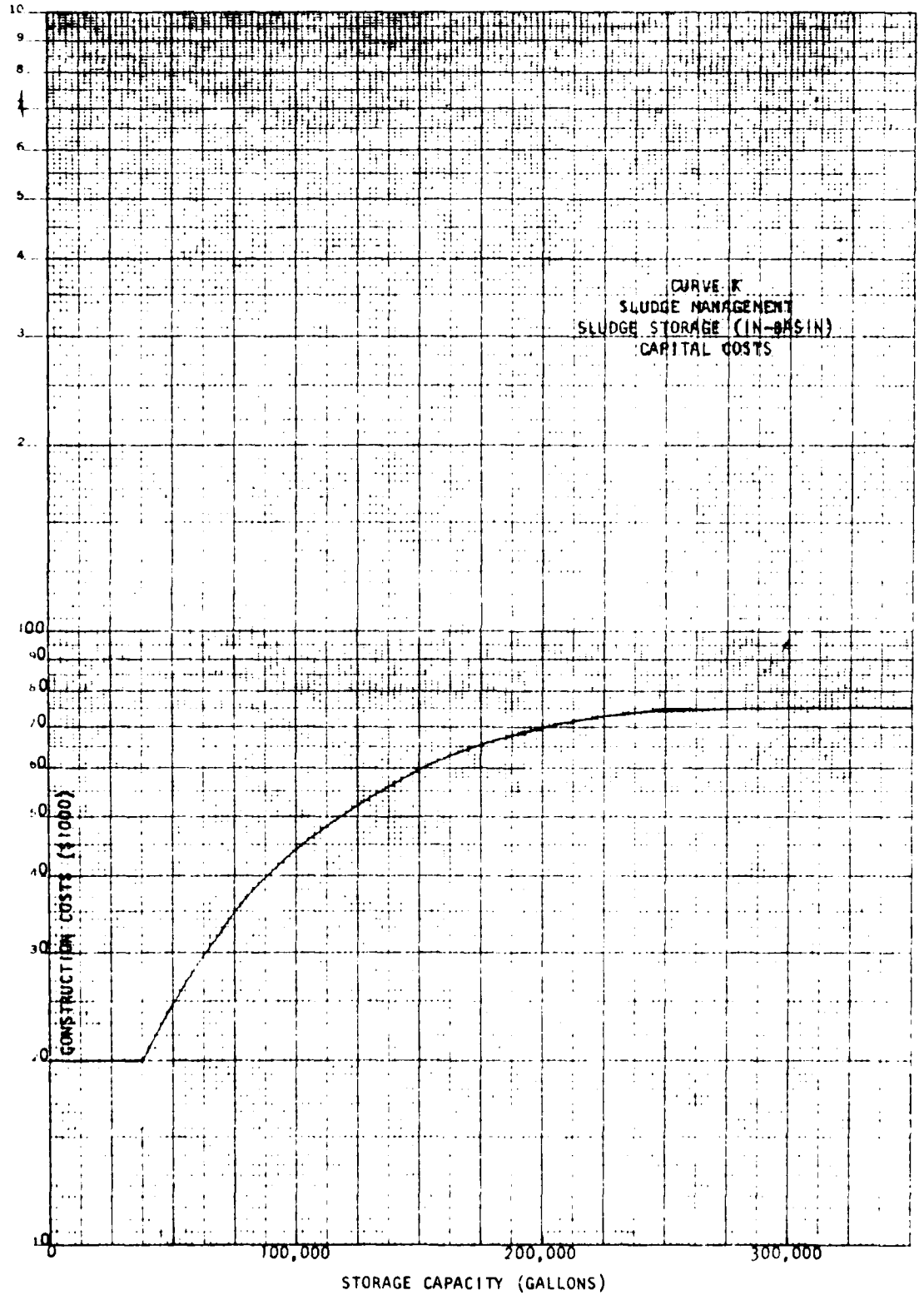
1) Based on costs of U.S. Bureau of Reclamation, W-ME Costs, and Anticipated Design Standards for Land Treatment Irrigation

2) Curve includes Standby Capacity.

CURVE 1

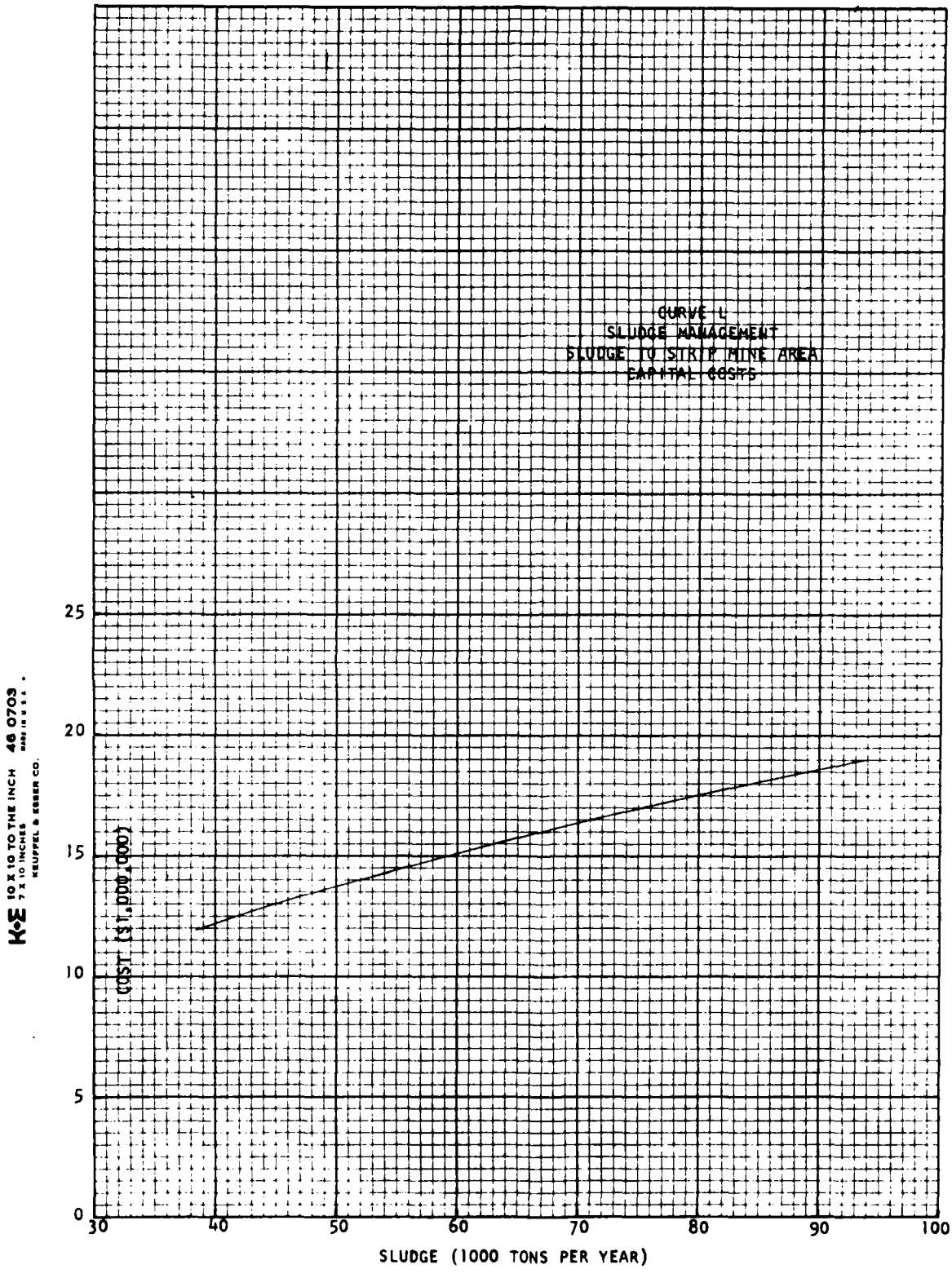

CURVE J
SEWER CONSTRUCTION - CAPITAL COSTS
(BASED ON OCE/C-SELM DATA)
AVERAGE UNIT COSTS $/FOOT
DIAMETER IN INCHES
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

CURVE J



CURVE K

K&E SEMI LOGARITHMIC 46 5133



CURVE L

K&E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES
KEUFFEL & ESSER CO.

OPERATION & MAINTENANCE COSTS

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 1-6 JOB NO. 71.2 - 70
ITEM: Basic Data BY GGR DATE 9-20-72

A. Cost Type: Capital Cost_____ Operation & Maintenance (O&M) X

B. General Component Heading:
Transmission Facilities_____ Irrigation System_____
Storage Reservoirs_____ Drainage_____
Land Treatment Site_____ Miscellaneous_____

C. Cost Item: Basic Data (Used in Costing) Column: 1-6
Name

The basic data shown in columns 1-6, as well as the costs compiled under the Capital Costs Section contained herein, were used to determine the various Operation and Maintenance unit costs which follow in this O&M Costs Section.

(See Capital Cost Sheet covering columns 1-6 for explanation of individual column items.)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 7-11 JOB NO. 712 - 70
ITEM: Treatment (In Plants or Aerated Lagoons) BY GGR DATE 9-20-72

A. Cost Type Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Treatment Facilities X Irrigation System ____
Transmission Facilities ____ Drainage ____
Storage Reservoirs ____ Miscellaneous ____
Land Treatment Site ____

C. Cost Item: Treatment (In Plants or Aerated Lagoons) Column: 7-11
Name

COMPUTATION:

All O&M costs for sewage treatment plants are supplied by Havens & Emerson except those for Aerated Lagoons. (See the computation sheets for Column 10 - Aerated Lagoons, which follow.)

Aerated Lagoons were used for 3 plants in Plan 9A and all plants in Plan 12.

EXPLANATION:

REFERENCES:

Havens & Emerson - Secondary, Tertiary and Advanced Wastewater Treatment Plant Costs
Wright-McLaughlin Engineers - Aerated Lagoon Costs

FINAL UNIT COST USED: All costs supplied by Havens and Emerson except as in Plans 9A & 12

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub-Item

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 3
FOR COLUMN #: 10A (Treatment) JOB NO. 72-70
ITEM: Aerated Lagoons - Power BY WAB DATE 9-20 72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Aerated Lagoons - Power (Name) Column: 10A

COMPUTATION:

For both IN-BASIN and OUT-OF-BASIN:

$7,550 x Total ADF (MGD)

Note: For Plan 9A, 3 plants which were costed individually have aerated lagoons; these costs were included in land treatment costs In Plan 12 all plants were costed with aerated lagoons

EXPLANATION:

Power costs for aeration include mixing and oxygen transfer. W-ME computed detailed horsepower requirements

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $7,550 x Total ADF (MGD)

NOTE: For Plans 9A and 12 only.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/~~Evaporation~~ Phase 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 3
FOR COLUMN #: 108 (Treatment) JOB NO. 712 - 70
ITEM: Aerated Lagoons - Maintenance and Labor BY HAB DATE 9-20-72

A. Cost Type: Capital Cost _____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities _____ Irrigation System _____
Storage Reservoirs _____ Drainage _____
Land Treatment Site _____ Miscellaneous _____

C. Cost Item: Aerated Lagoons - Maint. & Labor (Name) Column: 108

COMPUTATION:

3% of Capital Cost

Note: For Plan 9A, 3 plants which were costed individually have aerated lagoons; these costs were included in land treatment costs. In Plan 12 all plants were costed with aerated lagoons.

EXPLANATION:

Typical maintenance and labor figures based on W-ME experience were also used for comparison.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: 3% of Capital Cost

NOTE: For Plans 9A and 12 only.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 3 OF 3
FOR COLUMN #: 10C (Treatment) JOB NO. 712 - 70
ITEM: Chlorination - Aerated Lagoons - Maint. & Labor (Power Negligible) BY HAB DATE 9-20-72

A. Cost Type: Capital Cost ___ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ___ Irrigation System ___
Storage Reservoirs ___ Drainage ___
Land Treatment Site ___ Miscellaneous ___

C. Cost Item: Chlorination - Aerated Lagoons Column: 10C
Name

COMPUTATION:

In-Basin	$3,650 x Total ADF (MGD)
Out-of-Basin	$2,500 x Total ADF (MGD)

Note: For Plan 9A, 3 plants which were costed individually have aerated lagoons; these costs were included in land treatment costs. In Plan 12 all plants were costed with aerated lagoons.

EXPLANATION:

OCE and H&E curves for O&M were used to arrive at these two conversions. The Out-of-Basin unit costs are less because larger systems are used.

REFERENCES:

Havens and Emerson
OCE

FINAL UNIT COST USED: $3,650 x Total ADF (MGD), In-Basin

$2,500 x Total ADF (MGD), Out-of-Basin

NOTE: For Plans 9A and 12 only.

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 2
FOR COLUMN #: 13A JOB NO. 712 - 70
ITEM: Pump Station -- Power BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Misce'laneous ____

C. Cost Item: Pump Station -- Power Column: 13A
Name

COMPUTATION:

No In-Basin facilities

Out-of-Basin = $2,100 x Total ADF (MGD)

EXPLANATION:

Cost is based upon TDH of 100'.

Basic data ($.0121/kwhr and 65% wire to water efficiency used to provide costs consistent and comparable to costs provided by H&E.)

As a check, the maintenance and labor was added to the power and compared to annual O&M costs for pumping stations as provided by H&E. The total W-ME O&M costs were also checked against OCE curves.

REFERENCES:

$.0121/kwhr and 65% wire to water efficiency -- Havens & Emerson
Curve for Annual Power Costs by Wright-McLaughlin Engineers
ADF - computed by W-ME and H&E
TDH - W-ME computations for individual plans

FINAL UNIT COST USED: $2,100 x total ADF (MGD)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 2
FOR COLUMN #: 13B JOB NO. 712 - 70
ITEM: PUMP STATION - MAINTENANCE AND LABOR BY HAB DATE 9/21/72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____
C. Cost Item MAINTENANCE AND LABOR EXCLUDING POWER (Name) Column: 13B

COMPUTATION: FOR OUT-OF-BASIN PUMP STATIONS . . . . . 5% of Capital Cost

EXPLANATION: For annual maintenance and labor costs of pump stations, excluding power, 5% of the capital cost was used. This was obtained from expenses for given sized plants in Colorado based on past experience. As a check, maintenance and labor costs were added to power costs and compared to annual total O&M costs for pumping stations as defined by Havens and Emerson.

REFERENCES: See Sheet 1 of 2.

FINAL UNIT COST USED: 5 Percent of Capital Cost

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 14, 16 and 24 JOB NO. 712 - 70

ITEM: Force Main, Drop Shaft, Tunnel - Maintenance & Labor BY HAB DATE 8-20-72

A. Cost Type: Capital Cost _____ Operation & Maintenance (O&M) X

B. General Component Heading:

Transmission Facilities	X	Irrigation System	X
Storage Reservoirs		Drainage	
Land Treatment Site		Miscellaneous	

C. Cost Item: Force Main, Drop Shaft, Tunnel (Name) Column: 14, 16 and 24

COMPUTATION:

1/2% of Capital Cost

EXPLANATION:

The 1/2% rate was obtained from Havens & Emerson. This percentage was used for force mains, drop shafts, and tunnel costs in order to provide costs consistent and comparable to costs by Havens & Emerson.

REFERENCES:

Havens & Emerson

FINAL UNIT COST USED: 1/2% of Capital Cost

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 2
FOR COLUMN #: 15A JOB NO. 71-2-70
ITEM: Secondary Pump Plant - Power BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Secondary Pump Plant - Power (Name) Column: 15A

COMPUTATION:

In-Basin = $5,550 x Total ADF (MGD)

Out-of-Basin = $15,000 x Total ADF (MGD)

EXPLANATION:

In-Basin TDH = 265'
Out-of-Basin TDH = 720'

Basic data ($.0121/kwhr and 65% wire to water efficiency) used to provide costs consistent and comparable to costs provided by H&E.

As a check, the maintenance and labor was added to the power and compared to annual O&M costs for pumping stations as provided by H&E. The total W-ME O&M costs were also checked against OCE curves.

REFERENCES:

$.0121/kwhr and 65% wire to water efficiency -- Havens & Emerson
Curve for Annual Power Costs by Wright-McLaughlin Engineers
ADF - computed by Wright-McLaughlin Engineers and Havens & Emerson
TDH - Wright-McLaughlin Engineers computations for individual plans

FINAL UNIT COST USED: $5,550 x Total ADF (MGD), In-Basin
$15,000 x Total ADF (MGD), Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 2
FOR COLUMN #: 15B JOB NO. 712 - 70
ITEM: Secondary Pump Plant - Maintenance and Labor BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities X Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Secondary Pump Plant - Maint. & Labor (Name) Column: 15B

COMPUTATION:

For In-Basin Pump Stations . . . . . 5% of Capital Cost

For Out-of-Basin Pump Stations . . . . 3% of Capital Cost

EXPLANATION:

For annual maintenance and labor costs of pump stations, excluding power, 5% of the capital cost was used for in-basin stations and 3% of the capital cost for stations out-of-basin. This was obtained from expenses for given sized plants in Colorado based on past experience. As a check, maintenance and labor costs were added to power costs and compared to total annual O&M costs for pumping stations as defined by Havens and Emerson. Out-of-Basin costs are less because the pump station capital costs included shafts and other related items which would have an O&M of approximately 1/2% x capital.

REFERENCES:

See Sheet 1 of 2.

FINAL UNIT COST USED: 5% of Capital Cost, In-Basin
3% of Capital Cost, Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 17 JOB NO. 712 - 70
ITEM: Reservoir - Maintenance & Labor BY HAB DATE 9-20-72

A. Cost Type: Capital Cost _____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities _____ Irrigation System _____
Storage Reservoirs X Drainage _____
Land Treatment Site _____ Miscellaneous _____

C. Cost Item: Reservoir - Maintenance & Labor Column: 17
Name

COMPUTATION:

1/2% of Capital Cost

EXPLANATION:

Based on O&M cost for force mains and shafts plus general experience with similar type reservoirs.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: 1/2% of Capital Cost

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 18A - Power; 18B - Maintenance & Labor JOB NO. 71-2 - 70
ITEM: Aeration BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs X Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Aeration - Power/Maint.& Labor (Name) Column: 18A and 18B

COMPUTATION:

For Plans 9A and 12
In-Basin
Power = $20 x Storage Reservoir Volume in MG

Maintenance and Labor:

$20 x Storage Reservoir Volume in MG

Out-of-Basin and in reservoirs for stormwater runoff in-basin there is no aeration of storage reservoirs.

EXPLANATION:

In-Basin, Plans 9A and 12 -- Power was determined by W-ME.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $20 x Storage Reservoir Volume in MG for Power and
$20 x Storage Reservoir Volume in MG for Maintenance & Labor

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 19B JOB NO. 712 - 70
ITEM: Chlorination - Maint. & Labor (Assumes Power Cost Negligible) BY HAB DATE 9-21-72

A. Cost Type: Capital Cost _____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities _____ Irrigation System _____
Storage Reservoirs X Drainage _____
Land Treatment Site _____ Miscellaneous _____

C. Cost Item: Chlorination (Name) Column: 19B

COMPUTATION:

Effluent to storage reservoirs to land site treatment:

$1,825 x Total ADF (MGD)

EXPLANATION:

This is 1/2 of the H&E and OCE chlorination O&M costs as the chlorine treatment concentration is less than 1/2 required for secondary treated sewage. This cost is equivalent to that used by Bauer Engineering.

REFERENCES:

OCE
Bauer Engineering

FINAL UNIT COST USED: $1,825 x Total ADF (MGD)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item: _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 20 and 22 (Col. 21 Cost was dropped) JOB NO. 71-2 - 70
ITEM: Purchase & Relocation; Site Preparation BY W-ME DATE 9-22-72

A. Cost Type: Capital Cost _____ Operation & Maintenance (O&M) X

B. General Component Heading:

Transmission Facilities		Irrigation System	
Storage Reservoirs		Drainage	
Land Treatment Site	X	Miscellaneous	

C. Cost Item: Purchase & Relocation; Site Prep. (Name) Column: 20 and 22

THERE ARE NO OPERATION AND MAINTENANCE COSTS FOR THE FOLLOWING:

Component	Column
Land Treatment Site	
Purchase and Relocation	20
Site Preparation	22

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 2
FOR COLUMN #: 23A JOB NO. 71-2-70
ITEM: Pump Station - Power BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X

B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Pump Station - Power (Name) Column: 23A

COMPUTATION:

In-Basin = Wastewater: $18 x acres
Separate Stormwater: $36 x acres

Out-of-Basin = $16 x acres

EXPLANATION: In-Basin
Wastewater - TDH = 150'
Average application rate = 75"
Stormwater - TDH = 150'
Average application rate = 150"
Out-of-Basin
TDH = 150'
Average application rate = 66"

Basic data ($.0121/kwhr and 65% wire to water efficiency) used to provide costs consistent and comparable to costs provided by H&E. The total W-ME O&M costs were also checked against OCE curves.

REFERENCES:

$.0121/kwhr and 65% wire to water efficiency - Havens & Emerson
ADF computed by Wright-McLaughlin Engineers and Havens & Emerson
TDH - Wright-McLaughlin Engineers computations for individual plans

FINAL UNIT COST USED: In-Basin Wastewater - $18 x acres
In-Basin Separate Stormwater - $36 x acres
Out-of-Basin - $16 x acres

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 2 OF 2
FOR COLUMN #: 23B JOB NO. 712 - 70
ITEM: Pump Station - Maintenance and Labor BY W-ME DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Pump Station - Maintenance & Labor (Name) Column: 23B

COMPUTATION:

For In-Basin Pump Stations . . . . . 5% of Capital Cost

For Out-of-Basin Pump Stations . . . 3% of Capital Cost

EXPLANATION:

For annual maintenance and labor costs of pump stations, excluding power, 5% of the capital cost was used for in-basin stations and 3% of the capital cost for stations out-of-basin. This was obtained from expenses for given sized plants in Colorado based on past experience. As a check, maintenance and labor costs were added to power costs and compared to total annual O&M costs for pumping stations as defined by Havens and Emerson.

REFERENCES:

See Sheet 1 of 2.

FINAL UNIT COST USED: 5% of Capital Cost In-Basin
3% of Capital Cost Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 25 JOB NO. 712 - 70
ITEM: Equipment and Distribution Piping - Maint. & Labor BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System X
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Equipment and Distribution Piping (Name) Column: 25

COMPUTATION:

In-Basin = $4/acre

Out-of-Basin = $10/acre

EXPLANATION:

Mini-border system used in-basin and some solid set system. Both would have same maintenance and labor costs. The $10 rate reflects an increase due to higher labor and maintenance on pivot sprinklers.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: $4/acre In-Basin
$10/acre Out-of-Basin

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: 26 JOB NO. 712 - 70

ITEM: Tile - Maintenance and Labor BY HAB DATE 9-21-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X

B. General Component Heading:

Transmission Facilities ____	Irrigation System ____
Storage Reservoirs ____	Drainage X
Land Treatment Site ____	Miscellaneous ____

C. Cost Item: Tile - Maintenance and Labor (Name) Column: 26

COMPUTATION:

In-Basin = $4/acre

Out-of-Basin = $4.50/acre

EXPLANATION:

Maintenance is approximately 1% of Capital Cost.

REFERENCES:

Donald L. Miles - Agricultural Extension Agent for Colorado
Wright-McLaughlin Engineers

FINAL UNIT COST USED: In-Basin - $4/acre

Out-of-Basin - $4.50/acre

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 27 JOB NO. 712 - 70
ITEM: Conduits and Canals - Maintenance & Labor BY KRW DATE 9-16-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage X
Land Treatment Site ____ Miscellaneous ____

C. Cost Item: Conduits and Canals (Name) Column: 27

COMPUTATION:

Cost of construction will be an average of $25/acre over and above drainage unit costs.

Maintenance and Labor cost for conduits and canals will be $2/acre.

EXPLANATION:

Conduits will be required to convey return flow to suitable discharge points. Canals will be used where volumes are large. Hydrological studies in western Ohio show stream regimes to be generally suitable. Based on evaluation of typical units and topographical maps, and on hydrological study of streams.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: $2/acre
(Revision as of 9-14-72)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase: 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 28 JOB NO. 71-2-70
ITEM: Sludge Management (Includes Power Cost) BY HAB DATE 9-21-72

A. Cost Type: Capital Cost _____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities _____ Irrigation System _____
Storage Reservoirs _____ Drainage _____
Land Treatment Site _____ Miscellaneous _____

C. Cost Item: Sludge Management (Includes Power Cost) Column: 28
Name

COMPUTATION:

In-Basin
No O&M cost for separate stormwater derived sludge.
Plans 9A & 12 = $750 x Total ADF (MGD)
All other plans = $1200 x Total ADF (MGD)

Out-of-Basin
Plans 9A and 12 = $750 x Total ADF (MGD)
All other plans = $480 x Total ADF (MGD)

EXPLANATION:

The $750/MGD is equivalent to $25/ton for aerated lagoons. This was determined by W-ME based upon the required equipment and sludge disposal on land within approximately 6 miles.

The $480/MGD rate is equivalent to $16/ton which was obtained from the Bechtel Report on pipeline sludge disposal to strip mine areas.

The $1200/MGD is equivalent to $40/ton for In-Basin combined sludge disposal.

REFERENCES:

Wright-McLaughlin Engineers
Bechtel Corporation

FINAL UNIT COST USED: In-Basin - $1200 x Total ADF (MGD)
In-Basin Plans 9A and 12 - $750 x Total ADF (MGD)
Out-of-Basin - $480 x Total ADF (MGD)
Out-of-Basin Plans 9A and 12 - $750 x Total ADF (MGD)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item:

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1
FOR COLUMN #: 29 JOB NO. 712 - 70
ITEM: Miscellaneous - Maintenance & Labor BY KRW DATE 9-16-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X
B. General Component Heading:
Transmission Facilities ____ Irrigation System ____
Storage Reservoirs ____ Drainage ____
Land Treatment Site ____ Miscellaneous X

C. Cost Item: Miscellaneous - Maint. & Labor (Name) Column: 29

COMPUTATION:

Compute O&M as 10% of capital cost of this item.

EXPLANATION:

Miscellaneous includes capital cost for administration building, monitoring holes for ground water, also outside electrical costs not already included in other major components and laboratories.

REFERENCES:

Wright-McLaughlin Engineers

FINAL UNIT COST USED: 10% of Capital Cost as computed for Miscellaneous in Column 29

CONTINGENCIES

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF

FOR COLUMN #: JOB NO. 712 - 70

ITEM: Contingency BY KRW DATE 9-15-72

A. Cost Type: Capital Cost X Operation & Maintenance (O&M)

B. General Component Heading:

Transmission Facilities	Irrigation System
Storage Reservoirs	Drainage
Land Treatment Site	Miscellaneous

C. Cost Item Contingency (Name) Column: ----

COMPUTATION:

1. A 20-percent contingency allowance will be added to the total cost estimate to allow for uncertainties.
2. An additional 5-percent will be added for engineering and design
3. An additional 5-percent will be added for supervision and administration

Total contingency added is 30 percent to capital costs.

EXPLANATION:

REFERENCES: Wastewater Management Program, "Study Procedure" by C.C.E dated May ., 1972.

FINAL UNIT COST USED: CAPITAL COSTS - 30%

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND - AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

Land Treatment/Formulation Phase 2 Sub - Item _____

UNIT COST CONTAINED IN DETAILED COSTING SHEETS SHEET NO. 1 OF 1

FOR COLUMN #: -- JOB NO. 71.2 '0

ITEM: Contingency BY KRW DATE 9-6-72

A. Cost Type: Capital Cost ____ Operation & Maintenance (O&M) X

B. General Component Heading:

Transmission Facilities	____	Irrigation System	____
Storage Reservoirs	____	Drainage	____
Land Treatment Site	____	Miscellaneous	____

C. Cost Item Contingency (Name) Column: --

COMPUTATION:

1. For O&M, a 20% contingency will be added for uncertainties and overhead/administration, and control operations. (NO E&D or S&A added to O&M)

EXPLANATION:

REFERENCES: Wastewater Management Program, "Study Procedure," by OCE dated May 1, 1972

FINAL UNIT COST USED: O&M Costs - 20%

DETAILED [illegible] FOR [illegible]

FOR FACILITIES RECEIVING: Municipal-Industrial from S.R.D./Municipal S.R.C. Treated S.R.C. _____
Separately Treated Only . . . . . _____

PERCENT OF GRAND TOTAL FOR CAPITAL COSTS: Municipal and Industrial . . . . . _____
Municipal and Separately-Treated S.R.C. _____

All costs in $1,000

	R.S.T. DESIGN DATA					TREATMENT FACILITIES						TRANSMISSION FACILITIES			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
[illegible] ME	Detention Storage MG	Plant Capacity (MGD)	Raw Sludge [illegible]	Digested Storage MG	Acres	Detention Storage	Sewers	Sump Station	Plant	Sludge	Total Columns 7-11	Pump Station	Force Main from Shaft Tunnel	Secondary Pump Station	Force Main

E [illegible] S T S F O R P L A [illegible]

F A [illegible] E F E R E N C E : Mun[illegible] S.R. /Municipal S [illegible].P. Treated S.R.O.

All costs in $1,000

| | | |

1,000

| | | TRANSMISSION FACILITIES | | |

GET TLES OPERATION AND MAINTENANCE COSTS FOR PLANT _____

FOR FACILITIES RECEIVING: Municipal-Industrial Combined S.W.D./Municipal S.T. / Treated S.T.E. _____
Separately Treated S.T.E. Only . . . . . _____

All Costs in $1,000

	STORAGE RESERVOIR					LAND TREATMENT SITE		IRRIGATION SYSTEM			DRAINAGE SYSTEM			M SC.	
	17	18	19			20	21	22	23	24	25	26	27	28	29	30
PLANT TYPE	Reservoir 17 Maintenance Labor	Operation 18 Power	Chlorination 19 Power	19 Maint. Labor		Purchase and Relocation M		Site Preparation	Pump Station 23B Maint. Labor		Force Main Maintenance Labor	Equipment Distribution Piping Maint. Labor		Tile Maintenance Labor	Ditches & Canals Maint. & Labor	Sludge Management Power	Maint. Labor	Monitoring Equip. Lab., Elec. Maint. & Labor	Total Columns 7-29

COMPARABLE ANNUAL COST INDEX — YEAR 2020
COST IN $ 1000

ITEM	1 CAPITAL COST	2 SALVAGE FACTOR	3 NET CAPITAL INVESTMENT	4 CAPITAL RECOVERY FACTOR	5	6	7	8	9	10	11 ANNUAL WORTH VALUE(7+10)	12
TREATMENT PLANT												
DETENTION BASINS												
SEWERS												
PUMP STATION												
PLANT												
SUB-TOTAL												
TRANSMISSION FACILITIES												
PUMP PLANT												
FORCE MAIN-STATION												
SECONDARY TREATMENT												
FORCE MAIN												
SUB-TOTAL												
DRAINAGE RESERVOIRS												
CHANNELS												
CULVERTS												
DESILTATION												
SUB-TOTAL												
FLOODWALLS & LEVEES												
ACQUIRED LAND												
[illegible]												
[illegible]												
[illegible]												
PUMP STATIONS												
FORCE MAIN												
[illegible]												
SUB-TOTAL												
DRAINAGE SYSTEM												
TILE												
[illegible]												
SUB-TOTAL												
[illegible]												
[illegible]												
[illegible]												
GRAND TOTAL												

CLEVELAND-AKRON METROPOLITAN
AND THREE RIVERS WATERSHED AREA
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY

LAND TREATMENT

PHASE III REPORT

PREPARED
FOR
U. S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

UNDER CONTRACT NO.: DACW49-72-C-0051

WRIGHT-McLAUGHLIN ENGINEERS
ENGINEERING CONSULTANTS
DENVER, COLORADO

APRIL 19, 1973

TABLE OF CONTENTS

		Page
LIST OF TABLES		v
LIST OF FIGURES		vi
SECTION I	BACKGROUND INTRODUCTION	1-1
	Scope of Work	1-2
	Summary of Phase I and Phase II	1-3
	Soil Inventory	1-3
	Geology and Ground Water Hydrology	1-4
	Surface Hydrology	1-6
	Soil Selection	1-7
	Final Selection Criteria	1-8
	Farm Management	1-10
	Strip-Mined Land Reclamation	1-11
	Land Treatment Components	1-12
	Aerated Lagoons	1-12
	Wastewater Renovation	1-13
	The Land Treatment System	1-16
	Costing	1-17
SECTION II	SCHEMATIC DESIGNS -- LAND TREATMENT COMPONENTS	II-1
	Criteria and Scheduling	II-2
	Land Treatment Components	II-2
	Aerated Lagoons	II-2
	Municipal Land Treatment In-Basin on Chill Soils	II-3
	Municipal Land Treatment In-Basin on Mahoning Soils	II-3

TABLE OF CONTENTS (Continued)

		Page
SECTION II	Continued	
	Separate Storm Runoff Land Treatment In-Basin	II-4
	Combined Sewer Overflow Temporary Treatment for 1980-1985	II-5
	The Transmission Tunnel	II-5
	The Western Land Treatment Area for Plan C	II-9
	Sludge Management	II-13
	In-Basin Agricultural Application	II-14
	Strip-Mine Renovation	II-15
	Sludge Application Rates	II-17
SECTION III	FARM MANAGEMENT TECHNIQUES - OPERATION AND PERFORMANCE OF LAND TREATMENT SYSTEMS	III-1
	Western Land Treatment Area Crops and Application Rates	III-1
	Application Rates for the Three Selected Soils	III-3
	Infiltration Rate	III-4
	Permeability	III-5
	Nutrient Balance	III-6
	Renovative Capacity	III-6
	Drainage	III-7
	The Chill Association	III-7
	Cardington-Bennington Association in Western Ohio	III-7

TABLE OF CONTENTS (Continued)

		Page
SECTION III	Continued	
	Mahoning Soils	III-9
	Cropping and Projected Production	III-9
	Salinity Control	III-11
	Nutrients	III-13
	Nitrogen	III-13
	Application Rates and Nitrogen Balance	III-15
	Phosphorous Loading	III-17
	Potassium Application	III-18
	Recycled Nutrients	III-18
	Heavy Metals	III-21
	Sources of Heavy Metals	III-21
	Heavy Metal Uptake by Crops	III-22
	Heavy Metal Management	III-28
SECTION IV	COSTS	IV-1
	Cost Revisions and Refinements	IV-1
SECTION V	EARLY ACTION IMPLEMENTATION	V-1
	Drainage District, Rocky River 31 Early Action Program for Storm Runoff Treatment	V-4
	Burton Early Action Program	V-5
	Location of Collection Point	V-5
	Irrigation System	V-6
	Drainage System	V-8

TABLE OF CONTENTS (Continued)

		Page
SECTION V	Continued	
	Reservoir	V-9
	Preliminary Investigation	V-9
	New Medina Early Action Program	V-10
	Bucyrus Early Action Program	V-10
	Liverpool Early Action Program, Sludge Disposal on Agricultural Land	V-12
	Strip-Mined Land Early Action Program	V-13
	Water Quality and Quantity Monitoring System	V-13
SECTION VI	RESOURCE REQUIREMENTS	VI-1
	Chemicals	VI-1
	Electric Power	VI-1
	Land	VI-3
	Manpower	VI-4
	Nutrients	VI-4
COST APPENDIX		
BIBLIOGRAPHY		

LIST OF TABLES

		Page
TABLE I-1	IRRIGATION WATER QUALITY	I-14
I-2	WASTEWATER RENOVATION OF SECONDARY EFFLUENT	I-15
TABLE II-1	PLAN C COMPONENT SUMMARY FOR 2020 CONDITIONS MUNICIPAL/INDUSTRIAL WASTEWATER ONLY	II-18
TABLE III-1	SUMMARY OF CROPS, YIELDS AND ANNUAL GROSS INCOME FOR 2020 FLOWS IN PLAN C	III-10
III-2	SUMMARY OF NUTRIENTS IN SEWAGE EFFLUENT, STORMWATER AND SLUDGE (Based on 2020 Flows in Plan C)	III-20
III-3	STORM RUNOFF FLUSHING OF HEAVY METALS	III-22
III-4	CONTENT OF SOME HEAVY METALS IN TYPICAL CROPS	III-23
III-5	REMOVAL OF TYPICAL HEAVY METALS BY PLANTS	III-24
TABLE VI-1	ANNUAL RESOURCE REQUIREMENTS	VI-2

LIST OF FIGURES

		Page
FIGURE II-1	TUNNEL PROFILE AND GEOLOGICAL FORMATIONS	II-7
II-2	PLAN C, WESTERN LAND TREATMENT AREA	II-10
II-3	LAND TREATMENT SITES FOR PLAN C WITHIN THE THREE RIVERS BASIN	II-19
FIGURE V-1	CONCEPTUAL REPRESENTATION, TYPICAL UPSTREAM PONDING FOR P.U.D.	V-3
V-2	BURTON EARLY ACTION LAND TREATMENT SITE FOR 1990 FLOWS	V-7

SECTION I

BACKGROUND INTRODUCTION

The Cleveland-Akron Metropolitan and Three Rivers Watershed Area wastewater management planning effort included the study of alternative wastewater treatment methods as specified in the Water Pollution Control Act Amendments of 1972.

One of the alternative methods studied in detail is land treatment as related to irrigated agriculture using treated wastewater effluent.

This report presents the findings and conclusions of the Land Treatment Contractor as defined by the scope of work for this portion of the overall effort.

Land treatment provides for reclaiming and recycling of certain pollutants and water, and the confined disposal of other pollutants not recycled. The land treatment technology provides the opportunity for revenue-producing facilities through the production of agricultural goods. It has been estimated that the readily-identifiable equivalent crop fertilizer market value of the nutrients in the effluent of the Study Area approaches $10,000,000 for 2020 flows.

The planning for this alternative has incorporated the opportunity for waste heat dissipation from power plants on a revenue-producing basis. Open space and recreational considerations have been integrated into the in-basin wastewater management facilities, and recharge of ground-water aquifers is provided in the upper Cuyahoga River valley.

The land treatment investigations have resulted in the development of wastewater management system components for Plans B and C as described in the Formulation Final Report.

Land treatment is the application of closely controlled amounts of secondarily-treated wastewater to the land surface to percolate through the soil zone for final treatment of the water and beneficial reuse of many of the pollutants as crop nutrients. The treated water is then recovered for discharge to a natural body of water, or recycled to towns and industry.

SCOPE OF WORK

The Survey Scope Study was undertaken by various organizations with specific and different assignments as follows:

1. Associated Water and Air Resource Engineers, Inc., of Nashville, Tennessee, was assigned a scope for defining industrial waste problems anticipated for 1990 and 2020, and defining the scope and cost for treatment of non-compatible wastes.
2. Havens and Emerson, Ltd., of Cleveland was assigned a scope for defining and resolving domestic and stormwater runoff problems for 1990 and 2020 and to assist in developing alternative plans.
3. Wright-McLaughlin Engineers of Denver, Colorado, was given the assignment of formulating regional management systems to include land treatment systems for ultimate disposal.

The land treatment systems are presented in this report as a part of Item 3 by the land treatment contractor.

The objective of the work of the land treatment contractor is to provide a viable alternative wastewater management plan which is based on recycling resources to agriculture, and which meets environmentally sound principles. This included three phases.

Phase I is to search out and identify land areas suitable for land treatment of wastewater. Phase II is the providing of area-wide wastewater management plans with land treatment components to meet 1983 and 1985 goals. Phase III work of the land treatment contractor is to refine the designs and costs of the land treatment components and to estimate the incremental costs associated with the phased implementation of the land treatment components.

SUMMARY OF PHASE I AND PHASE II

The detailed investigations of the Phase I and Phase II land treatment contractor's assignment are presented in those two technical appendices. Also included are supporting references. A brief summary of certain findings is presented below.

Soil Inventory

Potentially suitable lands were searched for and identified, where available, in 21 counties of the Lake Erie basin of northern Ohio. For this purpose the county soil maps, Soil Conservation Service field data, and publications of various local, state, and federal agencies were fully utilized.

In all, 1.66 million gross acres were finally inventoried as being potentially suitable for consideration. These 2600 square miles could

have been increased by incorporating other irrigation land management techniques.

The reader is referred to Sections II and III of the Phase I Land Treatment Report for detailed soil data for the 2600 square miles and the data source listing.

Geology and Ground Water Hydrology

The geology of northern Ohio is compatible with the utilization of a land treatment system for the management of the wastewaters of the study area. It is feasible to construct components such as large diameter transmission tunnels, winter storage reservoirs, and land treatment sites. Tunnels would probably be lined through limestones and shales, but supports would only need to be light. The extensive underlying glacial deposits are generally tight.

The levels and quality of ground water will not be significantly affected in the western land treatment areas by irrigation.

For more detailed discussion of the subsurface condition, Sections IV and V of the Phase I Land Treatment Report are available to the reader.

A proposed tunnel alignment to transport wastewater to the western land treatment site would traverse the Lake Erie shoreline from near Eastlake to a load point at the present Cleveland Westerly Sewage Treatment Plant and then follow a line southwesterly across Cuyahoga, Lorain and Huron Counties to a centralized winter storage reservoir site near the southwest corner of Huron County. The Transmission Tunnel route would be able to remain in the relatively more favorable shale tunneling environment for most of its length, the western portion being in limestone.

The quality of most of the existing ground water derived from the area would generally be classed as fair-to-poor, due to high TDS concentrations, as well as hardness, sulfate, hydrogen sulfide, and iron in certain areas.

A major ground water problem in the Western Land Treatment Area is the presently contaminated ground-water region centered around Bellevue. The present region of pollution extends to one mile east of Clyde and south several miles into Seneca County. This contaminated region underlies about 3,200 acres considered earlier in this study as a potential land treatment site. The condition at Bellevue illustrates the potential of well-designed land treatment systems as a means of improving a variety of hydrological conditions.

At present it is known that large springs exist on land and in Lake Erie which are discharge points for the limestone aquifer. It is estimated that perhaps 500 to 1,000 cfs total flow issues from the various springs.

In the Three Rivers Watershed a comparison of finally-selected land treatment and reservoir sites indicates that ground-water relationships present no significant constraints upon the land treatment proposals within this area. In general, relatively tight soil conditions and extremely impermeable substrata would retard ground water recharge from the winter storage reservoirs and the artificially drained irrigation sites. A system of ground and surface water quality monitoring stations would be designed for each treatment site to establish the potential hydrological impact over time of the land treatment system.

Surface Hydrology

The streams within the study area flow into Lake Erie in north-central Ohio. The major uses of surface water within the Three Rivers basin are for power and manufacturing. Lesser uses are for domestic, commercial, irrigation, and rural purposes. Some smaller towns tend to rely on ground water. As the area grows, a greater dependence upon surface water is expected, with low-flow augmentation efforts aimed at improving the low-flow condition of the streams.

The average precipitation for the State of Ohio is 37 inches per year and varies from 32 inches in northwestern Ohio to 44 inches in southwestern Ohio. The study area receives less than the average rainfall for the entire state. Although Lake Erie affects the climate near the shoreline, the main influence is from air masses moving eastward across the great plains.

In the western land treatment area, the average stream flow constantly decreases from a peak in March or April to a low in September or October when it begins to increase again. From 40 percent to 50 percent of the average annual runoff volume occurs during March and April. For an individual water year, low flows can extend into November and December, and some large winter storms between December and March can cause high peak runoff values and discharge volumes. The stream flow from June to October is generally lower than the average discharge and is less erratic from one year to the next. Summer and fall flows are less variable than winter and spring flows.

Irrigation of treated wastewater on agricultural lands will improve the low-flow conditions of the Sandusky, Vermillion and Huron river basins. The return flow will occur during the months of worst low-flow conditions and will add to the natural waters. During high-water periods, the return flow increment will not be of a sufficiently large enough proportion of the total flow to create flooding.

Within the Three Rivers Basin the return flow from land treatment would provide a beneficial increase of the low flows in the upper Cuyahoga and the upper Rocky River. The Chagrin has adequate low flows.

The natural sustained dry weather flow in the Cuyahoga below Lake Rockwell is relatively high per square mile of drainage area due to the inflow from ground water discharge. However, the municipal diversions from Lake Rockwell still cause the stream to drop to less than 10 cfs at times.

The low-flow conditions in the river between Lake Rockwell and Yellow Creek will worsen in the future without a major change in the direction of water management.

In the Rocky River, portions of which are in the area-wide park system, low-flow conditions contribute to environmental problems, particularly in the lower reaches near the more densely populated areas.

Soil Selection

The three basic techniques now used in the United States for land treatment of wastewater are rapid infiltration, spray irrigation, and overland runoff. The first requires very permeable soil and subsurface conditions, the second requires moderate permeabilities with few constraints

on subsurface geology, and the third technique operates best with very tight and impermeable soils. The techniques are defined as follows: Spray irrigation is the controlled spraying of liquid onto the land, with the flow path being infiltration and percolation within the boundaries of the site. Overland runoff is the controlled discharge of liquid onto the land, with the flow path being downslope sheet flow. Rapid infiltration is the controlled discharge, by spreading or other means, of liquid onto the land, at a rate measured in feet per week, with the flow path being high-rate infiltration and percolation.

These techniques provide for a range of soil characteristics suitable for effluent treatment which includes very tight soils with almost no permeability or infiltration capacity, to extremely coarse soils such as one would find in sand and gravel pit areas. As the type of soil criteria varies, the land treatment management and farming practices should significantly vary.

It follows that an almost infinite number of variations could be developed to suit soils falling between the coarse and fine-grained soil extremes. A selection philosophy was developed which was based on tailoring of farm management techniques to best suit specific and unique soils.

Final Selection Criteria

The final soil selection criteria was based upon testing the overall soil renovative capacity and character against specific objective and subjective measuring constraints including:

1. Reasonably high and suitably safe hydraulic capacity, as related to specific irrigation application and management methods, of more than

50 inches per year.

2. A high degree of heavy metal removal and storage capacity approaching 100 percent.
3. Nitrogen removal, with reuse, temporary storage, and atmospheric loss potential without significant leaching, of between 80 and 99 percent.
4. Phosphorous and calcium removal, with reuse or storage potential without significant leaching, approaching 99 percent.
5. Suitability for economically reasonable artificial and natural drainage control.

The constraints of present land use, because of forests, highways, homes, and general development, eliminated large areas of land from consideration for land treatment in this study. On the other hand, present agricultural and open space land use provided great areas which could be further considered in detail. In addition, some lands in northern Ohio have serious handicaps which could be greatly improved by initiation of land treatment.

The following drainage problems and needs have been described by the Great Lakes Basin Commission:

1. The "problem lands" are concentrated in northwestern Ohio, in an area of 5.5 million acres (four million of these are in crop and pasture land);
2. One and one-half million acres of drainage work must be done if the basin is to meet its allocation of the national requirement for food and fibers from this area.

In 1968, some 10,000 acres were irrigated in the general area west of Cleveland. In April, 1971, the Great Lakes Basin Commission pointed

out that irrigation would improve the existing form of agriculture and enable farmers to increase their income without competing for additional high value land. By choosing inadequately drained lands for land treatment purposes, additional benefits are gained because of the new drain tiling of such lands as part of the land preparation.

The final selection of the optimum lands for further consideration for use in the Cleveland-Akron-Three Rivers Wastewater Management Study resulted in the selection of three basic soil associations:

1. Mahoning-Ellsworth
2. Cardington-Bennington
3. Chili

For detailed information on the soil association characteristics, the reader is referred to the Phase I and II reports.

Farm Management

The success of land treatment areas for productive farming and ranching operations, coupled with efficient renovation of treated sewage effluent into good quality water, is dependent upon careful planning and proper farm management. The basis of this planning must include consideration of the right surface form, water application technique, soil preparation, and drainage system.

Tight, fine-grained soils have the greatest potential, if managed properly, for a high degree of sewage effluent renovation by land treatment. Sandier soils, with high permeability, suitable for conventional spray irrigation, might be selected when finer-grained soils are not

readily available near a metropolitan area, or if farming operations and traditional practices tend to prevail. In northern Ohio, both the sandy and the fine-grained soils are found.

Various farming techniques have been defined for the various soils. Most suitable methods are:

Chili -- Spray irrigation, using center-pivot rigs and solid sets, depending upon specific field configuration and size. Drainage by wells where aquifer conditions permit, and by drain tile systems elsewhere.

Mahoning-Ellsworth -- Overland runoff/infiltration method with drain tile systems. A rough grass crop would be grown.

Cardington-Bennington -- Spray irrigation, using center-pivot rigs and solid sets. Corn and grass would be the primary crops. These would be rotated. Drainage by drain tile systems.

To prepare the Mahoning-Ellsworth land for irrigation, deep plowing is contemplated to improve the soil characteristics for this purpose.

Strip-Mined Land Reclamation

The major solids by-product of any wastewater treatment is sludge, containing inorganic and decayed organic matter. This product, containing phosphorous and organic nitrogen, is suitable for application to strip-mined coal lands.

There are more than 190,000 acres of such land lying within 150 miles of Cleveland. Restoration includes three elements: (a) providing a supply of organic matter and plant nutrients, (b) improving the moisture retention capacity, and (c) reducing the acid condition at depth.

Treatment of the strip-mined lands with sludge should permit growth of numerous species of plants.

Land Treatment Components

The land is only one component of the land treatment system. To function as a comprehensive land treatment system, the wastewater must be collected, transported, pumped, applied to the land, and then returned to the stream or to the recycling process once again for use by municipalities or industry.

Basic components include:

1. Wastewater collection system
2. Secondary treatment facilities
3. Transmission conduits (pipes and tunnels)
4. Storage reservoirs
5. Land treatment site
6. Irrigation system
7. Drainage system
8. Sludge management facilities
9. Monitoring and labs.

In addition, farming operations ranging from plowing, planting and weeding to harvesting and marketing are an integral part of land treatment operations.

Aerated Lagoons

Aerated lagoons are sometimes utilized for secondary treatment of wastewater prior to land application. The secondary treatment can also be accomplished with activated sludge, trickling filter, or extended aeration plants.

Aerated lagoons are characterized by the relatively large volume of wastewater under treatment at any given time, introduction of air into the wastewater, and creation of a suitable environment for bacterial action. In many ways, it can be thought of as a slow activated sludge system, and which parallels natural processes.

Aerated lagoons are basins in which an active biological mass, oxygen, and wastewater are brought together. The resulting biological system is a variation of the activated sludge process. Wastewater organics, in the presence of oxygen, are utilized by the active mass. Therefore, the basic biological relationships pertinent to activated sludge apply to aerated lagoons.

The particular lagoon system proposed for this study consists of two stages: the first stage, or aerobic lagoon; and the second stage, or facultative lagoon. The amount of mixing created by the aeration equipment is the distinguishing factor between the two lagoons. An aerobic lagoon is one in which mixing keeps the solids in suspension.

Wastewater Renovation

The renovative capacity and efficiency of the land treatment systems vary from soil to soil, with crops grown, with the character of irrigation and drainage, and with the quality of the effluent being applied as irrigation water.

The following table presents the projected quality of the irrigation water following secondary biological treatment and assuming a mix 81 percent municipal-industrial sewage and 19 percent storm water. The concentrations shown are conservatively high for computational purposes.

TABLE I-1

IRRIGATION WATER QUALITY

Constituent	Municipal-Industrial and Combined Wastewater (mg/l)	Storm Runoff (mg/l)	Municipal-Industrial Combined and Storm Runoff (mg/l)
Suspended Solids (SS)	25	25	25
Biochemical Oxygen Demand (BOD)	15	15	15
Chemical Oxygen Demand (COD)	69	69	69
Total Dissolved Solids (TDS)	520	200	460
Nitrogen (N)	19.7	2.2	16.4
Phosphorous (P)	10.2	0.5	8.3
Heavy Metals	2.0	0.2	1.7

The quality of the western land treatment site drain tile effluent, after treatment, is represented in the following table along with the quality of storm runoff return flow. The sandier Chili soil would provide an effluent with a slightly higher BOD, COD, and N than that of the Cardington-Bennington soils.

Layout of drain tile systems has been undertaken to permit early spring planting without a high water table problem as now occurs in some years. The water table will decline rapidly enough following irrigation, and the aeration requirements will be met. Studies show that with average application rates of 120 inches per year on Cardington-Bennington soils, 30-foot spacings would be adequate for tiles. Closer spacing has been selected, however. Using the center-pivot rig on the Cardington-Bennington

soils at average rates of 120 inches per year, the soil zone would be constantly in an aerated condition.

TABLE 1-2

WASTEWATER RENOVATION OF SECONDARY EFFLUENT

	Municipal/Industrial/Combined Cardington-Bennington Soils		Storm Runoff Mahoning-Ellsworth Soils
Constituent	Removal Rate (Percent)	Return Flow (mg/l)	Return Flow (mg/l)
SS	99	< 0.3	< 0.3
BOD	99	< 0.2	< 0.2
COD	99	0.7	0.7
TDS	5-10	450-500 **	150-200 **
N	85-95 *	< 1 - 2.5	< 0.1
P	99+	< 0.1	< 0.01
Metals	99+	Trace	Trace
Virus	99+		
Bacteria	99+		

* The removal rate will depend on the crops grown, yields, and product removal. Unexplained losses of up to 50 percent to the atmosphere may occur.

** Average values are shown; lower or higher values are possible, depending on rainfall and evapotranspiration rates.

The approximate difference between ordinary alfalfa hay and typical Reed Canarygrass irrigated by sewage effluent with a good supply of nutrients is shown below:

	Protein %	Fiber %	TDN %	Phos. %	Nitrogen %	Dry Matter %
Alfalfa Hay	14.7	29	50.3	.21	2.35	90.4
Reed Canarygrass	20+	27	60	0.5	3	92

THE LAND TREATMENT SYSTEM

The land treatment system consists of a series of components including:

1. Sewage collection system
2. Secondary treatment
3. Pumping and transmission pipe for wastewater
4. Winter storage reservoir
5. Pumping and distribution to farms after chlorination
6. Irrigation application equipment
7. The soil (living filter)
8. Subsurface drainage
9. Canals and conduits
10. Sludge treatment.

In a combined sewerage system, the stormwater is treated with the municipal/industrial wastewater. Detention storage is provided to reduce the peak rate of storm runoff so that the transmission pipe can be sized for a controlled flow level.

In a separate stormwater sewerage system, the runoff is detained to reduce the peak of the hydrograph. When the storm runoff is released, it may be mixed with the municipal/industrial wastewater prior to treatment; then the combined storm runoff and the municipal/industrial

wastewater receive secondary treatment. When it is more cost-effective, the stormwater bypasses secondary treatment and is mixed with municipal/industrial secondary effluent. In either case, the treated effluent is then transported to winter storage.

With minor variations, the above described process is used in all 23 municipal/industrial land treatment systems in Plan C.

In a completely separate stormwater treatment system the water is detained in basins, then transported directly to the winter reservoir without being mixed with municipal/industrial wastewater.

COSTING

The planning effort included detailed costing of land treatment components so that overall costing could be accomplished by the Formulation Contractor, and meaningful cost comparisons made.

The reader is referred to Section VI of the Land Treatment Phase II Report for detailed costing data, and to Section IV and the Cost Appendix of this report.

The following five sections of this report provide schematic designs, farm management and treatment performance estimates, incremental costs on a time-phased basis, a discussion of early-action recommendations, and a tabulation of resource requirements for land treatment alternatives.

SECTION II

SCHEMATIC DESIGNS -- LAND TREATMENT COMPONENTS

Land application of wastewater effluent from secondary biological treatment facilities is referred to as land treatment. Secondary biological treatment may be accomplished in aerated lagoons or conventional secondary treatment plants. For separate storm runoff, the treatment prior to land application consists of pre-treatment followed by three to thirty days storage in detention basins. From the detention basin, the storm runoff may be released to a sanitary sewer during off-peak periods for secondary treatment in a municipal sewage treatment plant, or it may be given separate preliminary treatment and then pumped directly to a winter storage reservoir. For both the municipal/industrial wastewater and the storm runoff, all of the wastewater is eventually pumped to separate or combined reservoirs prior to land treatment.

No land treatment of wastewater effluent or storm runoff is included in Plan A. In Plan B, all of the wastewater from the upper-basin municipal plants, except Kent and Akron, goes to land treatment sites. In addition, land treatment of storm runoff, where feasible, is included in Plans B and C. Plan C provides for land treatment of those in-basin plants included in Plan B plus Kent, as well as land treatment in western Ohio for the wastewater from the shoreline plants. The reader is referred to the *Formulation Final Report* for a description of the Plan C wastewater system.

CRITERIA AND SCHEDULING

The wastewater management goals for Phase III are based upon the guidance provided by the Corps of Engineers (NCBED-PB, 31 January 1973) to comply with the Corps' interpretations of the Federal Water Pollution Control Act Amendments of 1972. The proposed State of Ohio effluent standards, the O. C. E. goals, and Level and Level 2 criteria, are summarized in Table II-1 of the Formulation Final Report. New construction or expansion will be phased according to the following schedule:

Municipal and Industrial Wastewater

a. Secondary treatment by 1977

b. Level 1 by 1983

c. Level 2 by 1985

Storm Runoff and Combined Sewer Overflows

a. Combined overflow to Level 1 by 1980

b. Separate storm runoff to Level 1 by 1983, except for the separate basins tributary to the tunnel.

c. All runoff treatment to Level 2 by 1985.

LAND TREATMENT COMPONENTS

1. Aerated Lagoons are planned to begin operation by 1977 for the 23 small in-basin municipal plants in Plan C. For Plan B, however, the Kent plant would be a physical-chemical treatment plant. Except for the early-action projects at Burton and New Medina, which will receive land treatment in 1977, the

effluent from the aerated lagoons will be discharged to streams and rivers until 1983. Thereafter, the effluent will be pumped to the land treatment reservoir sites. To assure adequate BOD and SS removals during the 1977-1983 period, the activated lagoons built in 1976 are oversized by 50 per cent or more. The schematic design, operation, and removal efficiencies of the aerated lagoons are discussed in Section IV of the Land Treatment Phase II Report.

2. Municipal Land Treatment In-Basin on Chili Soils occurs primarily in the Cuyahoga River Basin. The design criteria for these sites are listed below:

Application rates:	60 inches per year
Irrigation System:	Sprinklers by solid set or center pivot
Crops	Corn and Reed Canary Grass
Drainage system:	Depth = $5\frac{1}{2}$ feet Spacing = 60 feet
Site criteria:	Buffer strips of 100 feet near residences
Winter storage:	113 days
Special provisions:	Optional deep plowing

3. Municipal Land Treatment In-Basin on Mahoning Soils occurs in the Chagrin and Rocky River Basins. The design criteria for these sites are listed following:

Application rates:	90 inches per year
Irrigation system:	Border Method (overland-flow/infiltration)

Crops:	Reed Canary Grass
Drainage system:	Depth = 3 feet Spacing = 20 feet
Site criteria:	No buffer strips
Winter storage:	85 days
Special Provisions:	Optional deep plowing

4. Separate Storm Runoff Land Treatment In-Basin as distinguished from storm runoff that is treated in the municipal plants with the domestic and industrial sewage, receives considerably less pre-treatment, consisting of settling for three days in a detention basin followed by storage and stabilization in the winter storage reservoir prior to land treatment. Where this storm-water is to be applied to the Mahoning soils at a rate of 150 inches per year, separate storage reservoirs are planned. For the Chili Soils, where the application rate is maintained at the municipal sewage effluent rate of 60 inches per year, the storm water is pumped from the detention basin directly to the municipal winter storage reservoir, where economically advantageous.

The design criteria for separate storm runoff are summarized below:

	Soil	
	Chili	Mahoning
Application rates:	60 inches per year	150 inches per year
Irrigation System:	Center pivot or solid set	Border Method
Crops:	General	Reed Canary Grass

	Soil	
	Chili	Mahoning
Drainage system:	Depth = $5\frac{1}{2}$ feet Spacing = 60 ft.	Depth - 3 feet Spacing = 20 feet
Winter storage:	113 days	85 days
Site criteria:	No buffer strips	No buffer strips
Deep plowing:	Optional	Yes

The various farm management and irrigation methods for the different soils are discussed in Section IX of the Land Treatment Technical Appendix. Golf courses may be used in lieu of agricultural land where feasible. However, the application rates would be reduced unless adequate subsurface drainage were provided.

5. Combined Sewer Overflow Temporary Treatment for 1980-1985 is accomplished by providing tunnel and mined storage in addition to concrete basins for the one-year storm and treating this wastewater at the Southerly, Westerly, and Easterly treatment plants over a three-day period for the design storm. This plan calls for building the T-section connecting the above plants, constructing the mined storage in this segment and installing temporary pumps at the three plants. This component applies only to Plan C.

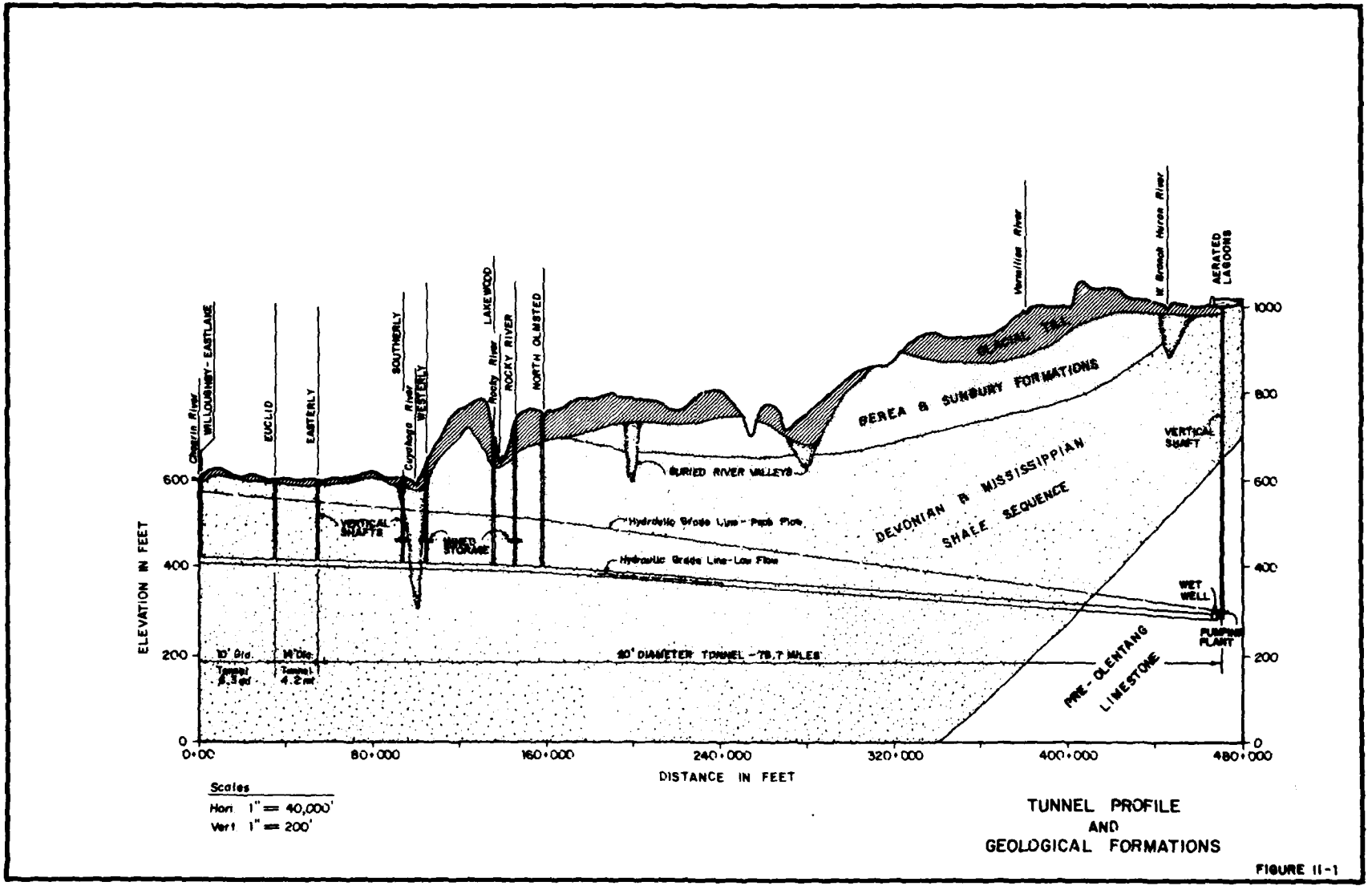
6. The Transmission Tunnel consists of a lined tunnel ninety-one miles long beginning at Willoughby-Eastlake and terminating at the aerated lagoons of the western Ohio land treatment site. The purpose of this tunnel is to transmit the municipal and industrial wastewater from the shoreline plants to western Ohio. In addition, this tunnel, coupled with surface detention storage and tunnel-mined storage, is capable of transmitting the one-year storm runoff

from the Cleveland metropolitan area. The main tunnel varies in size from ten feet in diameter to twenty feet in diameter, as shown on Figure II-1. Several tunnel spurs connecting the plants of Southerly, Rocky River, Lakewood, and North Olmstead to the main tunnel are also necessary. Other spurs and shafts will allow access for storm runoff. **The Tunnel component applies only to Plan C.**

a. Geological Formations are shown on Figure II-1. For the the most part, the tunnel goes through shale formations, the Devonian and Mississippian Shale Sequence. The last segment of the tunnel penetrates Pre-Olentang limestone. Except for the sections which run through buried river channels, it is anticiapted that moling machines will be used to excavate the tunnel.

b. Lining in the form of reinforced concrete from one foot to two feet, depending on the tunnel diameter, will be utilized. Special provisions may be required for the tunnel in the old river channel under the Cuyahoga River.

c. Capacity of the tunnel for the maximum section and maximum hydraulic grade line will exceed 1,800 MGD. For normal domestic and municipal flows of 550 MGD, the twenty-foot tunnel will flow about half full at a velocity of six feet per second. During peak stormwater runoff coincident with peak domestic and municipal flows, the maximum discharge will be approximately 1,730 MGD with



TUNNEL PROFILE
AND
GEOLOGICAL FORMATIONS

FIGURE II-1

velocities of about 8.5 feet per second.

d. Surcharge Storage, or mined storage chambers, consisting of wall and pillar construction will be provided to store large intermittent wastewater flows. Reading from left to right on Figure II-1, the mined storage chambers are to have a capacity of 180, 50, and 150 MG (million gallons). Another large storage chamber of 280 MG will be constructed in the Southerly spur at about the point the CU-2 drainage basin runoff enters the tunnel via a drop shaft. At this point, the tunnel would be reduced from a fourteen-foot diameter to a ten-foot diameter for the purpose of limiting the maximum flows into the main tunnel. The detention time of the mined storage chambers will vary from one to twelve hours for the one-year storm runoff depending on the storm pattern, storm frequency, and the storm's coincidence with the municipal and industrial peak flows.

e. Sediment Buildup is not expected to occur because of the velocities in the tunnel which vary between six and eight feet per second. Pre-treatment of the wastewater flows will remove debris and trash. Provision at the end of the tunnel for collection and removal of the large particles will be made.

f. Aeration will be provided at ten-mile intervals to avoid

septicity of the wastewater which requires about a twenty-hour travel time through the tunnel.

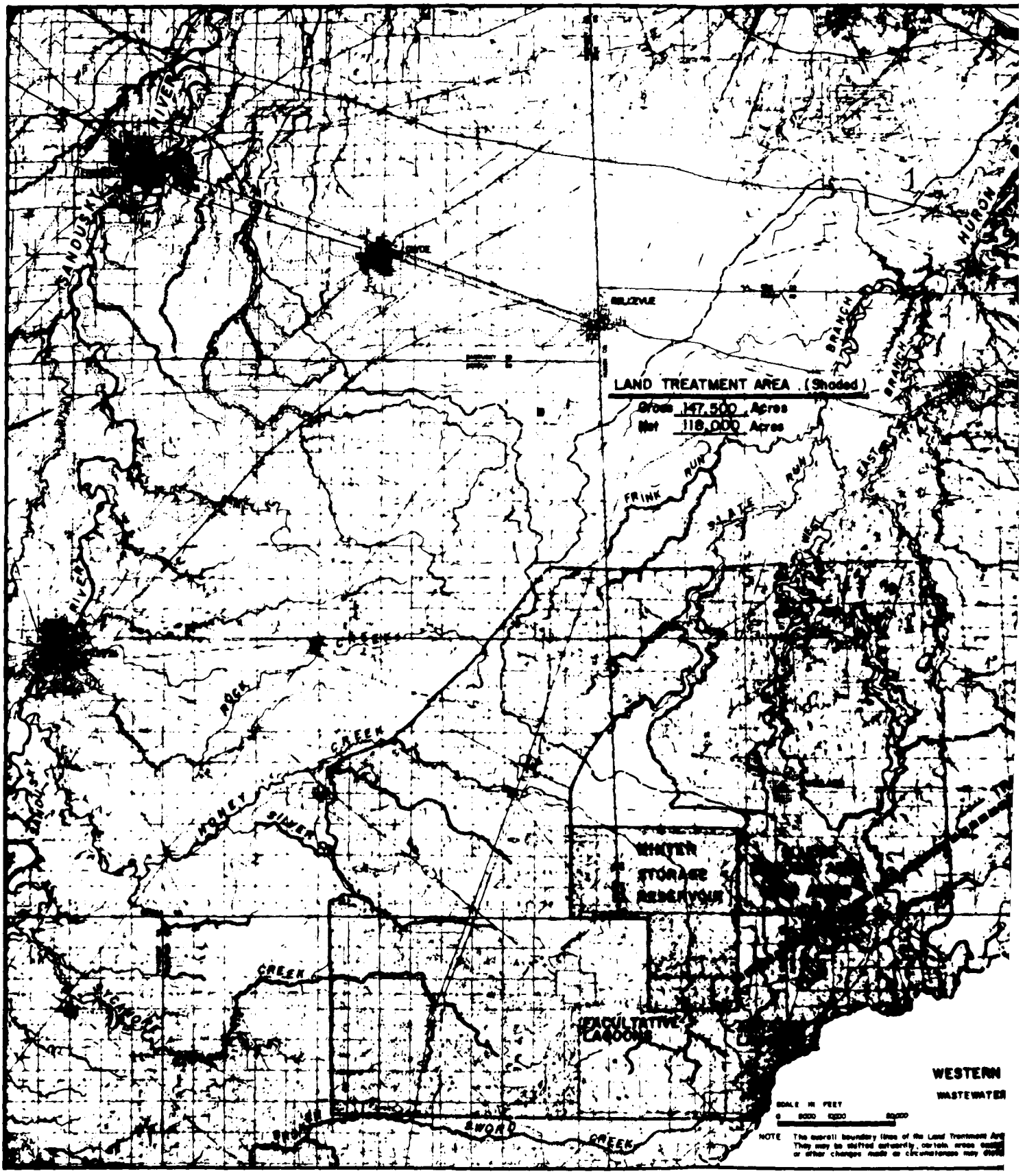
g. Standby Power will be provided at the end of the tunnel in case of a power interruption. Storage will also be provided at that location.

h. Construction Timing. The initial construction of the tunnel for the temporary combined storm runoff will give the contractors and planners valuable experience regarding construction methods, cost estimates, and scheduling. For cost-phasing purposes, construction of the tunnel will occur prior to 1985.

7. The Western Land Treatment Area for Plan C consists of 118,000 net irrigated acres to treat an average annual wastewater flow of 240,000 MG, based on an application rate of 75 inches per year. An additional 4,000 acres will be required for land treatment of sludge. These areas are depicted on Figure II-2.

a. Aerated Lagoons and Facultative Lagoons are discussed in depth in Section IV of the Land Treatment Phase II Report. Because of the delay until 1990 in phasing out secondary treatment at the shoreline plants, the aerated lagoons at the Western Land Treatment Area will not become operational until that year.

b. The Winter Storage Reservoir for the Western Land Treatment Area is shown on Figure II-2. As located, the


SANDUSKY RIVER
BUCYRUS
BELLEVUE
BRANCH
HURON
LAND TREATMENT AREA (Shaded)
Gross 147,500 Acres
Net 118,000 Acres
FRINK RUN
STATE
EAST
ROCK CREEK
MONEY
SWEET
WINTER STORAGE RESERVOIR
FACULTATIVE LAGOONS
SWORD CREEK
WESTERN
WASTEWATER
SCALE IN FEET
NOTE

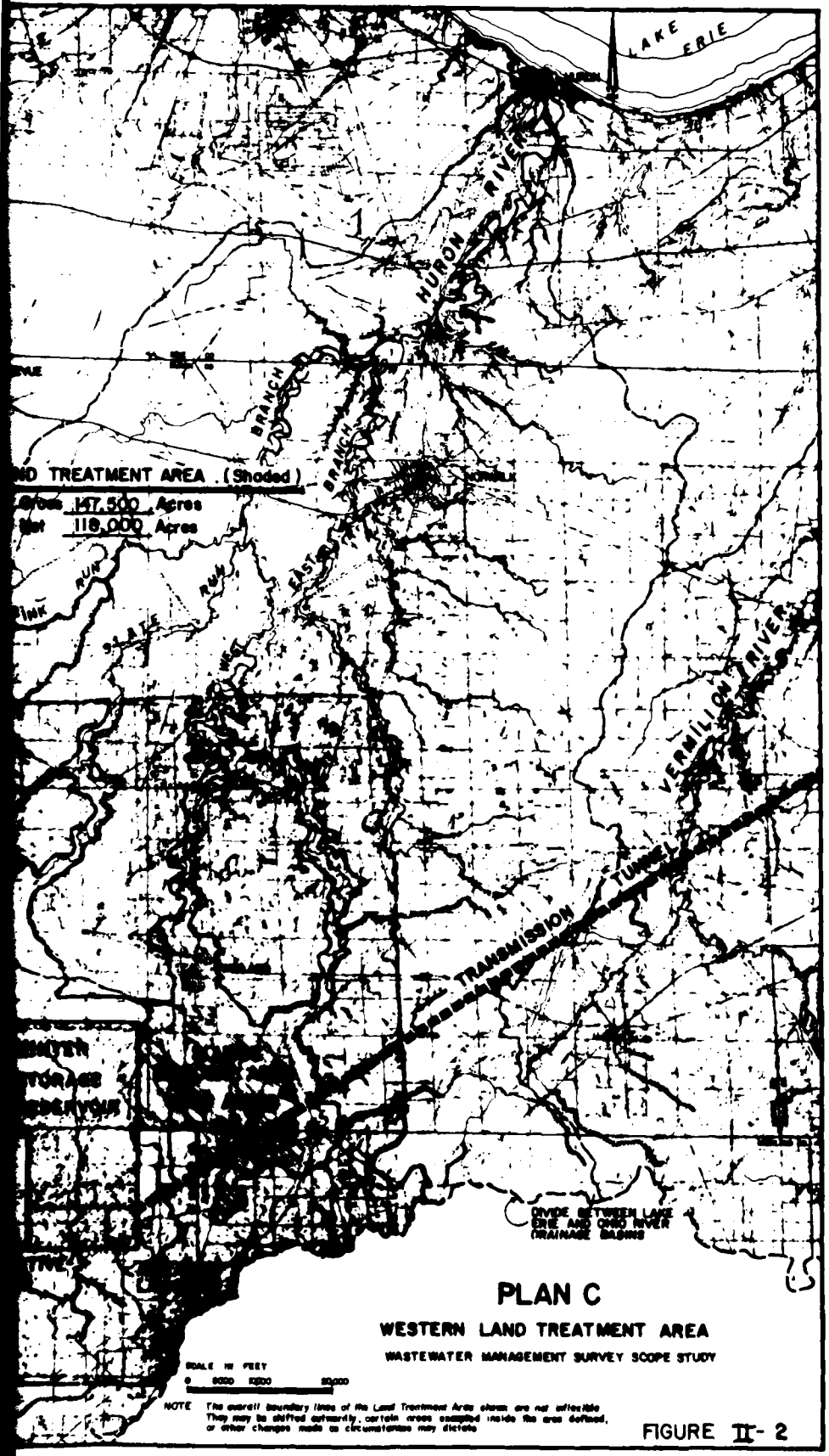

LAKE ERIE
HURON RIVER
BRANCH
BRANCH
EAST
RUN
RUN
STATE
VERMILION RIVER
TUNNEL
TRANSMISSION
DIVIDE BETWEEN LAKE ERIE AND OHIO RIVER DRAINAGE BASINS
ND TREATMENT AREA (Shaded)
Gross 147,500 Acres
Net 118,000 Acres
PLAN C
WESTERN LAND TREATMENT AREA
WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
SCALE IN FEET
0 5000 10000 20000
NOTE The overall boundary lines of the Land Treatment Area shown are not inflexible. They may be shifted outwardly, certain areas excluded inside the area defined, or other changes made as circumstances may dictate

FIGURE II- 2

effluent from the facultative lagoons will flow by gravity into the winter storage reservoirs, which will consist of sixteen to eighteen large cells of about 15,000 MG each for a total storage volume of over 84,000 MG. The uninterrupted storage period is expected to be 113 days, or about sixteen weeks. The materials for the dikes will come primarily from excavation of the soil within each cell. Riprap for the inside banks will be required to prevent erosion of these banks. A minimum freeboard of six feet will be provided. The shape of the cells, as well as maximum water level differentials, will depend on the topography.

For the period 1985 through 1990, before any of the shoreline treatment plants are phased out and any of the aerated lagoons are operational, the winter reservoir will receive secondary-treated effluent directly. The occasional slugs of untreated stormwater coming into the system during the 1985-1990 period will be highly diluted when combined with the treated effluent in the storage reservoir and no problems are anticipated prior to the operation of the aerated lagoons in 1990.

c. Reservoir Rainfall and Evaporation. The winter storage reservoirs will gain water from precipitation and lose part of this water by evaporation. For the 10-year period,

1961 - 1970 inclusive, the average precipitation at the Tiffin, Ohio, weather station was reported to be 34.13 inches. The closest station with complete evaporation records is at Wooster, Ohio, which reported an average pan evaporatior of 39.46 inches. This would amount to an average annual evaporation of approximately 28 inches using a pan coefficient of 0.70 which would create an annual surplus of about six inches.

During the normal storage period, November through March, little evaporation would occur. The precipitation during this period is approximately 12 inches. Until 2020 there would normally be excess reservoir storage capacity to absorb this excess. At 2020, the reservoir would fill up by the end of the storage season and begin to encroach on the six feet of freeboard provided. For the short time period involved, this freeboard encroachment will not impose a hazard to the embankment.

The excess of rainfall over evaporation in the reservoir will provide a dilution of total dissolved solids in the same manner as does storm runoff, benefitting the effluent quality all year long.

d. Irrigation Pumping Plants. For cost purposes, four pumping plants adjacent to the reservoir, are planned. Buried force mains to the land sites will decrease in diameter from the pumping plant to the land farthest away from the

reservoir. Booster pumps may be or may not be required depending on final design considerations.

e. Irrigation Equipment and Drainage Systems have been discussed in Section III of the Land Treatment Phase II report.

f. Crops grown at the Western Land Treatment Area will be corn and Reed Canary Grass covering approximately 40 percent and 60 percent respectively of the irrigated acreage. This subject is more thoroughly discussed in the following section of this report.

SLUDGE MANAGEMENT

A cost study was made to determine the most feasible methods of sludge handling and disposal. Comparisons were made between the transportation of liquid sludge via truck or pipeline to agricultural lands, the transmission of liquid sludge via pipeline to the strip-mined area, the transportation of dry sludge via truck to agricultural lands, and the incineration of sludge at the treatment plants. In each case, available lands and their relation to the treatment plant site, were considered in choosing the best method of sludge handling and disposal for each plant. In addition, the particular phasing requirements for Plans A, B, and C were considered in choosing the methods of sludge management.

The cost comparisons considered varying plant sizes, liquid and dry sludge application techniques, and the distance from the treatment plant to the application site. These were plotted to

determine graphically the optimum method of disposal for each plant with its initial and ultimate size considered in the choice of sludge management. For example, a small plant whose initial capacity would warrant liquid sludge trucking, might require a pipeline with the future expansion of the plant. In this case, to build pipelines initially would be more economical than to phase out trucks and build pipelines and pump stations later.

In-Basin Agricultural Application

Liquid sludge is pumped from the digester to sludge holding tanks located on the treatment plant site or immediately adjacent. Storage capacity is sized for six months, assuming a six-month irrigation season. During the irrigation season, sludge is pumped from the storage holding tanks into liquid sludge trucks. Trucks would be equipped for highway travel and for crossing agricultural fields while applying the sludge. The use of six-month storage takes into account inclement weather and holidays.

Liquid sludge trucking appeared most efficient in plants having 0.5 to 10.0 MGD capacity. For certain small plants, e.g. East Clarion and Troy Township, it was shown to be more economical to digest the sludge and dewater on sand drying beds. Periodic removal of the dried sludge to agricultural lands in adjacent areas would replace liquid sludge trucking and be most cost effective.

For plants larger than 10.0 MGD but smaller than 15.0 MGD, vacuum filtration and truck transport of the dried sludge proved more economical than either liquid sludge trucking or pipeline transmission.

In the case of vacuum filtered sludge, storage is again supplied for the dried sludge over the winter months. This necessitates building sludge storage basins, preferably near the land application sites. The vacuum filtered sludge would be trucked and dumped into the storage basins, stored, and removed for the summer land treatment season. Capital expenditures would include trucks, sludge storage basins, and sludge removal equipment, with the capital cost of sludge spreading equipment born by the user. Storage capacity would also be for an approximate six-month period.

Pipeline transmission of liquid sludge proved more cost effective than either the liquid sludge trucking, or the vacuum filtration/trucking systems when larger volumes of sludge were involved. In this case, liquid sludge would be piped to sludge holding tanks adjacent to the application sites. Again, storage would be for the six-month period with the total sludge volume withdrawn and applied over the five to six-month irrigation season. Capital costs for sludge pipelines are high compared with other systems of handling, and the permanence of the pipeline dictates the continued use of this method and adjacent agricultural lands.

In isolated instances, the most economically feasible method of sludge disposal was incineration. This applied where incinerators were already in use, and would continue for their useful life. The residue or ash from the incineration process was disposed of by land fill.

Strip-Mine Renovation

Plans A and B employ a method of sludge disposal which includes

constructing a pipeline to connect Euclid, Easterly, Southerly, Akron and Ravenna with the strip-mined lands. This required approximately 120 miles of pipe. An annual total of ten months of sludge application is expected to be feasible on the strip-mined lands.

Because of the large volume of sludge from those plants using the strip-mined area, storage in lagoons proved more economical than the construction of concrete or steel holding tanks. Capacity was provided for a two-month storage period.

Costs for agricultural application of liquid sludge include:

Pump stations

Liquid sludge holding tanks

Sludge hauling trucks/spreaders

Land purchase

Costs for agricultural application of vacuum-filtered sludge include:

Sludge hauling trucks

Storage basins

Sludge removal equipment

Sludge hauling and spreading equipment (privately owned)

Costs for agricultural application via liquid sludge pipeline include:

Sludge pump stations (booster stations where required)

Pipelines

Liquid sludge holding tanks (lagoons)

Sludge removal pumping equipment

Distribution systems/trucks

Land purchase.

Sludge management facilities were chosen to optimize costs, with consideration given to available agricultural land, synergistic benefits and phasing. In addition, operation and maintenance costs were a key factor in the overall design capabilities of the plant. For liquid sludge application, truck drivers, land management personnel and storage basin operators will be required. The vacuum-filtered sludge applications required personnel to operate sludge holding basins, drive trucks, and manage sludge distribution centers. Liquid sludge pipelines required personnel to maintain pump stations, operate sludge holding tanks and sludge distribution centers in addition to operation of liquid sludge dispensing equipment. Sludge piped to strip-mined areas requires similar personnel and operations as liquid sludge to agricultural lands. In all cases mechanics, laborers, operators, secretarial personnel, etc., are required to operate and maintain these sludge management systems.

Sludge Application Rates

On agricultural land, the projected sludge application rate is ten dry tons per acre per year. The amount applied at one time can be varied depending on the cropping pattern, crops grown or equipment used to apply the sludge. Application of 30 dry tons in one year with a two-year rest period is an alternative. Monitoring the release of nutrients and its effect on the drainage effluent would be required for a number of years to optimize the rate of application.

On strip mines, an application rate of 200 dry tons per acre every ten years has been projected for costing. Initially higher application rates may be permissible.

TABLE II-1

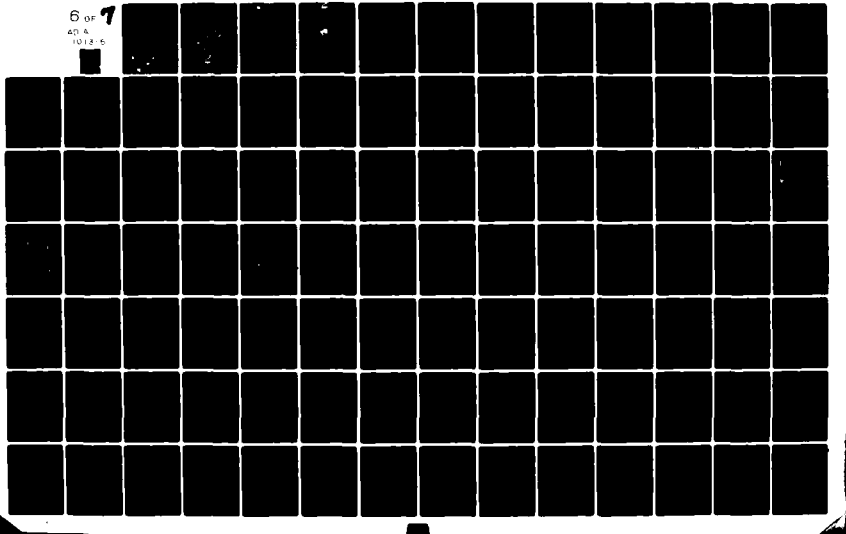
PLAN C COMPONENT SUMMARY FOR 2020 CONDITIONS
MUNICIPAL/INDUSTRIAL WASTEWATER ONLY

Plant	Projected Population (2020)	M&I/ADF (MGD)	Secondary Treatment	Winter Storage (MG)	Soil Type	Area Irrigated (Acres)	Application Method	Application Rate In/Yr.	Drain Tile Depth (Ft)	Drain Tile Spacing (Ft)	Crops	Sludge Treatment
Randolph	5,000	0.75	AL	85	Chili	168	SS, CPR	60	5½	60	C, RCG	Ag. Land
New Kent	150,600	28.41	AL	2,785	Chili	5,522	SS, CPR	60	5½	60	C, RCG	Ag. Land
Burton	13,300	3.61	AL	408	Chili	809	SS, CPR	60	5½	60	C, RCG	Ag. Land
Mantua	3,975	0.86	AL	97	Chili	193	SS, CPR	60	5½	60	C, RCG	Ag. Land
Butternut Creek	7,800	1.17	AL	132	Chili	262	SS, CPR	60	5½	60	C, RCG	Ag. Land
Chardon	13,300	0.20	AL	17	Mahoning	30	OVF/INF	90	3	20	RCG	Ag. Land
East Claridon	3,200	0.48	AL	54	Mahoning	108	OVF/INF	90	3	20	RCG	Ag. Land
Troy Township	3,140	0.47	AL	53	Chili	105	SS, CPR	60	5½	60	C, RCG	Ag. Land
Auburn Township	5,600	0.84	AL	95	Chili	188	SS, CPR	60	5½	60	C, RCG	Ag. Land
Shalersboro	13,333	2.00	AL	226	Chili	448	SS, CPR	60	5½	60	C, RCG	Ag. Land
Ravenna	74,315	12.34	AL	1,394	Chili	2,764	SS, CPR	60	5½	60	C, RCG	Ag. Land
Aurora Central	16,285	2.98	AL	253	Mahoning	445	OVF/INF	90	3	20	RCG	Ag. Land
Fairmount Road	22,680	3.40	AL	384	Chili	762	SS, CPR	60	5½	60	C, RCG	Ag. Land
Fowler's Road	13,200	1.98	AL	224	Chili	444	SS, CPR	60	5½	60	C, RCG	Ag. Land
Newbury Township	10,300	1.54	AL	131	Mahoning	230	OVF/INF	90	3	20	RCG	Ag. Land
Chagrin Falls	51,296	7.87	AL	669	Mahoning	1,176	OVF/INF	90	3	20	RCG	Ag. Land
Chagrin East Branch	13,020	1.95	AL	166	Mahoning	291	OVF/INF	90	3	20	RCG	Ag. Land
Upper East Branch	7,333	1.11	AL	94	Mahoning	166	OVF/INF	90	3	20	RCG	Ag. Land
Hinckley	11,470	1.72	AL	146	Mahoning	255	OVF/INF	90	3	20	RCG	Ag. Land
Medina County	33,333	5.00	AL	425	Mahoning	747	OVF/INF	90	3	20	RCG	Ag. Land
New Medina	49,666	9.49	AL	807	Mahoning	1,418	OVF/INF	90	3	20	RCG	Ag. Land
Medina Creek	4,000	0.60	AL	68	Mahoning	134	OVF/INF	90	3	20	RCG	Ag. Land
[illegible] pool	33,333	5.00	AL	425	Mahoning	747	OVF/INF	90	3	20	RCG	Ag. Land
[illegible] and Treatment Area	2,618,522	549.21	AL	62,061	Cardington-Bennington	98,473	SS, CPR	75	3	20	C, RCG	Ag. Land

[illegible]
OF - Overland Flow/Infiltration
[illegible] Set Sprinkler
[illegible] Pivot Rig
[illegible] Aerated Lagoons

C - Corn
RCG - Reed Canary Grass
Ag. Land - Agricultural Land

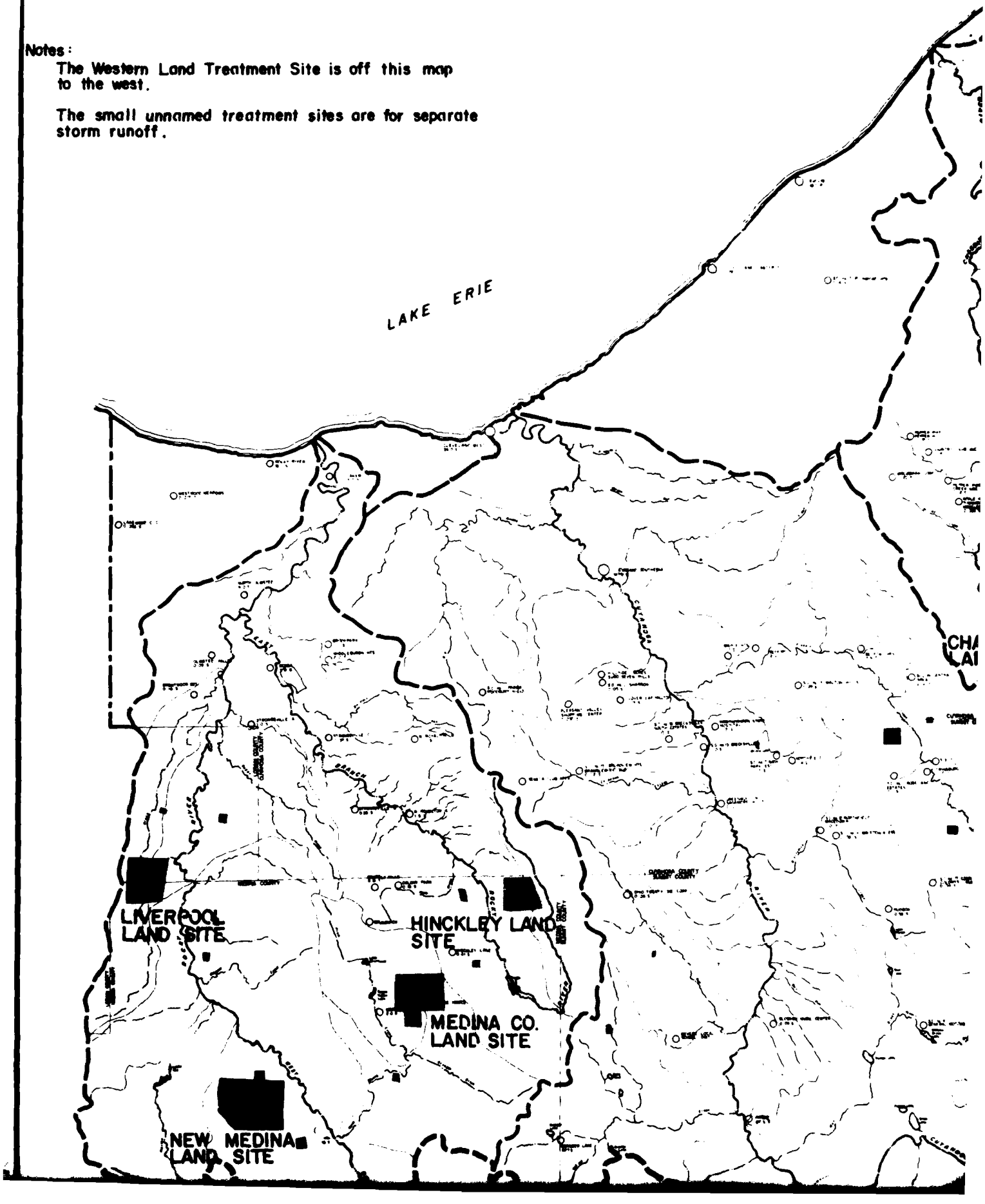
AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA, W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL

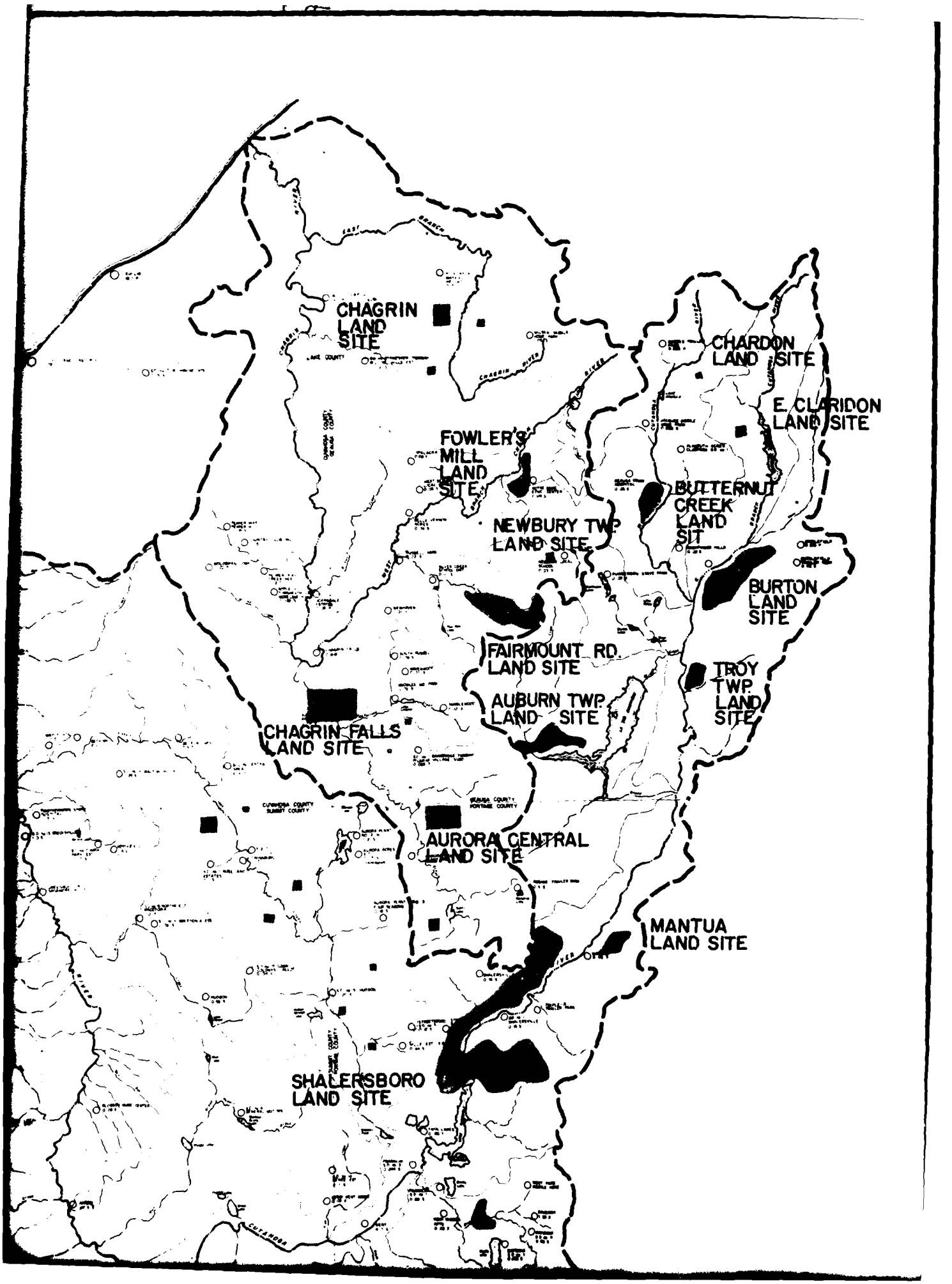


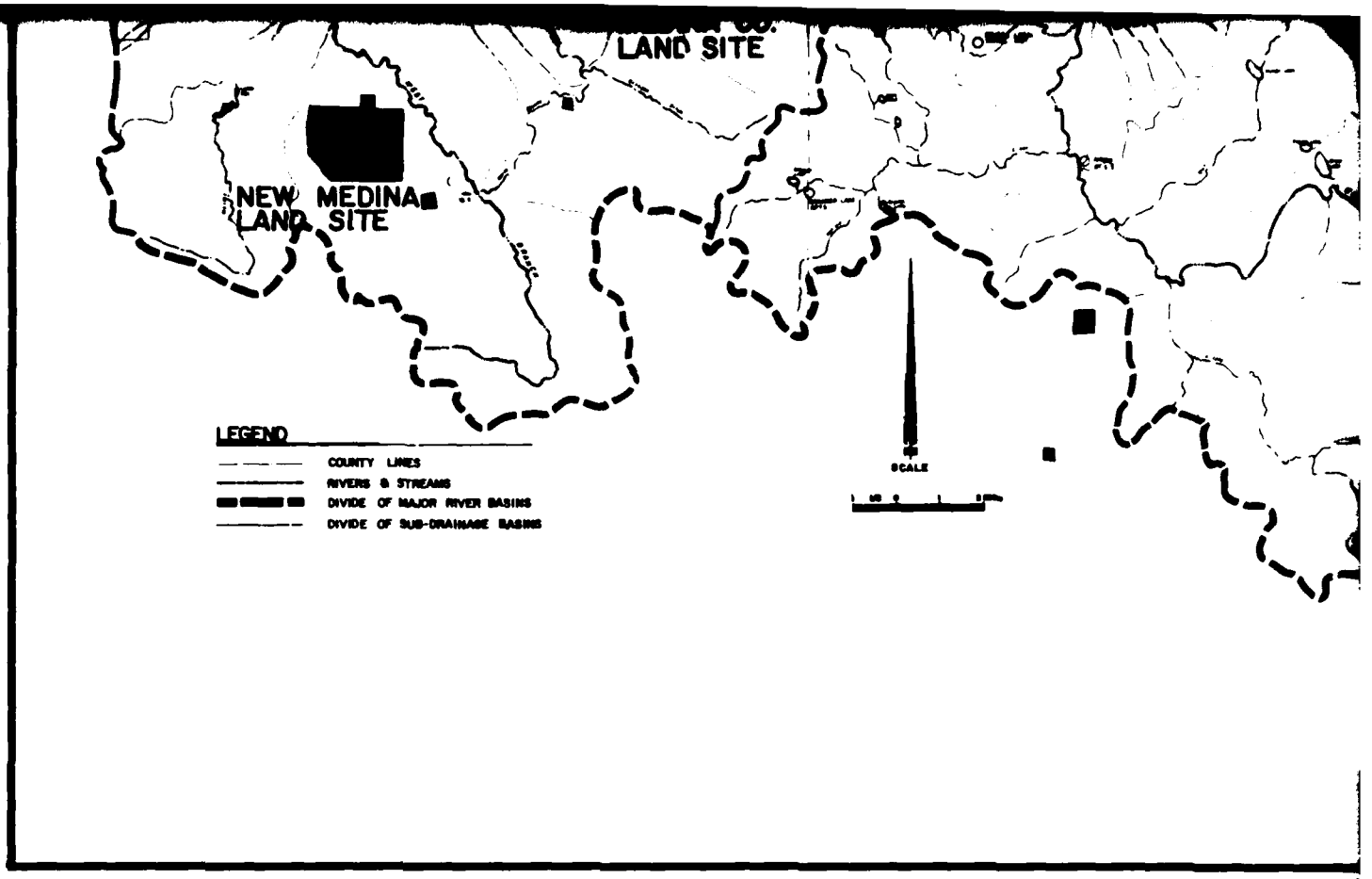
Notes:

The Western Land Treatment Site is off this map to the west.

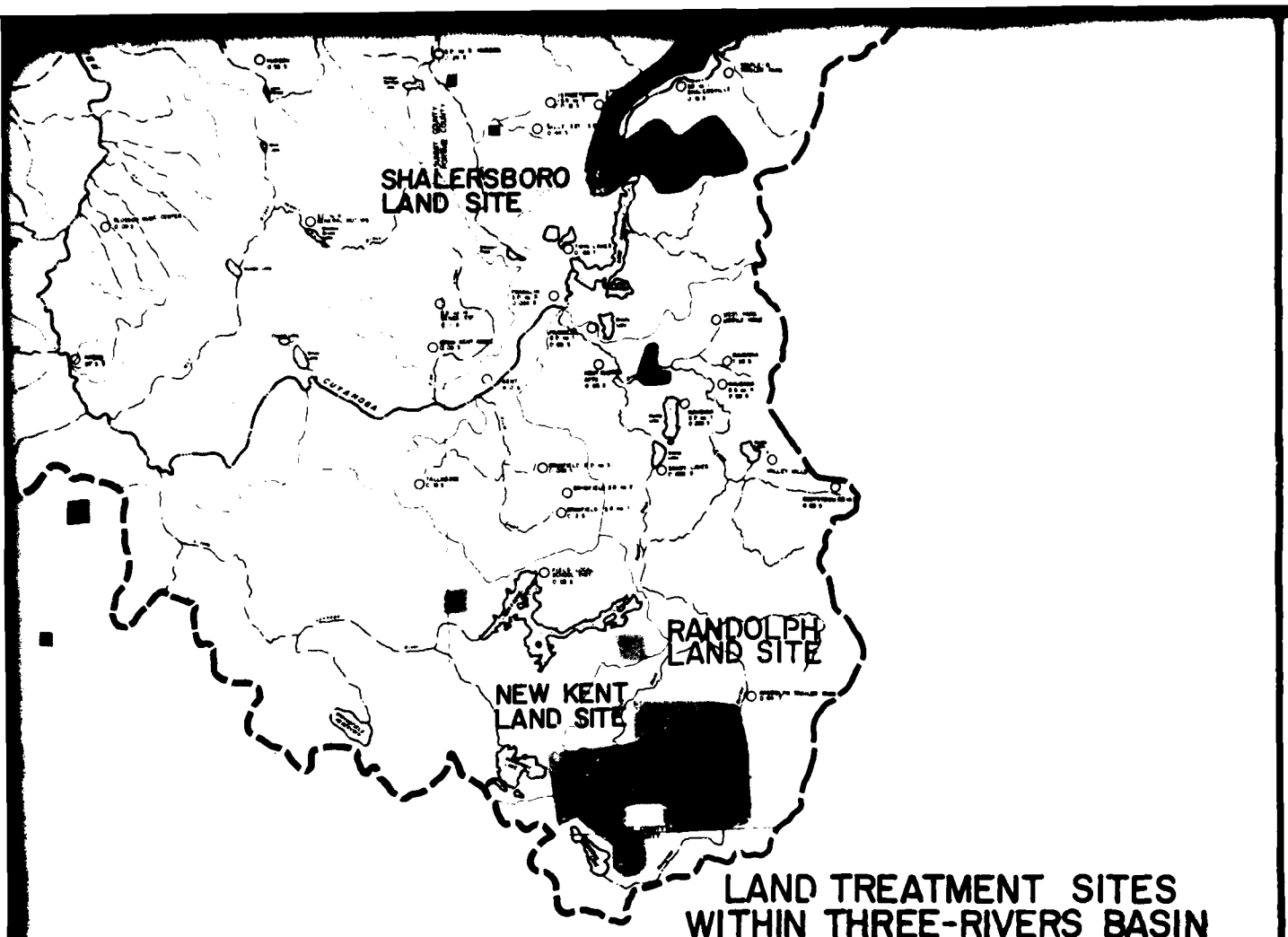
The small unnamed treatment sites are for separate storm runoff.




CHAGRIN LAND SITE
CHARDON LAND SITE
E. CLARIDON LAND SITE
FOWLER'S MILL LAND SITE
BUTTERNUT CREEK LAND SIT
NEWBURY TWP LAND SITE
BURTON LAND SITE
FAIRMOUNT RD. LAND SITE
TROY TWP. LAND SITE
AUBURN TWP. LAND SITE
CHAGRIN FALLS LAND SITE
AURORA CENTRAL LAND SITE
MANTUA LAND SITE
SHALERSBORO LAND SITE


LAND SITE
NEW MEDINA
LAND SITE
LEGEND
COUNTY LINES
RIVERS & STREAMS
DIVIDE OF MAJOR RIVER BASINS
DIVIDE OF SUB-DRAINAGE BASINS
SCALE

3



LAND TREATMENT SITES
WITHIN THREE-RIVERS BASIN
FOR PLAN C

FIGURE 11-3

SECTION III

FARM MANAGEMENT TECHNIQUES

OPERATION AND PERFORMANCE OF LAND TREATMENT SYSTEMS

Farm management varies from soil to soil. For optimum performance the management techniques must be specifically designed and operated to meet the physical and environmental constraints peculiar to each location.

Farm management for the Mahoning-Ellsworth soil association would utilize the overland-flow/infiltration method for both municipal/industrial wastewater and separate storm runoff.

On Chili soils, spray irrigation would be employed with center-pivot rigs and solid-set sprinklers.

The Western Land Treatment Area, which accounts for the major portion of irrigated lands in Plan C, is located on Cardington-Bennington soils, where center-pivot rigs and solid-set sprinklers would be used. The Western Land Treatment Area is shown in Figure II-2.

WESTERN LAND TREATMENT AREA CROPS AND APPLICATION RATES

To enable farmers to maintain the current practice of growing 30 to 40 percent corn, farming would be done in circular strips whenever the center-pivot irrigation rigs were used. Alternate strips of Reed Canary grass and corn would form concentric rings approximately 14 feet wide. This width would accommodate modern machinery and allow six rows of corn at 30-inch spacing, although the row spacing is not critical.

Within the irregular areas between the center-pivot irrigation rigs, solid-set irrigation systems would be used. It is contemplated that Reed Canary grass would be grown in these smaller irregular areas.

Several patterns of corn-to-grass crop rotation would be possible under the center-pivot irrigation rigs.

For example, the grass strips could be maintained for three to ten years, after which they would be plowed under and planted in corn. The old corn strips would be planted in grass during the preceding autumn. This method would require lower than average irrigation rates until approximately the first cutting, to allow new grass to become established. The reduction, however, would not significantly diminish the annual capacity of the land treatment area, since the alternation between corn and grass would be made for only 10% to 30% of the irrigation rigs each year.

Another method of crop rotation would be to plant Reed Canary grass over the entire area using a desiccant to retard growth of the grass in the corn strips from spring to early fall. The grass would reassert itself in the fall and become the grass strips in the following year. Corn would be planted in the spring, on the preceding year's grass strips after the desiccant was applied, resulting in a no-tillage type of farming.

One of the desiccants used would be Paraquat, which is non-selective when applied at very high rates. At lower rates it kills annual weeds and grasses while preventing growth of perennial grasses until later in the season by acting as a contact desiccant.

Paraquat is subject to very rapid and complete inactivation by the soil. Therefore, there is no danger of its moving with the drainage water. (Herbicide Handbook of the Weed Society of America, Second Edition, 1970). Low concentrations which might occur in runoff have very little effect on plant and animal life on land or in water. (Ecological Effects of Pesticides on Non-Target Species, published by the Executive Office of the President, June 1971).

Regrowth of the grass before harvest time could be advantageous in a wet fall, since heavy corn-harvesting equipment could operate in the fields. During the fall of 1972, some of the corn crop was lost due to the problem of soft ground making fields impassable.

Center-pivot irrigation rigs would apply the treated wastewater directly only on the grass strips at twice the average application rate, For the Cardington-Bennington soils in western Ohio on which an average application rate of 75 inches per year is proposed, the grass strips would receive 150 inches per year. The spray nozzles would produce droplets having low kinetic energy, which would limit the dispersion of soil aggregates upon impact. Grass cover would also prevent soil dispersion on these silty soils.

The center-pivot rigs would make three to four revolutions daily applying approximately 0.18 inches of water on each pass. This water would infiltrate long before the next rotation of the sprinkler.

On the area irrigated by the solid-set sprinklers, 75 inches of water per year would be applied uniformly over the surface. Applications can be scheduled as desired at a rate of approximately 0.25 inches per hour. Applications of 2.5 inches per week would require ten total hours of sprinkling at this rate. Applications on these lands could readily be increased to 120 inches per year or more, which provides a safety factor of significant proportions.

APPLICATION RATES FOR THE THREE SELECTED SOILS

The selection of an application rate for each soil was based on the parameters of infiltration rate, permeability, nutrient balance, and renovative capacity of the soil.

Infiltration Rate

Details of soil infiltration capacity are given in the Land Treatment Phase I Technical Appendix. This parameter may become the limiting condition for soils with a high silt content in the upper horizon, which is characteristic of both the Chili and Cardington-Bennington soils. Large drops of water on the bare soil have a tendency to disperse the soil structure, which reduces the infiltration capacity and forms a thin crust upon drying.

a. Chili soils have a silt content of approximately 60 percent in the upper two feet. Below this depth, the soil generally changes drastically to a sand and gravel layer where the silt content drops to about 18 percent as shown in Table II-1 of the Land Treatment Technical Appendix. Deep plowing to a depth of 30 to 36 inches could overturn the soil profile, depositing the coarser soil on top. Considerable mixing would be likely to occur under these circumstances.

b. Cardington-Bennington soils in western Ohio have relatively high silt contents in the top layer, which gradually diminish with depth. Reed Canary grass used in conjunction with a solid-set irrigation system would avoid the soil dispersion effect of large droplets on bare soil. Similarly, the center-pivot irrigation rigs can be used successfully with alternate strips of corn and grass, as discussed above. The infiltration capacity of the Cardington-Bennington soil was the single most important constraint governing the selection of the farm management method. With a total grass crop, the average application rates could be increased to about 120 inches per year for optimum nitrogen balance.

c. Mahoning-Ellsworth soils have a lower silt content than the Chili or Cardington-Bennington soil associations, so that the infiltration rate is dependent not on surface conditions, but on the sub-surface permeability of the soil. The overland-flow/infiltration method of irrigation is proposed for the Mahoning-Ellsworth soils.

Permeability.

The permeability of a soil controls the rate at which percolating water can reach the tile drain system and the degree of aeration in the root zone. Detailed drainage analyses have indicated suitable tile spacings greater than those selected in this study. The analyses were based upon computations using standard agricultural engineering methods, and upon recent Ohio field tests made on similar soils.

The drain tile spacing in the Western Land Treatment Area is satisfactory for root aeration of both the corn and the Reed Canary grass proposed. See Land Treatment Phase II Appendix.

The permeability of the Cardington-Bennington soils varies from 0.63 to 2.0 inches per hour in the plow layer. Beneath this zone, the permeability decreases to 0.2 to 0.63 inches per hour.

For the Mahoning soils the overland-flow/infiltration method on Reed Canary grass was chosen. This method simulates the border method (overland flow) of releasing the water at the upper end of a ten-foot wide strip and allowing the water to flow by gravity towards the lower end. Any water remaining at the lower end is collected and released to the next lower battery of borders. For this method, 90 inches per year for municipal/industrial effluent and 150 inches for storm water were selected. The higher rate for storm water was used because of the considerably lower concentration of

nutrients and BOD. Permeability of these soils will permit complete infiltration of the wastewater through the soil zone, which will result in a double treatment.

The Chili soils are sufficiently permeable so that this parameter does not limit any reasonable application rate. For the upper two feet, the permeability varies from 2.0 to 6.3 inches per hour and increases to more than 12.0 inches per hour below the C-horizon. The rate of 60 inches per year was selected on the basis of nitrate leaching potential. This application rate is considered conservative, and higher application rates may be found reasonable after testing.

Nutrient Balance

The subject of nutrient balance is discussed in a separate subsection beginning on page III-13. Generally, the application rate is selected to provide enough nitrogen for optimum crop yields without losing excessive nitrates by leaching. An allowance should also be made for up to 40 to 50 percent nitrogen loss before plant uptake of nitrogen. Much of this nitrogen is volatilized. The percentage lost to the atmosphere will depend on the soil texture, temperature, moisture conditions and acidity.

Renovative Capacity

The renovative capacity is dependent upon the soil and plants. Too high an application rate would cause an excess of nitrogen to be carried into the drainage water. The amount would depend on the type of crop, soil texture, organic matter in the soil, and other factors. The selection of application rates equal to 60, 90 and 75 inches per year on the Chili, Mahoning and Cardington-Bennington soils, respectively, was based primarily on providing enough nitrogen to the crops for satisfactory yields while meeting the max-

imum O.C.E. levels for nitrogen as N of 4 mg/l.

Renovation of wastewater for other pollutants such as phosphorous and heavy metals is related more to the soil's capacity to store these elements, although plant uptake is important for phosphorous removal, especially that which is in the soluble forms.

The renovation of the wastewater for each of the farm management methods is discussed in detail in the Land Treatment Phase II Appendix. The return flow will be renovated to a degree meeting the 1985 effluent goals.

DRAINAGE

Drainage, both surface and subsurface, is of paramount importance to farmers in Ohio. Artificial drainage helps the farmer to get into the fields early in the spring and at harvest time during a wet fall and lessens the possibility of depressed yields resulting from a prolonged rainy period.

The Chili Association

This soil is relatively coarse having a permeability range from 2.0 to 6.3 inches per hour in the A and B horizons. Below this, the soil has sand and gravel texture with permeabilities in excess of 12 inches per hour. For an application rate of 60 inches per year, subsurface drainage would not be required on high ground, but could be limited to the low areas where the water table is high in the spring. For cost purposes, drains were assumed to be constructed at a depth of five and one-half feet and spaced 60 feet apart. Shallow wells may be preferable to subsurface drains, especially for reuse of the renovated effluent.

Cardington-Bennington Association in Western Ohio

This soil association requires subsurface drainage under present con-

ditions. The drains are placed approximately 36 inches deep at the top of the glacial till. The drain spacing recommended by the 1965 Ohio Drainage Guide is 50 to 75 feet for general crops. The permeability of the "A" horizon is from 0.63 to 2.0 inches per hour and diminishes to 0.2 to 0.63 inches per hour in the "B" and "C" horizons.

Two types of irrigation, the center-pivot and the solid-set systems, have been proposed for these soils. The large center-pivot irrigation rigs would be suitable for about 75 percent of the area, and the irregular areas remaining would be irrigated by the solid-set system. All of the irrigation would take place on Reed Canary grass.

Irrigation will cease during wet periods, corn planting and during harvesting periods. When irrigation is interrupted during the planting and harvesting seasons, the water table will tend to drop to the level of the drains at about 36 inches. When the irrigation rigs are operating full time, the phreatic line will fluctuate within a relatively narrow range between the ground surface and the drains.

The best estimate of the drain system flow-through rate comes from Schwab and Fouss. Their experimental data for soils with characteristics similar to the Mahoning soils, documented the performance of a system with a drain spacing of 40 feet. This drain system discharged, from a saturated profile, two inches per day. For a 20-foot spacing, as proposed for the Cardington-Bennington soils, the discharge from the drains should approximately double. Since the water is to be applied on only one-half of the surface area, eight inches per day, including rainfalls, would be the theoretical maximum application rate for the hydraulic capacity of the soil zone-drain tile system under saturated conditions. The proposed irrigation rate is approximately five inches per week on the grass strips. A drainage analysis is presented in

the Land Treatment Phase II Technical Appendix.

Mahoning Soils

The method of irrigation proposed for these soils is similar to the border system still used in the western states. The borders would be ten feet wide. Water would be released at the upper end and allowed to run overland through a grass cover to the lower end. All of the water will infiltrate through the soil column so that there will be no excess at the lower end.

The permeability of these soils is lower than that of the Cardington-Bennington soils, ranging from 0.2 to 0.63 inches per hour in the upper foot, and from 0.063 to 0.2 inches per hour in the next 18 to 24 inches. These permeabilities are identical to the Fulton soils on which Schwab and Fouss conducted their experiemnts. In this case, however, the water will be applied once a week at the rate of about two and one-half inches per week (90 inches per year) for municipal and industrial effluent, and about four inches per week (150 inches per year) for storm water. The application time will be governed by the infiltration rate and length of run.

CROPPING AND PROJECTED PRODUCTION

The crops currently grown in northern and western Ohio include corn, soybeans, wheat, oats and hay. In 1970 these crops represented approximately 32%, 33%, 13%, 7% and 15% of the harvest, respectively. On the Cardington-Bennington soils, by use of alternating strips of grass and corn, half of the area under the center-pivot system would be planted in corn. It is estimated that 75 percent of the area in the western Ohio land treatment site can be put under a center-pivot system which allows approximately 35 to 40 percent of the land to be planted in corn. The remainder would be in Reed Canary grass.

The overland-flow/infiltration method recommended for the Mahoning-Ellsworth soil association requires grass for the entire site. For convenience in estimating crop production, it has been assumed that the Chili soils will be 70 percent corn and 30 percent grass. With the above assumptions the values of the crops from the land treatment areas are shown in Table III-1.

TABLE III-1

SUMMARY OF CROPS, YIELDS AND ANNUAL GROSS INCOME
FOR 2020 FLOWS IN PLAN C

Soil Association	Crop	Acres(1)	Yield Amount	Yield Unit	Unit Price ($)	Gross Value ($/Acre)	Gross Total Value ($1000)
Chili	Corn	9,284	160	Bu/Ac	1.50	240.00	2,228
	Reed Canary-grass	4,000	4	T/Ac	50.00	200.00	800
Mahoning	Reed Canary-grass	6,280	4	T/Ac	50.00	200.00	1,256
Cardington-Bennington	Corn	41,300	200	Bu/Ac	1.50	300.00	12,390
	Reed Canary-grass	76,727	5	T/Ac	50.00	250.00	19,182
	TOTALS	137,591					35,856

(1) Does not include land irrigated by separate storm runoff treatment systems.

The yields for the crops shown above are based on recommended farm managment practices. Nutrients will be provided by the wastewater. The unit prices are based on current (April, 1973) quotes which are now in an upward trend and higher than the depressed prices received by the farmers a year ago. The gross annual return per acre amounts to $262, resulting in a net profit of about $200 per acre to the farmer, disregarding costs of land treatment components. The net profit also includes the fertilizer value in the wastewater effluent which is provided at no cost to the farmer, but has a value of approximately $60 per acre. Without the amount of nutrients provided in the sewage

effluent, the yields would generally be lower since most Ohio farmers would not spend more than $40 per acre on commercial fertilizer. Furthermore, commercial fertilizers in Ohio are applied once or twice a year, rather than in steady daily or weekly doses, which would not provide the nutrients as efficiently as would the steady applications. Sewage effluent also contains other nutrients in readily available form which are not generally provided in commercial fertilizers unless a critical deficiency has been indicated by a county extension agent.

In the future, wastewater renovation ponds and reservoirs may provide a direct source of cattle feed. The University of California at Davis has developed and tested a pilot plant which removes algae from these basins and converts it to a high-protein cattle food. Analyses have shown that the protein content is comparable to mature alfalfa hay and high quality oat hay.

SALINITY CONTROL

In arid areas of the world, a hazard of irrigation is the salinization or alkalization of the soil. This hazard is related to the quality of irrigation water and to subsurface drainage.

Water quality for irrigation depends on (1) total dissolved solids concentration, (2) the proportion of sodium to other cations, and (3) the presence of special toxic ions such as borate or, for some crops, possibly chloride, sodium, or bicarbonate. Unfortunately, usual chemical analyses of the Cleveland shoreline plants' effluent does not include information on elements such as sodium, potassium, calcium and magnesium. On February 23, 1973, a sample of the Cleveland Southerly plant was analyzed for the pertinent elements with the following results:

Calcium	92 mg/l
Sodium	150 mg/l
Magnesium	4.1 mg/l
Potassium	82 mg/l
Total Dissolved Solids	752 mg/liter

Sodium chloride and calcium chloride are used on the streets to melt the snow and ice in Cleveland. The snow was melting on February 23, 1973. The calcium, sodium and total dissolved solids in this sample are higher than would be normal.

The U.S. Salinity Laboratory uses the sodium adsorption ratio (SAR) and the electrical conductivity of the water as criteria to evaluate the sodium hazards of irrigation water. For this particular sample, the electrical conductivity and sodium adsorption ratio is equal to 1175 micromhos/cm x 10^6 and 4.2, respectively. A diagram used by the U.S. Salinity Laboratory for classifying irrigation water based on the above two parameters would place this sample into the better quality side of Class C3-S1. As far as sodium is concerned, the water could be used on almost all soils with little danger of accumulation of harmful amounts of exchangeable sodium. In an arid climate, where conservation of water is necessary, there would be little surplus water applied which would leach excess salts downward. With such practices in mind, the U. S. Salinity Laboratory classified this water as a medium salinity water, which can be used on soils of medium permeability. They also recommend that plants of moderate salt tolerance should be selected and that special salinity control management should be used. At the proposed irrigation application rates of 60 to 90 inches per year, however, salts would be leached to the drainage system, so that they would not tend to accumulate. In the moderately humid climate of Ohio, at high application rates and with the proposed drainage tile spacing of 20 feet the leaching would constitute

a special management control.

It has been concluded that the Cleveland area wastewater is quite suitable for irrigation from the standpoint of salinity and the SAR of the soil.

An advantageous aspect of the land treatment system in Plan C relative to total dissolved solids is the fact that combining storm runoff with municipal and industrial wastewater in the Western Land Treatment Area will reduce the TDS concentration of the municipal/industrial wastewater and of the effluent discharged to natural watercourses.

NUTRIENTS

Sewage effluent from an activated sludge plant, or an aerated lagoon, is rich in nutrients required for plant growth. Typical sewage effluent in the Study Area contains macro-nutrients such as nitrogen, phosphorous, potassium, calcium, magnesium and sulphur; and micro-nutrients such as iron, copper and zinc.

When sewage effluent is utilized in a land treatment program and applied at a rate of 60 inches or more a year, most of these nutrients (with the possible exception of nitrogen) exceed plant requirements. This excess is usually captured by soil adsorption onto clays, cation exchange or attachment to organic matter. In areas with heavy rainfall and good soil drainage, some calcium, magnesium and potassium will migrate with the soil solution into the ground water aquifer or into subsurface drains.

The nutrients, nitrogen, phosphorous, and potassium are considered primary nutrients for plant growth and are discussed below.

Nitrogen

More laboratory and field work has been done on nitrogen than on any other plant nutrient. Despite this research, conclusive statements about the

behavior of nitrogen in the soil are scarce. Nitrogen is mobile and can be transformed from the solid to the liquid or the gaseous state under the proper conditions. The soil's acidity, temperature, and moisture content, and the availablility of oxygen, are the most important variables which influence the behaviour of the element.

The concentration of nitrogen in effluent from a standard activated sludge plant is approximately 20 mg/l. Typically, 80 to 90 percent of this nitrogen is in the form of ammonium ions. Most of the remainder is in the organic form with a small amount of nitrate and nitrite ions. Wastewater which has received treatment in an aerated lagoon system may contain more nitrogen in the form of nitrates than wastewater treated in an activated sludge plant.

Nitrogen uptake by plants reaches a peak during the growing season, In warm, moist weather nitrification of the ammonium ion also proceeds rapidly. Most plants require some of the nitrogen to be in the form of nitrates, although the roots can readily accept the ammonium ion and sometimes prefer it.

When the soil temperature is below 50^{o}F, nitrification takes place much more slowly. Nitrogen is then stored in the form of ammonia and held by the soil colloids. Experiments have been conducted in which anhydrous ammonia fertilizer is applied to agricultural land for several years. After this period, succeeding applications do not increase the crop yields, as large amounts of nitrogen, stored in the form of the ammonium ion, are available in the soil profile.

In a sandy, coarse-textured soil, excess nitrates will eventually migrate with the ground water into the subsurface drainage system and pass into the creeks and rivers.

Nitrate leaching may occur in fine-textured soils but the extent of the

leaching is limited by the soil's basic properties. The abundant clay colloids tend to store the nitrogen as ammonia and to release it according to the plant demand. In addition, the nitrates migrate more slowly through a fine-textured soil, giving root fibers more time to absorb these ions. When sewage effluent is applied to fine-textured soils at a rate of two to four inches per week, alternating aerobic and anaerobic conditions result in a nitrification-denitrification process. During these reversals, nitrogen will be lost to the atmosphere in the form of nitrogen gas (N_2). This loss may equal up to fifty percent of the nitrogen applied.

Application Rates and Nitrogen Balance

To ensure the proper nitrogen balance in soils receiving applications of sewage effluent, the application rates were calculated separately for each soil type. In the coarse-textured soils of the Cuyahoga Basin where there is some risk of nitrate leaching to the ground water, application rates have been limited to 60 inches per year. On the tighter Cardington-Bennington and Mahoning-Ellsworth soils, the application rates have been set at 75 and 90 inches per year, respectively.

The effluent applied on the Cardington-Bennington soils in western Ohio will be a mixture of municipal/industrial wastewater and storm runoff, with nitrogen concentrations of 19.7 and 2.2 mg/l respectively. The mixture of 83 percent M & I wastewater, and 17 percent storm runoff will result in an effluent containing nitrogen at approximately 16.4 mg/l, as stated in the Phase II Land Treatment Report. At an average application rate of 75 inches per year, the average nitrogen application would amount to 278 lbs/acre/year. The direct application rate of 150 inches per year on one-half of the area irrigated by center-pivot rigs would result in a nitrogen application of 556 lbs/acre/year to the grass strips only. Volatilization losses of nitrogen

will range up to 50 percent of the total amount applied. Assuming a 40% volatilization loss of 225 lbs/acre/year from the Cardington-Bennington soils planted in strips of Reed Canary grass, 331 pounds of nitrogen would be available for crop uptake annually. Assuming a harvest of 4.5 tons of Reed Canary grass per acre per year and a nitrogen content of 62 lbs. per ton, the crop uptake would be 279 lbs/acre/year leaving a balance of 52 lbs/acre/year.

There are three possibilities for the disposition of the balance: leaching, uptake by the adjacent corn rows and storage in the soil. It is estimated that the adjacent corn rows would utilize at least 30 pounds of the excess nitrogen from the irrigated grass strips. Neglecting storage of nitrogen in the soil, approximately 22 lbs. of nitrogen per acre per year would migrate through the soil zone to be carried in the return flow. However, this represents an average migration of 11 lbs/acre/year from the gross acreage under irrigation by the center-pivot rigs.

Based upon the effluent criterion for nitrogen of 4.0 mg/l for Level II Standards, the permissible leaching of nitrogen with the return flow should be limited to the range of 50 - 70 lbs/acre/year or approximately 120 lbs/acre/year from the directly-irrigated grass portion of the center-pivot rig acreage.

If only Reed Canary grass were grown, as described in the Phase II Report, average application rates should be raised to 120 inches/year for optimum balance between high-protein grass and nitrogen application.

That portion of the Cardington-Bennington soil irrigated by solid-set sprinklers (25 percent) would receive a nitrogen application of only 278 lbs/acre/year. The optimum nitrogen application for Reed Canary grass is approximately 445 lbs/acre/year. Therefore, a substantial safety factor exists

for readjusting the application rates between areas irrigated by the center-pivot rigs and the solid-set equipment. The amount of water applied by the solid-set equipment might be increased to 120 inches per year, permitting a reduction in the application rate of the center-pivot rigs.

On Chili soils within the Three Rivers Watershed, where an irrigation rate of 60 inches/year of municipal/industrial effluent has been proposed, the annual nitrogen application would be 268 lbs/acre. Volatilization from this relatively coarse-grained soil would account for a lower percentage of the nitrogen than would volatilization from the Cardington-Bennington soils. Assuming a nitrogen loss of 25 percent of 67 lbs/acre/year through volatilization from the Chili soils, an annual balance of 201 lbs/acre would be available for crop uptake or leaching. The rate of nitrogen uptake would be 160 lbs/acre/year for corn and significantly more for Reed Canary grass, leaving a maximum of 41 lbs/acre/year for leaching and storage in the soil.

The application of 90 inches/year to the fine-grained Mahoning soils, using the overland-flow/infiltration method would result in a nitrogen application of 400 lbs/acre/year. It is anticipated that crop uptake by the Reed Canary grass and the volatilization of nitrogen would account for essentially the full amount of nitrogen applied.

Phosphorous Loading

According to the Phase I Report by Havens & Emerson, the phosphate contents of municipal/industrial wastewater and storm runoff are 10.2 mg/l and 2.2 mg/l, respectively. At the Western Land Treatment Area, the combination of municipal/industrial wastewater and storm runoff would result in an approximate phosphorous concentration of 8.3 mg/l, as stated in the Phase II Land Treatment Report. With an application rate of 75 inches per year the phosphorous loading would amount to 145 pounds per acre per year. This repre-

sents approximately three times as much phosphorous as would normally be applied in commercial fertilizers for good yields on typical soils. The excess phosphorous would react chemically with the aluminum and iron ions abundant in the Cardington-Bennington soils. This process would proceed rapidly and the phosphorous would not easily be released. Calcium ions, provided by lime applications, would combine chemically with phosphorous to form a tightly held precipitate.

These processes would provide a high level of removal at the Western Land Treatment Area. The treatment will meet the Level II Standards easily and may satisfy the more stringent O.C.E. Goals of 0.10 mg/l for phosphorous as PO_4. Treatment on the Mahoning-Ellsworth soils utilizing the overland-flow/infiltration method should achieve a similar level of removal. On the more coarsely textured Chill soils, the application rates have been limited to 60 inches per year to meet the Level II Standards.

Potassium Application

Potassium is a primary crop nutrient. The Ohio Agronomy Guide suggests an application rate of 250 pounds/acre of potassium as K for best crop yields. This crop requirement would be satisfied by a concentration of 15 mg/l in effluent applied at a rate of 75 inches per year. The potassium content of wastewater from the Study Area has not been documented by this study, but certainly exceeds the crop requirement. Excess potassium would be leached to the drainage system. The Level II water quality standards do not set a limitation on the concentration of potassium in treated effluent, since it is not considered a harmful pollutant.

RECYCLED NUTRIENTS

Nutrients contained in wastewater from the Cleveland-Akron Metropolitan

and Three Rivers Watershed Area represent a substantial resource, which will become more valuable as the elements become scarce and the cost and energy required to process them escalate. Table III-2 presents the amounts of nitrogen, phosphorous and potassium contained in Study Area wastewater, storm runoff and sludge, summarized according to treatment facilities proposed in Plan C for the year 2020. The value of these nutrients was based on 1972 unit costs of 15 cents per pound for nitrogen, ten cents per pound for phosphorous, and five cents per pound for the amount of potassium recommended for crops. The net totals for the value of phosphorous were halved, since the total amount applied to the land would be twice that required for top yields.

The estimated value of the reclaimable nutrients is $9,450,000 for the year 2020. (Approximately $705,000 worth of nutrients from the water-based Akron plant are not included.) The additional value of the secondary nutrients sulfur, calcium and magnesium, and the mirco-nutrients contained in the effluent and sludge has not been estimated. However, the value of these nutrients may increase considerably as the costs to process similar fertilizers escalate.

TABLE III-2

SUMMARY OF NUTRIENTS IN SEWAGE EFFLUENT, STORMWATER AND SLUDGE

(Based on 2020 Flows in Plan C)

	NITROGEN		PHOSPHOROUS		POTASSIUM	
	Million Lbs.	$1000	Million Lbs.	$1000	Million Lbs.	$1000
WESTERN OHIO LAND TREATMENT AREA						
Sewage Effluent	32.9	$4800	17.3	$ 860	24.4	$1220
Storm Runoff	.2	30	.1	5	.2	10
Sludge	2.9	435	1.7	85	.9	45
Subtotal	36.0	$5265	19.1	$ 950	34.5	$1275
IN-BASIN TREATMENT						
Sewage Effluent	5.6	$ 840	2.9	$ 145	4.3	$ 215
Storm Runoff	1.5	225	.3	15	1.3	65
Sludge	0.5	75	0.3	15	0.1	5
Subtotal	7.6	$1140	3.5	$ 175	7.1	$ 285
AKRON TREATMENT PLANT						
Sewage Effluent *	9.0	$ 135	4.6	$ 230	6.8	$ 340
Sludge	1.6	240	1.6	80	0.8	40
Subtotal	10.6	$ 375	6.2	$ 310	9.9	$ 380
TOTAL	54.2	$6780	28.8	$1435	51.5	$1940

* These nutrients would be discharged to the Cuyahoga River and would not be reclaimable.

HEAVY METALS

Sources of Heavy Metals

The metals in urban wastewater are generated by industry, domestic wastes and storm runoff. The industrial sources have been studied by AWARE and are discussed in detail in their Industrial Wastes Phase I Report. Five possible levels of industrial pretreatment were defined and costed by AWARE. These alternatives varied substantially in cost, depending upon their removal criteria. Alternative 3 provided for the most complete in-house industrial treatment and was the most expensive alternative, with a present worth cost, at seven percent interest, of $1,013.8 million. Alternative 5A, which called for a lower degree of industrial pretreatment with removal completed by land treatment, had a present worth of $518.7 million (at seven percent interest), or a present worth approximately half that of Alternative 3. The cost of industrial pretreatment is thus in the same general range as that of the total municipal/industrial treatment system, which is approximately $1,400 million.

The U.S. Army Corps of Engineers has directed that all three wastewater management plans include Alternative 3, with a high removal of heavy metals; therefore, the discussion of confined disposal of heavy metals from industry in the soil zone using land treatment is intended for general information purposes only.

Section X of the Land Treatment Phase I Report provides a discussion concerning the potential load of heavy metals from industry and their accumulation in the soil. Specific reference is made to Table X-8 which tabulated long-term concentrations of some typical heavy metals, assuming no industrial pretreatment to remove them. Furthermore, these metal loadings assume no major future change in the present philosophy of use and conservation of natural resources by industry.

Stormwater contributes heavy metals to the total treatment load as it cleanses the streets, parking lots, lawns, driveways, raw material stockpiles, and open industrial areas. The stormwater carries litter, particulate exhaust emissions, hydrocarbons, heavy metals, toxic compounds, fertilizers, and pesticides.*

The heavy metals washed into receiving waters during a 0.5 inch/hour rainstorm from a typical urban area of one (1) million people were estimated by Condon:

TABLE III-3

STORM RUNOFF FLUSHING OF HEAVY METALS

Elements	Runoff Load in Lbs/Hours
Zinc	2,600
Copper	800
Lead	2,300
Nickel	200
Mercury	290

The domestic contribution of heavy metals is not well known because nearly all municipal effluent contains industrial wastes to some extent. However, a review of the lables of typical household products such as cleaners, breakfast foods, vitamin pills, toothpaste and common medicines indicates that a steady stream of heavy metals is contributed by domestic sewage.

Heavy Metal Uptake by Crops

Typical quantities of some heavy metals found in common crop plants are presented in Table III-4. Since general agricultural conditions cause tremendous variability in uptake, the figures given represent values near the middle of the range reported. (Allaway, 1968, and Chapman, 1966). The average values given in the final column were used to calculate the amounts of heavy metals removed from the soil by typical plant growth, as shown in Table III-5. The annual heavy metals uptake was calculated based upon an average removal of

* Condon, Francis J. "Treatment of Urban Runoff", APWA Reporter.

TABLE III-4

CONTENT OF SOME HEAVY METALS IN TYPICAL CROPS*

(Ppm in dry plant material)

Element	Alfalfa	Barley	Beans	Cabbage	Carrot	Clover	Coffee	Corn	Soybean	Tomatoes	Plant Matter Typical Values
Cadmium											0.5
Chromium		1						0.5			0.8
Copper		10				10	10	9		20	10
Iron								100	120	107	110
Lead	5	1	2	0.5	2.6	6				5	5
Nickel	2	4		3	1	1	0.4	0.14	4		2
Silver	0.3					0.5	0.02				0.3
Zinc	30					39	7	50		13	30

*Values near the middle of the range reported by Allaway (1968) and Chapman (1966). See references No. 1 and 2.

TABLE III-5

REMOVAL OF TYPICAL HEAVY METALS BY PLANTS

Element	Annual Loading Rate (Lbs/Acre) (1)	Additional Annual Concentration in Soil from Irrigation Water (ppm/Acre-foot Slice)	Concentration of Elements After 100 Years (ppm/Acre-foot Slice) (2)	Normal Plant Content (ppm) (3)	Annual Plant Removal (Lbs/Acre) (4)	Percent of Annual Addition Removed By Plant	Normal Soil Content (ppm)
Cadmium	0.075	0.019	1.9	0.5	0.003	4.0	.01 - 7
Chromium	3.41	0.85	85	0.8	0.0048	1.4	5 - 3,000
Copper	2.12	0.53	53	10	0.06	2.8	2 - 180
Iron	16.4	4.1	410	110	0.66	4.0	50,000
Lead	0.066	0.016	1.6	5	0.03	45	2 - 200
Nickel	2.12	0.53	53	2	0.012	0.57	10 - 1,000
Silver	0.0115	0.0029	0.29	0.3	0.0018	15.6	1 - 5
Zinc	2.63	0.66	66	30	0.18	6.8	10 - 300

(1) Values taken from Table X-8, Wright-McLaughlin Land Treatment Phase I Report.
(2) These values are based on an irrigation rate of 75 inches per year.
(3) Values derived from preceding Table III-4.
(4) These values are based on removal of 6,000 pounds of dry plant material per acre, and the normal plant content.

three tons of dry plant material per acre. This removal figure is too high for some plants and too low for others, but it is sufficiently accurate to illustrate the point that a fairly low percentage of the heavy metals added each year would be removed with the crops. As indicated in Column 6 of Table III-5, the percentage removal would range from less than 1 to about 16 percent.

The capacity of soil to adsorb heavy metal ions varies widely, but is at least 20,000 lbs/acre-foot slice. Of the elements treated in this report, exclusive of iron, soils contain about 2,000 - 2,500 lbs/acre-foot slice. The amount of these elements added each year with 75 inches of effluent, would be about 20 - 40 lbs/acre-foot slice (exclusive of iron). This is a fairly insignificant amount compared to the total adsorption capacity of the soil. It also represents a small percentage of the natural "background" concentration of these elements in soils.

The total amount of a particular heavy metal present in the soil may not be very meaningful in terms of plant growth, plant toxicity or leaching. It is the solubility of the element that is most critical and this information is difficult to isolate due to the many factors, such as soil pH, degree of soil aeration, texture and kind of clay mineral, organic matter, temperature and moisture, which cause variations. The most critical factor is soil pH, because the solubility of heavy metals is closely dependent upon it. Generally, as pH increases, solubility decreases.

A brief discussion of some important heavy metals is given below:

Cadmium. The chemistry of cadmium is somewhat similar to zinc. It would take more than 100 years of adding .075 lbs/acre/year to reach the upper limit of the normal range of cadmium in soils. John et al. (1972) showed that 90 lbs/acre of cadmium added to the soil surface over several years did not move below

the 4-inch level in the soil profile. They also showed little increase in cadmium uptake in oats. Traynor and Knezek (1972) found some increase in uptake in corn with cadmium application to the soil. Unless soluble and mobile complexes with low molecular weight organic compounds are formed, there should be little danger of leaching in high pH soils (Murrmann and Koutz, 1972).

Chromium. Although the three pounds of chromium per acre per year to be added to soil through land treatment of effluent is relatively high compared to some of the other heavy metals, it has a low solubility and for several years this addition should be well within the normal range in soils. Knezek (1973) indicated that soils have a high capacity to fix chromium. Pratt (1966) found no appreciable accumulation of chromium in plants in cases where chromium toxicity has been thought to exist. However, Turner and Rust (1971) found a chromium toxicity in soybeans when 10 lbs. chromium per acre was added, although the concentration of chromium in the plants was not reported. Soane and Saunder (1959) showed that chromium added to sand cultures at concentrations of 10 ppm caused toxicity to tobacco plants; however, they did not prove that a high chromium content in the serpentine soils was the cause of infertility.

Copper. Ellis and Knezek (1972) showed that copper would be bound to organic and clay complexes near the soil surface. Reuther and Labanauskas (1966) reviewed the chemistry and toxicity of copper and indicated that it should cause no plant toxicity problems. Mitchell (1964) showed that there would be a minimal leaching of organic complexes containing copper into drainage waters. With the small amount of copper added each year in effluent there should be few if any problems for many years, as long as the pH of the soil is maintained near 7.0.

Iron. Relatively large quantities of iron compared to other heavy metals will be added in the effluent, but compared to the total of 50 tons or more per acre-foot slice in soil already, it is a minute amount. Since the added iron will be fixed rapidly (Mitchell, 1962), and since iron is seldom toxic to plants grown in natural soils (Wallahan, 1966), little if any problem should result from the effluent addition to soils of high pH. The major potential problem could be interaction with the uptake of zinc and manganese, if the pH of the soil were to drop. (Mitchell, 1964; Sauchelli, 1969; Wallahan, 1966).

Lead. Plants can accumulate high concentrations of lead (64 - 196 lbs/acre, according to Cox and Rains, 1972) although it is not known to be essential for animal or plant growth. Much of the lead from sewage treatment plants remains with the sludge, so that the effluent has a low concentration of this element. (Lead solubility is low at pH of 7.0, so leaching should present little problem.) Plants will die of lead toxicity before the concentration reaches levels high enough to be toxic to animals (Allaway, 1968). Solution culture with lead concentrations up to 200 ppm had no depressing effect on apples and grapes (Childers, 1941). Similar results with orange seedlings were found in California (Vanselow and Bradford, 1960). However, Wilkins (1957) found that lead concentrations of 10, 30, and 100 ppm in solution cultures, measureably retarded, markedly retarded and stopped growth respectively of fescue plants.

Nickel. Nickel is not known to be essential for plant growth but is taken up by plants in concentrations of 0.5 to 150 ppm. Two ppm of nickel is quite normal. A middle-of-the-range concentration in soils would be 100 ppm (Swaine, 1955), most of which is not soluble at any given time. The amount of soluble nickel approaches 1 ppm (Vanselow, 1966). In all but serpentine and basic igneous rock-derived soils, nickel toxicity should not be a serious problem.

Silver. Little is known about silver in soils, except that it occurs almost universally but only in minute amounts. Seldom does it exceed 1 ppm (Vanselow, 1966; Rogers et al., 1939; Swaine, 1951). It has been reported in plant tissue in amounts of less than 0.01 and no higher than 1.3 ppm in the dry matter. The occurrence of toxic amounts of silver is quite unlikely because of its extremely low solubility. Little leaching and movement through the soil profile should occur.

Zinc. Although zinc additions may be high from some effluents, comparable quantities are added as a fertilizer on field beans and corn in Michigan (Virande et al., 1967) with beneficial effects. Melton, et al. (1970) indicates that there is little danger of leaching or toxicity from zinc added with effluent, unless a zinc-sensitive plant is grown. Allaway (1968) indicated that some animal feeds are deficient in zinc, so additional zinc could be beneficial to animals. Zinc is needed at a concentration of 8 - 15 ppm in the forage dry matter. Animals require about 10 - 40 ppm zinc in the diet. At 200 ppm of the dry matter zinc is toxic.

An unpublished work of Sabey and Hart (1973) indicated that there was a build-up of extractable zinc, copper, iron and manganese on an irrigated sandy loam in the zone of incorporation of sewage sludge. No downward movement of these elements occurred during the first year after application.

The elements in Table III-IV should pose no serious threat to the groundwater or to plants growing on medium to fine-textured soils if the pH of the soil is maintained near 7.0. If however, the pH of the soil decreased to below 6.0, there is a possibility of increasing solubility of several of the elements, therefore increasing the likelihood of groundwater pollution and plant toxicity.

Heavy Metal Management

Maintenance of a sufficiently high pH (equal to 6.0 or more) in soils

receiving heavy metals would be an important part of land management unless monitoring demonstrated that somewhat increased solubilization of the heavy metals at lower pH values was not a hazard. Maintaining the pH at this level should pose no problem for agriculturalists, as good farm management generally dictates the use of lime to raise the pH to approximately 6.5. Lime applications are common on Ohio soils.

The Ohio 1972-1973 Agronomy Guide, Bulletin 472, published by the Cooperative Extension Service of Ohio State University, reported that lime applications on acid soils often return $6.00 to $9.00 for every dollar invested. According to this bulletin, approximately ten tons per acre would be required to increase the present soil pH of about 5.5 to a level of 6.5. Subsequent annual lime applications of about three tons per acre per year may be required to maintain the pH at about the 6.5 level.

It is clear that the possibility of toxicity to plants is greatest with an acid soil (pH less than approximately 6.0).

Field tests conducted at the University of Illinois have shown the feasibility of managing heavy metals on agricultural land. Should monitoring indicate an undesirable rate of accumulation for a particular heavy metal, management steps might include reduction of that metal at the source, incorporation of special removal processes at the secondary treatment stage, recycling of the element by industry, and rotation or substitution of crops.

SECTION IV

COSTS

All three plans are designed to meet the same Level 2 effluent standards; thus the costs may be compared equally. No cost credit is given to any plan for special benefits which may be unique to that plan.

The study period begins on January 1, 1972, and ends on December 31, 2019. At the end of the period, most of the components will have a residual value which is accounted for in the present worth comparisons. All capital expenditures are considered to be made at the beginning of the year in which the item is constructed. Operation and maintenance costs are evaluated as if spent at the end of the year and coincide with the amortized annual capital repayments.

Present worth computations have been made at discount rates of 5-3/8, 7 and 10 percent. These costs are summarized in Tables V-1 through V-6 of the Formulation Report. Annual costs or total annual costs are the sum of the operation and maintenance costs and the annual capital costs. These costs are summarized in Tables V-7, through V-12, of the Formulation Report at the three interest rates.

COST REVISIONS AND REFINEMENTS

The capital and the annual operation and maintenance costs for the land treatment components are presented in the summary of unit costs entitled "Cost Estimation Methodology and Unit Costs" as revised October 6, 1972. During the Phase III portion of the work, refinements and revisions were made to the unit cost of the following items:

1. Temporary Pumps. Capital costs were derived from Curve E (Phase II Report) and decreased 25 percent because of their temporary nature. The operation and maintenance costs were calculated according to previously established unit costs.

2. The mined storage constitutes a partial displacement of the storage previously costed for the concrete detention basins in the Phase II work. The capital costs for mined storage were estimated at $15 per cubic yard. The operation and maintenance costs were estimated to be 0.5 percent of the capital costs.

3. Miscellaneous capital costs were calculated as follows:

   .10 x Capital cost of aerated lagoons
   + .09 x Capital cost of land purchase and preparation
   + .05 x Capital cost of irrigation system
   + .05 x Capital cost of drainage system

   The first two items represent additions to the Phase II Capital Costs, which included administration, laboratory and monitoring facilities. The extra cost for aerated lagoons is to allow for possible channel realignment, fencing and piping. The extra nine percent for land purchase and preparation allows for about 20 percent land which must be purchased but cannot be readily used for land treatment. This would include items such as roads, buffer strips along streams, trees which would not be uprooted and other obstructions.

   The miscellaneous operation and maintenance costs are estimated to be five percent of the capital costs.

4. Shafts and Tunnels - Aeration. A capital cost for aeration of $17,000,000

was added for the tunnel construction costs of these units at ten-mile intervals.

The operation and maintenance cost for aeration was estimated to be $4 per MG.

5. Sludge Management. For Plans A, B and C, sludge application to agricultural or strip-mined land is accomplished in various ways. The time-phasing for these various methods for each plan is summarized in Tables IV-10, IV-11 and IV-12 of the Formulation Final Report. The various methods costed for strip-mine and agricultural sludge disposal are enumerated below.

   a. Use of Existing Pipeline to Strip-Mined Land prior to 1990.

      The capital costs include construction of pump station, rehabilitation of pipeline, construction of sludge lagoons, application appurtenances and supporting equipment.

      The operation and maintenance costs include power, maintenance of the pipeline, lagoons, application and labor costs. This amounted to between $18 and $20 per dry ton, depending on amount generated.

   b. Vacuum Filtered Sludge Trucked to Agricultural Land.

      The capital costs include the cost of trucks and holding tanks at terminal points.

      The operation and maintenance costs amount to a trucking cost of $1/ton-mile plus $40 to $50 per dry ton for the cost of spreading and working the sludge into the soil and paying the farmer to take the sludge.

c. New Pipeline to Strip Mines after 1990.

The capital costs include the cost of a new pipeline, pump stations, sludge holding lagoons, distribution piping, giant sprinklers and other appurtenances.

The operation and maintenance costs include the operation and maintenance of the above facilities, and power and labor costs. The total O & M cost amounts to $3.50 per dry ton.

d. Digested Liquid Sludge to Agricultural Land by Pipeline or Truck.

The capital costs include the cost of pipeline (if applicable), pumps, sludge holding tanks, sludge hauling trucks, spreading equipment and the cost of land.

The operation and maintenance costs include the operation and maintenance of the above equipment and power costs. The cost per dry ton decreases with output varying from $45 per ton in the early years to $35 per ton in 2020.

e. Liquid Sludge from Aerated Lagoons to Agricultural Land.

The capital costs include the costs of pumps, pipeline, vacuum system, spreading and land purchase.

The operation and maintenance costs consist primarily of the cost of maintenance of the above system, pumping costs, and labor. They vary from $10 to $20 per dry ton, depending on the size of the plant.

The Cost Appendix at the end of this report contains a complete display of the costs developed for Plan C.

SECTION V

EARLY ACTION IMPLEMENTATION

The need to establish present base mark conditions of water resources, and to inventory historic trends, is a key factor in this wastewater management plan.

Early-action programs should be initiated to produce data before the first major phase of construction. The objectives would be to provide experience for refining and optimizing designs and for making future decisions concerning the wastewater management system. Firm data on the costs and effectiveness of wastewater management techniques will require thorough monitoring programs to establish baseline environmental conditions and to record changes. Early-action programs will also demonstrate the practicality and benefits of the wastewater treatment systems and facilitate public review and participation. Suggested projects are summarized below:

1. Urban Stormwater Runoff Treatment Plants

   Land-based treatment of runoff from a separately-sewered, moderately-populated area not in a metropolitan urban environment (a sub-urban residential area such as a smaller outlying city in rural surroundings) -- earthen basin storage -- quantity and quality monitoring for Level 2 treatment.

2. Final Municipal Wastewater Treatment

   Land Treatment - (1) at an in-basin site using the overland flow/infiltration method -- (2) at an in-basin site using the spray irrigation method on Chili Soils -- (3) at a site in the Western Land Treatment Area using the center pivot rig

spray irrigation method on Cardington-Bennington Soils - with various land management techniques.

3. Storm Runoff Reduction by Urban Drainage Management

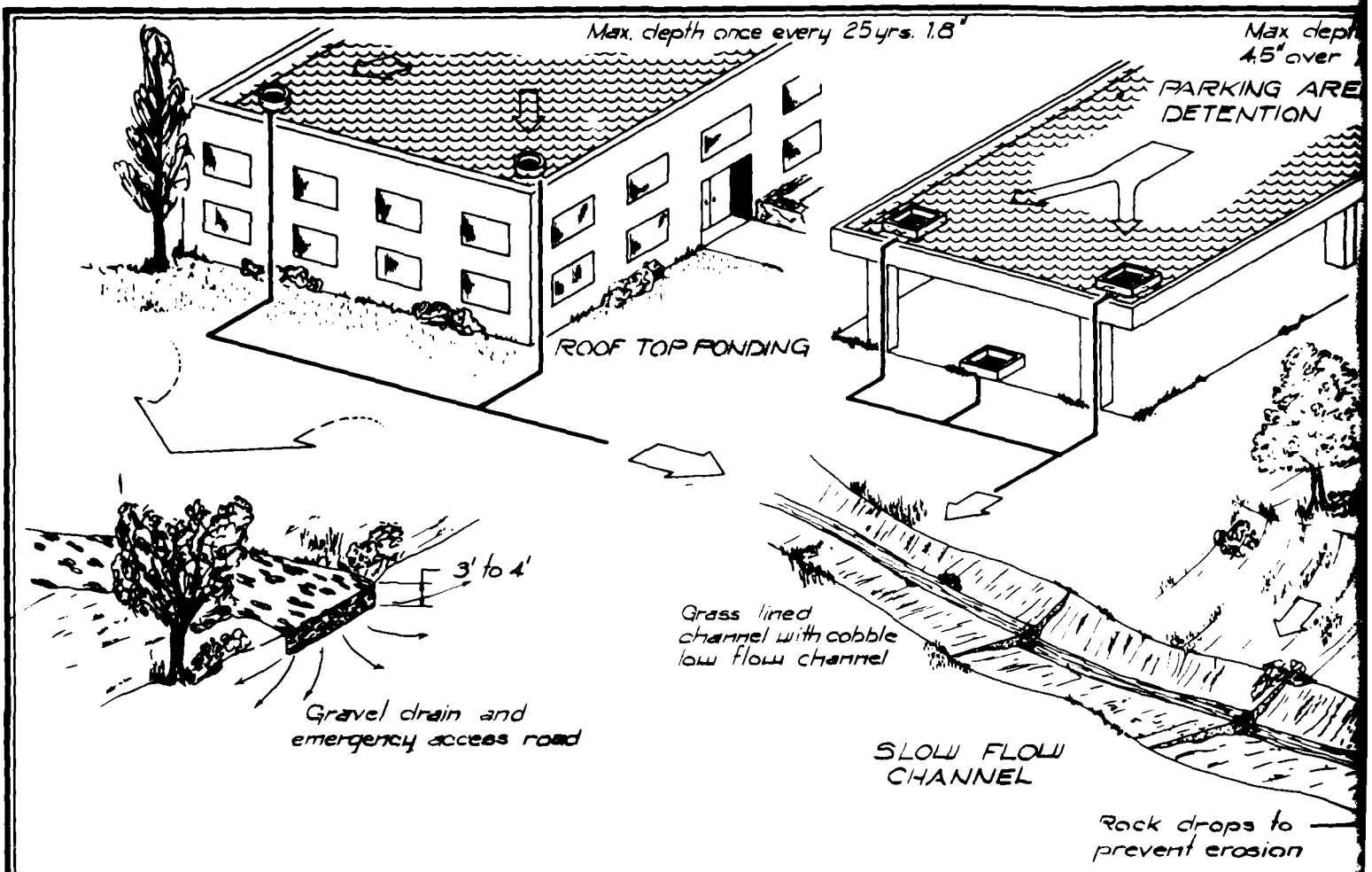
Provide storm drains, on-site storage, parking-lot storage, roof-top storage, and site work designed for maximum infiltration -- demonstrate techniques to reduce runoff -- sedimentation control practices to be demonstrated -- Planned Unit Development Concept applied to demonstration site -- use a commercial building block in a major city -- use open space in a major city suburb. See Figure V-1.

4. Sludge Handling

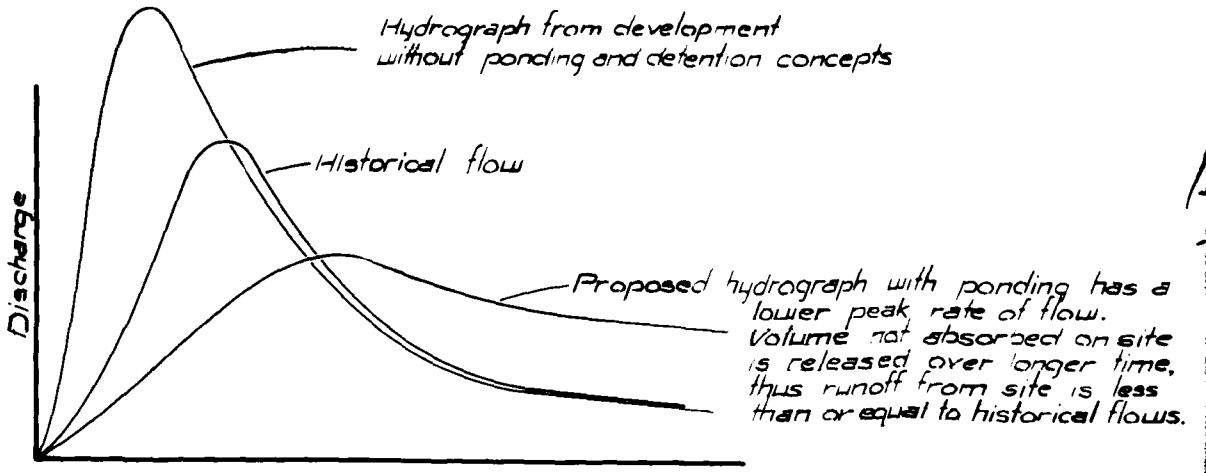
Show various ways to handle sludge -- apply to agricultural land, strip-mined land, and sanitary landfill -- monitor leacheate and surface runoff for loss of metals, salts, nutrients, and viruses -- compare crop yields and physical characteristics using conditioned soil with crops from non-conditioned soil -- study sludge application techniques, including injection and costs -- study problems posed by wintertime conditions -- use a mixed municipal-industrial sludge to measure heavy metal disposal capabilities of soil in agricultural land area -- demonstrate reclamation potential in strip-mined lands and other sterile areas.

5. Water Quality and Quantity Monitoring System

Master system for entire Three Rivers Basin Study Area -- computerized control center for water intelligence.

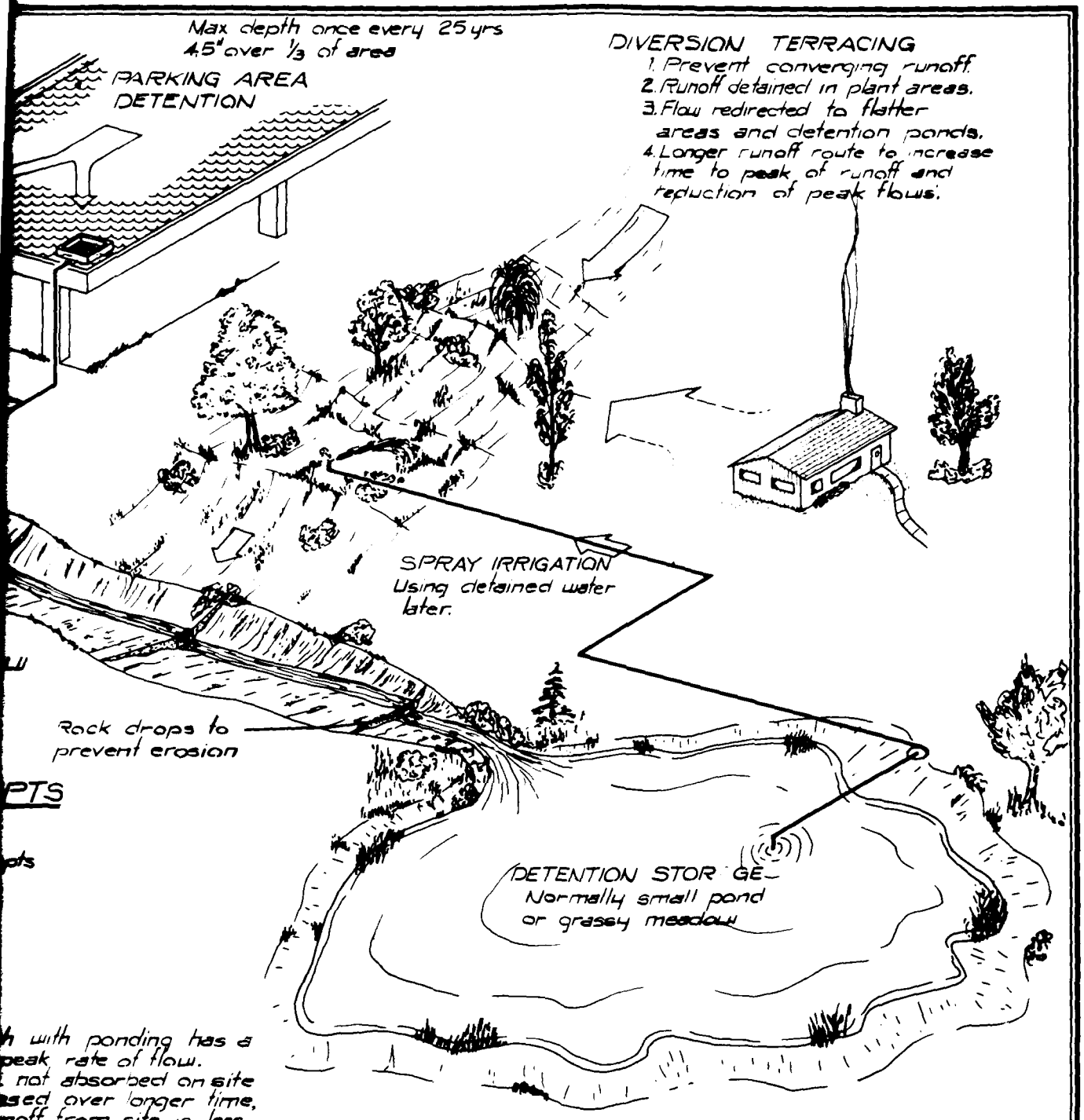


PONDING AND DETENTION CONCEPTS



HYDROGRAPH

EFFECTS OF PONDING AND DETENTION ON NEIGHBORS AND COMMUN



...h with ponding has a ...eak rate of flow. ... not absorbed on site ...ged over longer time, ...noff from site is less ...equal to historical flows.

CONCEPTUAL REPRESENTATION
TYPICAL UPSTREAM PONDING FOR P.U.D.

...ORS AND COMMUNITY

FIGURE V-1

Early action programs have been proposed for several specific sites in the Study Area. They would provide data related to the projects listed above.

DRAINAGE DISTRICT, ROCKY RIVER 31
EARLY ACTION PROGRAM FOR STORM RUNOFF TREATMENT

The use of a 10 acre site for overland flow/infiltration of separate urban storm runoff from Drainage District R-31 would demonstrate the use of the Mahoning-Ellsworth Soils for an application rate of 150 inches per year. The land would be prepared as described in the Land Treatment Phase II Report, using the Mini-border system layout.

The early action effort would not include reservoir construction. Detained water would be applied directly to the land to provide a severe test of removal efficiency.

BURTON EARLY ACTION PROGRAM

Location of Collection Point

At the present time, the town of Burton treats approximately 0.30 MGD of wastewater by means of an Imhoff Tank. The plant is overloaded, effluent is reported to be bad, and the city has voted funds for a new treatment facility. The adjacent Town of Middlefield treats approximately 0.45 MGD in an aerated lagoon followed by a settling pond. The removal rates for suspended solids and BOD are reportedly in the neighborhood of 95 percent.

The proposed location of the new Burton plant for Plans A, B, and C is nearly a mile downstream from the existing Burton plant. This location provides for inclusion of new development outside the existing muncipal boundary lines. In Plan C, the old Burton plant site functions as a collection point for preliminary treatment before the wastewater flows into the aerated lagoon. The sites for the preliminary treatment and the aerated lagoon could be contiguous, however.

The land selected as most suitable for the effluent application and irrigation lies south of Burton and the Cuyahoga River. The proposed land site includes 420 irrigated acres; the capacity of the winter storage reservoir, based on 1990 wastewater flows, is 211 MG.* Stormwater would not be treated until 1990. An 18-inch transmission line, from the aerated lagoon to the storage reservoir will be more than adequate for the 2020 flows as the mitigating effect of the aerated lagoons on peak sewage flows will allow for pumping average daily flows.

* The local County Sanitary Engineer believes that year round irrigation is feasible on Chili soils, however.

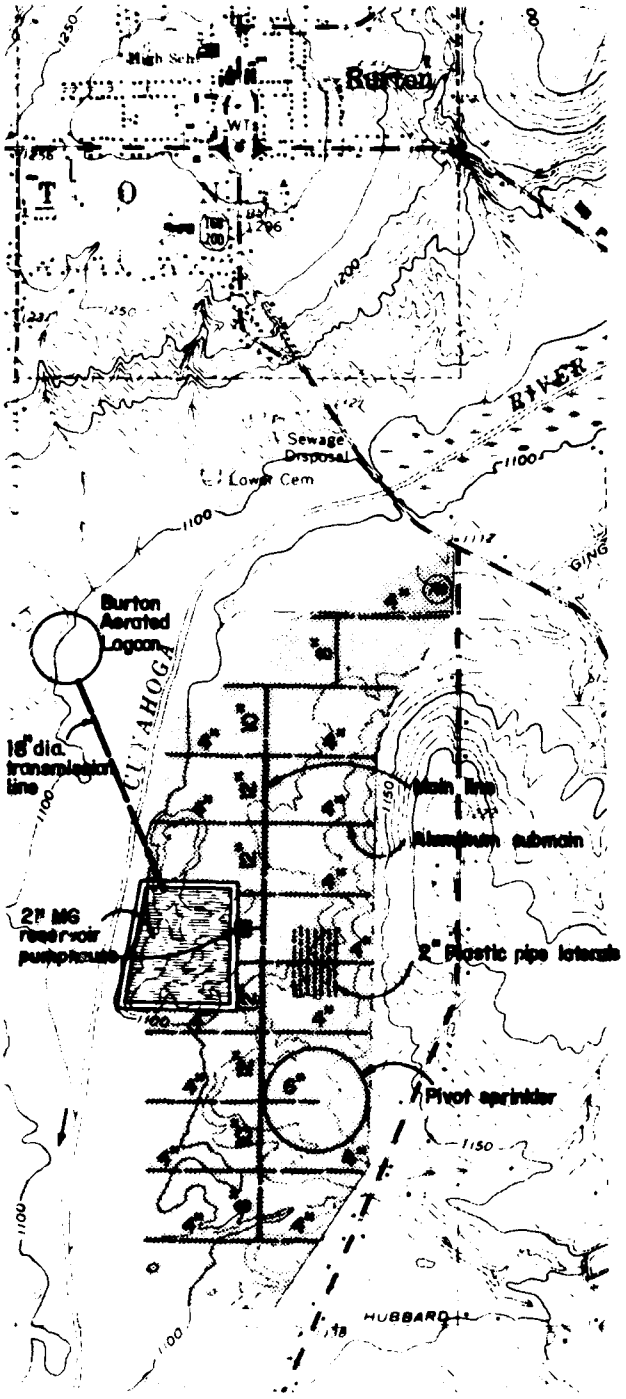
In Plan C it was conlcuded that the sewage from Middlefield would be collected and conveyed to the new Burton site. The early action land site, as shown in Figure V-2, is based upon a combined sewage collection and treatment system.

Irrigation System

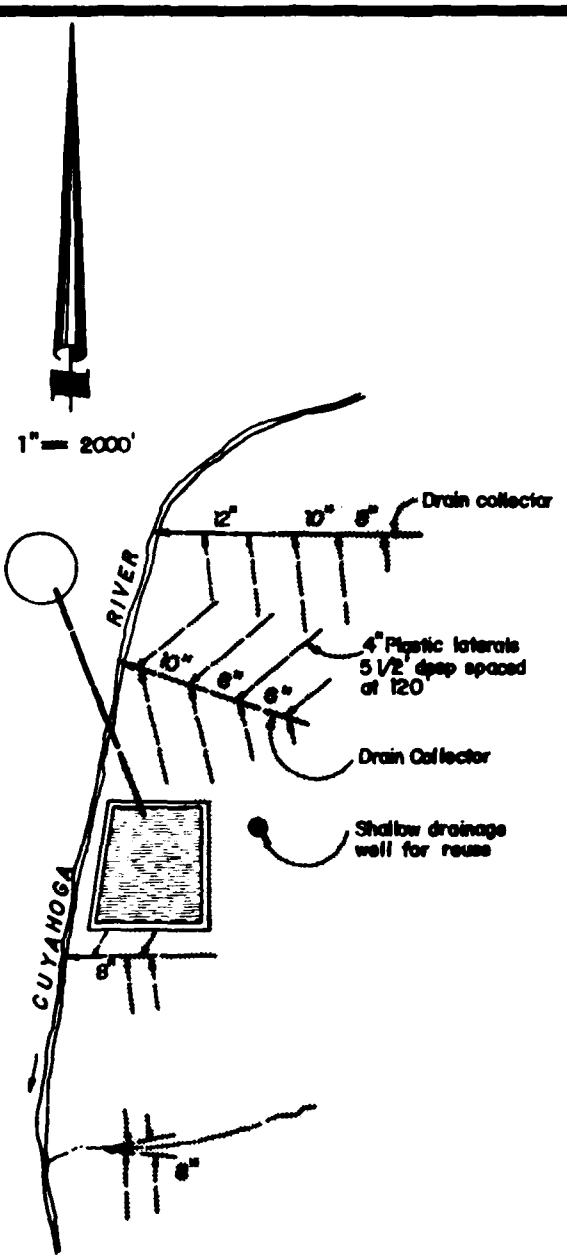
The proposed land site lies on Chili soil. An application rate of 60 inches per year was chosen. Monitoring of this system may show that rates as high as 90 inches per year are feasible as hydraulic loading is not a limitation in the coarse-grained soils.

Two types of irrigation methods are possible for this area. Because much of the area is forested, a solid set system is the logical method. The main line will be either installed as a portable aluminum surface main line or buried main line. The capital costs for a completely buried system are high, but savings in man-power and better control required for high value crops may favor the permanent installation. The exact makeup of the solid-set system is a final design decision which will depend on the type of forest cover, the amount of clearing contemplated and the crops grown.

The center pivot sprinkler consists of a pipeline with sprinkler heads properly spaced. The pipeline is suspended above ground on tower units which can be electrically driven or water driven. The electrically powered units would be much the superior type for sewage effluent.



IRRIGATION LAYOUT



DRAINAGE LAYOUT

BURTON EARLY ACTION LAND TREATMENT SITE FOR 1990 FLOWS (420 ACRES)

FIGURE V-2

Drainage System

Because of the topography relative to the Cuyahoga River flood plain and the very pervious Chili soils, subsurface drainage will probably be required at only the low elevations as shown on Figure V-2. For the light application rates of two inches per week, a 4-inch drain plastic pipe spaced at 120 feet and installed at a depth of five and one-half feet should provide adequate drainage. If monitoring of the drainage effluent constituents indicates that higher applications are possible, the drain spacing could be decreased to 60 feet by installing a 4-inch plastic drain pipe in between the existing 4-inch pipe.

The size of the laterals is a final design feature which depends on the slope, length spacing, roughness factor and drainage coefficient. Similarly the size of the collector will depend on these factors as well as the area drained. A drainage coefficient of 3/8-inch in 24 hours should be adequate.

The drainage well shown is located to intercept water in the aquifer from the surrounding area. This water could be reused to supplement Burton's water supply if a good yielding well can be developed. At present, the depth and characteristic of the aquifer at this specific location is unknown. Should wells prove infeasible, however, collection of the effluent from the subsurface drains for reuse would also be feasible. Such reuse would help alleviate the potential problem of adequate drainage outlets.

Reservoir

The winter reservoir is located on a knoll as shown on Figure V-2. More information is required about the substratum to determine the need for lining the reservoir bottom and the side slopes. A more detailed study of the soils may indicate that another reservoir site within the land treatment area is more suitable than the one shown on Figure V-2.

Preliminary Investigation

The above description of the land site clearly indicates that a thorough final design investigation of the land treatment site is required before design progresses very far; however, the data to date shows that Burton and Middlefield are excellent candidates for land treatment early action work. Detailed studies and present constraints may indicate that the Middlefield aerated lagoon, which is now functioning very well, should initially be utilized for secondary treatment prior to land treatment.

In addition, the winter reservoir would be postponed while early action monitoring and testing was accomplished, and the results studied.

NEW MEDINA EARLY ACTION PROGRAM

At New Medina the overland flow/infiltration technique would be utilized on Mahoning soil with an annual application rate of 90 inches of municipal/industrial effluent per year.

BUCYRUS EARLY ACTION PROGRAM

The present population of Bucyrus is approximately 14,000 people. The existing treatment facilities were constructed in 1939 and expanded in 1961 to include the activated sludge process. Screening, comminution, grease removal and grit removal processes precede the secondary treatment phase. The plant discharges into the Sandusky River approximately one mile downstream of downtown Bucyrus. Bucyrus is a polluter of the river.

Because Bucyrus lies outside of the Three Rivers Study Area, the intention of this program is to test land treatment methods rather than to construct facilities for a long term solution to the wastewater problem of Bucyrus.

For this reason the plant facilities would be designed for approximately 2.0 MGD. Sizing for future loads would be outside the early action funding program, and construction associated with growth would be under conventional financing methods.

The facilities would include an aerated lagoon, pumping facilities, a winter storage reservoir, irrigation pumps and equipment, artificial drainage, and the acquisition of farmland. The facilities would provide the treatment needed to meet the 1985 Level 2 effluent standards.

The estimated costs which follow are based upon incomplete information, without the benefit of a field inspection of the site.

CAPITAL COSTS FOR THE COMPONENTS OF A 2.0 MGD LAND TREATMENT SYSTEM

Aerated Lagoons	$ 680,000
Pumping Plant to Reservoir	168,000
Force Main	105,000
Storage Reservoir	1,140,000
Reservoir Aeration & Chlorination	215,000
Land Purchase and Preparation	304,000
Irrigation System	266,000
Drainage System	181,000
Sludge Management	120,000
Miscellaneous	119,000
Total Construction Cost	$3,298,000

The total cost of the land treatment system, including contingencies, would amount to $4,300,000. The operation and maintenance and annual capital costs at a seven percent interest rate would be about $110,000 and $341,000, respectively, for operation at full capacity. This would result in a total annual cost of $451,000. Research and special monitoring by universities, state and federal agencies are not included.

This early action estimate is based upon the abandonment of the existing activated sludge plant which has a low reliability factor and problems in treating combined sewage during rainstorms. However, in more detailed studies, the expansion of the activated sludge plant should be analyzed with possible elimination of the aerated lagoon component. The cost effectiveness of this alternative should be determined.

In Bucyrus there is considerable local interest for treating the wastewater effluent on land. The proposed land treatment site would be multipurpose with up to 12 land management methods used on approximately 400 acres. Winter storage would be provided. Application of municipal

effluent at rates of 40, 60, 75, 90, 120, and 150 inches per year would be used, and heavy metals would be selectively introduced into the wastewater. The site would be located on Cardington-Bennington soil and would thus provide valuable information applicable to the Western Land Treatment Site.

This program would provide the needed field demonstration of land management methods for these fine-grained soils. A center-pivot rig would apply the wastewater on a selective basis to individual, but varied circular strips, using manually operated controls at the nozzles. The valving would permit applications to one strip, reduced applications to other strips, and no application of water to still other strips.

Drain systems of different depths and spacing would also be tested. Groundwater table and soil moisture measurements would be made.

Dissolved heavy metal solutions would be injected into the wastewater for application to selected fields in predetermined concentrations. Uptake of heavy metal to crops would be measured against concentrations in the soil. In the remaining areas lying between those irrigated by center-pivot rigs, solid-set sprinklers would be installed. Special valving on the solid-set sprinklers would permit selective application rates to particular tracts of land. See Figure III-2, Land Treatment Phase II Report.

LIVERPOOL EARLY ACTION PROGRAM, SLUDGE DISPOSAL ON AGRICULTURAL LAND

The Liverpool plant generated about 2.09 dry tons of sludge in 1972. The early ction program would consist of the application of sludge to an agricultural land site at rates of 5, 10, 15, 20, and perhaps up to

75 tons per year. Monitoring the effect of heavy metals and nutrients on the crops and drainage effluent would provide basic useful information. The site required would approximate 40 acres.

STRIP-MINED LAND EARLY ACTION PROGRAM

This program would involve piping the sludge from Ravenna and/or Willoughby Eastlake to strip-mined land in southeastern Ohio via an existing pipeline once used to pipe coal slurry to Lake Erie. The segment of this pipeline from Ravenna to the strip-mined area would require the least initial capital investment and pumping cost. In 1972, the Ravenna plant treated 2.05 MGD and produced 1.39 dry tons of sludge per day.

A simplified early action program for sludge would consist of hauling the Ravenna or Kent solids by tank truck.

Any early action sludge project should involve personnel from Case-Western University where a pool of expertise already exists.

WATER QUALITY AND QUALITY MONITORING SYSTEM

The monitoring program will be similar to that outlined in the *Havens & Emerson, Ltd., Phase III Report.* The reader is referred to that report for the Plan C early action work on monitoring.

SECTION VI

RESOURCE REQUIREMENTS

Wastewater treatment results in consumption of resources such as chemicals, power, land, and manpower. If any of the key resources used for the liquid or solid phase of the wastewater treatment are in short supply, the plan could be deficient unless alternative resources are available. The various resources required for the land treatment components of Plans A, B and C are summarized in Table VI-1.

A. Chemicals. The only chemical used for the land treatment in Plans B and C is chlorine for disinfection of the aerated lagoon effluent and the reservoir effluent. According to the Havens and Emerson, Ltd., Phase III Report, chlorine gas is fifth in the list of the top chemicals produced in the United States. National capacity at present is 28,960 tons per day, and the annual production increases have averaged eight percent per year.

Under present assumptions, chlorine would be required for the aerated lagoons and reservoirs. However, in the Western Land Treatment Area, which comprises the bulk of the chlorine use for Plan C, experiments could be conducted omitting chlorination.

B. Electric Power. As stated in the formulation contract, the energy requirement for Plan C in the year 2020 is 2.5 times the energy required for Plan A. A good deal of this power is utilized to pump the wastewater from the tunnel to the aerated lagoons in the Western Land Treatment Site. Some generation of power could be accomplished by

TABLE VI-1

ANNUAL RESOURCE REQUIREMENTS

YEAR AND PLAN	CHEMICALS (1000's TONS)			ELECTRIC POWER (1000's MWH)			LAND (1000's ACRES)			MANPOWER (PERSONS)		
	Waste-water	Storm-water	Total	Waste-water	Storm-water	Total	Waste-water	Storm-water	Total	Waste-water	Storm-water	Total
1980												
A	-	-	-	6.0	.1	6.1	.5	.2	.7	109	9	118
B	.5	-	.5	72.8	.1	72.9	.3	.1	.4	279	24	303
C	.7	-	.7	82.3	.1	82.4	4.4	.2	4.6	312	26	338
1990												
A	-	-	-	13.6	3.6	17.2	7.8	2.7	10.5	116	28	144
B	.7	.2	.9	164.4	19.0	183.4	15.1	4.8	19.9	359	87	446
C	11.0	2.4	13.4	458.3	211.4	669.7	121.5	27.1	148.6	355	86	441
2000												
A	-	-	-	14.3	4.0	18.3	8.8	3.1	11.9	133	35	168
B	1.4	.3	1.7	197.4	31.6	229.0	18.6	7.0	25.6	371	96	467
C	12.4	2.8	15.2	1,229.2	239.8	1,469.0	139.1	32.8	171.9	553	144	697
2010												
A	-	-	-	15.8	4.3	20.1	9.9	3.3	13.2	153	39	192
B	1.8	.4	2.2	235.1	37.9	273.0	22.3	8.1	30.4	418	108	526
C	13.7	3.1	16.8	1,354.8	263.0	1,617.8	154.1	36.1	190.2	619	160	779
2020												
A	-	-	-	17.3	4.4	21.7	11.7	3.5	15.2	170	43	213
B	2.1	.5	2.6	277.3	44.3	321.6	26.2	9.0	35.2	460	117	577
C	14.7	3.3	18.0	1,462.5	550.6	2,013.1	168.4	38.4	206.8	676	171	847

inserting turbines in shoreline access shafts to the tunnel. Another opportunity is to provide mined storage at the end of the tunnel so that power to lift the sewage to the aerated lagoons is off-peak or surplus power. The pump turbines could be reversible so that power could be generated during peak-power periods by reversing the flow from the aerated lagoon to the tunnel.

Plan C has an important built-in element which would facilitate the generation of electric power needed for wastewater treatment in excess of the scale projected in the study. This element is the creation of a large body of cooling water in the Western Land Treatment Area which would be utilized by a power plant. The adverse ecological effects normally associated with increased water temperatures would not be of concern and this same body of cooling water would become more efficient in its biological function of oxidizing the carbonaceous material in the wastewater.

C. Land. Plan C utilizes a considerable amount of land totaling 206,800 acres. Most of this land will be improved for agriculture production because of the nutrients and organic matter from the wastewater effluent or sludge. It has been estimated that the value of the produce from this land, at present prices, will amount to $36,000,000 a year.

The closely-spaced drainage system and alternate strips of corn and Reed Canarygrass in the Western Land Treatment Area will assure that the corn can be planted early and harvested on time.

D. Manpower. The manpower requirements shown in Table [illegible] be a constraint, but a benefit in terms of furnishing employment for workers in the agricultural industry.

E. Nutrients. The land treatment systems are designed to balance the nitrogen applied and the crop requirements. As a commercial fertilizer, the value of the nutrients in the sludge and wastewater for Plan C is estimated to be worth about $10,000,000 per year.

COST APPENDIX

The detailed computer tabulation of costs for each municipal plant and for the total costs of municipal/industrial wastewater and storm runoff treatment are presented in this appendix for Plan C.

Plant Number	Plant Name
1	Randolph
2	New Kent
3	Burton
4	Mantua
5	Butternut Creek
6	Chardon
7	East Claridon
8	Troy Township
9	Auburn
10	Shalersboro
11	Ravenna
12	Aurora Central
13	Fairmount Road
14	Fowler's Mill
15	Newbury Township
16	Chagrin Falls
17	Chagrin East Branch
18	Upper East Branch
19	Hinckley
20	Medina County
21	New Medina
22	Mallet Creek
23	Liverpool
26	Akron
27	Euclid
28	Lakewood

Plant Number	Plant Name
29	North Olmsted
30	Rocky River
31	Willoughby Eastlake
32	Easterly
33	Southerly
34	Westerly
35	Western Land Treatment Area
36	Interim Plants

Then follows:

Total Costs for Municipal/Industrial Wastewater Treatment
Total Costs for Stormwater Treatment
Total Costs for Wastewater and Stormwater Treatment

The costs for each treatment plant were assigned according to the particular components. The listing of components is the same in each of the following tables, even though a given plant may not have any costs for several components depending upon the treatment processes included in that plant. A brief explanation of the "components" follows:

1. PLANTS This item includes capital costs for replacement and expansion of existing secondary-level treatment facilities, new plant construction, even when built to meet Level I criteria, and construction of "preliminary" treatment facilities in conjunction with aerated lagoons or tunnel inlets. All operation and maintenance costs for water-based treatment plants, regardless of level, are included in this item, rather than being distributed among the first three items. For Storm Runoff, this component includes advanced stormwater treatment plants and preliminary treatment facilities

prior to separate land treatment. Costed by Havens & Emerson, Ltd. (H & E).

2. & 3. EXPAND TO LEVEL 1 and EXPAND TO LEVEL 2 These two items include only capital costs for municipal/industrial treatment plant components specifically classified as Level 1 or Level 2, (H & E) and do not reflect the operation and maintenance costs incurred by the expansion of the plant.

4. & 5. SLUDGE FACILITIES and SLUDGE FACILITIES EXPANSION These items include capital and operation and maintenance costs for both municipal/industrial and storm runoff sludge-handling facilities. (H & E) Where a sludge disposal scheme involves land treatment on either agricultural or strip-mined land, the storage, transportation, and application steps were costed by Wright-McLaughlin Engineers (WME) in Item Number 20.

6. & 7. SEWERS and SEWER EXPANSION These items include both the municipal/industrial and storm sewer systems costs for capital and operation and maintenance. (H & E)

8. & 9. DETENTION BASINS and BASIN EXPANSION These items relate only to capital costs for storm runoff. (H & E)

10. TEMPORARY PUMPS This is a special storm runoff item, which includes capital and operation and maintenance costs, and pertains only to an interim mode of treatment for combined sewer overflows in Plan C between 1980 and 1985. (WME)

11. SHAFTS and TUNNELS This item pertains only to the Transmission Tunnel in Plan C and includes capital and operation and maintenance costs allotted to both municipal/industrial and storm runoff in proportion to the average daily flow contributed to the tunnel from each source. The costs include mined storage space for flow-levelling and tunnel aeration equipment. (WME)

12. AERATED LAGOONS This item appears in Plans B and C where aerated lagoons were assumed for estimating costs of secondary treatment prior to land treatment in municipal systems. Both the aerobic and faculative lagoons are included in this item. Costs were prorated for storm runoff treated in municipal facilities. Site acquisition costs were included in this item. (WME)

13. SECONDARY PUMPING This item refers to capital and operation and maintenance costs for pumping municipal/industrial secondary effluent from aerated lagoons to winter storage reservoirs within the Study Area and for the lift from the lower end of the tunnel to the aerated lagoon at the Western Land Treatment Area. Pumping costs from detention basins to winter storage reservoirs were included for storm runoff. (WME)

14 FORCE MAINS This item pertains to all force mains associated with the pumping stations in the preceding item, including the lift shaft from the tunnel and force mains to winter storage reservoirs within the Study Area. (WME)

15. STORAGE RESERVOIRS This item refers to winter storage reservoirs for municipal/industrial secondary effluent and for preliminarily-treated storm runoff prior to land treatment. Land costs for site acquisition were included in this item. (WME)

16. RESERVOIR AERATION and CHLORINATION This item includes aeration and chlorination for municipal/industrial winter storage reservoirs for in-basin treatment and chlorination only for separate storm-runoff winter storage reservoirs, and for the Western Land Treatment Area reservoir. (WME)

17. LAND PURCHASE and PREPARATION This capital cost item includes two categories of land. The costs of site acquisition for water-based plants are treated as occurring in 1972 and are the only capital costs appearing in that year. (H & E) The costs for purchase of land treatment areas and the necessary "one-time" relocation, clearing, and land-forming costs occur later. (WME) All costs on this line are amortized over an assumed fifty-year life, but the total undepreciated expenditures are retained as the 2020 residual amounts for purposes of calculating present-worth costs.

18. IRRIGATION SYSTEMS This item comprises the distribution and irrigation systems from the winter storage reservoirs to the irrigated fields, including force mains and pumping facilities. (WME)

19. DRAINAGE SYSTEMS This item includes all portions of the drainage systems for the land treatment sites and the conduits and canals required to convey the tile effluent to natural drainage channels with adequate capacity. (WME)

20. SLUDGE MANAGEMENT This item includes costs for storage, transportation, and land application of sludge to receive land treatment. All costs for the pipeline to the strip-mined area are included in this item, as are costs of agricultural lands. (WME)

21. MISCELLANEOUS *This item is not a contingency allowance*, but rather an estimation of the costs for a category of appurtenances and ancillary features, which would be characteristic of the transition to a geographically dispersed land treatment system. Miscellaneous capital costs were calculated as follows: ten per cent of the capital expenditures for aerated lagoons, representing costs for fencing and for pipeline connections to existing treatment plants and to temporary stream return-flow structures from the aerated lagoons within the Study Area during the period 1977 to 1983; PLUS nine per cent of the capital expenditures for land purchase of an additional twenty per cent of the net acreage needed for land treatment; PLUS five per cent of the capital expenditures for both irrigation and drainage systems, representing costs for monitoring stations and some re-channeling of small creeks and streams. Miscellaneous operation and maintenance costs were calculated as five per cent of all foregoing miscellaneous capital expenditures. (WME)

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AREA THREE RIVERS WATERSHED AREA

RANDOLPH PLANT SIZE: 0.75(MGD) JULY-T YPE PROFILE APPLICATION RATES: 60 IN/YR RANDOLPH PLANT

BASIC DESIGN DATA

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL Q				0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.45	0.50	0.57	0.65	0.72	0.75
					0.69						0.53								0.50	0.57	0.65	0.72	0.75	0.75	0.75
TREATMENT PLANT CAPACITY (MGD)																									
SLUDGE DISCHARGED (TPD)							0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.10	0.11	0.12	0.14	0.15	0.16
WINTER STORAGE (MG)					28	29	31	32	33	34	35	36	37	38	40	41	42	43	44	45	50	56	64	73	79	85
LAND AREA (ACRES)					56	58	60	63	65	67	69	72	74	76	78	81	83	85	87	89	101	112	128	146	157	168

PLAN C PLANT 1

CAPITAL COSTS IN $1,000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	16	22	1	21	20	0	19	17	0	17
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXPN.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	211	21	100	1	179	172	0	171	158	0	158
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	240	0	0	0	0	0	0	0	0	0	0	0	0	0	160	0	0	0	0	210	0	580	244	240	19	220	205	9	196	164	2	162
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	71	0	0	0	0	0	0	0	0	71	0	0	0	71	0	0	213	71	77	5	71	60	2	58	41	1	40
PCRCE MAINS	50	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	36	88	2	85	76	1	74	57	0	57
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	50	0	120	0	90	0	0	550	240	223	19	203	178	9	169	123	2	121
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0	59	0	75	0	85	0	85	351	85	86	6	79	62	3	59	37	1	36
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	51	0	0	0	0	0	0	0	0	0	11	0	7	0	0	70	111	53	8	44	44	4	40	33	1	32
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	0	0	0	5	6	7	8	9	5	5	136	61	62	4	57	32	2	30	22	0	21
DRAINAGE SYSTEMS	15	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	5	5	6	7	8	5	0	68	15	28	1	26	22	0	21	15	0	15
SLUDGE MANAGEMENT	15	0	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	144	62	61	5	56	53	2	51	44	0	43
MISCELLANEOUS	15	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	1	1	1	1	0	75	0	30	0	30	26	0	26	20	0	20
TOTAL		0	0	0	234	290	0	0	0	0	0	654	0	0	0	0	18	0	0	0	290	222	220	27	215	426	90	2526	962	1135	77	1058	956	37	918	737	4	727
PW 11/72% 5 3/8		0	0	0	202	235	0	0	0	0	0	387	0	0	0	0	8	0	0	0	93	66	50	4	29*	46	7	0	0	1235	77	1058	0	0	0	0	0	0
PW 11/72% 7 %		0	0	0	198	221	0	0	0	0	0	332	0	0	0	0	6	0	0	0	76	46	33	2	16	23	3	0	0	0	0	0	956	37	918	0	0	0
PW 11/72% 10 %		0	0	0	175	198	0	0	0	0	0	252	0	0	0	0	4	0	0	0	63	34	25	1	5	7	0	0	0	0	0	0	0	0	0	737	4	727

O & M COSTS IN $1,000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	29	31	33	36	38	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	4	4	5	5	6	313	0	177	0	177	160	0	160	139	0	139
SLUDGE FACILITIES	35	1	1	1	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	14	0	14	13	0	13	12	0	12
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0	14	0	14	11	0	11	7	0	7
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	9	9	9	9	9	10	10	10	10	10	10	10	10	10	11	11	12	17	17	18	18	19	606	0	194	606	0	194	111	0	111	66	0	66	66	0	66
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	5	5	5	6	6	6	6	7	9	9	10	10	11	11	339	0	73	0	73	49	0	49	25	0	25	25	0	25
PCRCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	3	3	3	77	0	15	0	15	10	0	10	5	0	5
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	3	3	4	4	4	104	0	21	0	21	14	0	14	7	0	7
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	146	0	31	0	31	21	0	21	11	0	11
DRAINAGE SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
SLUDGE MANAGEMENT	15	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	42	0	12	0	12	9	0	9	5	0	5
MISCELLANEOUS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		32	34	34	41	43	14	14	14	15	15	15	28	27	28	29	29	30	36	35	37	45	45	51	51	0	1761	0	533	0	0	414	0	0	288	0	0
PW 11/72% 5 3/8		30	32	34	38	40	13	13	14	14	14	14	26	25	26	27	27	28	28	154	175	192	204	217	218	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 7 %		30	30	30	33	33	10	9	9	9	9	9	16	14	13	13	12	12	12	66	72	66	36	29	22	0	5	0	552	0	0	0	0	0	0	0	0	0
PW 11/72% 10 %		29	31	31	33	34	10	9	8	8	8	8	13	12	11	11	10	9	9	43	47	44	24	18	13	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 15 %		29	29	29	31	30	9	8	8	7	7	7	12	11	10	10	9	8	8	30	31	27	14	9	6	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 20 %		29	28	27	28	26	7	7	6	6	5	5	9	8	7	7	6	6	5	21	20	15	7	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 25 %		29	28	27	27	25	6	6	5	5	4	4	7	6	6	5	5	4	4	15	14	10	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 30 %		29	28	27	26	24	6	5	5	4	4	3	6	5	5	4	4	3	3	12	11	8	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 40 %		29	28	27	26	24	5	5	4	4	3	3	5	4	4	4	3	3	2	9	7	5	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/72% 50 %		29	28	27	26	24	5	5	4	4	3	3	5	4	4	4	3	3	2	8	6	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL CAPITAL COSTS AT 7% IN $1000

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	2	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXPN.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	30	2	2	2	2	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	27	27	27											
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	11	11	11	11	11	11	11											
PCRCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	18	18	18	18	18	18	18	18	24	24	33	33	39	39	39											
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7	9	9	12	12	14	14	14											
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	5	5	6	7	8	8	8											
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	4	4	5	5	6	6	6											
DRAINAGE SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	3	3	4	4	5	5	5											
SLUDGE MANAGEMENT	15	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	6	6	7	7	7											
MISCELLANEOUS	15	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3											
% SYDE CAP		0	0	0	13	14	32	32	32	32	32	75	75	75	75	76	76	76	76	89	103	114	116	122	124	124											
% E CAP		0	0	0	37	35	39	39	39	39	39	91	91	91	91	92	92	92	92	108	124	137	140	148	150	150											
10 % CAP		0	0	0	24	24	54	54	54	54	54	124	124	124	124	126	126	126	126	147	169	187	190	200	204	204											

TOTAL ANNUAL CAPITAL COSTS IN $1000

CAPITAL RECOVERY FACTOR AT 7 3/8%

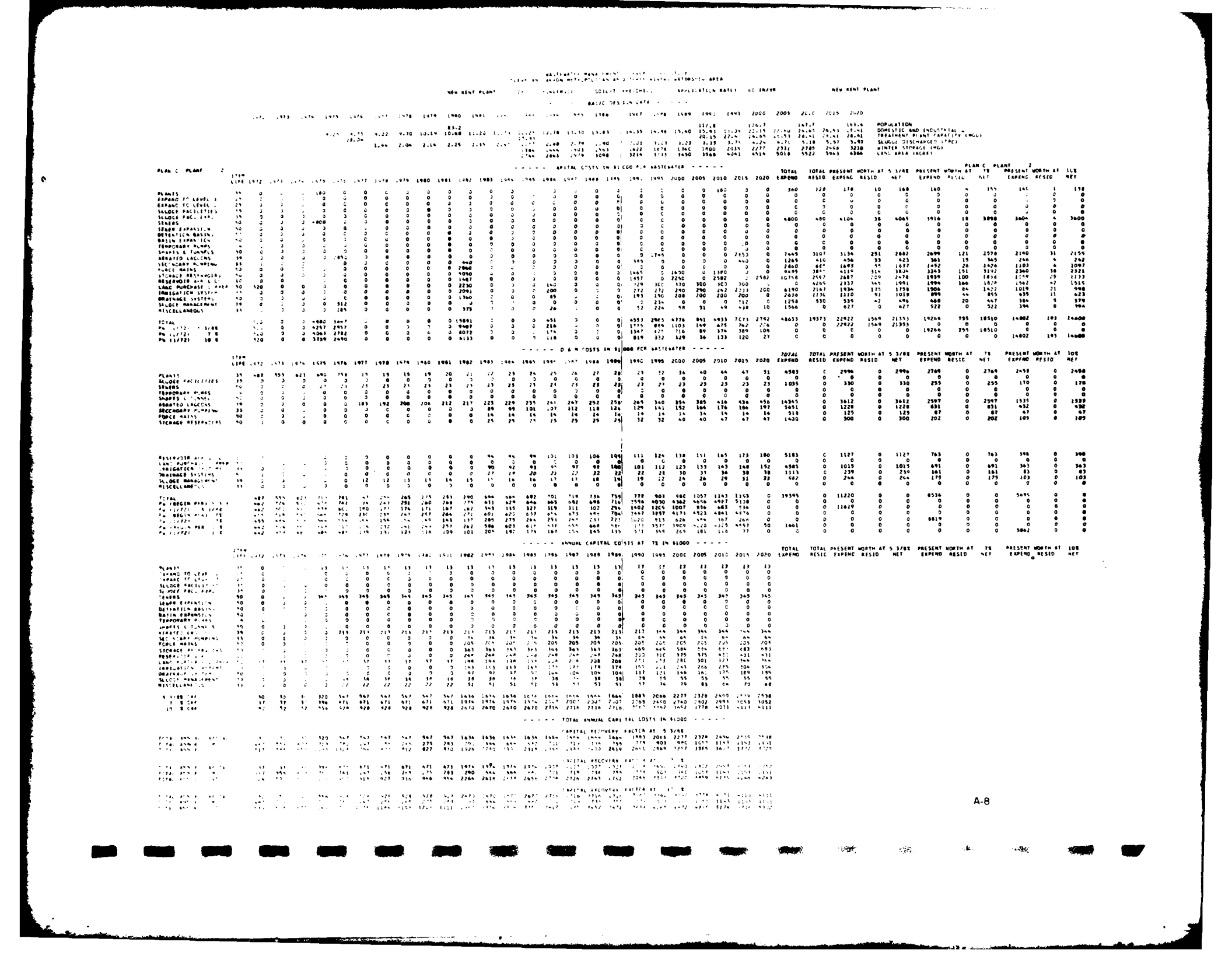
TOTAL ANNUAL CAPITAL																																					
TOTAL ANNUAL O&M																																					
TOTAL ANNUAL COST																																					

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL																																					
TOTAL ANNUAL O&M																																					
TOTAL ANNUAL COST																																					

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL																																					
TOTAL ANNUAL O&M																																					
TOTAL ANNUAL COST																																					



A-8

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

BURTON PLANT SIZE: 3.0 MGD SOIL: T YPE: SILT APPLICATION RATE: 50 IN/YR BURTON PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL				1.17	1.21	1.25	1.29	1.34	1.38	1.43	1.48	1.53	1.58	1.63	1.67	1.72	1.77	1.82	1.87	2.38	2.62	2.78	2.62	2.95	3.28
TREATMENT PLANT CAPACITY (MGD)					2.00						1.87								2.28	2.62	2.95	3.28	3.61	3.61	3.61
SLUDGE DISCHARGED (TPD)						0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.39	0.40	0.44	0.48	0.55	0.62	0.69	0.76
WINTER STORAGE (MG)											167	175	178	184	189	195	200	206	211	235	258	286	313	341	369
LAND AREA (ACRE)											332	343	354	365	374	385	397	408	419	466	511	567	661	735	809

PLAN C PLANT 3

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

PLAN C PLANT 3

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	TR NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	0	0	114	40	56	3	53	50	1	44	4	0	43
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	970	97	824	7	821	791	1	767	728	0	727
SEWER EXPANSION	50	0	0	0	0	0	0	0	492	0	0	0	0	0	0	0	0	0	240	0	0	0	0	0	0	0	732	193	417	13	401	357	1	349	272	1	271
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	545	0	0	0	0	0	0	0	0	0	0	0	0	0	385	0	0	0	545	0	0	1470	624	615	50	565	527	24	503	424	6	418
SECONDARY PUMPING	30	0	0	0	0	182	0	0	0	0	0	0	0	0	0	0	0	0	83	0	0	0	182	0	0	0	447	155	284	10	193	177	5	172	144	1	142
FORCE MAINS	50	0	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87	12	70	0	69	66	0	65	59	0	59
STORAGE RESERVOIRS	50	0	0	0	0	822	0	0	0	0	0	0	0	0	0	0	0	0	230	0	0	345	0	345	0	0	1737	684	882	55	827	772	26	746	635	4	631
RESERVOIR ABR & CL	30	0	0	0	0	181	0	0	0	0	0	0	0	0	0	0	0	0	228	0	0	286	0	349	0	364	1404	564	577	29	548	488	14	474	396	3	393
LAND PURCHASE & PREP	50	34	0	0	0	279	0	0	0	0	0	0	0	0	0	0	0	0	61	0	0	100	0	98	0	0	0	538	322	43	279	289	20	268	267	5	261
IRRIGATION SYSTEMS	35	0	0	0	0	248	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0	95	0	322	0	0	722	261	292	21	271	247	10	237	197	2	194
DRAINAGE SYSTEMS	35	0	0	0	0	184	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0	68	0	66	0	0	364	130	194	11	183	171	5	166	147	1	146
SLUDGE MANAGEMENT	35	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	100	0	228	92	100	7	92	87	3	84	73	0	72
MISCELLANEOUS	35	0	0	0	0	101	0	0	0	0	0	0	0	0	0	0	0	0	33	30	16	0	28	54	0	0	249	0	110	0	110	95	0	95	77	0	77
TOTAL		34	0	0	1027	2134	0	0	0	492	0	0	0	0	0	0	0	0	0	969	474	888	0	1642	699	364	8531	3178	4476	257	4217	3924	125	3800	3265	51	3213
PW (1/72) 5 3/8%		34	0	0	878	2217	0	0	0	323	0	0	0	0	0	0	0	0	377	184	205	0	197	73	29	0	0	0	4476	257	4217	0	0	0	0	0	0
PW (1/72) 7 %		34	0	0	838	2086	0	0	0	286	0	0	0	0	0	0	0	0	286	95	133	0	169	38	14	0	0	0	0	0	0	3924	125	3800	0	0	0
PW (1/72) 10 %		34	0	0	771	1867	0	0	0	229	0	0	0	0	0	0	0	0	196	50	61	0	82	17	3	0	0	0	0	0	0	0	0	0	3265	51	3213

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	TR NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	126	136	148	158	168	3	3	3	4	4	8	10	12	18	21	24	27	30	33	20	7	8	9	10	11	1274	0	792	0	792	721	0	721	625	0	625
SLUDGE FACILITIES	35	6	7	9	10	11	6	6	6	6	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	147	0	39	0	39	38	0	38	35	0	35
SEWERS	50	4	4	4	4	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	330	0	99	0	99	71	0	71	65	0	65
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	32	32	32	32	33	34	34	35	36	37	35	36	37	39	46	53	60	63	66	68	2108	0	528	0	528	380	0	380	226	0	226
SECONDARY PUMPING	30	0	0	0	0	0	13	13	14	14	15	15	15	15	16	16	16	16	17	19	20	22	24	26	26	28	880	0	228	0	228	166	0	166	99	0	99
FORCE MAINS	50	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	43	0	12	0	12	9	0	9	6	0	6
STORAGE RESERVOIRS	50	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	7	8	9	9	9	272	0	66	0	66	47	0	47	28	0	28
RESERVOIR ABR & CL	30	0	0	0	0	0	11	11	11	11	12	12	12	12	12	13	13	13	13	14	16	18	20	22	22	23	726	0	185	0	185	136	0	136	80	0	80
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	35	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	13	13	16	18	20	20	20	20	448	0	167	0	167	122	0	122	73	0	73
DRAINAGE SYSTEMS	35	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	5	5	5	5	159	0	42	0	42	32	0	32	19	0	19
SLUDGE MANAGEMENT	35	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	4	4	5	126	0	32	0	32	23	0	23	14	0	14
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		136	147	157	172	183	87	88	89	96	98	101	104	106	123	128	121	125	129	141	132	147	158	171	177	0	6613	0	2191	0	0	1745	0	0	1253	0	0
PW (DRGIN PERI 5 3/8		129	139	148	163	173	82	83	84	89	92	95	98	100	107	112	106	108	122	982	595	651	700	742	758	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %		129	137	146	159	169	80	80	81	86	88	91	93	95	99	103	97	98	110	856	509	551	578	604	609	0	0	0	2266	0	0	0	0	0	0	0	0
PW (DRGIN PER 10 %		127	134	144	156	165	78	78	78	82	83	86	88	89	93	96	90	91	101	746	434	461	477	493	494	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %		124	131	140	152	160	76	76	76	79	81	83	85	86	89	92	86	87	96	672	378	398	409	419	417	0	0	0	1800	0	0	0	0	0	0	0	0
PW (DRGIN PERI 10%		123	131	139	150	158	74	74	74	77	79	81	82	83	86	89	83	84	93	651	367	385	394	402	399	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	TR NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	35	35	35	35	35	35	35	35	35	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
SECONDARY PUMPING	30	0	0	0	0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
FORCE MAINS	50	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
STORAGE RESERVOIRS	50	0	0	0	0	59	59	59	59	59	59	59	59	59	59	59	59	59	59	75	75	75	100	100	125	125	125	125	125	125	125	125	125	125	125	125	125
RESERVOIR ABR & CL	30	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20	20	25	25	25	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
LAND PURCHASE & PREP	50	2	2	2	2	22	22	22	22	22	22	22	22	22	22	22	22	22	22	27	27	27	34	34	41	41	41	41	41	41	41	41	41	41	41	41	41
IRRIGATION SYSTEMS	35	0	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	19	25	25	31	31	36	36	36	36	36	36	36	36	36	36	36	36	36
DRAINAGE SYSTEMS	35	0	0	0	0	13	13	13	13	13	13	13	13	13	13	13	13	13	13	16	16	16	21	21	26	26	26	26	26	26	26	26	26	26	26	26	26
SLUDGE MANAGEMENT	35	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	[illegible]

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THAT RIVER WATERSHED AREA

MANTUA PLANT SIZE: 3.81 MGD SOIL: TYPE SHEDLEY APPLICATION RATE: 60 IN/YR MANTUA PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL				0.327	0.335	0.343	0.352	0.360	0.368	0.381	0.394	0.408	0.421	0.434	0.447	0.460	0.474	0.487	0.500	0.560	0.680	0.680	0.740	0.801	0.861
TREATMENT PLANT CAPACITY (MGD)					0.540							0.500							0.580	0.680	0.743	0.801	0.861	0.861	0.861
SLUDGE DISCHARGED (TPD)						0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.14	0.16	0.17	0.18
WINTER STORAGE (MG)													46	48	49	50	52	54	55	56	66	75	84	91	97
LAND AREA (ACRE)													91	94	97	100	103	106	109	112	121	130	148	166	179	193

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

PLAN C PLANT A

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET
PLANTS	35	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	50	17	24	1	23	22	0	21	19	0	19
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	230	0	0	0	0	0	0	0	0	0	0	0	0	170	0	0	0	230	0	0	630	265	261	21	240	224	10	213	180	2	177
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	64	0	0	0	0	0	0	0	0	0	0	0	64	0	0	128	55	44	4	40	36	2	33	25	0	25
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	14	34	1	33	29	0	28	22	0	22
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	277	0	0	0	0	0	0	80	0	106	0	79	0	0	0	542	225	230	18	212	186	8	177	134	2	128
RESERVOIR APP & CL	50	0	0	0	0	0	0	0	0	0	0	96	0	0	0	0	0	0	64	0	80	0	92	0	92	0	384	92	96	7	89	69	3	66	42	0	42
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	47	0	0	0	0	0	0	6	6	12	12	9	9	0	0	129	54	10	44	44	5	19	31	1	1	30
IRRIGATION SYSTEMS	25	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	0	0	5	5	6	9	8	7	7	8	196	87	61	7	54	48	3	44	33	0	32
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	4	4	5	8	6	6	5	0	78	33	32	2	30	26	1	25	19	0	19
SLUDGE MANAGEMENT	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	156	61	67	4	62	58	2	55	47	0	47
MISCELLANEOUS	33	0	0	0	0	23	0	0	0	0	0	11	0	0	0	0	1	0	0	0	17	1	1	1	1	0	82	0	34	0	34	28	0	28	22	0	22
TOTAL		0	0	0	25	317	0	0	0	0	0	643	0	0	0	22	0	0	0	159	224	216	78	219	476	100	2304	978	963	75	863	774	38	736	574	5	544
PW (1/72) 5 3/8%		0	0	0	21	257	0	0	0	0	0	380	0	0	0	10	0	0	0	62	68	49	4	30	49	8	0	0	963	79	863	0	0	0	0	0	0
PW (1/72) 7 %		0	0	0	20	241	0	0	0	0	0	326	0	0	0	8	0	0	0	47	48	32	2	16	26	3	0	0	0	0	0	774	38	736	0	0	0
PW (1/72) 10 %		0	0	0	18	216	0	0	0	0	0	248	0	0	0	5	0	0	0	28	25	14	1	9	8	1	0	0	0	0	0	0	0	0	574	9	564

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET
PLANTS	35	42	44	45	47	48	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	4	5	5	6	377	0	230	0	230	211	0	211	186	0	186
SLUDGE FACILITIES	35	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	12	0	12	12	0	12	11	0	11
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	10	10	10	10	10	10	11	11	11	11	11	12	12	12	14	16	17	19	20	22	674	0	170	0	170	122	0	122	73	0	73
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	6	6	6	6	6	6	7	7	7	8	232	0	55	0	55	36	0	36	19	0	19
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	67	0	14	0	14	9	0	9	5	0	5
RESERVOIR APP & CL	50	2	2	2	0	0	0	0	0	0	0	0	3	3	3	3	3	3	4	4	4	4	4	5	5	5	152	0	34	0	34	23	0	23	12	0	12
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	25	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	4	4	5	5	5	5	166	0	31	0	31	21	0	21	11	0	11
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
SLUDGE MANAGEMENT	25	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	45	0	12	0	12	9	0	9	6	0	6
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		45	47	48	50	51	14	14	14	14	14	29	29	30	30	30	32	33	34	37	42	48	49	0	1789	0	578	0	0	459	0	0	331	0	0
PW (BEGIN PER) 5 3/8		42	44	45	47	48	13	13	13	13	13	27	27	27	28	28	28	30	31	34	37	42	44	46	46	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %		42	42	41	40	39	10	9	8	7	7	15	14	14	13	12	12	12	12	12	12	13	12	12	11	0	593	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		42	43	41	40	39	11	11	10	9	9	19	18	18	17	16	16	15	15	15	15	16	15	15	14	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%		42	41	39	38	36	9	8	8	7	7	16	15	15	14	13	13	12	12	12	11	12	11	11	10	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 10%		40	42	43	45	46	12	12	12	12	12	26	26	27	27	27	27	29	30	32	34	37	38	39	39	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%		40	38	36	34	31	7	7	6	5	5	9	8	7	7	6	6	5	5	5	4	5	4	4	3	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET
PLANTS	35	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE FAC. EXP.	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
AERATED LAGOONS	30	0	0	0	0	0	17	17	17	17	17	17	17	17	17	17	17	17	17	17	30	30	30	30	30	30								
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4								
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4								
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	19	19	19	19	19	19	19	19	25	25	33	33	33	33	33								
RESERVOIR APP & CL	50	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	9	9	10	10	13	13	15	15	15								
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	5	5	7	7	8	8	9								
IRRIGATION SYSTEMS	25	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	6	6	6	6	7	8	8	9	9	9								
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	3	3	3	3	4	4	4	5	5	5								
SLUDGE MANAGEMENT	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
MISCELLANEOUS	33	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	4	4	4	5	5	5								
% 3 PE CPF		0	0	0	1	21	21	21	21	21	21	65	65	65	65	66	66	66	66	71	87	97	99	105	108	114								
7 % CPF		0	0	0	1	25	25	25	25	25	25	78	78	78	78	79	79	79	79	85	105	117	119	127	130	140								
10 % CPF		0	0	0	2	34	34	34	34	34	34	105	105	105	105	107	107	107	107	115	141	158	161	171	174	185								

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL		1	1	0	1	1	23	21	21	21	21	65	65	65	65	66	66	66	66	71	87	97	99	105	108	114								
TOTAL ANNUAL O&M		45	47	48	50	51	14	14	14	14	14	29	29	30	30	30	32	33	34	37	42	48	49	0	1789	0								
TOTAL ANNUAL COSTS		45	47	48	51	52	37	35	35	35	35	94	94	95	95	96	98	99	100	107	129	145	148	105	1897	114								

CAPITAL RECOVERY FACTOR AT 7%

TOTAL ANNUAL CAPITAL		1	1	0	1	25	25	25	25	25	25	78	78	78	78	79	79	79	79	85	105	117	119	127	130	140								
TOTAL ANNUAL O&M		45	47	48	50	51	14	14	14	14	14	29	29	30	30	30	32	33	34	37	42	48	49	0	1789	0								
TOTAL ANNUAL COSTS		45	47	48	50	76	39	39	39	39	39	107	107	108	108	109	111	112	113	122	147	165	168	127	1919	140								

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL		2	2	0	2	34	34	34	34	34	34	105	105	105	105	107	107	107	107	115	141	158	161	171	174	185								
TOTAL ANNUAL O&M		45	47	48	50	51	14	14	14	14	14	29	29	30	30	30	32	33	34	37	42	48	49	0	1789	0								
TOTAL ANNUAL COSTS		45	47	48	52	85	48	48	48	48	48	134	134	135	135	137	139	140	141	152	183	206	210	171	1963	185								

BUTTERNUT CREEK PLANT SIZE: [illegible] SCOPE SPECIMEN APPLICATION RATE: 60 IN/YR BUTTERNUT CREEK PLANT

BASIC DESIGN DATA

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL G				3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
TREATMENT PLANT CAPACITY (MGD)					3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
SLUDGE DISCHARGED (TPD)						0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.12	0.14	0.15	0.17	0.19
WINTER STORAGE (MG)												45	47	49	50	52	53	54	55	75	85	101	116	132	148
LAND AREA (ACRES)												90	94	98	99	103	105	108	112	150	170	199	231	262	294

PLAN C PLANT 5

CAPITAL COSTS IN $1000 FOR WASTEWATER

	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	75 NET	PRESENT EXPEND	WORTH AT RESID	100 NET
PLANTS	35	0	3	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	56	14	27	1	26	24	0	24	21	0	21
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS FAC. LITTLES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	3	0	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	480	48	410	3	406	391	1	389	368	0	368
SEWER EXPANSION	50	0	0	0	0	0	0	0	460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	460	91	307	7	300	272	3	268	218	0	217
DEFINITION PASTEL	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TREATMENT PLANTS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMPING STATIONS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	25	0	0	0	0	240	0	0	0	0	0	0	0	0	0	0	0	0	240	0	0	0	0	480	0	720	285	291	23	267	246	11	235	194	2	191
SECONDARY PUMPING	25	0	0	0	0	0	0	0	0	0	71	0	0	0	0	0	0	0	71	0	0	0	0	71	0	213	71	77	5	71	60	2	58	46	0	46
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120	24	71	2	68	60	1	59	46	0	46
STORAGE DESERT (MG)	50	0	0	0	0	0	0	0	0	0	420	0	0	0	0	0	0	0	130	0	170	0	195	0	0	795	382	294	30	263	231	14	216	154	3	152
RESERVOIR #4 (MG)	50	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	76	0	100	0	120	0	130	486	130	116	10	106	62	5	57	48	1	47
ARC PURCHASE & PREP	50	12	0	0	0	0	0	0	0	0	86	0	0	0	0	0	0	0	12	12	18	18	22	24	0	186	95	75	15	60	62	7	55	44	1	44
CONSTRUCTION SYSTEMS	50	0	0	0	0	0	0	0	0	0	80	0	0	0	0	10	0	0	0	0	0	0	0	0	0	90	13	12	1	11	9	1	8	6	0	6
BALANCE SYSTEMS	50	0	0	0	0	0	0	0	0	0	60	0	0	0	0	5	0	0	7	7	11	11	14	15	0	136	42	39	3	36	30	3	28	20	0	20
SLUDGE MANAGEMENT	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
TOTAL		12	0	3	504	240	0	0	0	460	0	746	0	0	0	25	0	0	0	306	327	514	40	407	961	140	3681	1490	1900	119	1780	1619	57	1562	1271	14	1256
PW EXPAND - PHASE		12	3

WASTEWATER MANAGEMENT SEWER SYSTEM STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

CHARDON PLANT SIZE: 0.20(MGD) SCALE PREPARED: APPLICATION RATE: 90 IN/YR CHARDON PLANT

BASIC DESIGN DATA

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	
POPULATION																										
DOMESTIC AND INDUSTRIAL W				3.05						0.07	0.07	0.08	0.09	0.08	0.09		0.09	0.09	0.10	0.10	0.11	0.13	0.15	0.17	0.18	0.20
TREATMENT PLANT CAPACITY (MGD)					0.11					0.10										0.13	0.15	0.17	0.18	0.20	0.20	0.20
SLUDGE DISCHARGED (TPD)										0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.03	0.04	0.04
WINTER STORAGE (MG)													7	7	8	8	8	8	8	6	6	5	11	15	16	17
LAND AREA (ACRES)													12	12	12	13	13	13	13	15	15	16	19	23	26	27

PLAN C PLANT A

CAPITAL COSTS IN $1000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT 5 3/8% RESID	TB NET	PRESENT EXPEND	WORTH AT RESID	TB NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	10	0	9	0	0	0	0	0	0	0	0	0	0	0	0	10	0	20	8	7	0	6	6	0	6	4	0	4
EXPAND TC LEVEL I	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0
EXPAND TC LEVEL II	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	200	122	119	9	108	130	4	96	80	1	38
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	120	52	41	4	37	33	2	31	24	0	29
FORCE MAINS	50	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	9	19	0	19	17	0	17	10	0	10
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	180	58	98	4	83	72	2	70	50	0	50
RESERVOIR AFR & CL	10	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	17	0	21	0	25	0	25	0	101	25	76	2	72	17	0	16	10	0	10
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	2	2	2	0	15	21	8	1	6	6	0	5	4	0	4
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	1	2	2	2	1	1	14	1	43	14	30	1	29	8	0	8	5	0	5
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	2	2	1	1	1	0	14	3	9	0	9	4	0	4	3	0	3
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	12	0	0	36	13	34	1	33	12	0	11	9	0	9
MISCELLANEOUS	33	0	0	0	0	0	10	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	10	0	0	30	0	12	0	12	10	0	10	8	0	8
TOTAL		0	0	0	0	122	0	0	0	219	0	0	0	0	0	0	0	0	112	112	28	3	28	209	26	851	322	348	26	322	287	12	274	222	3	209
Pw 11/72(5 3/8%		0	0	0	0	98	0	0	0	176	0	0	0	0	0	0	0	0	63	33	4	0	3	21	2	0	0	348	26	322	0	0	0	0	0	0	0
Pw 11/72(7 %)		0	0	0	0	93	0	0	0	167	0	0	0	0	0	0	0	0	57	23	4	0	2	11	1	0	0	348	26	322	287	12	274	222	3	209	0
Pw 11/72(10 %		0	0	0	0	83	0	0	0	84	0	0	0	0	0	0	0	0	20	12	1	0	0	5	0	0	0	348	26	322	287	12	274	222	3	209	209

O & M COSTS IN $1000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT 5 3/8% RESID	TB NET	PRESENT EXPEND	WORTH AT RESID	TB NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	10	0	1	0	1	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMP.	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AFR & CL	10	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	0	8	0	8	4	0	4	3	0	3
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	4	0	4	3	0	3
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	4	0	4	3	0	3
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	0	0	5	5	5	5	5	5	15	13	13	13	13	13	13	13	14	17	17	19	19	0	616	0	190	0	0	106	0	0	61	0	0	0
Pw 1BEGIN PERI 5 3/8		0	0	0	0	4	4	4	4	6	12	12	12	12	12	12	12	12	55	64	72	72	72	61	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 11/72(5 3/8%		0	0	0	0	3	3	3	3	5	9	9	8	8	8	8	8	8	41	49	55	55	55	47	0	0	0	190	0	0	0	0	0	0	0	0	0
Pw 1BEGIN PERI 7%						4	4	4	4	6	12	12	12	12	12	12	12	12	53	61	69	69	74	77	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 11/72(7%						3	3	3	3	5	9	9	8	8	8	8	8	8	39	47	53	53	53	45	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 1BEGIN PERI 10%						4	4	4	4	6	11	11	11	11	11	11	11	11	49	58	65	65	66	72	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 11/72(10%		0	0	0	0	3	2	2	2	4	9	9	8	8	8	8	8	8	37	45	51	51	51	43	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL CAPITAL COSTS AT 7% IN $1000

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT 5 3/8% RESID	TB NET	PRESENT EXPEND	WORTH AT RESID	TB NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
EXPAND TC LEVEL I	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
EXPAND TC LEVEL II	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
BASIN EXPANSION	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
RESERVOIR AFR & CL	10	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17										
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37										
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37										
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
5 3/8% CRF		0	0	0	0	7	7	7	7	8	8	22	22	22	22	22	22	22	22	25	31	37	37	37	18	18											
7 % CRF		0	0	0	0	8	8	8	8	9	9	27	27	27	27	27	27	27	27	35	43	46	46	45	46	46											
10 % CRF		0	0	0	0	12	12	12	12	13	13	36	36	36	36	37	37	37	37	47	59	60	60	60	62	62											

TOTAL ANNUAL CAPITAL COSTS IN $1000

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL			0	0	7	7	7	7	8	8	22	22	22	22	22	22	22	22	26	32	37	37	37	18	18
TOTAL ANNUAL O&M			0	0	0	5	5	5	5	5	15	13	13	13	13	13	13	13	14	17	17	19	19	0	0
TOTAL ANNUAL COST			0	0	7	12	12	12	13	13	37	35	35	35	35	35	35	35	40	49	54	56	56	18	18

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL			0	0	8	8	8	8	9	9	27	27	27	27	27	27	27	27	35	43	46	46	45	46	46
TOTAL ANNUAL O&M			0	0	0	5	5	5	5	5	15	13	13	13	13	13	13	13	14	17	17	19	19	0	0
TOTAL ANNUAL COST			0	0	8	13	13	13	14	14	42	40	40	40	40	40	40	40	49	60	63	65	64	46	46

SPECIAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL			0	0	9	9	9	9	10	10	36	36	36	36	36	37	37	37	47	59	62	62	62	62	62
TOTAL ANNUAL O&M			0	0	0	5	5	5	5	5	15	13	13	13	13	13	13	13	14	17	17	19	19	0	0
TOTAL ANNUAL COST			0	0	9	14	14	14	15	15	51	49	49	49	49	50	50	50	61	76	79	81	81	62	62

WASTEWATER MANAGEMENT SURVEY SC PH STUDY

CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHEDS AREA

EAST CLAIRDON PLANT — SIZE: [illegible] — SOIL-T TREATMENT: — APPLICATION RATE: 90 IN/YR — EAST CLAIRDON PLANT

- - - - - - BASIC DESIGN DATA - - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	
POPULATION																										
DOMESTIC AND INDUSTRIAL G				0.11	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16	0.16	0.17	0.18		0.19	0.19	0.20	0.21	0.26	0.31	0.35	0.35	0.35	0.48
TREATMENT PLANT CAPACITY (MGD)					0.26						0.21									0.32	0.39	0.39	0.43	0.48	0.48	0.48
SLUDGE DISCHARGED (TPD)						0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04		0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.08	0.05	0.10
WINTER STORAGE (MG)											18	18	19	20			21	21	23	24	29	35	40	44	49	54
LAND AREA (ACRES)											36	36	38	40			43	43	44	47	58	70	79	87	96	108

PLAN C PLANT 7 — PLAN C PLANT 7

- - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	16	16	0	15	14	0	13		
EXPANC TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
EXPANC TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SEWERS	50	0	0	0	123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	123	0	0	0	0	0	0	0	0		
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
AERATED LAGOONS	30	0	0	0	0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	150	0	440	183	179	164	152	7	165	170	1	118	
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	78	0	0	0	0	0	0	0	0	0	0	0	0	78	0	156	67	54	5	48	65	2	61	31	0	30	
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	5	5	1	5	0	0	0	0	0	0
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	70	0	0	0	0	74	0	164	21	0	0	0	20	1	19	17	0	17	
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	70	0	0	0	0	0	0	97	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	3	3	2	2	2	28	0	64	31	22	2	19	17	1	16	11	0	11	
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	5	5	4	4	4	5	0	46	18	18	1	16	14	0	13	9	0	9	
SLUDGE MANAGEMENT	19	0	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	36	0	90	55	38	2	35	33	1	31	27	0	26	
MISCELLANEOUS	33	0	0	0	0	15	0	0	0	0	0	4	0	0	0	0	0	0	0	1	15	0	0	0	17	0	52	0	21	0	21	17	0	17	13	0	13	
TOTAL		0	0	0	138	201	0	0	0	0	0	338	0	0	0	0	0	0	0	124	185	122	11	149	322	47	1579	766	684	61	622	373	29	541	441	1	433	
PW (1/72) 5 3/8%		0	0	0	117	161	0	0	0	0	0	200	0	0	0	0	0	0	0	49	56	29	1	20	33	3	0	0	684	61	622	0	0	0	0	0	0
PW (1/72) 7 %		0	0	0	112	153	0	0	0	0	0	171	0	0	0	0	0	0	0	36	39	18	1	11	17	1	0	0	0	0	0	573	29	543	0	0	0
PW (1/72) 10 %		0	0	0	103	137	0	0	0	0	0	130	0	0	0	0	0	0	0	22	21	8	0	4	5	0	0	0	0	0	0	0	0	0	441	9	433

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	11	12	13	14	15	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3	3	4	158	0	76	0	76	67	0	67	56	0	56	
SLUDGE FACILITIES	35	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	4	0	4	4	0	4	3	0	3	
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	8	12	12	13	13	14	413	0	101	0	101	72	0	72	42	0	42
SECONDARY PUMPING	33	2	2	2	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	5	5	5	6	6	6	7	109	0	44	0	44	30	0	30	16	0	16
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	47	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	47	0	9	0	9	6	0	6	3	0	3
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	3	3	3	3	85	0	17	0	17	11	0	11	6	0	6
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	4	0	4	3	0	3
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	4	0	4	3	0	3
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	43	0	12	0	12	6	0	6	4	0	4
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		12	13	14	15	17	8	8	8	8	8	17	17	17	17	18	18	19	21	22	28	29	31	31	35	1061	0	294	0	0	721	0	0	565	0	0	
PW (BEGIN PER) 5 3/4		11	12	13	14	15	7	7	7	7	7	16	16	16	16	17	17	18	19	20	25	25	26	26	30	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/4%		11	11	11	12	12	5	5	5	5	5	9	8	8	7	7	7	7	7	55	52	27	22	16	16	15	0	0	294	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		11	12	13	14	15	7	7	7	7	7	15	15	15	15	16	16	17	18	19	27	27	22	16	16	15	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%		11	11	11	11	11	5	5	5	5	5	9	8	8	7	7	7	7	7	49	102	124	123	129	130	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 10%		10	11	12	13	14	7	7	7	7	7	15	15	15	15	16	16	17	18	19	25	25	21	17	17	17	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%		10	10	10	10	9	4	4	4	4	3	5	5	4	4	4	4	3	3	3	5	3	3	2	2	2	0	0	0	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											
EXPANC TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPANC TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
% 3/8% CRF		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
7 % CRF		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
10 % CRF		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

TOTAL ANNUAL CAPITAL																																					
TOTAL ANNUAL O&M																																					
TOTAL ANNUAL COST																																					

- - - - - - ANNUAL REVENUE REQUIREMENTS AT [illegible] - - - - - -

TOTAL ANNUAL CAPITAL																																					
TOTAL ANNUAL O&M																																					
TOTAL ANNUAL COST																																					

- - - - - - ANNUAL REVENUE REQUIREMENTS AT [illegible] - - - - - -

TOTAL ANNUAL CAPITAL																																					
TOTAL ANNUAL O&M																																					
TOTAL ANNUAL COST																																					

WASTEWATER MANAGEMENT | SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AREA | THREE RIVERS WATERSHED AREA

AUBURN PLANT SIZE: 0.84(MGD) SOIL-T YPE:CHILI APPLICATION RATE: 60 IN/YR AUBURN PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL W					0.22	0.23	0.24	0.26	0.27	0.28	0.29	0.30	0.32	0.33	0.34	0.35			0.36	0.37	0.38	0.39	0.41	0.53	0.61
						0.44						0.39										0.52	0.62	0.74	0.76
TREATMENT PLANT CAPACITY (MG							0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07			0.08	0.08	0.08	0.08	0.10	0.11	0.13
SLUDGE DISCHARGED (TPD)													36	37	38	40			41	42	43	44	46	69	79
WINTER STORAGE (MG)													72	74	76	78			80	83	85	87	103	119	137
LAND AREA (ACRE)																									

PLAN C PLANT 9 — - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - — PLAN F PLANT A

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	TOTAL PRESENT EXPEND	WORTH AT 5 3/8% RESID	WORTH AT 5 3/8% NET	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	50	17	24	7	28	22	9	22	14	9	19
EXPAND TO LEVEL I	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL J	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	336	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	336	67	221	5	219	194	2	194	194	2	194
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	0	0	0	0	210	0	0	0	0	0	0	0	0	0	0	0	0	0	105	0	0	0	0	210	0	525	242	247	25	227	210	9	210	167	7	165
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	63	0	0	0	0	0	0	0	63	0	0	0	0	63	0	189	63	68	5	63	54	2	51	36	1	34
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	14	35	1	34	30	0	29	17	0	29
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	125	0	130	0	120	0	0	615	89	239	7	232	183	3	186	129	3	128
RESERVOIR AREA CLEAR	10	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0	62	0	60	0	64	0	94	377	94	90	7	83	65	3	61	38	3	37
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	52	0	0	0	0	0	0	0	11	0	12	0	12	0	0	35	126	56	10	46	46	4	41	34	1	33
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	63	0	0	0	0	0	0	0	8	0	9	0	9	0	7	72	5	196	83	57	6	51	45	30	3	41	30	0	29
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	82	0	0	0	0	0	0	0	7	0	8	0	7	0	6	28	0	76	28	29	2	27	27	22	2	22	26	0	24
SLUDGE MANAGEMENT	19	0	0	0	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	59	0	148	47	63	4	58	55	2	52	44	0	44
MISCELLANEOUS	33	0	0	0	0	21	0	0	0	0	0	9	0	0	0	0	0	0	0	1	0	20	1	1	1	0	79	0	31	0	31	26	0	26	20	0	20
TOTAL		0	0	0	29	290	0	0	0	336	0	976	0	0	0	0	15	0	0	0	267	260	260	29	263	447	2721	980	1147	71	1095	965	34	930	718	8	709
Pw (11/72) 5 3/8%		0	0	0	23	235	0	0	0	221	0	549	0	0	0	0	7	0	0	0	104	79	55	5	36	46	0	0	1167	71	1095	0	0	0	0	0	0
Pw (11/72) 7 %		0	0	0	20	221	0	0	0	205	0	492	0	0	0	0	5	0	0	0	75	54	36	3	19	24	3	0	0	0	0	965	34	930	0	0	0
Pw (11/72) 10 %		0	0	0	18	198	0	0	0	196	0	222	0	0	0	0	3	0	0	0	48	29	16	1	7	7	0	0	0	0	0	0	0	0	718	8	709

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	TOTAL PRESENT EXPEND	WORTH AT 5 3/8% RESID	WORTH AT 5 3/8% NET	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	24	26	28	31	33	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	4	4	5	5	6	280	0	152	0	152	137	0	137	118	0	118
SLUDGE FACILITIES	35	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	4	0	4	4	0	4	3	0	3
SEWERS	50	3	3	3	3	3	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	40	0	10	0	10	7	0	7	4	0	4
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	0	0	0	0	0	18	18	18	18	18	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	959	0	238	0	238	177	0	177	100	0	100
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	6	6	6	6	8	8	9	9	10	11	113	0	67	0	67	45	0	45	23	0	23
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	3	3	3	3	90	0	18	0	18	12	0	12	6	0	6
RESERVOIR AREA CLEAR	10	0	0	0	0	0	0	0	0	0	0	3	2	2	2	2	2	2	3	5	5	3	4	4	5	5	136	0	29	0	28	18	0	18	9	0	9
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	4	4	5	5	5	5	6	161	0	35	0	35	23	0	23	12	0	12
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	4	0	4
SLUDGE MANAGEMENT	19	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	43	0	12	0	12	9	0	9	6	0	6
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		28	30	32	35	37	20	20	20	21	22	76	77	77	78	78	79	79	80	82	84	86	87	88	89	90	2101	0	596	0	0	443	0	0	282	0	0
Pw (1972$ PRES. V. P		28	28	29	30	32	15	15	15	17	17	18	30	30	30	30	32	34	34	34	192	231	244	256	269	278	0	0	0	0	0	0	0	0	0	0	0
Pw (12/72) 5 3/8%		27	26	26	27	27	11	11	11	12	12	12	20	20	20	20	21	22	22	22	29	31	33	33	34	35	439	0	76	0	0	0	0	0	0	0	0
Pw (1972$ PRES. V.		26	26	27	28	29	13	14	14	16	16	17	28	28	29	29	30	32	32	32	184	221	233	244	257	266	261	265	0	0	0	0	0	0	0	0	0	0
Pw (11/72) 7%		23	23	23	24	24	10	9	9	9	9	9	14	13	12	11	11	11	10	10	54	66	55	46	39	34	0	0	0	0	0	459	0	0	0	0	0
Pw (1972$ PRES. V.		22	24	24	25	25	9	9	9	10	10	10	17	16	15	14	14	14	13	12	170	204	218	230	233	240	0	0	0	0	0	0	0	0	0	0	0
Pw (11/72) 10%		21	21	21	21	21	8	7	7	7	6	6	10	9	8	7	7	7	6	6	50	62	55	45	39	34	0	0	0	0	0	301	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	TOTAL PRESENT EXPEND	WORTH AT 5 3/8% RESID	WORTH AT 5 3/8% NET	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	2	2	2	3	3	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											
EXPAND TO LEVEL I	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL J	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	0	0	0	0	0	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	20	0	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	25	29	29	29	29	29											
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	5	4	4	4	4	4	4	4	4	5	6	6	6	7	8											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	18	18	18	18	18	18	18	18	18	45	45	45	45	44	44											
RESERVOIR AREA CLEAR	10	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7	12	12	13	13	13	13	13											
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	5	5	7	8	8	9	9											
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7	8	8	9	9	9	9	9											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	3	4	4	4	4	5	5											
SLUDGE MANAGEMENT	19	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4											
MISCELLANEOUS	33	0	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	4	4	4	4	4	4											
% TYPE TAX		0	0	0	2	17	22	26	22	19	18	78	78	74	74	74	79	79	79	79	54	126	122	114	133	134											
5 3/8% TAX		0	0	0	2	15	24	24	24	44	48	55	55	55	55	55	55	55	55	55	134	135	134	134	133	134											
10% TAX		0	0	0	3	33	51	55	55	66	66	129	129	129	129	129	133	133	133	133	174	181	179	179	177	178											

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

CAPITAL AND VARIABLE AT 7 YEAR

TOTAL ANN. $ AT 7%																																					
TOTAL ANN. $																																					
TOTAL ANN. P																																					

TOTAL ANN. $ AT 5 3/8% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
TOTAL ANN. $ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
TOTAL ANN. P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

TOTAL ANN. $ AT 10% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
TOTAL ANN. $ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
TOTAL ANN. P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

WASTEWATER MANAGEMENT SUBAREA SCALE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

SHALERSBORO PLANT SIZED 2,000,000 GPD SIZED FOR FLOW APPLICATION RATE 60 IN/YR SHALERSBORO PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL				0.71	0.73	0.76	0.78	0.81	0.84	0.87	0.90	0.92	0.95	0.98	1.01		1.04	1.07	1.09	1.12	1.27	1.42	1.58	1.73	1.88	2.03
TREATMENT PLANT CAPACITY (MGD)					1.27						1.12									1.42	1.58	1.73	1.88	2.03	2.18
SLUDGE DISCHARGES (TPCD)						0.16	0.16	0.17	0.18	0.18	0.19	0.19	0.20	0.21	0.21		0.22	0.22	0.23	0.24	0.27	0.31	0.33	0.36	0.39	0.42
WINTER STORAGE (MG)												104	107	111	114		118	121	124	127	144	161	176	192	210	228
LAND AREA (ACRES)												206	213	219	227		233	239	244	251	284	318	354	385	417	448

PLAN C PLANT ID

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8R NET	PRESENT EXPEND	WORTH AT RESID	% 7R NET	PRESENT EXPEND	WORTH AT RESID	10R NET
PLANTS	35	1	2	3	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	28	36	2	37	35	1	34	31	3	30
EXPAND TO LEVEL 1	25	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXPN.	35	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	1	2	3	0	0	0	556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	556	111	365	8	356	123	4	119	259	1	258
SEWER EXPANSION	50	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OPTEN/TECH PAGING	50	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	19	1	2	3	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	1	2	3	94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	0	0	0	0	0	0	94	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	1	2	3	140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	0	0	0	0	0	0	0	0	0
RESERVOIR ADD'L CAP.	50	1	2	3	0	0	0	0	0	0	0	360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	360	0	0	0	0	0	0	0	0	0	0
RESERVOIR ADD'L EXP.	50	1	2	3	0	0	0	0	0	0	0	126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	126	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE (1 PARK)	50	35	2	3	0	0	0	0	0	0	0	151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	1	2	3	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	1	2	3	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	35	1	2	3	0	0	84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	33	1	2	3	0	0	40	0	0	0	0	0	25	0	0	0	0	2	0	0	0	0	3	31	3	3	2	50	0	159	0	65	0	65	55	0	55	62	0	62
TOTAL			33	3	0	40	524	0	0	0	556	0	1338	0	0	0	0	0	0	509	636	459	58	491	827	228	5246	1746	2288	141	2146	1894	88	1825	1412	17	1394
Pw (1/72) 5 3/8			33	3	0	34	424	0	0	0	365	0	782	0	0	0	0	0	0	20	0	0	0	358	133	106	10	67	86	18	0	0	2288	141	2146	0	0	0	0	0	0
Pw (1/72) 7 R			33	3	0	32	395	0	0	0	323	0	679	0	0	0	0	0	0	15	0	0	0	190	91	68	6	37	45	5	0	0	0	0	0	1894	68	1825	0	0	0
Pw (1/72) 10 R			33	3	0	30	357	0	0	0	259	0	516	0	0	0	0	0	0	10	0	0	0	91	48	31	2	13	14	2	0	0	0	0	0	0	0	0	1412	17	1394

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8R NET	PRESENT EXPEND	WORTH AT RESID	7R NET	PRESENT EXPEND	WORTH AT RESID	10R NET
PLANTS	35	2	2	2	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	5	6	6	7	7	8	231	0	64	0	64	48	0	48	31	0	31
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	80	0	21	0	21	15	0	15	9	0	9
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	19	23	24	25	25	25	25	25	25	25	25	25	25	25	29	29	29	29	29	30	31	32	33	34	35	36	1870	0	469	0	469	336	0	336	197	0	197
SECONDARY PUMPING	33	1	2	3	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	11	13	13	14	15	16	17	17	425	0	96	0	96	65	0	65	31	0	31
FORCE MAINS	50	1	2	3	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	3	3	3	82	0	16	0	16	10	0	10	5	0	5
RESERVOIR ADD'L CAP.	50	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	8	8	8	9	10	11	12	12	13	361	0	70	0	70	53	0	53	28	0	28
LAND PURCHASE (1 PARK)	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	8	8	10	11	12	14	15	355	0	78	0	78	52	0	52	27	0	27
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	3	3	3	89	0	19	0	19	13	0	13	7	0	7
SLUDGE MANAGEMENT	35	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	73	0	18	0	18	12	0	12	7	0	7
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		2	2	2	3	3	30	31	31	33	33	33	61	61	62	63	63	64	67	78	95	103	110	116	118	0	3657	0	872	0	874	593	0	593	349	0	349
Pw 1DEGIN PAR. 5 3/8			1	1	1	2	2	28	29	29	31	31	31	57	57	54	54	54	54	54	60	62	63	63	64	64	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 1/72 7 R			1	1	1	2	2	21	21	20	20	19	32	32	32	32	32	32	32	32	32	32	32	32	32	32	0	917	0	0	0	0	0	0	0	0	0	0	0	0
Pw 1DEGIN DEBT 7 R			1	1	1	2	2	28	28	28	30	30	32	47	47	44	44	44	44	58	60	62	63	63	64	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 10 7 R			1	1	1	2	2	26	26	26	28	28	30	44	44	41	41	41	41	54	56	58	59	59	60	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 1DEGIN DEBT 10 R			1	1	1	2	2	24	24	24	26	26	28	41	41	38	38	38	38	50	52	54	55	55	56	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw 10 10 R			1	1	1	2	2	24	24	24	26	26	28	41	41	38	38	38	38	50	52	54	55	55	56	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pw (1/72) 10 R			1	1	1	2	1	15	15	14	13	12	11	16	16	15	15	13	12	12	12	12	12	12	12	11	7	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7R IN $1000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8R NET	PRESENT EXPEND	WORTH AT RESID	10R NET
PLANTS	35	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE FAC. EXPN.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SEWERS	50	0	0	0	0	0	0	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40								
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
OPTEN/TECH PAGING	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
AERATED LAGOONS	19	0	0	0	32	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30								
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	14	16	16	16	16	16								
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	13	10	10	10	10	10	10	10	10	10	10	10	10	10								
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46								
RESERVOIR ADD'L CAP.	50	0	0	0	0	0	0	0	0	0	0	0	23	21	21	21	21	21	21	21	21	21	21	21	21	21								
LAND PURCHASE (1 PARK)	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	11	11	11	11	11	12	12	12	14	15	16	17	18	19								
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5								
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
5 3/8E CRF			1	1	1	4	37	37	37	37	69	69	161	161	161	161	161	161	161	161	161	161	161	161	161	161								
7 E CRF			2	2	2	5	44	44	44	44	86	86	196	196	196	196	196	197	197	197	197	197	197	197	197	197								
10 E CRF			3	3	3	7	61	61	61	61	117	117	261	261	261	261	261	261	261	261	261	261	261	261	261	261								

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
TOTAL ANNUAL CAPITAL	1	1	1	4	37	37	37	37	69	69	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161
TOTAL ANNUAL O&M	2	2	2	3	3	31	33	33	33	61	61	94	94	94	97	97	97	98	101	112	120	127	133	134	134
TOTAL ANNUAL COSTS	3	3	3	7	40	67	68	68	102	130	222	255	255	255	258	258	258	259	262	273	281	288	294	295	295

CAPITAL RECOVERY FACTOR AT 5 3/8E

TOTAL ANNUAL CAPITAL	1	1	1	4	37	37	37	37	69	69	161	161	161	161	161	161	161	161	161	161	161	161	161	161	161
TOTAL ANNUAL O&M	2	2	2	3	3	31	33	33	33	61	61	94	94	94	97	97	97	98	101	112	120	127	133	134	134
TOTAL ANNUAL	3	3	3	7	40	67	68	68	102	130	222	255	255	255	258	258	258	259	262	273	281	288	294	295	295

CAPITAL RECOVERY FACT R AT 7 E

TOTAL ANN E CAPITAL	2	2	2	5	44	44	44	44	86	86	196	196	196	196	197	197	197	197	197	197	197	197	197	197	197
TOTAL ANNUAL O&M	2	2	2	3	3	31	33	33	33	61	61	94	94	94	97	97	97	98	101	112	120	127	133	134	134
TOTAL ANNUAL	4	4	4	8	47	74	77	77	119	147	257	289	289	289	293	293	293	294	297	308	316	323	329	330	330

CAPITAL RECOVERY FACTOR AT 10 E

TOTAL ANN E CAPITAL	3	3	3	7	61	61	61	61	117	117	261	261	261	261	261	261	261	261	261	261	261	261	261	261	261
TOTAL ANNUAL O&M	2	2	2	3	3	31	33	33	33	61	61	94	94	94	97	97	97	98	101	112	120	127	133	134	134
TOTAL ANNUAL	5	5	5	10	64	92	94	94	150	178	322	355	355	355	358	358	358	359	362	373	381	388	394	395	395

WASTEWATER MANAGEMENT — SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AREA — THREE RIVERS WATERSHED AREA

RAVENNA PLANT — SIZE: 12.34(MGD) — SOIL-T YPE(CHILL) — APPLICATION RATE: 01 IN/YR — RAVENNA PLANT

- - - - - - BASIC DESIGN DATA - - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL G				2.70	2.83	2.96	3.09	3.22	3.35	3.56	3.76	3.97	4.17	4.38	4.59	4.79	5.00	5.20	5.41	6.97	8.53	9.57	10.63	11.67	12.34
					6.97						5.41								5.41			9.57	10.63	11.67	12.34
TREATMENT PLANT CAPACITY (MGD)						0.82	0.85	0.88	0.70	0.75	0.79	0.83	0.88	0.92	0.97	1.04	1.05	1.09	1.14	1.46	1.80	2.01	2.23	2.45	2.59
SLUDGE DISCHARGES (TPY)											425	446	471	495	519	561	565	588	622	788	964	1082	1198	1296	1394
WINTER STORAGE (MG)											862	889	934	981	1028	1072	1120	1165	1212	1561	1911	2144	2374	2569	2764
LAND AREA (ACRES)																									

PLAN C PLANT II — - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - — PLAN C PLANT II

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	0	0	250	85	124	7	116	3	108	47	0	96
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE HAUL EQPT	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	1479	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1479	147	1261	126	1250	1204	5	1199	1158	5	1187
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ABRATED LAGOONS	35	0	0	0	0	1320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1040	0	0	0	1320	0	3642	1524	1521	123	1397	1299	50	1239	1206	24	1209
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	180	0	0	0	0	0	0	0	180	0	0	0	0	0	0	542	180	195	14	181	154	7	147	126	7	105
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	1242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1242	248	736	34	709	629	11	618	549	12	479
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	1770	0	0	0	0	0	0	0	740	0	760	0	760	0	0	4032	1764	1616	244	1472	1289	64	1220	1069	77	872
RESERVOIR AER & CL	30	0	0	0	0	0	0	0	0	0	0	925	0	0	0	0	0	0	0	815	0	900	0	990	0	990	4629	990	1252	80	1172	756	38	718	448	5	438
LAND PURCHASE & PRES	50	0	0	0	0	0	0	0	0	0	0	751	0	0	0	0	0	0	0	232	233	155	155	155	130	130	1830	1835	725	148	576	577	71	506	395	14	381
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	725	0	0	0	0	0	0	0	325	195	130	130	130	130	130	2525	1073	781	82	698	602	39	563	498	14	484
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	415	0	0	0	0	0	0	0	142	142	93	79	79	79	79	1133	374	433	30	403	344	14	329	334	15	319
SLUDGE MANAGEMENT	35	0	0	0	0	223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	139	0	0	0	223	0	585	222	244	17	226	210	8	202	171	7	164
MISCELLANEOUS	15	0	0	0	0	132	0	0	0	0	0	0	0	0	0	0	0	0	0	44	139	29	24	21	189	2	711	0	177	9	277	228	0	228	170	5	170
TOTAL		0	0	0	1601	1675	0	0	0	0	0	5725	0	0	0	0	0	0	0	2477	1834	2067	388	2217	2593	1042	20331	8468	8565	685	8283	7610	336	7079	6537	84	6452
PW (1/72) 5 3/8%		0	0	0	1360	1359	0	0	0	0	0	3389	0	0	0	0	0	0	0	986	550	477	69	343	310	84	0	0	8965	685	8283	0	0	0	0	0	0
PW (1/72) 7 %		0	0	0	1304	1278	0	0	0	0	0	2908	0	0	0	0	0	0	0	733	386	315	43	155	162	45	0	0	0	0	0	7610	282	7079	0	0	0
PW (1/72) 10 %		0	0	0	1202	1144	0	0	0	0	0	2209	0	0	0	0	0	0	0	465	205	162	16	59	60	16	0	0	0	0	0	0	0	0	5537	84	5452

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	202	214	246	267	295	4	5	5	6	6	6	6	6	6	8	8	8	8	12	13	17	19	21	22	24	1853	0	1180	0	1180	1090	0	1090	997	0	997
SLUDGE FACILITIES	35	8	9	10	11	12	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	50	0	42	0	42	40	0	40	37	0	37
SEWERS	50	3	3	3	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	315	0	106	0	106	77	0	77	51	0	51
TEMPORARY PUMPS	5	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ABRATED LAGOONS	35	0	0	0	0	0	73	75	77	79	80	82	85	87	89	90	92	93	95	100	115	129	144	160	180	192	201	211	6152	0	1469	1043	0	1042	604	0	604
SECONDARY PUMPING	15	3	3	3	0	0	0	0	0	0	0	0	31	32	33	34	36	37	38	44	57	65	71	77	82	86	2326	0	482	0	482	321	0	321	162	0	162
FORCE MAINS	50	3	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	6	6	6	6	6	6	6	221	0	53	0	53	33	0	33	20	0	20
STORAGE RESERVOIRS	50	3	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	9	13	14	16	16	16	16	16	523	0	114	0	114	77	0	77	40	0	40
RESERVOIR AER & CL	30												32	32	32	33	33	33	34	48	49	54	45	25	76	78	2139	0	452	0	452	301	0	301	193	0	193
LAND PURCHASE & PRES	50												0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	35												29	29	29	30	31	32	33	43	45	53	55	62	62	62	1861	0	356	0	356	266	0	266	136	0	136
DRAINAGE SYSTEMS	50												7	7	8	8	8	8	9	10	12	13	15	16	17	17	479	0	106	0	100	67	0	67	36	0	36
SLUDGE MANAGEMENT	35												4	4	4	4	4	4	4	5	6	7	8	9	10	10	257	0	95	0	95	67	0	67	38	0	38
MISCELLANEOUS	15												0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		210	233	264	288	320	85	87	89	92	93	95	228	232	240	246	248	252	258	324	341	441	467	507	524	0	16347	0	4467	0	0	3388	0	0	2247	0	0
PW (1/72) 5 3/8 %		193	222	242	257	262	64	64	64	64	64	64	215	215	215	215	215	215	215	244	1374	1674	1945	2179	2179	2241	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %		196	219	243	264	294	73	73	73	73	73	73	221	221	221	221	221	221	221	251	517	552	665	370	361	335	0	0	4476	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %		191	217	239	264	294	77	77	77	77	77	77	227	227	227	227	227	227	227	251	1321	1512	1808	2002	1834	1685	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 12 %		188	213	238	263	294	80	80	80	80	80	80	233	233	233	233	233	233	233	251	1316	1496	1763	1968	1927	1799	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 15 %		185	209	234	261	294	85	85	85	85	85	85	239	239	239	239	239	239	239	251	1316	1463	1763	1968	1927	1799	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS																																					
EXPAND TO LEVEL																																					
EXPAND TO LEVEL																																					
SLUDGE FACILITIES																																					
SLUDGE HAUL EQPT																																					
SEWERS																																					
SEWER EXPANSION																																					
DETENTION BASINS																																					
BASIN EXPANSION																																					
TEMPORARY PUMPS																																					
SHAFTS & TUNNELS																																					
ABRATED LAGOONS																																					
SECONDARY PUMPING																																					
FORCE MAINS																																					
STORAGE RESERVOIRS																																					
RESERVOIR AER & CL																																					
LAND PURCHASE & PRES																																					
IRRIGATION SYSTEMS																																					
DRAINAGE SYSTEMS																																					
SLUDGE MANAGEMENT																																					
MISCELLANEOUS																																					
TOTAL																																					
PW (1/72) 5 3/8 %																																					
PW (1/72) 7 %																																					
PW (1/72) 10 %																																					
PW (1/72) 12 %																																					
PW (1/72) 15 %																																					

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

FACTOR OF EVERY YEAR AT 7 %

FACTOR OF EVERY YEAR AT 7 %

FACTOR OF EVERY YEAR AT 7 %

WASTEWATER MANAGEMENT SUBJECT SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHEDS AREA

AURORA CENTRAL PLANT SIZE: 2.4 MGD SOIL: PRETREATMENT APPLICATION RATE: 40 IN/YR AURORA CENTRAL PLANT

- - - - - - BASIC DESIGN DATA - - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL Q				0.410	0.448	0.486	0.524	0.562	0.600	0.672	3.744	0.816	0.888	0.960	1.032	1.104	1.176	1.248	1.320	1.925	1.730	2.02	2.31	2.65	2.98
TREATMENT PLANT CAPACITY (MGD)					1.52						1.32					1.73			2.02	2.31		2.65	2.98	2.98	2.98
SLUDGE DISCHARGED (TDC)						0.10	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.20	0.21	0.23	0.25	0.26	0.28	0.32	0.36	0.42	0.49	0.56	0.63
WINTER STORAGE (MG)											63	69	75	82	88	94	ICC	106	112	130	147	172	196	225	253
LAND AREA (ACRES)											111	122	133	143	154	165	176	186	197	228	259	302	345	396	445

PLAN C PLANT 12 - - - - - - CAPITAL COSTS IN $1CCC FOR WASTEWATER - - - - - - PLAN C PLANT 12

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	1	0	0	0	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	52	0	0	104	57	51	2	48	46	1	44	40	0	40
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	960	191	631	15	616	559	7	551	448	1	446
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1080	0	0	0	0	0	0	0	1080	431	421	54	365	319	14	302	194	4	190
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	415	0	0	0	0	450	0	1315	550	536	44	492	455	21	434	341	9	333
SECONDARY PUMPING	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PARK	50	50	0	0	0	0	0	0	0	0	102	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	173	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	30	0	0	0	0	0	0	0	0	0	95	0	0	0	0	10	0	0	0	0	7	0	11	0	10	12	0	145	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	40	0	0	0	0	0	0	0	0	0	69	0	0	0	0	14	0	0	0	0	14	0	20	0	19	23	0	199	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	30	0	0	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	0	0	0	0	87	221	85	93	8	86	81	3	77	64	0	64
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	44	4	4	4	4	55	0	175	0	69	0	69	57	0	57	44	0	44
TOTAL		50	0	0	0	52	582	0	0	0	960	0	1131	0	0	0	0	55	0	0	0	1441	546	493	62	644	562	239	6750	2737	2923	221	2701	2399	106	2292	1757	27	1730
PW 11/72 - 5 3/8		50	0	0	0	52	582	0	0	0	931	0	1069	0	0	0	0	25	0	0	0	583	183	133	11	88	90	19	0	0	2923	221	2701	0	0	0	0	0	0
PW 11/72 - 7 B		50	0	0	0	52	582	0	0	0	904	0	1036	0	0	0	0	20	0	0	0	427	115	73	6	48	47	9	0	0	0	0	0	2399	106	2292	0	0	0
PW 11/72 - 10 B		50	0	0	0	52	582	0	0	0	868	0	996	0	0	0	0	13	0	0	0	260	61	34	2	17	14	2	0	0	0	0	0	0	0	0	1757	27	1730

- - - - - - O & M COSTS IN $1CCC FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	30	38	47	56	66	1	1	1	2	2	2	2	2	3	3	3	3	3	4	5	6	7	8	9	10	458	0	266	0	266	220	0	220	109	0	109
SLUDGE FACILITIES	35	2	2	3	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	12	0	12	11	0	11	10	0	10
SEWERS	50	0	0	0	0	0	0	0	0	4	4	4	4	4	5	6	7	8	10	20	20	20	20	20	20	20	350	0	81	0	81	56	0	56	30	0	30
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	14	14	14	20	20	22	23	24	25	26	26	26	27	28	32	45	48	52	55	59	1061	0	396	0	396	279	0	279	161	0	161
SECONDARY PUMPING	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	141	0	141	96	0	96	50	0	50
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	37	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	4	4	4	5	5	5	151	0	32	0	32	22	0	22	11	0	11
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	6	6	7	7	8	9	12	12	14	15	16	399	0	81	0	81	54	0	54	27	0	27
LAND PURCHASE & PARK	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	6	7	7	10	10	12	12	12	342	0	71	0	71	48	0	48	24	0	24
DRAINAGE SYSTEMS	40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	3	3	4	4	93	0	19	0	19	9	0	9	5	0	5
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3	4	4	93	0	21	0	21	14	0	14	8	0	8
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		32	40	50	60	68	22	23	23	26	26	28	31	31	41	42	45	47	50	72	76	82	89	112	120	131	135	0	4222	0	1106	0	0	819	0	0	523	0	0
PW 11/72 - 5 3/8		30	37	47	56	64	20	21	21	24	24	26	29	29	37	38	41	43	46	66	70	76	82	103	111	120	124	0	0	0	1047	0	0	0	0	0	0	0	0
PW 11/72 - 7 B		30	36	47	56	64	16	15	15	18	17	17	19	19	24	25	27	28	30	43	45	49	53	66	71	77	80	0	0	0	673	0	0	0	0	0	0	0	0
PW 11/72 - 10 B		29	35	46	54	62	13	13	13	15	14	14	16	16	20	21	22	23	25	35	37	40	43	54	58	63	65	0	0	0	548	0	0	0	0	0	0	0	0
PW 11/72 - 5 3/8		29	34	45	54	61	19	20	20	23	23	25	28	28	36	37	40	42	45	64	68	74	80	100	108	117	121	0	0	0	1020	0	0	0	0	0	0	0	0
PW 11/72 - 7 B		29	34	45	54	61	19	20	20	23	22	24	27	27	34	35	38	40	43	61	64	70	76	94	101	110	114	0	0	0	958	0	0	0	0	0	0	0	0
PW 11/72 - 10 B		29	33	44	53	60	18	19	19	22	21	23	26	26	33	34	37	39	42	59	62	68	74	91	98	107	110	0	0	0	929	0	0	0	0	0	0	0	0
PW 11/72 - 5 3/8		29	33	44	53	60	18	19	19	22	21	23	26	26	33	34	37	39	42	59	62	68	74	91	98	107	110	0	0	0	929	0	0	0	0	0	0	0	0
PW 11/72 - 7 B		29	33	44	53	60	18	19	19	22	21	23	26	26	33	34	37	39	42	59	62	68	74	91	98	107	110	0	0	0	929	0	0	0	0	0	0	0	0
PW 11/72 - 10 B		29	33	44	53	60	18	19	19	22	21	23	26	26	33	34	37	39	42	59	62	68	74	91	98	107	110	0	0	0	929	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1CDD - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4											
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	0	0	0	0	0	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	77	77	77	77	77	77	77											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	30	0	0	0	0	0	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	66	66	66	66	66											
SECONDARY PUMPING	25	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	35	35	35	35	35	35	35	35	44	44	44	44	44											
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	17	17	17	17	17	17	17	17	22	22	22	22	22											
LAND PURCHASE & PARK	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
IRRIGATION SYSTEMS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	6	6	6	6	6											
DRAINAGE SYSTEMS	40	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6	7	7	7	7	7											
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6	8	8	8	8	8											
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
* 5 3/8% CAP		1	1	1	1	9	41	41	41	41	96	96	176	176	176	176	177	177	177	177	257	251	317	321	347	353	353											
7 B CAP		1	1	1	1	8	44	44	44	44	69	69	119	119	211	211	211	211	215	215	215	215	316	395	396	340	421	420	420									
10 B CAP		1	1	1	1	8	47	47	47	47	164	164	284	284	284	284	284	284	294	294	294	294	433	487	528	534	575	586	585									

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1CDD - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL		1	1	1	1	9	41	41	41	41	96	96	176	176	176	176	177	177	177	177	257	251	317	321	347	353	353											
TOTAL ANNUAL O&M		32	40	50	60	68	22	23	23	26	26	28	31	31	41	42	45	47	50	72	76	82	89	112	120	131	135	0	4222	0	1106	0	0	819	0	0	523	0	0
TOTAL ANNUAL COSTS		33	41	51	61	77	63	64	64	67	122	124	207	207	217	218	222	224	227	249	333	333	406	433	467	484	488	0	4222	0	1106	0	0	819	0	0	523	0	0

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL		1	1	1	1	9	44	44	44	44	69	69	119	119	211	211	211	211	215	215	215	215	316	395	396	340	421	420	420									
TOTAL ANNUAL O&M		32	40	50	60	68	22	23	23	26	26	28	31	31	41	42	45	47	50	72	76	82	89	112	120	131	135	0	4222	0	1106	0	0	819	0	0	523	0	0
TOTAL ANNUAL COSTS		33	41	51	61	77	66	67	67	70	95	97	150	150	252	253	256	258	265	287	291	297	405	507	516	471	556	420	4642	0	1506	0	1301	1219	0	1101	923	0	900

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL		1	1	1	1	8	47	47	47	47	164	164	284	284	284	284	284	284	294	294	294	294	433	487	528	534	575	586	585									
TOTAL ANNUAL O&M		32	40	50	60	68	22	23	23	26	26	28	31	31	41	42	45	47	50	72	76	82	89	112	120	131	135	0	4222	0	1106	0	0	819	0	0	523	0	0
TOTAL ANNUAL COSTS		33	41	51	61	77	69	70	70	73	190	192	315	315	325	326	329	331	344	366	370	376	522	599	648	665	710	586	4642	0	1506	0	1301	1219	0	1101	923	0	900

FAIRMOUNT ROAD PLANT — SIZE: 3.5 MGD — SOIL: E WPE(MSC) — APPLICATION RATE: .5 IN/YR — FAIRMOUNT ROAD PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL C																									
TREATMENT PLANT CAPACITY (MGD)				3.31	3.55	0.40	0.45	0.49	0.54	0.64	0.74	0.84	0.94	1.05	1.15	1.25	1.35	1.45	1.55	1.85	2.14	2.47	2.80	3.10	3.40
					1.85						1.45								2.14	2.47	2.80	3.10	3.40	3.40	
SLUDGE DISCHARGE (DRY TPD)						0.08	0.10	0.10	0.11	0.13	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.33	0.33	0.35	0.45	0.52	0.56	0.65	0.73
WINTER STORAGE (MG)												95	106	119	130	141	153	164	175	209	242	276	310	350	384
LAND AREA (ACRES)												188	211	235	258	280	302	325	347	414	479	553	627	694	762

PLAN C PLANT 13

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

PLAN C PLANT 13

	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	112	35	55	3	52	49	1	48	43	0	43
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	720	74	615	5	609	587	2	584	560	0	560
SEWER EXPANSION	50	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	458	0	0	0	0	0	0	461	145	194	16	178	167	7	139	99	8	87
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	520	0	0	0	0	0	0	0	0	0	0	0	0	0	445	0	0	0	520	0	1445	539	567	43	554	510	21	489	409	5	403
SECONDARY PUMPING	25	0	0	0	0	0	0	0	0	0	0	139	0	0	0	0	0	0	0	139	0	0	0	0	139	417	135	151	11	139	131	5	113	81	1	74
FORCE MAINS	40	0	0	0	0	0	0	0	0	0	0	385	0	0	0	0	0	0	0	0	0	0	0	0	0	385	92	227	7	220	195	3	181	148	0	147
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	715	0	0	0	0	0	0	295	0	335	0	325	0	0	1670	1124	660	91	569	525	43	481	367	11	349
RESERVOIR REC. &	50	0	0	0	0	0	0	0	0	0	0	192	0	0	0	0	0	0	218	0	0	292	0	340	0	1342	340	320	27	292	228	13	214	151	3	130
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	173	0	0	0	37	0	0	0	44	44	48	48	45	45	0	504	190	40	149	150	19	130	101	4	96
IRRIGATION SYSTEMS	25	0	0	0	0	0	0	0	0	0	0	101	0	0	0	45	0	0	0	49	58	37	36	33	165	65	659	280	194	22	171	16	137	94	2	86
DRAINAGE SYSTEMS	40	0	0	0	0	0	0	0	0	0	0	104	0	0	0	16	0	0	0	27	26	30	29	28	27	0	327	144	115	8	107	4	87	61	1	60
SLUDGE MANAGEMENT	30	0	0	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	0	0	0	95	0	239	93	101	7	94	3	84	71	0	71
MISCELLANEOUS	33	0	0	0	0	52	0	0	0	0	0	28	0	0	0	9	0	0	0	7	48	7	7	7	67	2	234	0	91	0	91	75	0	75	57	0	57
TOTAL		0	0	0	776	667	0	0	0	0	0	1867	0	0	0	147	0	0	0	1277	62C	756	120	834	1C88	367	8014	3530	3516	295	3230	2918	137	2780	2197	35	2162
PW (5/8%) & 10%		0	0	0	0	465	4C	0	0	0	0	1105	0	0	0	70	0	0	0	499	286	17C	22	614	724	33	0	0	3526	295	3230	0	0	0	0	0	0
PW (7%) & 10%		0	0	0	633	5C4	0	0	0	0	0	998	0	0	0	57	0	0	0	377	13C	11C	12	63	59	15	0	0	0	0	0	2918	137	2780	0	0	0
PW (10%) & 10 %		0	0	0	502	455	0	0	0	0	0	720	0	0	0	38	0	0	0	229	65	50	5	27	19	3	0	0	0	0	0	0	0	0	2197	35	2162

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	0	0	1	1	1	1	1	1	1	1	2	3	3	3	3	3	4	5	6	7	8	9	10	11	395	0	171	0	171	148	0	148	121	0	121
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	5	6	6	6	6	6	225	0	60	0	60	44	0	44	27	0	27
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	20	21	22	23	24	26	27	29	30	31	32	33	34	38	53	58	61	64	67	1932	0	453	0	453	359	0	359	182	0	182
SECONDARY PUMPING	25	0	0	0	0	0	0	0	0	0	0	0	12	12	13	13	14	14	15	22	24	25	27	29	31	33	404	0	190	0	190	127	0	127	64	0	64
FORCE MAINS	40	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	74	0	12	0	12	12	0	12	6	0	6
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	5	5	7	7	7	7	7	225	0	48	0	48	32	0	32	16	0	16
RESERVOIR REC. & [illegible]	50	2	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	2	3	3	0	0	0	0	0	0	0	0	10	10	11	11	11	11	11	13	14	16	18	19	19	19	576	0	124	0	124	84	0	84	43	0	43
IRRIGATION SYSTEMS	25	1	1	1	0	0	0	0	0	0	0	0	1	1	2	2	2	2	2	3	3	3	4	4	4	4	116	0	23	0	23	15	0	15	7	0	7
SLUDGE MANAGEMENT	30	1	2	2	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	3	3	3	4	4	108	0	24	0	24	17	0	17	9	0	9
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		4	14	29	43	53	27	27	28	29	29	30	70	72	77	81	83	84	87	107	110	144	157	165	172	0	5154	0	1238	0	0	983	0	0	522	0	0
PW (5 3/8%) & 10%		4	13	27	40	52	25	25	26	27	27	28	64	66	68	73	76	78	80	98	101	132	144	151	158	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (7%) & 10%		4	13	26	36	46	22	21	21	21	21	21	50	51	53	56	57	58	60	68	70	91	99	104	109	0	0	0	1238	0	0	0	0	0	0	0	0	0
PW (10%) & 10%		4	12	25	33	42	20	19	19	19	19	19	44	45	47	49	50	51	52	59	61	79	86	90	94	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (5 3/8%) & 10%		4	13	27	40	52	25	25	26	27	27	28	64	66	68	73	76	78	80	98	101	132	144	151	158	0	5154	0	1238	0	0	983	0	0	522	0	0
PW (7%) & 10%		4	13	26	36	46	22	21	21	21	21	21	50	51	53	56	57	58	60	68	70	91	99	104	109	0	0	0	1238	0	0	0	0	0	0	0	0	0
PW (10%) & 10%		4	12	25	33	42	20	19	19	19	19	19	44	45	47	49	50	51	52	59	61	79	86	90	94	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	[illegible]																																				
EXPAND TO LEVEL 1	25	[illegible]																																				
EXPAND TO LEVEL 2	25	[illegible]																																				
SLUDGE FACILITIES	35	[illegible]																																				
SLUDGE FAC. EXP.	35	[illegible]																																				
SEWERS	50	[illegible]																																				
SEWER EXPANSION	50	[illegible]																																				
DETENTION BASINS	50	[illegible]																																				
BASIN EXPANSION	50	[illegible]																																				
TEMPORARY PUMPS	4	[illegible]																																				
SHAFTS & TUNNELS	50	[illegible]																																				
AERATED LAGOONS	30	[illegible]				33	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
SECONDARY PUMPING	25	[illegible]																																				
FORCE MAINS	40	[illegible]																																				
STORAGE RESERVOIRS	50	[illegible]																																				
RESERVOIR REC. & [illegible]	50	[illegible]																																				
LAND PURCHASE & PREP	50	[illegible]																																				
IRRIGATION SYSTEMS	25	[illegible]																																				
DRAINAGE SYSTEMS	40	[illegible]																																				
SLUDGE MANAGEMENT	30	[illegible]																																				
MISCELLANEOUS	33	[illegible]																																				
[illegible]		[illegible]																																				
[illegible]		[illegible]																																				
[illegible]		[illegible]																																				

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

ANNUAL REVENUE REQUIRED AT [illegible]

[illegible]																																						
[illegible]																																						
[illegible]																																						

ANNUAL REVENUE REQUIRED AT [illegible]

[illegible]																																						
[illegible]																																						
[illegible]																																						

ANNUAL REVENUE REQUIRED AT [illegible]

[illegible]																																						
[illegible]																																						
[illegible]																																						

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

POWLER'S MILL PLANT SIZE: 1.2 MGD SOIL-Y YPSILANTI APPLICATION RATE: 60 IN/YR POWLER'S MILL PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL -				0.51	0.55	0.57	0.59	0.62	0.64	0.67	0.69	0.73	0.75	0.78	0.80	0.82	0.84	0.86	0.88	1.01	1.14	1.34	1.54	1.76	1.98
TREATMENT PLANT CAPACITY (MGD)					1.01						0.98								1.14	1.34	1.54	1.76	1.98	1.98	1.98
SLUDGE DISCHARGED (MGD)						0.22	0.22	0.23	0.23	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.16	0.18	0.19	0.21	0.24	0.32	0.37	0.42	
WINTER STORAGE (MG)												82	85	88	90	184	189	193	197	228	255	300	345	394	444
LAND AREA (ACRES)												184	188	175	179										

PLAN C PLANT 1A

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	40	28	30	2	37	35	0	34	31	0	30
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	979	97	837	7	829	798	3	795	735	0	734
SEWERS	50	0	0	0	979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	25	0	0	0	0	369	0	0	0	0	0	0	0	0	0	0	0	0	0	339	0	0	0	0	0	0	1025	427	416	34	381	352	16	336	276	4	274
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	252	84	91	6	84	72	3	68	48	0	48
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105	29	62	2	60	53	0	52	40	0	40
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105	29	62	2	60	53	0	52	40	0	40
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	105	0	0	0	0	0	0	0	0	0	0	0	1140	301	434	24	410	343	11	332	234	3	231
LAND PURCHASE & PREP	50	20	0	0	0	0	0	0	0	0	0	0	0	0	128	0	0	0	0	0	0	0	0	0	0	0	827	215	194	17	177	138	8	130	81	2	78
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	116	0	0	0	0	0	0	0	0	0	0	0	0	304	234	24	210	221	11	64	82	3	79
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	93	0	0	0	0	0	0	0	0	0	0	0	0	176	113	14	99	87	6	80	58	1	56
SLUDGE MANAGEMENT	35	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	302	176	113	14	99	87	6	80	58	1	56
MISCELLANEOUS	33	0	0	0	0	36	0	0	0	0	0	20	0	0	2	0	0	0	0	3	36	4	4	5	45	8	153	6	59	0	59	48	0	48	37	0	37
TOTAL		20	0	0	1019	485	0	0	0	0	0	1084	0	0	0	35	0	0	0	445	457	486	75	593	748	227	5526	1804	2536	144	2390	2170	70	2098	1725	18	1707
PW (1/1721) 5 3/8%		20	0	0	971	372	0	0	0	0	0	642	0	0	0	25	0	0	0	173	137	112	15	81	78	18	0	0	2536	146	2390	0	0	0	0	0	0	0
PW (1/1721) 7%		20	0	0	951	350	0	0	0	0	0	551	0	0	0	12	0	0	0	131	96	72	8	49	42	8	0	0	0	0	0	2170	70	2098	1725	18	1707
PW (1/1721) 10 %		20	0	0	765	317	0	0	0	0	0	419	0	0	0	8	0	0	0	80	51	33	3	16	12	2	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	61	66	71	77	82	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	5	6	7	8	528	0	343	0	343	317	0	317	282	0	282
SLUDGE FACILITIES	35	4	5	5	5	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	19	0	19	18	0	18	17	0	17
SEWERS	50	3	3	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190	0	57	0	57	44	0	44	29	0	29
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	25	0	0	0	0	0	16	16	16	16	16	17	17	17	18	18	19	19	20	20	24	29	34	36	40	42	1280	0	310	0	310	220	0	220	124	0	124
SECONDARY PUMPING	15	0	0	0	0	0	9	9	9	9	9	9	9	9	10	10	10	10	10	10	14	15	16	17	18	19	533	0	115	0	115	78	0	78	40	0	40
FORCE MAINS	50	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4	4	5	6	6	6	159	0	27	0	27	18	0	18	9	0	9
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	6	6	6	7	8	9	10	12	12	12	331	0	68	0	68	46	0	46	23	0	23
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	8	9	10	11	12	312	0	67	0	67	45	0	45	23	0	23
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	3	3	3	77	0	15	0	15	10	0	10	5	0	5
SLUDGE MANAGEMENT	35	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	83	0	15	0	15	11	0	11	6	0	6
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		65	73	75	86	92	24	24	24	24	25	50	50	53	55	55	55	56	63	77	87	97	92	101	107	0	3505	0	2092	0	0	838	0	0	570	0	0
PW (BEGIN PER) 5 3/8		61	66	71	81	87	22	22	22	22	22	45	47	50	50	52	52	53	299	351	381	409	444	467	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/1721) 5 3/8		61	63	64	69	70	17	16	15	14	13	26	25	25	23	22	21	20	138	105	88	72	60	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		60	65	70	78	83	21	21	21	21	22	45	45	48	48	50	49	50	287	336	364	394	431	441	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/1721) 7%		60	61	61	65	65	15	14	13	13	12	11	22	20	20	19	18	17	16	85	70	54	42	32	24	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 10%		59	63	68	78	83	21	21	21	21	22	45	45	48	48	50	49	50	269	312	343	368	389	412	3	0	106	0	0	0	0	0	0	0	0	0	0	0
PW (1/1721) 10%		59	57	56	58	57	13	12	11	10	9	8	15	14	13	12	11	10	10	47	34	23	15	10	7	0	0	0	0	0	0	0	583	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3											
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	25	0	0	0	0	0	25	25	25	25	25	25	25	25	25	25	25	25	25	25	51	51	51	51	51	51											
SECONDARY PUMPING	15	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	13	13	13	13	13	13											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	33	33	33	33	33	33	33	33	46	46	65	65	82	82	82											
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	16	16	16	16	16	16	16	16	21	27	28	28	35	35	35											
LAND PURCHASE & PREP	50	1	1	1	1	1	1	1	1	1	1	10	10	10	10	11	11	11	11	12	14	16	18	20	23	23											
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	9	9	11	12	14	15	17	19	19											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	6	7	8	9	10	11	13											
SLUDGE MANAGEMENT	35	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	8	9	9	9	9											
MISCELLANEOUS	33	0	0	0	0	0	7	7	7	7	7	6	6	6	6	6	6	6	6	6	7	7	8	5	7	7											
* 5 3/8 CRF		1	1	1	90	93	49	49	49	49	49	161	161	161	165	165	165	165	165	199	217	242	247	271	278	277											
7 % CRF		1	1	1	95	100	209	209	209	209	209	198	198	198	198	201	201	201	201	229	263	295	299	329	336	335											
10 % CRF		2	2	2	109	151	151	151	151	151	151	270	270	270	274	274	274	274	274	331	396	458	466	445	455	455											

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL		1	1	1	90	93	49	49	49	49	49	161	161	161	165	165	165	165	165	199	217	242	247	271	278	277											
TOTAL ANNUAL O&M		65	73	75	86	92	24	24	24	24	25	50	50	53	55	55	55	56	63	77	87	97	92	101	107	0											
TOTAL ANNUAL COSTS		66	73	76	176	185	113	113	113	113	113	199	211	213	216	220	220	221	228	276	304	339	339	372	385	277											

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL		1	1	1	95	100	209	209	209	209	209	198	198	198	198	201	201	201	201	229	263	295	299	329	336	335											
TOTAL ANNUAL O&M		65	73	75	86	92	24	24	24	24	25	50	50	53	55	55	55	56	63	77	87	97	92	101	107	0											
TOTAL ANNUAL COSTS		66	73	76	181	192	233	233	233	233	233	248	248	251	253	256	256	257	292	340	382	396	391	430	443	335											

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL		2	2	2	109	151	151	151	151	151	151	270	270	270	274	274	274	274	274	331	396	458	466	445	455	455											
TOTAL ANNUAL O&M		65	73	75	86	92	24	24	24	24	25	50	50	53	55	55	55	56	63	77	87	97	92	101	107	0											
TOTAL ANNUAL COSTS		67	75	77	195	243	175	175	175	175	176	320	320	323	329	329	329	330	337	408	483	555	558	546	562	455											

WASTEWATER MANAGEMENT SURVEY SECRE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

NEWBURY TOWNSHIP PLANT SIZE: (1.5MGD) SOIL-T TREATMENT APPLICATION RATE: 40 IN/YR NEWBURY TOWNSHIP PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION DOMESTIC AND INDUSTRIAL G				0.61	0.62	0.64	0.66	0.68	0.90	0.92	0.94	0.96	0.98	0.60	0.62		0.64	0.65	0.67	0.69	0.75	0.90	1.02	1.13	1.33	1.54
TREATMENT PLANT CAPACITY (MGD)					0.78						0.69									0.90	1.02	1.13	1.33	1.54	1.54
SLUDGE DISCHARGED (CFD)							0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13		0.13	0.14	0.15	0.17	0.19	0.21	0.24	0.28
WINTER STORAGE (MG)													48	49	91	88		94	96	99	97	97	87	94	113
LAND AREA (ACRES)													84	87	90	93		96	97	100	103	118	134	142	199

PLAN C PLANT 15 PLAN C PLANT 15

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	68	24	33	8	31	30	0	29	26	0	26
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	715	0	0	0	0	0	0	0	715	285	278	25	255	211	11	200	124	7	125
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	0	0	0	0	265	0	0	0	0	0	0	0	0	0	0	0	0	0	285	0	0	0	0	295	0	875	365	359	29	326	302	24	287	238	3	236
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	80	0	0	0	0	80	0	0	240	45	86	6	80	68	3	65	46	1	45
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	90	22	53	1	51	45	0	44	34	0	34
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	320	0	0	0	0	0	0	135	0	140	0	220	0	0	0	815	122	304	9	295	240	4	239	142	1	142
RESERVOIR AER & LA	10	0	0	0	0	0	0	0	0	0	0	87	0	0	0	0	0	0	80	0	48	0	130	0	130	0	500	130	118	10	108	84	5	79	49	1	48
LAND PURCHASE & PREP	50	19	0	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	10	11	12	11	20	21	0	0	0	154	71	12	59	60	4	56	44	1	44
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	7	53	0	0	133	60	60	4	55	51	2	49	29	1	28
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	42	0	0	0	0	0	0	7	7	8	8	14	0	0	0	105	40	38	3	35	32	1	31	21	0	20
SLUDGE MANAGEMENT	20	0	0	0	0	81	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	81	0	0	195	77	84	6	77	78	3	70	40	0	39
MISCELLANEOUS	35	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	42	0	42	35	0	35	27	0	27
TOTAL		19	0	0	34	408	0	0	0	0	0	0	710	0	0	0	0	18	0	0	0	1032	370	263	24	427	578	135	3842	1345	1510	109	1400	1214	52	1161	865	13	852
Pw (1/72) 5 3/8%		19	0	0	29	328	0	0	0	0	0	0	420	0	0	0	0	6	0	0	0	402	111	60	4	58	60	10	0	0	1510	109	1400	0	0	0	0	0	0
Pw (1/72) 7 %		19	0	0	27	309	0	0	0	0	0	0	360	0	0	0	0	6	0	0	0	305	78	39	2	52	51	9	0	0	0	0	0	1214	52	1161	0	0	0
Pw (1/72) 10 %		19	0	0	25	276	0	0	0	0	0	0	274	0	0	0	0	4	0	0	0	189	41	18	1	31	9	1	0	0	0	0	0	0	0	0	865	13	851

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	48	52	56	60	64	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	5	6	7	8	421	0	277	0	277	255	0	255	225	0	225
SLUDGE FACILITIES	35	7	8	9	10	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	14	0	14	13	0	13	12	0	12
SEWERS	50	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	90	0	17	0	17	11	0	11	5	0	5
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	14	14	15	15	15	15	16	16	17	17	17	18	18	18	18	18	18	18	18	27	29	31	32	34	1013	0	250	0	250	178	0	178	106	0	106
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	5	6	6	7	7	8	13	14	14	15	15	16	16	475	0	100	0	100	67	0	67	33	0	33
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	27	0	9	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	3	3	4	4	4	4	104	0	21	0	21	14	0	14	7	0	7
RESERVOIR AER & LA	10	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	4	5	6	7	8	8	8	211	0	42	0	42	27	0	27	14	0	14
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	186	0	58	0	58	29	0	29	13	0	13
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	42	0	9	0	9	6	0	6	3	0	3
SLUDGE MANAGEMENT	20	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	53	0	15	0	12	10	0	10	6	0	6
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		51	55	59	66	64	18	18	18	19	19	19	34	35	37	38	39	39	41	51	63	67	73	80	84	0	2745	0	795	0	0	618	0	0	491	0	0
Pw (BEGIN PER) 5 3/8		48	49	50	53	54	14	14	14	14	14	13	25	25	25	25	25	25	25	30	37	37	38	39	39	0	0	0	0	0	0	0	0	0	0	0	0
Pw (1/72) 5 3/8%		48	49	50	53	54	14	14	14	14	14	13	25	25	25	25	25	25	25	30	37	37	38	39	39	0	0	0	0	0	0	620	0	0	0	0	0
Pw (BEGIN PER) 7%		47	47	47	47	47	13	13	13	13	13	12	23	23	23	23	23	23	23	27	32	32	32	32	32	0	0	0	0	0	0	0	0	0	0	0	0
Pw (1/72) 7 %		47	47	47	47	47	13	13	13	13	13	12	23	23	23	23	23	23	23	27	32	32	32	32	32	0	0	0	0	0	0	0	0	0	0	0	0
Pw (BEGIN PER 10		46	46	46	46	46	12	12	12	12	12	11	21	21	21	21	21	21	21	24	29	29	29	29	29	0	0	0	0	0	0	0	0	0	0	0	0
Pw (1/72) 10 %		46	45	44	43	42	10	9	8	8	7	6	10	10	9	9	8	7	7	7	7	7	6	6	5	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - Annual CAPITAL COSTS AT 7% IN $1000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/4% EXPEND	PRESENT WORTH AT 5 3/4% RESID	PRESENT WORTH AT 5 3/4% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	0	0	0	4	7	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	51	51	51	51	51											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	20	0	0	0	0	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22											
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23											
RESERVOIR AER & LA	10	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10											
LAND PURCHASE & PREP	50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1											
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE MANAGEMENT	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
% $/YR COST					1	14	14	15	28	28	28	28	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										
5 3/8 $/YR					1	14	14	15	28	28	28	28	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										
10 $/YR					1	14	14	15	28	28	28	28	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

TOTAL ANNUAL $/YR																																						
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										

CAPITAL RECOVERY FACTOR AT 5 3/4%

TOTAL ANNUAL $/YR																																						
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL $/YR																																						
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL $/YR																																						
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										
TOTAL ANNUAL $/YR			21	23	25	43	34	34	34	34	34	34	76	76	76	76	77	77	77	77	126	126	127	127	152	165	155										

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND CANTON AREAS WATERSHED AREA

CHAGRIN FALLS PLANT SIZE 2.47 MGD SOIL-T YPE MANCHES APPLICATION RATE .40 GD/SQFT CHAGRIN FALLS PLANT

- - - - - - BASIC DESIGN DATA - - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1985	2000	2005	2010	2015	2020
				1.40	1.58 / 4.55	1.60	1.78	1.88	1.98	2.17	2.37 / 3.91	2.56	3.15	3.33	3.52	3.71	3.91
						0.35	0.37	0.40	0.42	0.46	0.50	0.54	0.68	0.70	0.74	0.78	0.82
												218	234	250	267	281	298
												382	411	439	469	492	526

POPULATION
DOMESTIC AND INDUSTRIAL =
TREATMENT PLANT CAPACITY (MGD)
SLUDGE DISCHARGED (TPD)
WINTER STORAGE (MG)
LAND AREA (ACRES)

	1995	2000	2005	2010	2015	2020
	6.55	6.80	7.23	7.87	7.87	7.87
	5.19 / 5.84	5.19 / 6.63	5.19 / 7.23	5.87	5.87	5.87
	0.82	0.86	0.90	0.94	0.98	1.02
	1.04	1.09	1.24	1.39	1.62	1.85
	387	441	501	561	614	668
	586	680	775	880	986	1080	1176

PLAN C PLANT 19

- - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	TE % NET	PRESENT EXPEND	WORTH AT RESID	LOS NET
PLANTS	35	0	0	0	94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	0	0	188	47	93	5	87	83	2	81	73	0	72
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE PUMP. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	3872	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3872	387	3310	31	3279	3159	19	3144	2907	3	2904
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	356	0	0	0	0	0	0	0	0	0	720	0	0	0	0	0	1076	494	387	40	346	303	19	284	206	4	201
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	690	0	0	0	980	0	2650	1114	1104	90	1014	967	43	903	765	22	752
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0	160	0	0	0	0	160	0	480	160	173	12	160	137	6	131	93	1	91
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	33	85	2	82	73	1	72	55	0	55
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	1170	0	0	0	0	0	0	0	0	685	0	460	0	0	0	0	2585	309	1050	32	1018	861	15	825	582	3	578
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	287	0	0	0	0	0	0	0	0	387	0	488	0	573	0	573	2319	573	564	46	517	464	22	382	239	5	233
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	352	0	0	0	0	0	0	0	0	66	0	70	0	0	66	0	0	788	310	63	246	267	90	216	169	7	162
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	192	0	0	0	0	0	0	0	0	63	0	63	0	0	0	0	381	63	29	25	22	195	28	150	98	2	84
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	210	0	0	0	0	0	0	0	0	43	0	43	0	0	43	0	528	172	209	24	184	166	6	159	116	1	112
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	158	172	12	160	149	6	143	122	1	120
MISCELLANEOUS	35	0	0	0	0	98	0	0	0	0	44	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	384	0	199	0	199	130	0	130	101	0	101
TOTAL		0	0	0	3966	1078	0	0	0	0	2691	0	0	0	0	0	166	0	0	0	0	1156	581	1844	280	1281	3857	402	15153	4575	7786	370	7415	6776	178	6598	5515	45	5469
Pw (1/72) $ 3/88		0	0	0	3390	1004	0	0	0	0	2211	0	0	0	0	0	79	0	0	667	0	494	425	28	1222	170	40	0	0	7786	370	7415	0	0	0	0	0	0
Pw (1/72) 7 %		0	0	0	3192	945	0	0	0	0	1969	0	0	0	0	0	64	0	0	556	0	394	276	17	958	93	23	0	0	0	0	0	0	6776	178	6598	0	0	0
Pw (1/72) 10 %		0	0	0	2978	866	0	0	0	0	1801	0	0	0	0	0	43	0	0	459	0	319	209	12	727	54	14	0	0	0	0	0	0	0	0	0	5515	45	5469

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	TE % NET	PRESENT EXPEND	WORTH AT RESID	LOS NET
PLANTS	35	123	145	168	189	209	3	3	3	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1237	0	784	0	784	723	0	723	640	0	640
SLUDGE FACILITIES	35	0	7	8	14	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	33	0	33	32	0	32	29	0	29
SEWERS	50	0	0	0	14	19	19	19	19	21	21	21	21	21	21	21	21	21	21	21	22	24	24	24	24	24	1005	0	309	0	309	233	0	231	152	0	152
TEMPORARY PUMPS	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	58	60	62	64	66	67	68	70	72	74	76	78	80	83	87	91	94	96	98	102	1685	0	998	0	998	732	0	732	445	0	445
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	22	23	24	25	25	27	28	41	43	46	49	52	56	99	2645	0	348	0	348	233	0	233	139	0	139
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	6	0	6	3	0	3	2	0	2
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	6	6	11	12	13	13	13	372	0	77	0	77	51	0	51	26	0	26
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	18	18	19	19	20	20	20	22	26	33	36	35	36	37	2109	0	240	0	240	161	0	161	83	0	83
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	12	13	13	14	15	15	15	19	21	24	27	30	30	30	871	0	182	0	182	122	0	122	62	0	62
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	4	4	4	5	5	6	6	7	7	204	0	63	0	63	29	0	29	14	0	14
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	0	0	2	3	3	3	4	4	4	5	5	6	6	7	7	7	255	0	60	0	60	42	0	42	24	0	24
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		129	152	171	212	236	86	88	91	96	98	99	166	169	175	178	184	189	192	224	236	263	276	289	299	0	10460	0	3086	0	0	2367	0	0	1802	0	0
Pw (8/88)N PRES $ 3/8		122	139	148	171	180	62	60	59	58	58	57	87	85	84	82	81	79	77	74	74	84	85	81	80	0	0	0	0	0	0	0	0	0	0	0	0
Pw (8/88)N PRES 7%		122	139	148	171	180	62	60	59	58	58	57	87	85	84	82	81	79	77	74	74	84	85	81	80	0	3173	0	0	0	0	0	0	0	0	0	0
Pw (8/88)N PRES 10%		120	135	144	166	175	60	58	57	56	56	55	84	82	81	79	78	76	74	71	71	80	81	77	76	0	0	0	0	0	0	0	0	0	0	0	0
Pw (1/72) $ 3/88		129	150	169	203	232	84	86	89	94	96	97	163	166	172	175	181	186	189	220	232	259	271	284	294	0	10460	0	3086	0	0	2367	0	0	1802	0	0
Pw (1/72) 7 %		129	150	169	203	232	84	86	89	94	96	97	163	166	172	175	181	186	189	220	232	259	271	284	294	0	3173	0	0	0	0	0	0	0	0	0	0
Pw (1/72) 10 %		129	150	169	203	232	84	86	89	94	96	97	163	166	172	175	181	186	189	220	232	259	271	284	294	0	2431	0	0	0	0	0	0	0	0	0	0
Pw (8/88)N PRES 10%		117	128	138	155	162	58	55	52	51	50	49	74	72	71	69	67	65	63	60	60	68	68	64	63	0	1639	0	0	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	TE % NET	PRESENT EXPEND	WORTH AT RESID	LOS NET
PLANTS	35	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7								
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE PUMP. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SEWERS	50	0	0	0	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278	278								
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	24	24	24	24	24	24	24	24	24	24	29	29	29	29	29	29								
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
AERATED LAGOONS	30	0	0	0	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73								
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	12	12	12	12	12	12	12	12	12	26	26	26	26	26	26	26								
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10								
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84								
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49								
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22								
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15								
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11								
% $/88 CRF		0	0	0	290	307	307	307	307	307	527	527	503	503	503	503	513	513	513	513	513	513	513	474	436	731	741	782	395	396				
7 % CRF		0	0	0	286	379	379	379	379	379	569	603	613	613	613	613	625	625	625	625	625	625	625	625	625	625	3CC	773	888	900	944	944	944	963		
10 % CRF		0	0	0	400	927	927	927	927	927	961	961	859	859	859	859	856	856	856	856	856	856	856	955	1C56	1211	1228	1254	1314	1313				

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

Capital Recovery Factor at 5 3/8%

TOTAL ANNUAL CAPITAL		0	0	0	290	307	307	307	307	307	527	527	503	503	503	503	513	513	513	513	513	513	513	474	436	731	741	782	395	396				
TOTAL ANNUAL O&M		129	152	171	212	236	86	88	91	96	98	99	166	169	175	178	184	189	192	224	236	263	276	289	299	0	10460	0	3086	0	0	2367	0	0	1802	0	0
TOTAL ANNUAL COSTS		129	152	171	502	543	393	395	398	403	625	626	669	672	678	681	697	702	705	737	749	776	789	763	735	731	11201	782	3481	396	944	2367	944	963	1802	0	0

Capital Recovery Factor at 7 %

TOTAL ANNUAL CAPITAL		0	0	0	286	379	379	379	379	379	569	603	613	613	613	613	625	625	625	625	625	625	625	625	625	625	3CC	773	888	900	944	944	944	963		
TOTAL ANNUAL O&M		129	152	171	212	236	86	88	91	96	98	99	166	169	175	178	184	189	192	224	236	263	276	289	299	0	10460	0	3086	0	0	2367	0	0	1802	0	0
TOTAL ANNUAL COSTS		129	152	171	498	615	465	467	470	475	667	702	779	782	788	791	809	814	817	849	861	888	901	914	924	625	14260	773	3974	900	944	3311	944	963	2765	0	0

Capital Recovery Factor at 10 %

TOTAL ANNUAL CAPITAL		0	0	0	400	927	927	927	927	927	961	961	859	859	859	859	856	856	856	856	856	856	856	955	1C56	1211	1228	1254	1314	1313				
TOTAL ANNUAL O&M		129	152	171	212	236	86	88	91	96	98	99	166	169	175	178	184	189	192	224	236	263	276	289	299	0	10460	0	3086	0	0	2367	0	0	1802	0	0
TOTAL ANNUAL COSTS		129	152	171	612	1163	1013	1015	1018	1023	1059	1060	1025	1028	1034	1037	1040	1045	1048	1080	1092	1119	1132	1244	1355	1211	11688	1254	4400	1314	1313	3311	1313	1312	2765	0	0

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

CHAGRIN EAST BRANCH PLANT SIZE: 1.35(MGD) SOIL-Y PREPANCHING APPLICATION RATE: 90 IN/YR CHAGRIN EAST BRANCH PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL Q				0.00	0.02	0.05	0.07	0.09	0.72	0.75	0.77	0.80	0.83	0.87	0.89	0.92	0.95	0.98	1.00	1.13	1.25	1.41	1.58	1.76	1.95
TREATMENT PLANT CAPACITY (MGD)					1.32							1.00							1.25	1.41	1.58	1.76	1.95	1.95	1.95
SLUDGE DISCHARGED (TPD)								0.14	0.14	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.21	0.22	0.23	0.24	0.26	0.29	0.32
WINTER STORAGE (MG)													68	71	74	76	78	80	82	83	95	106	120	134	150
LAND AREA (ACRE)													119	124	130	133	137	142	146	169	187	210	236	263	291

PLAN C PLANT 17 PLAN C PLANT 17

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPENC	WORTH AT 5 3/8% RESID	NET	PRESENT EXPEND	WORTH AT 7% RESID	NET	PRESENT EXPENC	WORTH AT 10% RESID	NET
PLANTS	35	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	80	28	39	2	37	35	1	34	31	0	30
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	819	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	819	81	700	4	693	668	3	665	615	0	614
SEWER EXPANSION	50	0	0	0	0	0	0	0	562	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	562	108	356	6	347	315	4	311	253	1	252
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIORITY ACQ & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120	0	0	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	50	0	0	0	0	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	50	0	0	0	0	37	0	0	0	0	0	0	0	0	1	0	0	0	0	32	2	2	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0
TOTAL		20	0	0	859	490	0	0	0	562	0	916	0	0	0	23	0	0	0	403	401	422	57	441	726	166	5232	1824	2593	147	2445	2235	71	2164	1786	18	1768
PW (1972) 5 3/8%		20	0	0	734	347	0	0	0	356	0	542	0	0	0	11	0	0	0	157	120	97	6	60	76	13	0	0	2593	147	2445	0	0	0	0	0	0	0
PW (1972) 7 %		20	0	0	704	373	0	0	0	315	0	465	0	0	0	8	0	0	0	119	84	63	3	33	39	6	0	0	0	0	0	2235	71	2164	0	0	0	0
PW (1972) 10 %		20	0	0	665	374	0	0	0	253	0	355	0	0	0	6	0	0	0	72	44	29	1	11	12	1	0	0	0	0	0	0	0	0	0	1786	18	1768

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPENC	WORTH AT 5 3/8% RESID	NET	PRESENT EXPEND	WORTH AT 7% RESID	NET	PRESENT EXPENC	WORTH AT 10% RESID	NET
PLANTS	35	71	76	82	87	92	2	2	2	3	3	3	3	3	3	3	3	3	3	4	4	5	5	6	7	8	595	0	393	0	393	364	0	364	324	0	324
SLUDGE FACILITIES	35	5	5	5	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	23	0	23	22	0	22	21	0	21
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	260	0	79	0	79	58	0	58	38	0	38
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	20	3	3	3	3	3	18	18	18	18	18	18	20	20	20	20	21	21	22	22	24	34	36	38	40	42	1275	0	316	0	316	227	0	227	134	0	134
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	18	19	20	21	22	23	663	0	142	0	142	96	0	96	49	0	49
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	6	0	6	4	0	4	1	0	1
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	3	3	4	4	4	4	4	124	0	26	0	26	17	0	17	9	0	9
PRIORITY ACQ & CL	10	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	25	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	3	3	3	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	6	0	6	4	0	4	1	0	1
SLUDGE MANAGEMENT	50	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	50	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		76	81	88	97	102	20	20	20	30	30	30	55	55	55	55	57	57	58	69	72	90	93	100	106	0	3841	0	1134	0	0	892	0	0	632	0	0
PW (1972) 5 3/8%		72	76	83	92	96	19	19	19	28	28	28	52	52	52	52	54	54	55	49	49	58	60	64	68	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972) 7 %		71	76	82	90	94	17	17	17	26	26	26	51	51	51	51	53	53	54	47	46	54	56	59	63	0	0	0	1155	0	0	0	0	0	0	0	0	0
PW (1972) 7%		71	76	82	90	94	17	17	17	26	26	26	51	51	51	51	53	53	54	47	46	54	56	59	63	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972) 10 %		71	75	81	89	92	17	16	15	24	24	24	49	49	49	49	51	51	52	45	44	52	54	57	61	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972) 10%

WASTEWATER MANAGEMENT SURVEY STEP 1 STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

UPPER EAST BRANCH PLANT — SCENARIO: CLEAN-WOOD — SOIL-TYPE: MIXED — APPLICATION RATES: 90 IN/YR — UPPER EAST BRANCH PLANT

BASIC DESIGN DATA

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
				0.22	0.24 0.76	0.27	0.30	0.33	0.36	0.39	0.42 0.68	0.45	0.49	0.52	0.55				0.58 0.81	0.61 0.85	0.65 0.96	0.68 1.03	0.74 1.11	0.81 1.21	0.85 1.31	0.96 1.41	1.03 1.51
						0.06	0.06	0.07	0.08	0.08	0.09	0.09 38 67	0.10 42 73	0.11 46 78	0.12 47 82				0.12 49 87	0.13 52 91	0.14 55 96	0.14 58 102	0.16 63 110	0.17 69 121	0.19 76 133	0.22 82 143	0.23 88 154	0.23 94 166

POPULATION
DOMESTIC AND INDUSTRIAL D
TREATMENT PLANT CAPACITY (MGD)
SLUDGE DISCHARGED (TDS)
WINTER STORAGE (MG)
LAND AREA (ACRES)

PLAN C PLANT 10

CAPITAL COSTS IN $1000 FOR WASTEWATER

PLAN C PLANT 10

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	35	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	52	18	25	1	24	23	0	22	20	0	20
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	280	0	0	0	0	0	0	0	0	0	0	0	0	350	0	0	0	280	0	0	710	200	301	16	285	260	7	252	212	2	210
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	97	0	0	0	0	0	0	0	86	0	0	0	97	0	0	280	99	101	7	93	80	3	76	54	0	55
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	22	53	1	51	45	0	44	34	0	34
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	360	0	0	0	0	0	0	0	0	110	0	120	0	120	0	0	710	114	300	4	290	242	4	238	170	1	169
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	78	0	0	0	0	0	0	0	0	95	0	110	0	126	0	126	533	126	135	10	125	98	4	93	59	1	57
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	5	0	5	0	5	0	0	0	91	42	7	35	35	3	31	25	0	24
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	46	0	0	0	0	0	0	0	0	2	3	2	2	2	2	0	115	50	57	4	53	30	1	28	20	0	20
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	4	4	5	5	5	5	0	76	18	32	1	30	26	0	25	18	0	18
SLUDGE MANAGEMENT	30	0	0	0	0	0	82	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	182	74	80	5	74	70	2	67	58	0	58
MISCELLANEOUS	33	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	84	0	34	0	34	31	0	31	29	0	29
TOTAL		0	0	0	26	390	0	0	0	0	0	772	0	0	0	0	0	0	0	500	157	242	11	283	547	131	2830	808	1346	65	1081	946	31	912	701	8	693
PW (11/72) 5 3/8%		0	0	0	22	316	0	0	0	0	0	457	0	0	0	0	0	0	0	119	55	55	2	58	57	10	0	57	1146	45	1081	0	0	0	0	0	0	0
PW (11/72) 7 %		0	0	0	21	267	0	0	0	0	0	392	0	0	0	0	0	0	0	88	41	36	1	31	30	5	0	0	0	0	0	944	31	912	0	0	0	0
PW (11/72) 10 %		0	0	0	19	246	0	0	0	0	0	297	0	0	0	0	0	0	0	54	22	16	0	7	9	1	0	0	0	0	0	0	0	0	701	8	693

O & M COSTS IN $1000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	35	0	0	0	0	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	5	6	7	7	8	195	0	44	0	44	31	0	31	17	0	17
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	11	11	11	12	12	12	13	13	14	14	15	15	15	16	22	22	23	24	24	25	438	0	213	0	213	153	0	153	90	0	90
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	7	8	8	8	8	8	8	11	11	11	12	12	12	12	299	0	89	0	89	61	0	61	32	0	32
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	19	0	19	13	0	13	7	0	7
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	3	3	3	3	89	0	19	0	19	13	0	13	7	0	7
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	4	4	4	4	5	5	6	6	172	0	36	0	36	24	0	24	12	0	12
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	4	4	4	5	5	5	5	151	0	33	0	33	22	0	22	12	0	12
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	43	0	12	0	12	6	0	6	3	0	3
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	0	0	1	1	14	14	14	16	16	16	34	36	37	37	38	38	39	45	51	53	57	61	61	0	1946	0	448	0	0	328	0	0	185	0	0
PW (BEGIN PER) 5 3/8		0	0	0	0	0	1	13	13	13	15	15	15	32	32	33	33	34	34	35	36	36	37	205	222	235	251	260	265	0	0	0	0	0	0	0	0	0
PW (11/72) 5 3/8%		0	0	0	0	0	1	12	9	9	9	9	8	18	17	17	16	16	15	15	80	66	54	44	35	27	0	0	0	488	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		0	0	0	0	0	1	12	11	10	11	10	9	21	21	20	19	19	18	18	58	44	33	25	19	13	0	0	0	0	0	0	0	0	0	0	0	0
PW (11/72) 7%		0	0	0	0	0	1	9	8	8	8	8	7	15	14	14	13	12	12	11	58	44	33	25	19	13	0	0	0	0	0	341	0	0	0	0	0	0
PW (BEGIN PER) 10%		0	0	0	0	0	0	12	12	12	14	14	14	30	30	33	33	34	34	35	181	147	111	226	225	237	1	45	0	0	0	0	0	0	0	0	0	0
PW (11/72) 10%		0	0	0	0	0	0	7	7	6	6	6	5	10	9	9	8	8	7	7	32	22	16	9	6	4	0	0	0	0	0	0	0	0	102	0	0	0

ANNUAL CAPITAL COSTS AT 7% IN $1000

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	RESID	NET	PRESENT WORTH AT 7% EXPEND	RESID	NET	PRESENT WORTH AT 10% EXPEND	RESID	NET
PLANTS	35	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2											
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	30	0	0	0	0	0	21	21	21	21	21	21	21	21	21	21	21	21	21	21	32	32	32	32	32	32											
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7	14	14	14	14	14	14	14											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	4	4	4	4	4	4	4											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25	25	25	33	33	42	42	51	51	51											
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	13	13	13	13	13	13	13	13	13	15	15	18	18	22	22	22											
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	4	4	5	5	6	6	6											
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	3	4	4	4	5	5											
SLUDGE MANAGEMENT	30	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7											
MISCELLANEOUS	33	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	1	1											
5 3/8% CRF		0	0	0	1	25	25	25	25	25	25	79	79	79	79	82	80	80	80	85	108	118	118	127	129	129											
7 % CRF		0	0	0	2	31	31	31	31	31	95	95	95	95	96	96	96	96	96	124	129	143	142	152	155	155											
10 % CRF		0	0	0	2	42	42	42	42	42	42	127	127	127	127	129	129	129	129	153	174	190	191	204	208	208											

TOTAL ANNUAL CAPITAL COSTS IN $1000

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL		2	2	2	1	25	27	25	25	25	28	79	79	79	80	80	80	80	80	95	108	118	119	127	129	129											
TOTAL ANNUAL O&M		0	0	0	0	1	1	14	14	14	16	16	16	34	36	37	37	38	38	39	45	51	53	57	61	61											
TOTAL ANNUAL COSTS		2	2	2	2	26	28	39	39	39	44	95	115	113	116	117	117	118	118	134	153	169	172	184	190	190											

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL		2	2	2	2	31	31	31	31	31	95	95	95	95	96	96	96	96	96	124	129	143	142	152	155	155											
TOTAL ANNUAL O&M		0	0	0	0	1	1	14	14	14	16	16	16	34	36	37	37	38	38	39	45	51	53	57	61	61											
TOTAL ANNUAL COSTS		2	2	2	2	32	32	45	45	45	111	111	111	129	132	133	133	134	134	163	174	194	195	209	216	216											

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL		2	2	2	2	42	42	42	42	42	127	127	127	127	129	129	129	129	129	153	174	190	191	204	208	208											
TOTAL ANNUAL O&M		0	0	0	0	1	1	14	14	14	16	16	16	34	36	37	37	38	38	39	45	51	53	57	61	61											
TOTAL ANNUAL COSTS		2	2	2	2	43	43	56	56	56	143	143	143	161	165	166	166	167	167	192	219	241	244	261	269	269											

WASTEWATER MANAGEMENT | SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

HINCKLEY PLANT SIZE: 1.72 MGD SOIL-P PREPHANCING APPLICATION RATE: 90 IN/YR HINCKLEY PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION				3.33	3.47	0.42	0.46	0.51	0.55	0.60	0.64	0.69	0.74	0.79	0.84	0.89	0.94	0.99	1.04	1.25	1.25	1.37	1.50	1.61	1.72
DOMESTIC AND INDUSTRIAL Q					1.15						1.04								1.04	1.25	1.37	1.50	1.61	1.72	1.72
TREATMENT PLANT CAPACITY (MGD)						0.09	0.10	0.11	0.12	0.13	0.13	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.24	0.26	0.29	0.32	0.34	0.36
SLUDGE DISCHARGED (TPD)												59	63	67	71	76	80	84	88	98	106	116	127	137	146
WINTER STORAGE (MG)												103	111	118	125	133	140	148	155	170	187	205	224	240	255
LAND AREA (ACRES)																									

PLAN C PLANT 19

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PLAN C PLANT 19 TR	PLAN C PLANT 19 PRESENT WORTH AT 5 3/8% NET	LOR NET
PLANTS	35	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	72	25	35	2	33	32	0	31	28	0	27
EXPANC TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPANC TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE PAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	2830	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2830	283	2419	22	2396	2309	11	2298	2.29	2	2328
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	19	0	0	0	0	375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	375	0	375	0	375	375	0	375	375	0	375
SECONDARY PUMPING	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	130	0	0	0	0	0	0	130	0	130	0	130	130	0	130	130	0	130
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	117	0	0	0	0	0	0	0	104	0	0	0	0	0	0	221	0	122	0	122	116	0	116	116	0	116
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	143	14	84	1	83	72	1	71	55	0	54
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	440	0	0	0	0	0	0	0	132	0	150	0	132	0	0	854	85	503	4	499	395	3	392	303	1	302
LAND PURCHASE & REHAB	50	0	0	0	0	0	0	0	0	0	0	92	0	0	0	0	0	0	0	108	0	129	0	145	0	145	619	145	157	11	146	114	5	109	84	0	84
IRRIGATION SYSTEMS	19	0	0	0	0	0	0	0	0	0	0	89	0	0	0	0	0	0	0	22	0	24	0	22	0	0	157	0	78	14	63	63	7	56	44	7	43
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	10	0	15	0	15	0	0	82	0	65	7	57	50	7	44	33	5	32
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	95	0	0	0	0	0	0	0	7	0	8	0	7	0	0	112	26	48	1	46	39	0	39	27	0	27
MISCELLANEOUS	19	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	27	0	0	0	0	0	0	141	77	83	6	76	72	3	69	47	0	47
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	24	2	2	1	42	0	125	0	92	0	92	44	0	44	34	0	34
TOTAL		0	0	0	2866	494	0	0	0	0	0	1011	0	0	0	50	0	0	0	373	308	318	38	343	706	158	6493	1751	3925	141	3783	3546	48	3478	3341	17	3023
PW $1/1723 % 5 3/8%		0	0	0	2450	408	0	0	0	0	0	598	0	0	0	24	0	0	0	145	92	75	6	68	74	12	0	0	3525	141	3383	0	0	0	0	0	0
PW $1/1723 7 %		0	0	0	2338	374	0	0	0	0	0	513	0	0	0	19	0	0	0	110	64	47	4	24	38	6	0	0	0	0	0	3546	48	3478	3341	17	3023
PW $1/1723 10 %		0	0	0	2152	337	0	0	0	0	0	390	0	0	0	13	0	0	0	87	34	21	1	9	12	1	0	0	0	0	0	0	0	0	3341	17	3023

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	TR	PRESENT WORTH AT 5 3/8% NET	LOR NET
PLANTS	35	0	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	5	6	7	7	8	145	0	66	0	66	51	0	51	17	0	17
SLUDGE FACILITIES	35	0	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	5	6	7	7	8	145	0	66	0	66	51	0	51	17	0	17
SEWERS	50	0	0	0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	630	0	201	0	201	199	0	199	149	0	149
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	19	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	19	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	112	0	26	0	26	37	0	37	9	0	9
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	1	0	1
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	7	7	8	8	9	9	9	275	0	66	0	66	40	0	40	21	0	21
LAND PURCHASE & REHAB	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	19	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	5	5	6	7	7	7	7	253	0	44	0	44	50	0	50	14	0	14
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	57	0	12	0	12	7	0	7	1	0	1
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	68	0	16	0	16	12	0	12	7	0	7
MISCELLANEOUS	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	0	25	19	19	19	19	21	21	21	34	34	35	36	36	36	36	47	48	61	68	75	75	82	1729	0	511	0	511	403	0	403	319	0	319
PW $1/1723 % 5 3/8%		0	0	0	24	17	16	15	14	15	14	13	20	19	18	17	16	15	14	17	16	20	21	22	21	22	629	0	230	0	230	92	0	92	62	0	62
PW $1/1723 7 %		0	0	0	23	16	15	14	13	14	13	12	19	18	17	16	15	14	13	16	15	18	19	20	19	20	577	0	208	0	208	83	0	83	56	0	56
PW $1/1723 10 %		0	0	0	22	15	14	13	12	13	12	11	17	16	15	14	13	12	11	15	14	16	17	18	17	18	524	0	189	0	189	75	0	75	51	0	51

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEN	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	TR	PRESENT WORTH AT 5 3/8% NET	R
PLANTS	35	0	0	0	4	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3							
EXPANC TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
EXPANC TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SLUDGE PAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SEWERS	50	0	0	0	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203							
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
AERATED LAGOONS	19	0	0	0	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28							
SECONDARY PUMPING	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
RESERVOIR AER & CL	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
LAND PURCHASE & REHAB	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
IRRIGATION SYSTEMS	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
MISCELLANEOUS	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
TOTAL ANN PL TOTAL		0	0	0	235	233	233	233	233	233	233	233	233	233	234	234	234	234	234	234	234	234	234	234	234	234							
TOTAL ANN PL % 5 3/8%		0	0	0	224	207	197	187	178	169	161	153	146	139	133	127	121	115	110	105	85	69	56	45	36	29							
TOTAL ANN PL 7%		0	0	0	219	194	181	169	158	147	137	128	119	111	104	97	91	85	79	74	56	43	33	25	19	15							

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

CAPITAL RECOVERY AT 5 3/8% AT 7 YEARS

TOTAL ANN PL TOTAL		0	0	0	266	257	257	257	257	257	257	266	266	266	266	267	267	267	267	267	267	267	267	267	267	267							
TOTAL ANN PL % 5 3/8%		0	0	0	224	207	197	187	178	169	161	153	146	139	133	127	121	115	110	105	85	69	56	45	36	29							
TOTAL ANN PL 7%		0	0	0	219	194	181	169	158	147	137	128	119	111	104	97	91	85	79	74	56	43	33	25	19	15							

CAPITAL RECOVERY AT 5 3/8% AT 10 YEARS

TOTAL ANN PL TOTAL		0	0	0	266	257	257	257	257	257	257	266	266	266	266	267	267	267	267	267	267	267	267	267	267	267							
TOTAL ANN PL % 5 3/8%		0	0	0	224	207	197	187	178	169	161	153	146	139	133	127	121	115	110	105	85	69	56	45	36	29							
TOTAL ANN PL 7%		0	0	0	219	194	181	169	158	147	137	128	119	111	104	97	91	85	79	74	56	43	33	25	19	15							

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

MEDINA COUNTY PLANT SIZE: 5.000MGD SOIL: T YPE:MAHLENBI APPLICATION RATE: 90 IN/YR MEDINA COUNTY PLANT

- - - - - - BASIC DESIGN DATA - - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL				0.86	0.93	1.04	1.13	1.22	1.31	1.37	1.44	1.50	1.57	1.63	1.70	1.76	1.83	1.89	1.96	2.26	2.57	2.99	3.41	4.25	5.00
TREATMENT PLANT CAPACITY (MGD)						2.26					1.96								2.57	2.57	3.41	4.25	5.00	5.00	5.00
SLUDGE DISCHARGED (DRY)						0.22	0.24	0.25	0.28	0.29	0.30	0.32	0.33	0.34	0.36	0.37	0.38	0.40	0.41	0.48	0.55	0.63	0.72	0.88	1.05
WINTER STORAGE (MG)												127	133	138	144	150	156	161	167	192	218	254	290	357	425
LAND AREA (ACRES)												224	235	244	254	265	276	282	293	338	383	447	510	628	747

PLAN C PLANT 20 — PLAN C PLANT 23

- - - - - - CAPITAL COSTS IN $1CQ0 FOR WASTEWATER - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT 5 3/8% RESID	TE NET	PRESENT EXPEND	WORTH AT RESID	TE NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	0	0	140	46	69	3	65	67	1	60	94	0	93
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	1336	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1336	133	1142	10	1131	1090	5	1084	1003	1	1002
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	19	0	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	670	0	0	0	580	0	0	1830	757	732	61	670	615	29	586	481	7	473
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	138	0	0	0	0	0	0	0	138	0	0	0	138	0	0	414	128	190	10	139	118	4	113	80	1	79
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	240	58	142	4	137	121	2	119	92	0	92
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	700	0	0	0	0	0	0	0	300	0	370	0	280	0	0	1650	243	655	19	635	621	9	611	357	2	354
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	380	0	0	0	0	0	0	0	210	0	225	0	390	0	390	1425	190	325	31	293	269	15	254	132	3	129
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	149	0	0	0	0	0	0	0	50	30	43	42	78	79	0	0	497	169	40	129	132	15	117	89	4	84
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	97	0	0	0	26	0	0	0	65	12	17	17	31	128	10	367	163	108	13	95	83	6	76	56	1	55
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	336	0	0	0	18	0	0	0	21	20	28	28	53	54	0	336	144	114	11	102	89	5	83	60	1	58
SLUDGE MANAGEMENT	35	0	0	0	0	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	0	0	0	105	0	279	104	116	8	108	100	4	96	81	1	80
MISCELLANEOUS	35	0	0	0	0	58	0	0	0	0	0	25	0	0	0	3	0	0	0	4	7	1	0	8	11	0	260	0	98	0	98	81	0	81	61	0	61
TOTAL		0	0	0	1412	743	0	0	0	0	0	2663	0	0	0	57	0	0	0	750	872	788	93	813	1150	400	8277	2670	3825	216	3608	3246	104	3142	2548	26	2521
PW (1/72) 5 3/8%		0	0	0	1202	657	0	0	0	0	0	972	0	0	0	27	0	0	0	292	261	170	16	125	121	32	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %		0	0	0	1147	564	0	0	0	0	0	836	0	0	0	22	0	0	0	222	185	110	9	69	63	15	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %		0	0	0	1055	507	0	0	0	0	0	634	0	0	0	16	0	0	0	135	97	50	3	24	19	4	0	0	0	0	0	0	0	0	0	2548	26	2521

- - - - - - O & M COSTS IN $1CQ0 FOR WASTEWATER - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT 5 3/8% RESID	TE NET	PRESENT EXPEND	WORTH AT RESID	TE NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	48	33	18	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	6	7	8	9	11	13	304	0	159	0	159	133	0	133	110	0	110
SLUDGE FACILITIES	35	5	7	8	10	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	0	34	0	34	32	0	32	29	0	29
SEWERS	50	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	270	0	86	0	86	64	0	64	44	0	44
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	19	0	0	0	0	0	29	30	31	32	33	34	35	36	37	38	39	39	39	40	43	46	48	76	84	93	2562	0	615	0	615	497	0	497	293	0	293
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	19	19	19	19	19	19	19	19	19	19	19	30	33	41	975	0	199	0	199	132	0	132	67	0	67
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	5	5	7	7	8	8	9	293	0	49	0	49	33	0	33	17	0	17
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	9	9	9	10	10	10	10	12	15	16	17	23	24	26	617	0	124	0	124	82	0	82	41	0	41
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	8	8	8	11	13	14	15	17	20	20	517	0	105	0	105	70	0	70	35	0	35
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	3	3	4	4	5	104	0	21	0	21	14	0	14	7	0	7
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	4	4	5	6	136	0	33	0	33	25	0	25	13	0	13
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		53	40	26	18	19	40	42	43	44	46	47	87	88	90	93	95	95	97	106	134	157	165	187	205	0	5876	0	1435	0	1034	0	0	625	0	0	0
PW (BEGIN PER) 5 3/8		50	37	24	17	18	37	38	40	42	43	44	82	83	85	88	90	90	92	513	621	690	751	836	908	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%		50	36	22	16	17	29	29	28	28	27	26	46	44	43	42	41	39	37	200	189	155	123	114	95	0	0	0	1490	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		49	37	24	16	17	37	39	40	42	42	43	81	82	84	86	88	88	90	693	594	660	723	812	867	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%		49	34	21	13	15	26	26	25	24	23	22	38	36	34	33	32	30	28	165	125	90	77	61	47	0	0	0	0	0	1072	0	0	0	0	0	0	0
PW (BEGIN PER) 10%		48	36	23	16	17	36	38	39	40	41	42	79	80	81	84	86	86	88	653	550	618	675	725	810	0	188	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%		48	33	19	12	11	22	21	20	19	17	16	27	25	23	22	20	18	17	81	61	42	29	19	13	0	0	0	0	0	0	0	0	0	0	646	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT 5 3/8% RESID	TE NET	PRESENT EXPEND	WORTH AT RESID	TE NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5											
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	19	0	0	0	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	93	93	93	93	93	93											
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	21	21	21	21	21	21	21											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	72	72	98	98	118	118	118											
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	26	25	26	26	26	26	26	26	35	45	45	45	65	65	65											
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	12	12	12	12	12	14	14	14	16	18	21	24	30	35	35											
IRRIGATION SYSTEMS	35	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	8	8	8	11	12	14	15	17	20	20											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	8	8	8	8	9	9	9	9	11	12	14	16	20	24	24											
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	12	13	13	13	13	13											
MISCELLANEOUS	35	0	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	7	12	13	13	13	13	13											
5 3/4% CAP		0	0	0	81	128	128	129	128	128	241	241	241	244	244	244	244	244	244	285	335	376	381	422	435	435											
7 % CAP		0	0	0	101	157	157	157	157	157	292	292	292	292	296	296	296	296	296	345	410	454	461	509	525	524											
10 % CAP		0	0	0	142	218	218	218	218	218	398	398	398	398	404	404	404	404	404	468	557	617	627	691	717	709											

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1CQ0 - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
TOTAL ANNUAL CAPITAL				81	128	128	129	128	128	128	241	241	241	244	244	244	244	244	244	285	335	376	381	422	435	435
TOTAL O&M				53	40	26	18	19	40	42	43	44	46	47	87	88	90	93	95	95	97	106	134	157	165	187	205	219
TOTAL ANNUAL COST				134	168	154	147	147	168	170	284	285	287	291	331	332	334	337	339	380	432	482	515	579	600	654

CAPITAL RECOVERY FACTOR AT 7 %

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
TOTAL ANNUAL CAPITAL				101	157	157	157	157	157	157	292	292	292	292	296	296	296	296	296	345	410	454	461	509	525	524
TOTAL O&M				53	40	26	18	19	40	42	43	44	46	47	87	88	90	93	95	95	97	106	134	157	165	187	205	219
TOTAL ANNUAL COST				154	197	183	175	176	197	199	335	336	338	339	383	384	386	389	391	440	507	560	595	666	690	743

CAPITAL RECOVERY FACTOR AT 10 %

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
TOTAL ANNUAL CAPITAL				142	218	218	218	218	218	218	398	398	398	398	404	404	404	404	404	468	557	617	627	691	717	709
TOTAL O&M				53	40	26	18	19	40	42	43	44	46	47	87	88	90	93	95	95	97	106	134	157	165	187	205	219
TOTAL ANNUAL COST				195	258	244	236	237	258	260	441	442	444	445	491	492	494	497	499	563	654	723	761	848	882	928

NEW REGINA PLANT SIZE: 9.4MMGD SOIL-T PRETREATMENT APPLICATION RATE: 40 IN/YR NEW REGINA PLANT

- - - - - - BASIC DESIGN DATA - - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL G	2.16	2.37	2.58	2.80	3.01	3.22	3.44	3.65	3.87	4.08	4.23	4.26	4.29	4.32	4.65	4.78	4.91	5.04	5.18	5.94	6.70	7.41	8.33	9.02	9.49
TREATMENT PLANT CAPACITY (MGD)					5.18														6.70		8.53		9.49	9.49	9.49
SLUDGE DISCHARGED (DRY)					0.85	0.68	0.72	0.77	0.81	0.84	0.87	0.89	0.92	0.95	0.98	1.00	1.03	1.06	1.09	1.24	1.41	1.60	1.75	1.86	1.99
WINTER STORAGE (MG)					256	274	292	310	329	343	351	362	373	384	395	404	417	428	440	505	570	647	725	787	807
LAND AREA (ACRES)					490	481	514	543	578	598	617	636	656	675	695	714	734	753	774	887	1001	1137	1274	1368	1418

PLAN C PLANT 21

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	TOTAL PRESENT EXPEND	WORTH AT RESID	4 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105	0	0	210	74	104	5	48	93	7	40	81	0	30
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	1430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1430	143	1222	11	1231	1286	5	1161	1075	1	1072
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	1070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1070	0	0	3080	1148	1346	92	1253	1153	44	1108	918	11	906
SECONDARY PUMPING	35	0	0	0	0	312	0	0	0	0	0	0	0	0	0	0	0	0	0	312	0	0	0	312	0	0	936	246	417	19	397	356	9	344	277	7	275
PEACE MAINS	50	0	0	0	0	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	70	405	5	399	381	2	378	361	0	360
STORAGE RESERVOIRS	50	0	0	0	0	1465	0	0	0	0	0	0	0	0	0	0	0	0	0	960	0	865	0	385	0	0	3095	1124	1608	91	1517	1409	45	1364	1259	11	1249
RESERVOIR AFR & CL	10	0	0	0	0	351	0	0	0	0	0	0	0	0	0	0	0	0	0	480	0	625	0	685	0	692	2833	692	763	56	707	581	26	554	593	6	587
LAND PURCHASE & PREP	50	0	0	0	0	548	0	0	0	0	0	0	0	0	0	0	0	0	0	658	0	182	0	96	0	0	0	965	531	76	455	492	36	455	504	4	504
IRRIGATION SYSTEMS	33	0	0	0	0	265	0	0	0	0	0	0	0	0	0	0	0	0	0	331	0	72	0	303	0	0	751	269	316	20	296	268	9	259	214	2	211
DRAINAGE SYSTEMS	50	0	0	0	0	348	0	0	0	0	0	0	0	0	0	0	0	0	0	102	0	123	0	65	0	0	638	216	359	17	341	319	8	310	269	2	264
SLUDGE MANAGEMENT	30	0	0	0	0	194	0	0	0	0	0	0	0	0	0	0	0	0	0	122	0	0	0	0	194	0	510	201	229	16	213	198	7	191	161	2	159
MISCELLANEOUS	33	0	0	0	0	184	0	0	0	0	0	0	0	0	0	0	0	0	0	128	0	26	0	27	207	0	467	0	216	0	216	187	0	187	151	0	151
TOTAL		0	0	0	1535	5209	0	0	0	0	0	0	0	0	0	0	0	0	0	2896	0	1663	0	1976	1376	692	14403	5108	7521	413	7108	6586	196	6387	5430	51	5379
PW (1/72) 5 3/8%		0	0	0	1312	4224	0	0	0	0	0	0	0	0	0	0	0	0	0	1129	0	584	0	270	144	56	0	0	7521	413	7108	0	0	0	0	0	0
PW (1/72) 7 %		0	0	0	1252	3674	0	0	0	0	0	0	0	0	0	0	0	0	0	857	0	249	0	150	75	26	0	0	0	0	0	6586	196	6387	0	0	0
PW (1/72) 10 %		0	0	0	1152	3157	0	0	0	0	0	0	0	0	0	0	0	0	0	521	0	114	0	53	23	9	0	0	0	0	0	0	0	0	4470	51	5379

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	161	176	192	208	223	6	6	6	8	8	8	8	6	6	9	9	9	9	21	32	36	36	38	19	20	1528	0	952	0	952	875	0	875	777	0	772
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	315	0	100	0	100	77	0	77	51	0	51
TEMPORARY PUMPS	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	68	70	72	74	76	78	80	81	83	90	92	104	111	118	152	192	146	156	161	167	54	2439	0	1372	0	1372	985	0	985	579	0	579
SECONDARY PUMPING	35	0	0	0	0	0	0	27	28	30	31	32	33	34	36	38	40	42	43	45	47	51	55	60	65	68	71	2239	0	567	0	565	406	0	406	239	0	239
PEACE MAINS	50	0	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	125	0	38	0	38	28	0	28	18	0	18
STORAGE RESERVOIRS	50	0	0	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	9	9	12	12	16	16	22	486	0	337	0	337	83	0	83	49	0	49
RESERVOIR AFR & CL	10	0	0	0	0	0	0	23	24	24	25	26	26	27	27	28	29	30	31	32	32	37	41	45	46	49	50	1647	0	422	0	422	305	0	305	182	0	182
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	20	20	21	21	22	22	23	23	24	24	25	25	26	27	32	33	35	36	38	38	1321	0	345	0	345	251	0	251	151	0	151
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5	6	8	8	9	9	9	330	0	77	0	77	56	0	56	34	0	34
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	7	8	9	10	11	11	12	349	0	86	0	86	61	0	61	36	0	36
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		161	176	192	215	298	186	193	196	205	209	213	211	212	219	223	243	249	260	276	366	331	357	386	396	0	13751	0	4078	0	0	9192	0	0	2115	0	0
PW (BEGIN REAL $ 3/8		152	157	162	203	265	164	173	178	184	189	192	192	197	200	207	217	227	238	246	1250	1270	1474	1584	1603	1701	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%		152	154	164	174	217	130	126	124	121	119	116	111	107	105	103	107	107	108	102	421	360	292	303	229	174	0	0	4227	0	0	0	0	0	0	0	0	0
PW (BEGIN REAL 7%		152	164	179	208	274	167	171	176	182	186	183	184	188	183	196	208	213	224	232	1158	1311	1610	1725	1670	1774	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%		152	153	170	194	241	135	134	135	136	141	136	131	131	126	131	135	135	136	134	544	439	433	383	323	249	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN REAL 10 %		152	151	166	187	220	122	116	111	107	104	98	93	92	87	89	91	91	91	89	358	283	270	236	192	140	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %		152	149	164	184	217	120	113	107	101	96	92	87	84	80	82	83	83	83	78	326	253	236	203	167	118	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN REAL 15 %		152	146	161	178	208	113	104	97	90	84	77	72	69	64	65	65	64	63	59	234	178	164	136	104	72	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 15 %		152	144	161	174	197	106	94	87	79	73	66	61	57	54	54	53	52	51	47	183	136	122	98	74	50	0	0	0	0	0	0	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1,000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	TOTAL PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	80	80	80	80	80	80	80	80	83	83	83	83	80	80	80	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
SECONDARY PUMPING	35	0	0	0	0	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	49	48	48	49	48	46	46	46	46	46	46	46	46	46	46	46	46
PEACE MAINS	50	0	0	0	0	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
STORAGE RESERVOIRS	50	0	0	0	0	104	105	105	105	105	105	105	105	104	105	105	105	105	105	105	145	144	142	142	139	139	139	139	139	139	139	139	139	139	139	139	139
RESERVOIR AFR & CL	10	0	0	0	0	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	54	74	124	174	174	174	174	174	174	174	174	174	174	174	174	174	174
LAND PURCHASE & PREP	50	0	0	0	0	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	43	47	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
IRRIGATION SYSTEMS	33	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	26	25	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
DRAINAGE SYSTEMS	50	0	0	0	0	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	29	29	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
SLUDGE MANAGEMENT	30	0	0	0	0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
MISCELLANEOUS	33	0	0	0	0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
% SYSTEM COST		0	0	0	49	617	617	617	617	617	617	617	617	617	617	617	617	617	617	574	575	526	454	369	292	192	692	692	692	692	692	692	692	692	692	692	692	692
7 % COST		0	0	0	111	509	509	509	509	509	509	509	509	509	509	509	509	509	509	506	506	450	395	303	243	161	593	593	593	593	593	593	593	593	593	593	593	593
10 % COST		0	0	0	155	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617	617

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

TOTAL ANNUAL																																					
TOTAL ANNUAL																																					
TOTAL ANNUAL																																					

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL																																					
TOTAL ANNUAL																																					
TOTAL ANNUAL																																					

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL																																					
TOTAL ANNUAL																																					
TOTAL ANNUAL																																					

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL																																					
TOTAL ANNUAL																																					
TOTAL ANNUAL																																					

WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

LIVERPOOL PLANT SIZE: 5.000 MGD SOIL-T PRETREATING APPLICATION RATE: 10 IN/WK LIVERPOOL PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
				3.86	0.95	1.04	1.13	1.22	1.31	1.38	1.44	1.51	1.57	1.64	1.70	1.77	1.83	1.90	1.96	2.27	2.57	2.89	3.41	4.21	5.00
					2.27						1.96								2.57	2.98	3.41	4.21	5.00	5.00	5.00
					0.22	0.24	0.26	0.28	0.29	0.30	0.32	0.33	0.35	0.36	C.37	C.38	0.40	0.41	0.48	0.54	0.63	C.72	0.88	1.09
											128	133	139	144	150	156	162	166	193	218	254	290	336	425
											226	235	245	254	264	273	284	293	339	384	447	509	589	747

POPULATION
DOMESTIC AND INDUSTRIAL Q
TREATMENT PLANT CAPACITY (MGD)
SLUDGE DISCHARGED (TPD)
WINTER STORAGE (MG)
LAND AREA (ACRE)

PLAN C PLANT 23

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENS	PRESENT WORTH AT 5 3/8% RESID	PLAN C PLANT 23 PRESENT WORTH AT 7% NET	PRESENT WORTH AT 7% EXPENS	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	0	0	0	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	0	0	140	49	65	3	65	62	1	60	54	0	55
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	2432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2432	243	2039	14	2059	1984	9	1975	1926	2	1824
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	580	0	0	0	0	0	0	0	0	0	0	0	0	0	580	0	0	0	0	0	0	580	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	81	0	0	0	0	0	0	83	0	0	0	0	83	0	0	1740	724	705	58	696	590	28	560	470	7	469
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	156	0	0	0	0	0	0	63	0	0	0	0	63	0	0	240	93	90	6	83	71	3	68	58	1	67
STORAGE RESERVOIRS	50	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	154	37	91	2	78	78	1	76	59	0	59
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	680	0	0	0	0	0	0	0	255	0	326	0	532	0	0	0	1791	222	644	17	628	505	8	496	342	2	336
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	136	0	0	0	0	0	0	0	196	0	257	0	372	0	372	0	1351	371	305	30	278	218	14	204	126	5	123
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	169	0	0	0	24	0	0	0	31	30	42	41	80	78	0	0	497	165	140	40	129	132	19	123	89	4	84
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	93	0	0	0	0	0	0	0	93	31	15	15	29	121	9	0	345	152	102	12	90	78	5	72	51	1	50
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	176	0	0	0	15	0	0	0	21	20	28	28	56	53	0	0	351	116	112	9	102	87	4	83	56	1	57
MISCELLANEOUS	33	0	0	0	0	108	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	108	0	0	206	98	114	7	111	103	3	99	83	0	82
		0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	62	5	5	11	73	0	247	0	95	0	78	78	0	78	59	0	59
TOTAL		0	0	0	2502	744	0	0	0	0	0	1476	0	0	0	41	0	0	0	616	733	671	89	1167	1056	380	9066	2592	4588	209	4376	3998	101	3867	3272	25	3246
Pw CE/721 5 3/8%		0	0	0	0	639	0	0	0	0	0	1272	0	0	0	24	0	0	0	239	232	155	15	159	115	30	0	0	4588	209	4379	0	0	0	0	0	0	0
Pw CE/721 7 %		0	0	0	0	565	0	0	0	0	0	748	0	0	0	19	0	0	0	181	163	100	9	89	60	14	0	0	0	0	0	3998	101	3867	0	0	0
Pw CE/721 10 %		0	0	0	0	509	0	0	0	0	0	568	0	0	0	23	0	0	0	110	84	46	3	33	18	3	0	0	0	0	0	0	0	0	3272	25	3246

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENS	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 7% EXPENS	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	48	45	82	100	117	2	2	2	3	3	3	3	3	4	4	4	4	4	3	4	7	8	9	12	12	403	0	407	0	407	370	0	370	323	0	323
SLUDGE FACILITIES	35	5	7	8	10	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	0	34	0	34	32	0	32	29	0	29
SEWERS	50	0	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	560	0	172	0	172	135	0	132	98	0	88
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	29	30	31	32	33	35	36	37	38	39	40	41	42	43	44	48	53	62	61	61	2678	0	638	0	638	452	0	452	260	0	260
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	23	23	23	24	24	24	25	25	25	26	27	29	29	31	36	822	0	168	0	168	112	0	112	57	0	57
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	37	0	8	0	8	6	0	6	3	0	3
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	3	3	4	6	6	9	9	9	226	0	44	0	29	29	0	29	14	0	14
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	9	9	10	10	10	10	10	12	13	16	18	23	26	26	623	0	326	0	125	83	0	83	62	0	62
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	9	12	13	14	15	20	21	21	941	0	410	0	110	73	37	0	37
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	2	2	2	3	5	4	4	5	5	117	0	23	0	23	15	0	15	7	0	7
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	1	2	2	2	2	2	2	3	3	3	3	3	4	5	6	5	5	6	6	136	0	33	0	33	23	0	23	13	0	13
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		53	52	90	122	140	46	48	49	51	52	96	91	92	96	98	95	101	103	113	135	144	132	157	214	0	6456	0	1767	0	0	1393	0	0	879	0	0
Pw (BEGIN PER) 5 3/8		50	48	82	105	112	43	43	44	44	43	76	69	66	65	64	59	59	57	63	67	63	51	58	70	0	0	0	0	0	0	0	0	0	0	0	0
Pw CE/721 5 3/8%		53	49	78	98	107	33	32	31	30	29	46	44	42	41	40	38	38	37	43	46	40	34	39	46	0	0	0	1725	0	0	0	0	0	0	0	0
Pw (BEGIN PER) 7%		49	47	84	114	130	42	44	47	48	50	87	85	89	91	92	96	96	96	107	108	89	69	76	87	0	0	0	0	0	0	0	0	0	0	0	0
Pw CE/721 7%		49	46	77	97	93	32	29	28	27	25	40	38	37	35	33	31	30	29	33	33	28	21	24	28	0	0	0	0	0	0	0	0	0	0	0	0
Pw (BEGIN PER) 10%		48	45	75	111	121	41	41	42	42	41	72	67	67	67	65	62	62	60	70	70	57	43	49	57	0	0	0	1372	0	0	0	0	0	0	0	0
Pw CE/721 10%		48	44	73	93	96	29	26	24	22	21	36	33	31	30	28	26	25	24	28	28	22	16	18	21	0	194	0	0	0	0	0	0	0	901	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENS	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 7% NET	PRESENT WORTH AT 7% EXPENS	PRESENT WORTH AT 7% RESID	PRESENT WORTH AT 10% NET
PLANTS	35	0	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5											
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SEWERS	50	0	0	0	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
TEMPORARY PUMPS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
AERATED LAGOONS	30	0	0	0	0	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43											
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6											
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11											
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48											
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26											
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12											
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7											
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8											
SLUDGE MANAGEMENT	30	0	0	0	0	0	0	0	0	0	0	9	9	9	9	9	9	9	9	10	12	14	14	14	14	14											
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
5 3/8% CRF		0	0	0	164	171	171	171	171	171	171	294	294	294	294	294	294	294	294	294	328	376	426	485	552	626											
7 % CRF		0	0	0	280	294	294	294	294	294	294	358	358	358	358	358	358	358	358	358	362	362	420	478	548	626											
10 % CRF		0	0	0	252	325	325	325	325	325	325	492	492	492	492	492	492	492	492	492	492	492	492	492	492	492											

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

TOTAL ANNUAL CAPITAL																																				
TOTAL O&M																																				
TOTAL ANNUAL COST																																				

CAPITAL RECOVERY FACTOR AT 5 3/8%

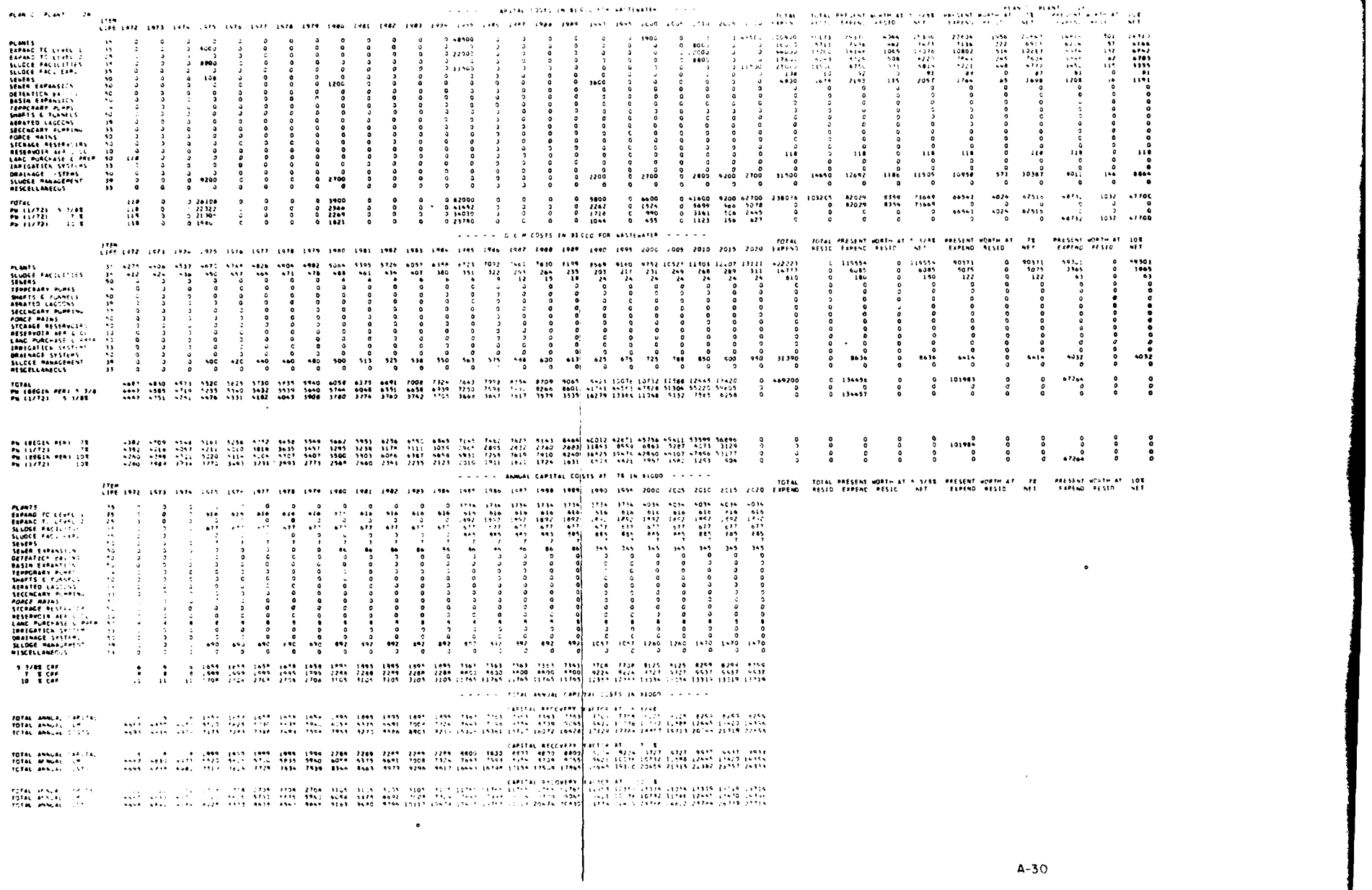
TOTAL ANNUAL CAPITAL																																				
TOTAL O&M																																				
TOTAL ANNUAL COST																																				

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL																																				
TOTAL O&M																																				
TOTAL ANNUAL COST																																				

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL																																				
TOTAL O&M																																				
TOTAL ANNUAL COST																																				



WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

EUCLID PLANT SIZE: 37.5(MGD) SOIL-T YPE(C-BEHAVIOR)APPLICATION RATE: 75 IN/YR EUCLID PLANT

PLAN C PLANT 27

- - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENC	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PLAN C PLANT 27 PRESENT WORTH AT 7% EXPENC	PRESENT WORTH AT 7% RESID	LCC NET
PLANTS	35	0	0	0	3500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3530	0	2992	0	2992	2856	0	2856
EXPAND TO LEVEL 1	25	0	0	0	1900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1900	0	1624	0	1624	1550	0	1550
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	2400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2430	0	2052	0	2052	1958	0	1958
SLUDGE FAC. EXPN.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	360	0	360	0	360	360	0	360
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	30	0	350	0	0	0	0	300	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	1110	0	961	0	961	925	0	868
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		360	350	0	7800	0	0	300	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	9270	0	7990	0	7990	7650	0	7086
PW (1/72) 5 3/8		360	331	0	6684	0	0	219	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7		360	701	0	6366	0	0	199	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7650	0	7650
PW (1/72) 10 8		360	681	0	5857	0	0	169	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7260	0	7086

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENC	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPENC	PRESENT WORTH AT 7% RESID	LCC NET
PLANTS	35	1034	1088	1142	1197	1229	1261	1293	1325	1360	1319	1278	1237	1196	772	789	808	823	840	44	48	52	57	62	65	68	21679	0	13208	0	13208	11674	0	11674
SLUDGE FACILITIES	35	112	118	124	130	133	136	139	142	147	150	153	146	149	100	102	104	106	108	0	0	0	0	0	0	0	2319	0	1412	0	1412	1303	0	1303
SEWERS	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	30	0	397	203	208	214	220	225	231	237	243	249	255	261	161	165	169	172	173	0	0	0	0	0	0	0	3583	0	2216	0	2216	1947	0	1559
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		1146	1603	1469	1535	1576	1617	1657	1698	1744	1712	1680	1648	1616	1033	1056	1079	1101	1121	44	48	52	57	62	65	0	27581	0	16895	0	0	14928	0	0
PW (BEGIN PER) 5 3/8		1087	1732	1704	1656	1698	1733	1771	1812	1853	1824	1794	1765	1737	1054	1003	1024	1045	1063	196	214	231	251	269	282	0	0	0	0	0	0	0	0	0	0
PW (1/72) 9 3/8		1087	1644	1555	1494	1533	1570	1612	1653	1694	1596	1565	1531	999	1003	1024	1045	1063		76	84	93	104	36	29	0	0	0	16895	0	0	0	0	0	0
PW (BEGIN PER) TE		1371	1309	1373	1435	1472	1510	1550	1588	1630	1598	1570	1540	1510	965	985	1010	1029	1046	188	204	221	242	261	270	0	0	0	0	0	0	0	0	0	0
PW (1/72) TE		1371	1224	1198	1171	1173	1174	1202	988	960	869	798	731	675	420	382	365	349	331	55	63	73	89	19	14	0	14928	0	0	0	0	0	0	0	0
PW (BEGIN PER) 10%		1041	1174	1215	1258	1432	1469	1507	1545	1583	1558	1523	1502	1469	936	955	984	999	1019	173	186	207	226	233	252	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%		1041	1114	1123	1048	1114	911	850	792	719	640	588	525	464	271	252	235	217	201	31	35	41	49	9	6	0	0	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENC	PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	PRESENT WORTH AT 7% EXPENC	PRESENT WORTH AT 7% RESID	LCC NET
PLANTS	35	0	0	0	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	0	0	0								
EXPAND TO LEVEL 1	25	0	0	0	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	163	0	0	0	0	0								
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE FACILITIES	35	0	0	0	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	0	0	0								
SLUDGE FAC. EXPN.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
LAND PURCHASE & PREP	50	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25								
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SLUDGE MANAGEMENT	30	0	58	56	56	56	56	78	78	78	78	78	78	78	83	83	83	83	83	83	83	83	83	83	83	27								
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
5 3/8% EXP		25	87	87	985	985	985	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	27	24						
7 % EXP		25	82	82	896	896	896	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	25	22						
10 % EXP		25	77	77	844	844	844	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	23	20						

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

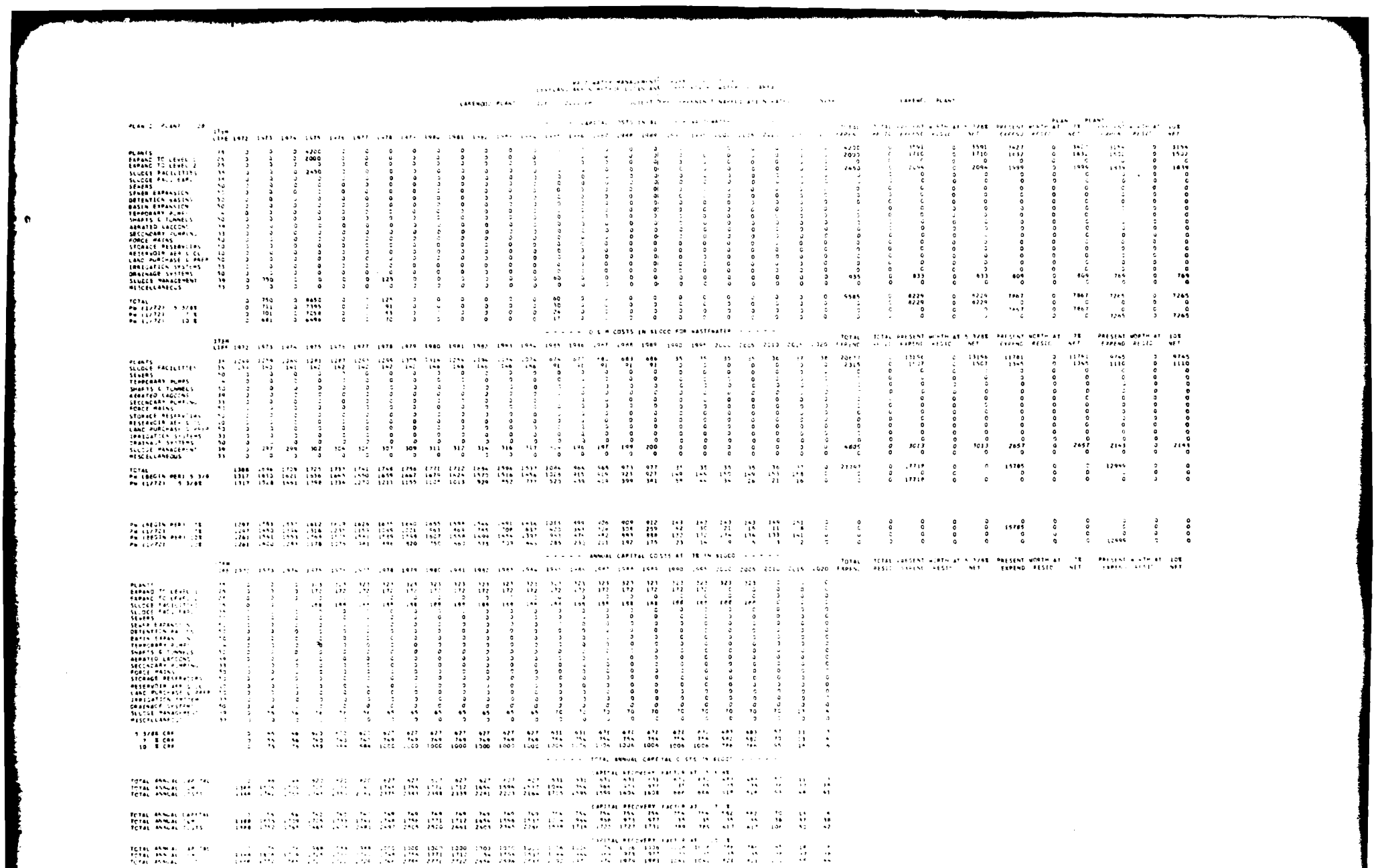
TOTAL ANNUAL CAPITAL		25	87	87	985	985	985	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	1004	27	24						
TOTAL ANNUAL O&M		1146	1603	1469	1535	1576	1617	1657	1698	1744	1712	1680	1648	1616	1033	1056	1079	1101	1121	44	48	52	57	62	65	0	27581	0	16895	0	0	14928	0	0
TOTAL ANNUAL COSTS		1146	1690	1556	2520	2561	2602	2661	2702	2748	2716	2684	2652	2620	2037	2060	2083	2105	2125	1048	1052	1056	1061	1066	1069	1004	27608	24	16895	0	0	14928	0	0

CAPITAL RECOVERY FACTOR AT 7%

TOTAL ANNUAL CAPITAL		25	82	82	896	896	896	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	912	25	22						
TOTAL ANNUAL O&M		1146	1603	1469	1535	1576	1617	1657	1698	1744	1712	1680	1648	1616	1033	1056	1079	1101	1121	44	48	52	57	62	65	0	27581	0	16895	0	0	14928	0	0
TOTAL ANNUAL COSTS		1171	1685	1551	2431	2472	2513	2569	2610	2656	2624	2592	2560	2528	1945	1968	1991	2013	2033	956	960	964	969	974	977	912	27606	22	16895	0	0	14928	0	0

CAPITAL RECOVERY FACTOR AT 10% 8

TOTAL ANNUAL CAPITAL		25	77	77	844	844	844	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	860	23	20						
TOTAL ANNUAL O&M		1146	1603	1469	1535	1576	1617	1657	1698	1744	1712	1680	1648	1616	1033	1056	1079	1101	1121	44	48	52	57	62	65	0	27581	0	16895	0	0	14928	0	0
TOTAL ANNUAL COSTS		1171	1680	1546	2379	2420	2461	2517	2558	2604	2572	2540	2508	2476	1893	1916	1939	1961	1981	904	908	912	917	922	925	860	27604	20	16895	0	0	14928	0	0



WASTEWATER MANAGEMENT SURVEY SCOPE STUDY
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA

NORTH OLMSTED PLANT SIZE: 37.001MGD SOIL-T YPE(C-BEARING)C=APPLICATION RATE(T 75 IN/YR NORTH OLMSTED PLANT

PLAN C PLANT 25

- - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	9500	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	9580	11	3650	0	3648	3224	0	3224	2562	0	2562
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3200	0	2736	0	2736	2611	0	2611	2402	0	2402
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	7141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7141	3428	4698	115	4583	4156	95	4100	3334	14	3320
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	30	0	356	0	0	0	0	520	0	0	0	0	0	0	72	0	0	0	0	0	0	0	0	0	0	0	1346	0	1151	0	113	1081	0	1081	994	0	994
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	356	0	3200	0	0	520	0	12641	0	0	0	0	72	0	0	0	0	80	0	0	0	0	0	0	17267	1439	12216	116	12099	11073	56	11017	9320	14	9306
PW (1/72) 5 3/8%		0	316	0	2736	0	0	376	0	8317	0	0	0	0	36	0	0	0	0	31	0	0	0	0	0	0	0	0	12216	116	12099	0	0	0	0	0	0
PW (1/72) 7 %		0	304	0	2611	0	0	346	0	7357	0	0	0	0	29	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	11073	56	11017	0	0	0
PW (1/72) 10 %		0	289	0	2483	0	0	293	0	5903	0	0	0	0	20	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9320	14	9306

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	363	422	477	835	925	1023	1117	1211	1307	1278	1249	1220	1191	801	823	845	867	889	45	45	54	58	62	66	66	18855	0	10770	0	10770	9346	0	9346	7362	0	7362
SLUDGE FACILITIES	35	14	20	26	32	35	38	41	44	51	51	51	51	51	31	31	31	31	31	0	0	0	0	0	0	0	660	0	402	0	402	352	0	352	276	0	276
SEWERS	50	0	0	0	0	0	0	0	0	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	1400	0	379	0	379	271	0	271	159	0	159
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	30	0	112	145	179	199	218	239	260	280	289	298	308	317	326	335	344	354	363	0	0	0	0	0	0	0	4567	0	2603	0	2603	2233	0	2233	1715	0	1715
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		377	652	848	1046	1165	1280	1397	1515	1673	1653	1633	1614	1596	1193	1224	1255	1287	1318	80	80	89	93	97	101	0	25482	0	14151	0	0	12203	0	0	9517	0	0
PW (BEGIN PER) 5 3/8		357	619	806	992	1106	1215	1326	1438	1586	1568	1550	1533	1515	1131	1162	1191	1221	1250	71	68	69	65	65	64	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%		357	587	729	848	894	934	968	996	1043	978	917	861	806	572	556	541	526	514	28	26	27	24	23	22	0	0	0	14151	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		352	636	792	978	1086	1195	1306	1415	1563	1541	1526	1509	1489	1115	1141	1170	1203	1230	70	352	373	390	406	409	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%		352	569	691	798	829	852	870	885	910	859	775	714	662	442	424	425	407	390	19	96	96	84	73	61	30	22	0	0	0	0	12203	0	0	0	0	0	0
PW (BEGIN PER) 10%		342	592	771	951	1057	1162	1270	1379	1518	1504	1480	1473	1444	1081	1112	1144	1168	1198	309	326	349	364	382	382	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%		342	538	656	714	722	721	716	707	709	638	571	514	462	313	282	273	256	237	55	31	24	15	9	6	0	0	0	0	0	0	0	0	0	9517	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	423	423	423	423	423	423	423	423	423	423	426	426	426	426	426	426	6	6							
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SLUDGE FACILITIES	35	0	0	0	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	3	3							
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SEWERS	50	0	0	0	0	0	0	0	0	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514							
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
SLUDGE MANAGEMENT	30	0	56	56	56	56	56	56	56	56	56	56	56	56	100	100	100	100	100	100	100	100	100	100	100	0	0							
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
5 3/8% CRF		0	56	56	251	251	251	251	251	1064	1064	1064	1064	1064	1056	1056	1056	1056	1056	1050	1050	1050	1050	1050	1050	423								
7 % CRF		0	56	56	302	302	302	302	302	1275	1275	1275	1275	1275	1265	1265	1265	1265	1265	1258	1258	1258	1258	1258	1258	506								
10 % CRF		0	56	56	409	409	409	409	409	1763	1763	1763	1763	1763	1753	1753	1753	1753	1753	1743	1743	1743	1743	1743	1743	706								

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

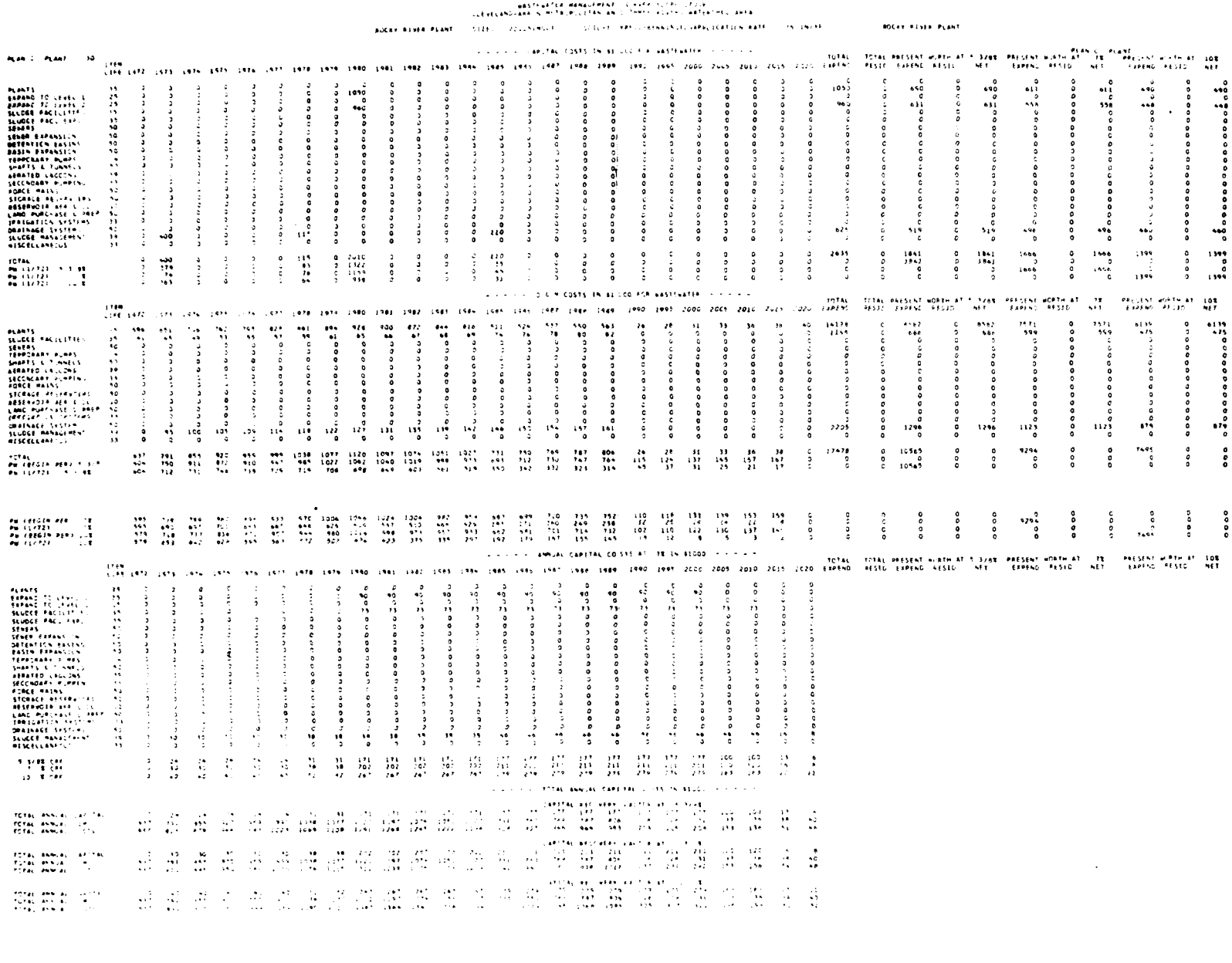
TOTAL ANNUAL CAPITAL		0	56	56	251	251	251	251	251	1064	1064	1064	1064	1064	1056	1056	1056	1056	1056	1050	1050	1050	1050	1050	1050	423								
TOTAL ANNUAL O&M		377	652	848	1046	1165	1280	1397	1515	1673	1653	1633	1614	1596	1193	1224	1255	1287	1318	80	80	89	93	97	101	0								
TOTAL ANNUAL COSTS		377	708	904	1297	1416	1531	1648	1766	2737	2717	2697	2678	2660	2249	2280	2311	2343	2374	1130	1130	1139	1143	1147	1151	423								

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL		0	56	56	302	302	302	302	302	1275	1275	1275	1275	1275	1265	1265	1265	1265	1265	1258	1258	1258	1258	1258	1258	506								
TOTAL ANNUAL O&M		377	652	848	1046	1165	1280	1397	1515	1673	1653	1633	1614	1596	1193	1224	1255	1287	1318	80	80	89	93	97	101	0								
TOTAL ANNUAL COSTS		377	708	904	1348	1467	1582	1699	1817	2948	2928	2908	2889	2871	2458	2489	2520	2552	2583	1338	1338	1347	1351	1355	1359	506								

CAPITAL RECOVERY FACTOR AT 10% E

TOTAL ANNUAL CAPITAL		0	56	56	409	409	409	409	409	1763	1763	1763	1763	1763	1753	1753	1753	1753	1753	1743	1743	1743	1743	1743	1743	706								
TOTAL ANNUAL O&M		377	652	848	1046	1165	1280	1397	1515	1673	1653	1633	1614	1596	1193	1224	1255	1287	1318	80	80	89	93	97	101	0								
TOTAL ANNUAL COSTS		377	708	904	1455	1574	1689	1806	1924	3436	3416	3396	3377	3359	2946	2977	3008	3040	3071	1823	1823	1832	1836	1840	1844	706								



WILLOUGHBY EASTLAKE PLANT SIZE: [illegible] SOIL: TYPE C-BENNINGTON APPLICATION RATE: .75 IN/YR WILLOUGHBY EASTLAKE PLANT

PLAN C PLANT 31

CAPITAL COSTS IN $1,000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	4150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4150	0	2730	0	2730	2415	0	2415	1938	0	1938
EXPANC TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPANC TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	1250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1250	0	1068	0	1068	1020	0	1020	938	0	938
SLUDGE FAC: EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	630	60	513	4	508	489	2	487	450	0	450
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	2194	0	0	0	0	0	0	0	0	0	2194	0	0	0	0	0	0	4540	1344	2402	108	2293	2017	52	1965	1493	13	1479
OBTENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER (LAG)	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE (LAGOON)	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	15	0	0	153	0	0	0	125	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	318	0	443	0	443	427	0	427	406	0	406
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	350	0	1850	0	0	0	6506	0	0	0	0	40	0	0	0	0	2184	0	0	0	0	0	0	11059	1404	7158	113	7044	6369	54	6314	5221	14	5206
PW (1/72) 5 3/8%			0	332		1588				5285	0	0	0	0	36	0	0	0	0	1551	0	0	0	0	0	0	0	0	7158	113	7044	6369	54	6314	0	0	0
PW (1/72) 7 %			0	327		1504				3786	0	0	0	0	34	0	0	0	0	646	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %			0	318		1389				2858	0	0	0	0	31	0	0	0	0	393	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3223	14	3206

O & M COSTS IN $1,000 FOR WASTEWATER

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	253	307	361	417	457	497	533	577	621	615	608	603	597	606	626	636	656	669	22	26	27	30	34	37	40	9566	0	5455	0	5455	4742	0	4742	3751	0	3751
SLUDGE FACILITIES	35	15	14	17	20	20	20	20	21	22	23	24	24	15	15	15	15	15	15	0	0	0	0	0	0	0	332	0	207	0	207	183	0	183	148	0	148
SEWERS	50	0	3	3	7	6	8	8	10	14	14	14	14	14	14	14	16	20	22	25	25	25	25	25	25	25	960	0	242	0	242	174	0	174	102	0	102
TEMPORARY PUMPS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER (LAG)	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE (LAGOON)	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	15	0	42	49	62	100	108	107	120	134	129	126	130	135	85	98	93	94	98	0	0	0	0	0	0	0	1778	0	1084	0	1084	948	0	948	754	0	754
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		284	412	472	536	581	634	672	737	770	770	770	771	773	723	743	763	788	804	46	48	52	55	59	62	0	12596	0	6990	0	0	6049	0	0	4756	0	0
PW (BEGIN PERIOD) 5 %		250	390	459	508	551	601	637	698	730	730	730	732	733	686	704	724	747	762	44	46	49	52	56	59	0	0	0	6990	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%		250	370	432	474	513	560	593	650	680	680	680	682	683	639	656	674	696	710	41	43	46	49	52	55	0	0	0	6990	0	0	0	0	0	0	0	0

PW (BEGIN PERIOD) 7 %		250	385	453	501	542	586	628	688	719	719	719	720	721	676	693	712	735	750	43	45	48	51	55	58	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %		250	358	415	456	494	539	571	626	655	655	655	657	658	616	632	649	670	684	39	41	44	47	50	53	0	0	0	6990	0	0	6049	0	0	0	0	0
PW (BEGIN PERIOD) 10 %		250	375	478	527	571	622	659	722	755	755	755	757	758	709	728	748	772	788	45	47	50	53	57	60	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %		250	338	373	381	426	454	446	526	547	547	547	548	549	513	527	541	558	570	32	34	36	38	41	43	0	0	0	6990	0	0	6049	0	0	4756	0	0

ANNUAL CAPITAL COSTS AT 7% IN $1,000

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	2	3						315	315	315	315	315	315	315	315	315	315	315	315	315	315	315													
EXPANC TC LEVEL 1	25									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
EXPANC TC LEVEL 2	25									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
SLUDGE FACILITIES	35									96	96	96	96	96	96	96	96	96	96	96	96	96	96	96													
SLUDGE FAC: EXP.	35									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
SEWERS	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
SEWER EXPANSION	50									194	194	194	194	194	194	194	194	194	194	194	194	194	194	194													
OBTENTION BASINS	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
BASIN EXPANSION	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
TEMPORARY PUMPS	15									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
SWAFTS & TUNNELS	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
AERATED LAGOONS	25									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
SECONDARY PUMPING	15									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
FORCE MAINS	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
STORAGE RESERVOIRS	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
RESERVOIR AER (LAG)	25									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
LAND PURCHASE (LAGOON)	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
IRRIGATION SYSTEMS	15									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
DRAINAGE SYSTEMS	50									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
SLUDGE MANAGEMENT	15			19	23	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	17											
MISCELLANEOUS	33									0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
5 3/8% CRF		0	21	21	21	21	21	21	21	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	466	871	871	371	371	371	835	835	835	358	358	358
7 % CRF		0	21	21	21	21	21	21	21	667	667	667	667	667	667	667	667	667	667	667	667	667	667	667	667	667	1274	1274	524	524	524	1221	1221	1221	525	525	525
10 % CRF		0	21	21	21	21	21	21	21	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	1778	1778	725	725	725	1731	1731	1731	754	754	754

ANNUAL O&M COSTS IN $1,000

TOTAL ANNUAL O&M		284	412	472	536	581	634	672	737	770	770	770	771	773	723	743	763	788	804	46	48	52	55	59	62	0	12596	0	6990	0	0	6049	0	0	4756	0	0
TOTAL ANNUAL CAP		0	21	21	21	21	21	21	21	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	1778	1778	725	725	725	1731	1731	1731	754	754	754
TOTAL ANNUAL		284	433	493	557	602	655	693	758	1629	1629	1629	1630	1632	1582	1602	1622	1647	1663	905	907	911	914	918	921	859	14374	1778	7715	725	725	7780	1731	1731	5510	754	754

TOTAL ANNUAL O&M		284	412	472	536	581	634	672	737	770	770	770	771	773	723	743	763	788	804	46	48	52	55	59	62	0	12596	0	6990	0	0	6049	0	0	4756	0	0
TOTAL ANNUAL CAP		0	21	21	21	21	21	21	21	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	1778	1778	725	725	725	1731	1731	1731	754	754	754
TOTAL ANNUAL		284	433	493	557	602	655	693	758	1629	1629	1629	1630	1632	1582	1602	1622	1647	1663	905	907	911	914	918	921	859	14374	1778	7715	725	725	7780	1731	1731	5510	754	754

TOTAL ANNUAL O&M		284	412	472	536	581	634	672	737	770	770	770	771	773	723	743	763	788	804	46	48	52	55	59	62	0	12596	0	6990	0	0	6049	0	0	4756	0	0
TOTAL ANNUAL CAP		0	21	21	21	21	21	21	21	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	859	1778	1778	725	725	725	1731	1731	1731	754	754	754
TOTAL ANNUAL		284	433	493	557	602	655	693	758	1629	1629	1629	1630	1632	1582	1602	1622	1647	1663	905	907	911	914	918	921	859	14374	1778	7715	725	725	7780	1731	1731	5510	754	754

EASTERLY PLANT — ALTERNATIVE — SCALE OF PROTECTION/REHABILITATION RATE — 75 LAYER — EASTERLY PLANT

PLAN C PLANT 12 — ANNUAL COSTS IN $1000 FOR WASTEWATER

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 1	25	0	0	0	15900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15900	0	13252	12648	0	13252	12648	0	11640	11640	0	11640
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	12900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12930	0	10687	10200	0	10687	10200	0	9187	9187	0	9187
SLUDGE PAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	1458	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1458	291	955	23	935	848	11	837	680	2	672	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMP	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AREA LAND	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & RELOC	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	0	28900	0	0	0	0	1458	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29458	291	24894	23	24874	23596	11	23685	21708	2	21705	0
PW (1972 $ 5 3/8)		0	0	0	21966	0	0	0	0	958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972 $ 7)		0	0	0	22748	0	0	0	0	1048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972 $ 10)		0	0	0	21028	0	0	0	0	930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PLAN C PLANT 12 — O & M COSTS IN $1000 FOR WASTEWATER

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	7928	7679	7429	7535	7456	7377	7296	8335	8431	8294	8377	7350	9471	9630	9534	9486	9510	9537	9655	250	134	134	134	134	134	184675	0	93563	0	93563	81535	0	81535	65176	0	65176
SLUDGE FACILITIES	35	1650	1605	1620	1637	1577	1519	1460	1496	1534	1573	1613	1654	1696	1740	1784	1829	1876	1924	1973	1324	1028	1037	1375	1375	1375	53625	0	19089	0	19089	16577	0	16577	13151	0	13151
SEWERS	50	0	0	0	0	0	0	0	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	240	0	75	0	75	54	0	54	31	0	31	0
TEMPORARY PUMP	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AREA LAND	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & RELOC	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		9578	9283	9049	9172	9033	8896	8756	9836	9972	9874	9997	9011	11174	11377	11325	11322	11393	11468	11635	1581	1169	1178	1516	1516	1516	238300	0	112731	0	112718	98167	0	98160	78359	0	78340	0
PW (BEGIN PER) 5 3/8		8520	8099	7870	7965	7871	7751	7626	8566	8656	8511	8539	7690	9440	9580	9501	9436	9470	9501	9631	1438	1035	1032	1297	1263	1192	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7		8920	8251	7662	7733	7621	7481	7322	8261	8278	8138	8154	7344	9000	9109	9019	8944	8970	8992	9107	1358	973	963	1202	1165	1094	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 10		9178	8465	7737	8021	7907	7795	7679	8655	8723	8573	8604	7676	9293	9414	9318	9238	9258	9278	9390	1277	900	884	1092	1043	974	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972$ 5 3/8)		8196	7785	7237	7351	7207	7056	6908	7795	7829	7645	7652	6723	8171	8224	8078	7933	7914	7898	7955	1044	729	694	852	812	753	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972$ 7)		8161	7568	7026	7033	6845	6696	6550	7366	7361	7188	7157	6325	7641	7654	7512	7375	7342	7309	7347	1000	688	650	797	757	701	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1972$ 10)		8126	7368	6826	6813	6585	6406	6240	7026	6996	6795	6730	5940	7141	7128	6966	6810	6762	6715	6732	892	598	563	690	653	604	0	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL CAPITAL COSTS AT 7% IN $1000

	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	5 3/8% NET	PRESENT EXPEND	WORTH AT RESID	7% NET	PRESENT EXPEND	WORTH AT RESID	10% NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 1	25	0	0	0	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	1333	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	0	962	0	962	962	0	962	962	0	962	0
SLUDGE PAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMP	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PUMPING	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AREA LAND	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & RELOC	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 3/8% CRF		0	0	0	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	0	2295	2295	0	2295	2295	0	2295	2295	0	2295
7 % CRF		0	0	0	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	0	2666	2666	0	2666	2666	0	2666	2666	0	2666
10 % CRF		0	0	0	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	0	3204	3204	0	3204	3204	0	3204	3204	0	3204

TOTAL ANNUAL CAPITAL COSTS IN $1000

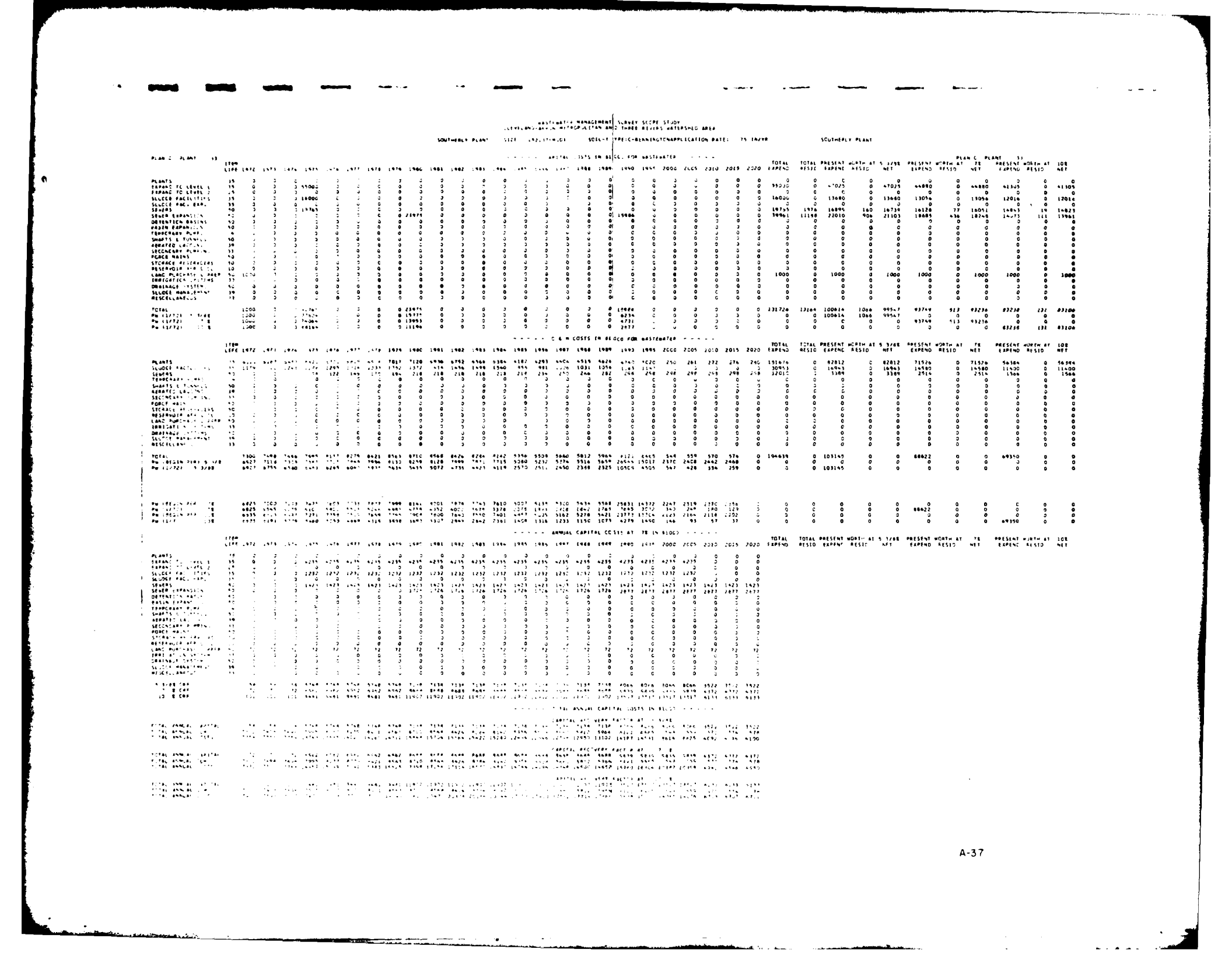
TOTAL ANNUAL CAPITAL		0	0	0	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	2295	0	2295	2295	0	2295	2295	0	2295	2295	0	2295
TOTAL ANNUAL O&M		9578	9283	9049	9172	9033	8896	8756	9836	9972	9874	9997	9011	11174	11377	11325	11322	11393	11468	11635	1581	1169	1178	1516	1516	1516	238300	0	112731	0	112718	98167	0	98160	78359	0	78340	0
TOTAL ANNUAL COST		9578	9283	9049	11467	11328	11191	11051	12131	12267	12169	12292	11306	13469	13672	13620	13617	13688	13763	13930	3876	3464	3473	3811	3811	3811	240595	0	115026	0	115013	100462	0	100455	80654	0	80635	0

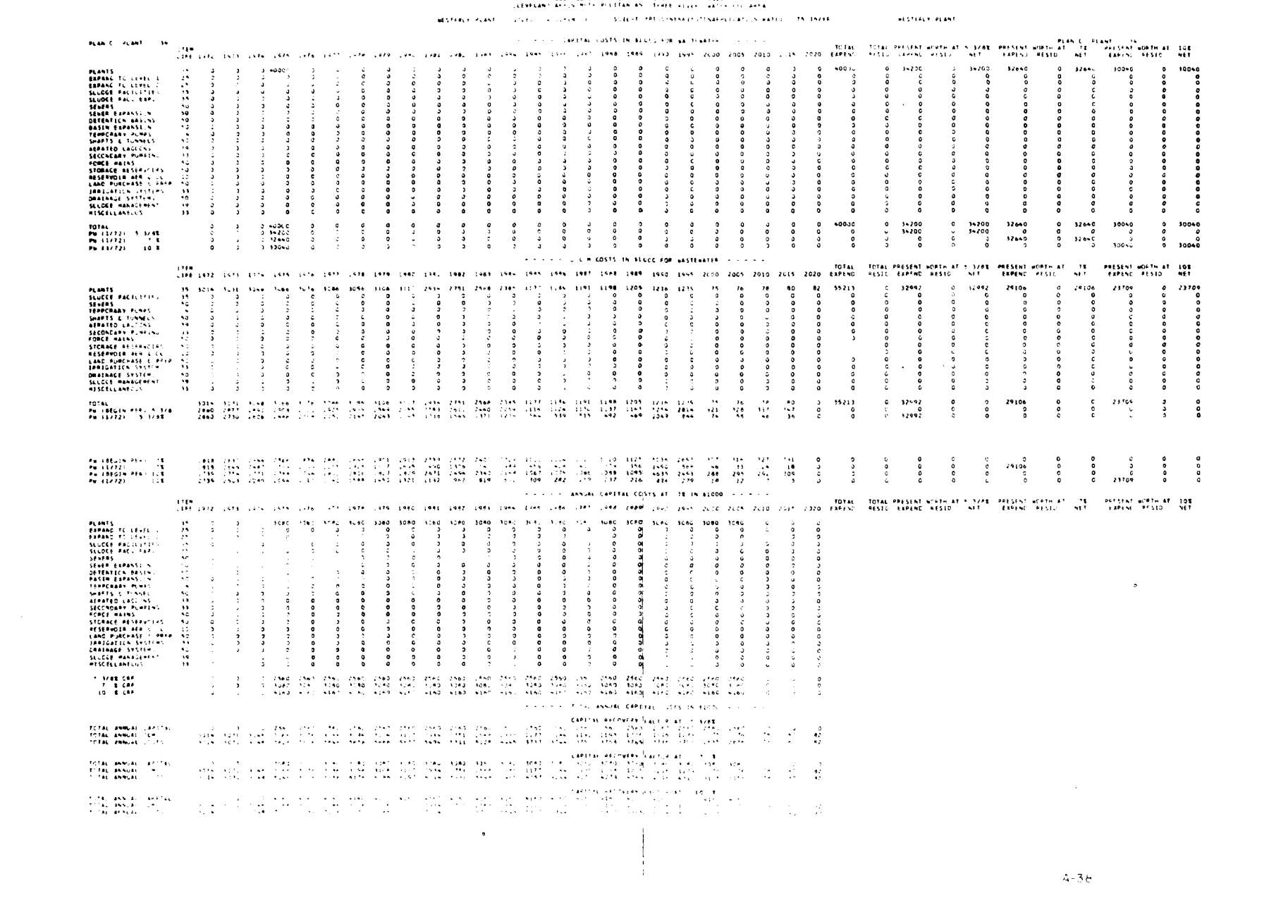
TOTAL ANNUAL CAPITAL COSTS AT 7% IN $1000 — APPLY RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL		0	0	0	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	2666	0	2666	2666	0	2666	2666	0	2666	2666	0	2666
TOTAL ANNUAL O&M		9578	9283	9049	9172	9033	8896	8756	9836	9972	9874	9997	9011	11174	11377	11325	11322	11393	11468	11635	1581	1169	1178	1516	1516	1516	238300	0	112731	0	112718	98167	0	98160	78359	0	78340	0
TOTAL ANNUAL COST		9578	9283	9049	11838	11699	11562	11422	12502	12638	12540	12663	11677	13840	14043	13991	13988	14059	14134	14301	4247	3835	3844	4182	4182	4182	240966	0	115397	0	115384	100833	0	100826	81025	0	81006	0

TOTAL ANNUAL CAPITAL COSTS AT 10% IN $1000 — APPLY RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL		0	0	0	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	3204	0	3204	3204	0	3204	3204	0	3204	3204	0	3204
TOTAL ANNUAL O&M		9578	9283	9049	9172	9033	8896	8756	9836	9972	9874	9997	9011	11174	11377	11325	11322	11393	11468	11635	1581	1169	1178	1516	1516	1516	238300	0	112731	0	112718	98167	0	98160	78359	0	78340	0
TOTAL ANNUAL COST		9578	9283	9049	12376	12237	12100	11960	13040	13176	13078	13201	12215	14378	14581	14529	14526	14597	14672	14839	4785	4373	4382	4720	4720	4720	241504	0	115935	0	115922	101371	0	101364	81563	0	81544	0





4-38

WSTRN LAND TRMT AREA PLANT SIZED: 545,210 MGD SCENT TYPE: GRAB ANALYSIS: APPLICATION RATE: 75 IN/YR WSTRN LAKE TRMT AREA PLANT

- - - - - BASIC DESIGN DATA - - - - -

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020
POPULATION																									
DOMESTIC AND INDUSTRIAL G														576.06	584.6	596.19	604.40	612.61	620.62	628.62	636.62	658.87	681.33	500.71	520.05
TREATMENT PLANT CAPACITY (MGD)													434.05						478.21		518.14		544.83		544.83
SLUDGE DISCHARGED (TPD)															19.82	20.22	20.62	21.02	21.42	36.88	39.21	101.08	105.15	109.22	112.28
WINTER STORAGE (MG)												62695	63913	64709	65662	66515	67409	68295	69315	51852	54393	56580	58770	60615	62061
LAND AREA (ACRE)												67427	69078	71073	72509	73945	74981	76816	78250	82275	86302	89777	93252	95863	98673

- - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - -

PLAN C PLANT 35

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESIC	TOTAL PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT WORTH AT EXPEND	RESID	TR NET	PRESENT EXPEND	WORTH AT RESID	LOR NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	21941	0	0	0	0	0	0	0	0	0	0	0	0	0	371084	95933	210246	7770	202475	178288	3761	176567	132636	959	131677
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56780	0	8630	0	0	0	0	68330	17980	25276	1456	23820	18965	701	18264	11341	179	11161
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5000	0	0	0	0	0	20000	45000	22000	24250	1782	22468	11260	858	10282	7482	220	7260
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	20906	0	0	0	0	0	0	0	0	0	0	0	0	270	56	106	4	102	88	2	86	63	0	63
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	34030	0	0	0	0	0	8370	0	7510	0	4350	0	0	56280	72474	24045	1820	22225	19198	876	18322	13051	226	12828
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	3020	0	0	0	0	0	3180	0	3370	0	3483	0	3496	16470	3460	4377	280	4097	3179	134	3044	1892	34	1858
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	52050	0	0	0	0	0	26470	26470	23130	23132	17186	11194	0	65482	31000	53064	25695	27281	25283	2553	22729	17716	654	17062
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	44530	0	0	0	0	0	2952	2255	1946	1941	1482	1462	46530	109041	52701	31593	4276	27317	24415	2058	22456	16374	527	15846
SLUDGE MANAGEMENT	-	0	0	0	0	0	0	0	0	0	0	0	0	40690	0	0	0	0	0	2690	2090	1907	1807	1358	1357	0	51199	17550	24238	1421	22816	19768	684	19083	13892	179	13677
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	4380	0	0	0	0	0	0	0	8177	0	1000	0	0	13557	4054	6471	490	5980	3336	234	3099	2052	60	1991
		0	0	0	0	0	0	0	0	0	0	0	0	9041	0	0	0	0	0	6481	508	1258	395	297	297	9041	27330	13416	8667	1086	7579	6656	523	6133	4511	134	4377
TOTAL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESIC	TOTAL PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT WORTH AT EXPEND	RESID	TR NET	PRESENT EXPEND	WORTH AT RESID	LOR NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6220	6670	7090	7295	7500	7695	7790	216115	0	40281	0	40281	25605	0	25605	11709	0	11709
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	0	0	6546	6696	6996	7146	7256	7633	7870	8260	8551	8774	9585	10096	280816	0	60796	0	60796	40849	0	40849	20857	0	20857
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	35	0	7	0	7	5	0	5	2	0	2
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	170	170	170	170	170	212	212	249	249	261	281	281	8440	0	1757	0	1757	1167	0	1167	584	0	584
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	723	738	753	767	782	798	837	878	916	960	976	1002	31018	0	6696	0	6696	4496	0	4496	2293	0	2293
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	2194	2260	2286	2332	2378	2322	2432	2526	2620	2690	2761	2761	88290	0	19507	0	19507	13162	0	13162	6742	0	6742
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	509	509	509	509	509	535	561	586	608	623	640	640	20555	0	4669	0	4669	3006	0	3006	1538	0	1538
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	83	85	86	88	89	104	103	121	122	139	451	483	11446	0	2035	0	2035	1282	0	1282	582	0	582
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	0	0	0	0	0	0	0	0	0	0	0	244	244	244	244	1014	1786	23041	23265	23698	23733	23936	20650	23739	23606	23746	24458	24675	0	748793	0	157059	0	0	104451	0	52372	0	0
PW (BEGIN PER) 5 3/8		0	0	0	0	0	0	0	0	0	0	0	0	0	231	231	231	231	961	1690	12370	12501	12604	13016	13123	9035	9582	8615	8215	8215	7905	0	3	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8%		0	0	0	0	0	0	0	0	0	0	0	0	0	160	152	144	137	541	902	6259	6243	5940	5636	5435	3126	2844	2342	1917	1655	1374	0	0	0	162286	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		0	0	0	0	0	0	0	0	0	0	0	0	0	227	227	227	227	947	1667	12192	12376	12611	12823	13032	8585	8735	7996	7611	7611	7321	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7%		0	0	0	0	0	0	0	0	0	0	0	0	0	142	132	123	115	470	742	5094	5001	4972	4767	4725	2942	2929	2679	2501	2379	2258	0	0	0	107926	0	0	0	0	0	0	0
PW (BEGIN PER) 10%		0	0	0	0	0	0	0	0	0	0	0	0	0	222	221	221	221	924	1621	11826	12054	12414	12656	12908	8436	8777	7966	7444	7444	7165	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10%		0	0	0	0	0	0	0	0	0	0	0	0	0	113	103	94	85	325	517	3629	3570	3460	3378	3298	2046	2015	1808	1638	1508	1384	0	0	0	94105	0	0	0	0	0	0	0

- - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESIC	TOTAL PRESENT EXPEND	WORTH AT RESID	% 3/8% NET	PRESENT WORTH AT EXPEND	RESID	TR NET	PRESENT EXPEND	WORTH AT RESID	LOR NET
PLANTS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TC LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	3519	3519	3519	3519	14616	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4477	4477	5124	5124	5124	5124	5124	5124	5124	5124	5124	5124	5124
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	0	0	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450	2450
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504	504
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760	3760
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629	3629
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929	2929
SLUDGE MANAGEMENT	19	0	0	0	0	0	0	0	0	0	0	0	0	0	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363	363
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	735	735	735	735	735	735	735	735	735	735	1209	1249	1467	1377	1461	1424	1424	1424	1424	1424	1424	1424	1424	1424
5 3/8% CRF		0	0	0	0	0	0	0	0	2935	2935	2935	2935	11773	34456	34456	34456	34456	34456	34456	34456	40433	40433	42393	42786	43522	43516	41716	43522	43516	41716	43522	43516	41716	43522	43516	41716
7 % CRF		0	0	0	0	0	0	0	0	3519	3519	3519	3519	14616	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601
10 % CRF		0	0	0	0	0	0	0	0	4937	4937	4937	4937	20501	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193	59193

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL				0	0	0	0	0	0	2935	2935	2935	2935	11773	34456	34456	34456	34456	34456	34456	34456	40433	40433	42393	42786	43522	43516	41716	43522	43516	41716	43522	43516	41716	43522	43516	41716
TOTAL ANNUAL O+M				0	0	0	0	0	0	244	244	244	244	1014	1786	23041	23265	23698	23733	23936	20650	23739	23606	23746	24458	24675	0	748793	0	157059	0	0	104451	0	52372	0	0
TOTAL ANNUAL				0	0	0	0	0	0	3079	3079	3079	3079	12787	36162	57497	57721	58154	58189	58392	55106	64172	64039	66139	67244	68197	43516	790509	43522	200775	41716	43522	147827	41716	95744	43522	43516

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL				0	0	0	0	0	0	3519	3519	3519	3519	14616	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601	47601
TOTAL ANNUAL O+M				0	0	0	0	0	0	244	244	244	244	1014	1786	23041	23265	23698	23733	23936	20650	23739	23606	23746	24458	24675	0	748793	0	157059	0	0	104451	0	52372	0	0
TOTAL ANNUAL				0	0	0	0	0	0	3763	3763	3763	3763	15630	49385	70642	70866	71299	71334	71537	68251	77340	77207	79307	80412	81365	47601	833594	47601	243834	41716	47601	189052	41716	100116	47601	47601

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL				0	0	0	0	0	0	4937	4937	4937	4937	20501	59193	59193	59193	59193

WASTEWATER MANAGEMENT SURVEY TYPE STUDY
CLEVELAND-AKRON METROPOLITAN AND SMALL RESERVE REFERENCE AREA

INTERIM PLANTS PLANT ... 1972 ... 1980 ... SOLUTION TYPE ... APPLICATION RATES ... 1972 ... INTERIM PLANTS PLANT

- - - - - - CAPITAL COSTS IN $1,000 FOR WASTEWATER - - - - - -

PLAN C PLANT ID	ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND.	TOTAL RESID.	PRESENT EXPEND	WORTH AT RESID.	% 1/ NET	PRESENT EXPEND	WORTH AT RESID.	PLAN C, PLANT ID, 75 NET	PRESENT EXPEND	WORTH AT RESID.	100 NET
PLANTS	50	0	0	0	11252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11252	0	9620	0	9620	9181	0	9181	8450	0	8450
EXPAND TO LEVEL 1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITY	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASIN	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PLANT	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PLANTS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AUG. & CL.	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & DEVP.	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL		0	0	0	11252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11252	0	9620	0	9620	9181	0	9181	8450	0	8450
PW 12/72 - 5 3/8%		0	0	0	9620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 12/72 - 5 3/8%		0	0	0	9181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW 12/72 - 10 %		0	0	0	8450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - - O & M COSTS IN $1,000 FOR WASTEWATER - - - - - -

ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 1/ NET	PRESENT EXPEND	WORTH AT RESID	75 NET	PRESENT EXPEND	WORTH AT RESID	100 NET
PLANTS 50	1492	1429	1369	1306	1889	1918	2050	2132	2178	2219	2244	2283	2332	2372	2410	2448	2486	2524	2564	282	0	0	0	0	0	35754	0	20412	0	20412	17741	0	17741	14088	0	14088
SLUDGE FACILITIES 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PLANTS 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PLANTS 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AUG. & CL. 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & DEVP. -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1492	1429	1369	1306	1889	1918	2050	2132	2178	2219	2244	2283	2332	2372	2410	2448	2486	2524	2564	282	0	0	0	0	0	35754	0	20412	0	20412	17741	0	17741	14088	0	14088
PW (BEGIN PERI 12	1319	1170	1024	1403	1692	1436	1420	1402	733	719	704	690	673	658	642	626	610	594	578	98	0	0	0	0	0	0	0	20412	0	0	0	0	0	0	0	0	0
PW 12/72 - 5 3/8%	1319	1170	1024	1403	1692	1436	1420	1402	733	719	704	690	673	658	642	626	610	594	578	98	0	0	0	0	0	0	0	20412	0	0	0	0	0	0	0	0	0

PW (BEGIN PERI 12	1296	1178	1067	1017	1767	1614	1917	1991	2090	2136	2172	2208	2244	2282	2319	2356	2394	2431	2469	2634	2809	2996	3196	3409	3636	0	0	0	0	0	0	0	0	0	0	0	0
PW 12/72 - 5 3/8%	1296	1178	1067	1017	1767	1614	1917	1991	2090	2136	2172	2208	2244	2282	2319	2356	2394	2431	2469	2634	2809	2996	3196	3409	3636	0	0	0	0	0	17741	0	17741	0	0	0
PW (BEGIN PERI 12	1283	1188	1076	1045	1716	1747	1966	1962	2067	2106	2137	2170	2204	2240	2276	2312	2350	2388	2426	2587	2758	2942	3138	3347	3570	0	0	0	0	0	0	0	0	14088	0	0	0
PW 12/72 - 10 %	1283	1188	1076	1045	1716	1747	1966	1962	2067	2106	2137	2170	2204	2240	2276	2312	2350	2388	2426	2587	2758	2942	3138	3347	3570	0	0	0	0	0	0	0	0	14088	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 75 IN $1000 - - - - - -

ITEM LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1992	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT EXPEND	WORTH AT RESID	% 1/ NET	PRESENT EXPEND	WORTH AT RESID	75 NET	PRESENT EXPEND	WORTH AT RESID	100 NET
PLANTS 50	0	0	0	0	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 1 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXPAND TO LEVEL 2 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITIES 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE FACILITY 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWER EXPANSION 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DETENTION BASIN 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PLANT 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AERATED LAGOONS 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECONDARY PLANTS 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AUG. & CL. 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & DEVP. -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$ 3/8% CAP	0	0	0	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7 % CAP	0	0	0	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 % CAP	0	0	0	1173	1173	1173	1170	1173	1170	1173	1173	1170	1173	1170	1173	1170	1173	1170	1173	1170	1173	1170	1173	1170	1173	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - - TOTAL ANNUAL COSTS - - - - - -

TOTAL ANNUAL COSTS/AC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ANNUAL	1492	1429	1369	2172	2755	2784	2916	2998	3044	3085	3110	3149	3198	3238	3276	3314	3352	3390	3430	3148	3039	3036	3039	3036	3039	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ANNUAL	1492	1429	1369	2172	2755	2784	2916	2998	3044	3085	3110	3149	3198	3238	3276	3314	3352	3390	3430	3148	3039	3036	3039	3036	3039	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - - CAPITAL AS CREDIT IN $ AT - - - - - -

TOTAL ANNUAL CAPITAL	0	0	0	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866	866

TOTAL PLN MUNICIPAL/INDUSTRIAL WASTEWATER FOR PLAN C

PLAN C

- - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	TE NET	PRESENT WORTH AT TE RESID	PRESENT WORTH AT TE NET	10E NET
PLANTS	35	3	3	3	62134	3	3	0	0	9846	0	0	2	3	48500	3	3	0	0	40	0	1401	0	1182	13	49500	171554	75022	87331	44132	47251	77430	1989	27419	44617	510	49523
EXPAND TC LEVEL I	25	3	3	3	52403	3	3	0	0	1050	0	0	0	0	0	0	0	0	0	0	0	0	0	6000	0	0	59453	32758	46621	222	69654	62444	57	62551
EXPAND TC LEVEL II	25	3	3	3	0	3	3	0	0	0	0	0	0	0	22003	3	3	0	0	0	0	0	0	22000	0	0	44023	13605	19136	1266	13976	19122	514	13547	19276	132	6962
SLUDGE FACILITIES	35	3	3	3	48600	3	3	0	0	960	0	0	0	0	0	0	0	0	0	0	0	0	0	840	0	0	54363	5247	11096	504	11171	35253	265	33604	35451	97	37615
SLUDGE FAC. EXPA	35	3	3	3	0	3	3	0	0	0	0	0	0	0	11500	0	0	0	0	0	0	0	0	0	0	11500	23030	11530	9750	931	9814	9221	448	4771	9615	115	1339
SEWERS	50	3	3	3	43130	0	0	0	0	12451	0	0	0	0	0	0	0	0	0	715	0	0	0	0	0	0	56296	8691	44031	561	41490	41648	246	41227	37344	66	37533
SEWER EXPANSION	50	3	3	3	0	3	3	0	0	29369	0	0	0	0	0	0	0	0	0	1420	0	720	0	0	0	0	53577	15753	29690	1274	27426	24192	823	23554	18635	159	17853
OXTENSION PASINS	50	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	3	3	3	0	3	3	0	46884	0	0	0	0154	100	168100	0	0	3	3	0	0	0	0	0	0	0	371084	99813	210268	8730	207475	178269	3761	176567	132838	965	131877
AERATED LAGOONS	35	3	3	3	0	12420	0	0	0	0	0	0	0	0	0	0	0	0	0	40643	8783	8630	0	0	0	12453	0	106843	52312	39654	2801	47053	41246	1292	30004	21188	323	20867
SECONDARY PUMPING	33	3	3	3	0	496	0	0	0	0	0	0	2394	0	20000	0	0	0	0	7378	0	0	0	496	2394	20000	53154	24644	17314	1956	15314	13430	962	12643	9223	268	8676
ROADS WALKS	50	3	3	3	0	587	0	0	0	0	0	0	6382	0	240	0	0	0	0	0	0	0	0	0	0	0	7345	1674	4341	235	4229	3778	65	3715	2528	14	2913
STORAGE RESERVOIRS	50	3	3	3	0	2287	0	0	0	0	0	0	14750	0	14310	0	0	0	0	14450	0	0	0	14443	0	12903	0	0	92863	35902	2817	36621	31771	1585	30386	22157	355	21701
RESERVOIR APP C	50	3	3	3	0	532	0	0	0	0	0	0	3738	0	3320	0	0	0	0	6736	0	0	0	0	0	0	11565	4935	11565	936	11004	9083	451	8661	6434	115	5359
LAND PURCHASE & PREP	50	2190	3	3	0	754	0	0	0	0	0	0	4817	0	52340	0	537	3	3	0	0	0	0	3777	3537	3536	1170	2933	2647	0	86560	77449	34301	6241	32610	31642	3029	28613	22965	776	22129
IRRIGATION SYSTEMS	25	0	0	0	0	519	0	0	0	0	0	0	4241	0	46510	0	442	0	0	0	0	0	0	4234	2894	4759	2758	2679	69576	6301	469731	119832	55552	45344	4762	31401	29364	2783	25642	18962	565	18357
DRAINAGE SYSTEMS	50	3	3	3	0	537	0	0	0	0	0	0	2955	0	40690	0	378	3	3	0	0	0	0	2783	2832	2566	2356	2363	1592	0	58622	35967	27470	1677	25812	22404	798	21606	15749	224	15545
SLUDGE MANAGEMENT	35	0	1004	0	9260	2452	0	1285	0	2700	0	0	0	0	4580	462	3	0	0	0	0	0	0	2322	1135	10477	0	3902	11457	2700	55553	23131	23188	1873	21814	20317	902	19414	16427	231	16196
MISCELLANEOUS	33	0	0	0	0	1363	0	0	0	0	0	0	781	0	9041	0	78	0	0	0	0	0	0	6733	1510	1432	521	482	1882	9256	32875	13410	10932	1586	9645	8556	523	8033	5774	134	5640
TOTAL			2190	5004		0241464	215170	0	1285	45884	56190	0	40058	156	100	178251	82362	2415	3	0	0	0	0	235234	20465	59050	8626	76763	352	61204	1505878	504848	755228	40892	714335	641173	19689	620084	501952	5048	496904
PW 11/721	5 3/8%		2190	2850		0206491	178246	0	865	33876	35057	0	23714	86604	62	81975	41665	679	3	0	0	0	0	52762	6135	13640	1435	10920	122	17173	0	0	755226	40892	714335	0	0	0	0	0	0
PW 11/721	7 %		2190	2154		0157034	147849	0	789	30454	31534	0	20369	73207	167	34	36373	563	3	0	0	0	0	40029	4312	8567	822	5835	2159	5961	0	0	0	0	0	0	645173	19689	626084	0	0	0
PW 11/721	10 %		2190	2330		0181339	156111	0	668	25077	25306	0	15462	53435	120	855	23879	372	3	0	0	0	0	29342	2292	4274	370	2671	267	1532	0	0	0	0	0	0	0	0	0	501952	5048	496904

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	TE NET	PRESENT WORTH AT TE RESID	PRESENT WORTH AT TE NET	10E NET
PLANTS	35	27407	28522	29038	30773	31634	29819	30382	30967	30516	29979	29446	28909	28374	27844	21785	22352	23015	23638	25547	21226	18672	11495	12336	14278	14216	910911	0	410421	0	410421	344438	0	344438	269010	0	269090
SLUDGE FACILITIES	35	3416	3522	3627	3762	3796	3704	3801	3848	3916	3963	3972	4001	4030	2627	2632	2537	2642	2647	2723	2635	231	249	268	289	311	80492	0	46703	0	46703	40312	0	40312	31764	0	31764
SEWERS	50	0	0	0	206	232	258	284	310	402	402	402	402	402	402	424	446	468	490	524	525	527	527	527	527	527	21326	0	6049	0	6049	4497	0	4497	2810	0	2810
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	244	244	244	244	1016	1788	2503	2376	2386	2398	2409	2421	2454	2487	2515	2543	2565	2579	91014	0	21508	0	21508	14895	0	14895	8064	0	8064
AERATED LAGOONS	35	0	0	0	0	0	676	694	712	733	747	767	792	809	828	452	475	899	926	7218	7855	8654	8748	9052	9271	9488	268790	0	53390	0	53390	31607	0	31607	17235	0	17235
E ENCARY PUMPING	33	0	0	0	0	0	40	41	44	45	47	48	326	336	6849	7064	7229	7391	7558	7791	8163	8554	8889	9223	9486	9746	502306	0	65504	0	65504	44056	0	44056	22954	0	22954
ROADS WALKS	50	0	0	0	0	0	0	4	4	4	4	4	4	44	44	45	45	45	45	45	45	45	45	45	45	45	1067	0	417	0	417	293	0	293	167	0	167
STORAGE RESERVOIRS	50	0	0	0	0	0	11	11	11	11	11	11	65	65	255	255	256	256	256	256	327	327	390	390	452	453	4458	0	2856	0	2856	1914	6	1914	980	0	980
RESERVOIR APP C	50	0	0	0	0	0	34	35	35	36	38	38	290	291	990	1011	1032	1054	1077	1129	1157	1352	1389	1462	1504	1541	46613	0	10113	0	10113	6825	0	6825	3531	0	3531
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	25	0	0	0	0	0	31	31	32	32	33	33	59	242	246	2443	2456	2545	2596	2643	2624	2757	2895	3015	3128	3210	3216	107934	0	22544	0	22544	15227	0	15227	7856	0	7856
DRAINAGE SYSTEMS	50	0	0	0	0	0	4	4	4	4	4	4	8	8	55	57	569	571	573	573	606	641	674	704	731	753	755	23879	0	5205	0	5205	3510	0	3510	1807	0	1807
SLUDGE MANAGEMENT	35	0	791	940	1291	1344	1442	1500	1559	1616	1656	1695	1736	1774	1738	1650	1686	1723	1761	845	913	1229	1300	1388	1457	1531	65078	0	21724	0	21724	17202	0	17202	12019	0	12019
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL			30823	32935	34157	36012	34964	36134	36844	37811	37016	37169	36729	37353	38393	40844	41861	42643	43599	46582	47336	43961	39167	42254	42178	43762	0	1952502	0	666410	0	0	528173	0	0	371480	0	0
PW 11/721	5 3/8%		29278	31159	32163	32165	31421	30226	30241	30666	29067	28733	27502	26244	25067	24443	23684	23067	22732	23582	22270	20396	18421	17592	16836	15719	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/721	7 %		29451	29584	29155	29265	27415	26377	25519	24896	23617	22804	21638	20638	19874	19605	19324	18464	17918	17379	16231	14424	13217	12517	11894	11343	0	0	0	0	0	0	0	0	0	0	0	0
PW 11/721	10 %		29605	29043	28464	27696	26472	25277	24474	23707	22515	21693	20477	19479	18567	18167	17821	16917	16750	16159	14855	12593	11261	10516	9916	9434	8321	7266	5153	0	0	0	0	0	0	0	0	0	0
PW 11/721	12 %		29819	29154	27929	27477	26115	24955	23956	22908	21963	20881	19743	18651	17630	16951	15967	15204	14459	13820	13190	11346	10166	9497	8963	8504	7511	6556	4651	0	0	0	0	0	0	0	0	0	0
PW 1968/9 PLAN C	8		29607	29926	28554	27837	26547	25426	24502	23615	22871	21982	20854	19972	19115	18381	17643	16951	16318	15732	14572	12792	11627	10768	10081	9561	8448	7371	5230	0	0	0	0	0	0	0	0	0	0
PW 11/721	10 %		28318	27121	25611	24906	23619	22379	21903	21067	20349	19367	18353	17507	16747	16063	15265	14596	13982	13423	12207	10417	9341	8645	8095	7677	6781	5918	4201	0	0	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1000 - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL PRESENT WORTH AT 5 3/8% RESID	PRESENT WORTH AT 5 3/8% NET	TE NET	PRESENT WORTH AT TE RESID	PRESENT WORTH AT TE NET	10E NET
PLANTS	35	0	0	0	6630	6630	6630	6630	6630	6630	5374	5374	5374	5374	5374	5108	5128	5108	5108	5108	5114	5114	5417	5415	4375	4172	4232										
EXPAND TC LEVEL I	25	0	0	0	6519	6519	6519	6519	6519	6609	6609	6609	6609	6609	6623	6623	6609	6609	6609	6609	6609	6609	6609	6609	6609	6609	6616	6616	6616								
EXPAND TC LEVEL II	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492								
[illegible]	35	0	0	0	3488	3488	3488	3488	3488	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562	3562								
SLUDGE FACILITIES	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	445	445	885	885	885	885	885	885	885	885	885	885	885	885								
SEWERS	50	0	0	0	3205	3205	3205	3205	3205	3205	3457	3457	3457	3457	3457	3457	3457	3457	3457	3457	3505	3505	3505	3505	3505	3505	3505	3505	3505								
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	2134	3864	3864	3864								
EXTENSION PASINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
TEMP ARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	3519	3519	3519	3519	3519	3519	3519	14606	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718	26718								
AERATED LAGOONS	35	0	0	0	0	0	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	6785	6785	6785	6785	6785	6785	6785								
SECONDARY PUMPING	33	0	0	0	0	0	38	38	38	38	38	38	225	225	225	1744	1744	1744	1744	1744	1744	1744	2392	2392	2392	2392	4360	4360	4360								
ROADS WALKS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	501	501	516	516	516	516	516	516	516	516	516	516	516	516								
STORAGE RESERVOIRS	50	0	0	0	0	0	184	184	184	184	184	184	1226	1227	1675	1676	1676	1676	1676	1676	4317	4317	4317	4317	4317	4317	4698	4698	4698								
RESERVOIR APP C	50	0	0	0	0	0	60	60	60	60	60	60	494	494	2182	2180	2180	2180	2180	2180	5149	5149	5149	5149	5149	5149	5317	5317	5317								
LAND PURCHASE & PREP	50	147	147	147	147	147	214	214	214	214	214	214	541	541	4358	4308	4345	4345	4345	4345	4617	4617	5125	5125	5125	5125	5244	5244	5244								
IRRIGATION SYSTEMS	25	0	0	0	0	0	42	42	42	42	42	42	370	370	4200	4074	4074	4074	4074	4074	4342	4342	4342	4342	4342	4342	4317	4317	4317								
DRAINAGE SYSTEMS	50	0	0	0	0	0	33	33	33	33	33	33	251	251	1141	1181	1205	1208	1208	1208	1208	1208	1208	1208	1208	1208	1208	1208	1208								
SLUDGE MANAGEMENT	35	0	1285	2251	915	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255								
MISCELLANEOUS	33	0	0	0	0	0	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104	104								
TOTAL			327	333	931	35143	35258	37059	39247	39007	37203	37203	37203	37203	37947	44484	47344	47343	47343	47343	47343	47343	47343	47343	47343	47343	47343	47343	47343								
PW 11/721	5 3/8%		297	302	845	31913	32029	33670	35652	35427	33800	33800	33800	33800	34474	40406	43014	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013								
PW 11/721	7 %		297	302	845	31913	32029	33670	35652	35427	33800	33800	33800	33800	34474	40406	43014	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013								
PW 11/721	10 %		297	302	845	31913	32029	33670	35652	35427	33800	33800	33800	33800	34474	40406	43014	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013								
PW 11/721	12 %		297	302	845	31913	32029	33670	35652	35427	33800	33800	33800	33800	34474	40406	43014	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013	43013								

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

CAPITAL RECOVERY FACTOR AT 7%

CAPITAL RECOVERY FACTOR AT 10 %

AD-A101 315 WRIGHT-MCLAUGHLIN ENGINEERS DENVER CO F/G 13/2
CLEVELAND-AKRON METROPOLITAN AND THREE RIVERS WATERSHED AREA. W--ETC(U)
AUG 73 DACW49-72-C-0051
UNCLASSIFIED NL

TOTAL STORMWATER FOR ALL SOURCES FOR PLAN C

PLAN C

- - - - - - CAPITAL COSTS IN $1,000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	7% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	10% NET
PLANTS	35	0	0	0	16172	2290	2760	2796	2804	94433	5075	2927	2779	2531	90442	3064	2826	2629	26327	1437	1476	1910	1462	1676	1744	1744	385902	110735	167626	4967	136662	114477	4317	114477	4317	114477
EXPAND TO LEVEL 1	25	0	0	0	0	45	45	45	45	109	109	109	109	109	109	109	109	109	109	126	126	126	126	126	126	126	2268	0	1914	0	1005	825	0	825	0	825
EXPAND TO LEVEL 2	25	0	0	0	0	115	115	115	115	115	115	115	115	115	115	115	115	115	115	253	253	253	253	253	253	253	4554	0	1717	0	1717	1395	0	1395	0	1395
SLUDGE FACILITIES	35	0	0	0	1491	0	0	0	0	1657	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3148	0	1491	0	1491	1071	0	1071	0	1071
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	88517	0	0	0	0	93069	0	0	0	0	72478	0	0	0	0	4073	0	5211	0	0	0	0	307177	98749	175343	7192	168154	159239	3463	149735	1731	122624
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67005	0	0	0	0	0	0	0	0	0	0	67005	0	0	0	0	0	0	0	0	0
DETENTION BASINS	50	0	0	0	64930	0	0	0	0	0	63410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128340	51600	161612	6180	155432	144952	7012	122668	516	122552
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	2768	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2768	0	1918	0	1918	1726	0	1726	0	1726
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	20930	0	0	0	0	37830	40830	0	0	0	0	0	0	0	0	0	0	99590	29539	57568	2027	55540	49137	676	48146	270	39702
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12300	1837	1370	75	0	5	0	15517	4232	5663	360	5303	4232	183	4049	1513	42
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3631	0	0	3205	0	12	2098	4208	18982	7482	808	6674	5444	291	4152	3017	74
SECONDARY PUMPING	15	0	0	0	0	0	0	0	0	12	0	0	0	2032	0	4000	0	0	0	904	0	1276	0	0	0	0	5458	2075	2395	168	2225	1932	80	1851	1367	20
FORCE MAINS	50	0	0	0	0	0	0	0	0	68	0	0	0	2620	0	40	0	0	0	6356	0	7658	0	1553	0	0	26536	11129	10941	901	9640	4764	434	7830	4431	111
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	3856	0	7115	0	0	0	1567	0	2146	0	2321	0	2731	9340	2367	2166	169	1996	1522	91	1429	462	23
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	401	0	634	0	0	0	1210	24	1408	56	913	68	0	12435	4114	5810	349	5461	4722	188	4554	3293	43
LAND PURCHASE & PREP	50	7466	0	0	0	0	0	0	0	0	0	0	0	1067	0	10947	0	0	0	1670	24	1714	33	548	1674	9710	23591	22938	744	958	6781	6081	481	5626	4253	118
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	1023	0	9730	0	0	0	1210	24	1408	56	913	68	0	12435	4114	5810	349	5461	4722	188	4554	3293	43
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	898	0	8490	0	0	0	0	0	0	0	0	0	0	9388	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9305	0	0	0	540	0	356	0	68	0	0	5075	666	2525	93	2471	2272	29	2246	1401	4
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	180	0	1885	0	0	0	1471	232	429	24	225	70	1895	6150	900	1941	72	1918	1536	35	1499	997	8
TOTAL		7466	0		322C9270	2939	2960	2954	267631	553029	5290	14985	40833	907231	903382	3437	3215	3033	2831	204626	42871	53508	2211	24425	30404	30656	1196141	336497	609944	27417	582532	521874	13200	508673	405375	1584
PW (8/72) 5 3/8%		7466	0		0173795	2162	2268	2156	184321	006693	7058	6971	22744	46946	96331	2454	2475	2323	2183	75826	12896	24326	957	3346	3822	5422	0	0	0	0	0	0	0	0	0	0
PW (8/72) 7 %		7466	0		0165868	2041	2100	1967	166460	890621	6596	6238	19395	40741	75028	1935	1871	1708	1605	45755	5004	15776	715	1856	2002	2410	0	0	0	0	0	0	0	0	0	0
PW (8/72) 10 %		7466	0		0152853	2004	1829	1686	153139	714664	5598	5784	16291	28940	55210	903	773	661	580	36832	480	7266	86	656	618	669	0	0	0	0	0	0	0	0	0	0

- - - - - O & M COSTS IN $1,000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	TOTAL PRESENT WORTH AT 5 3/8% EXPEND	TOTAL PRESENT WORTH AT 5 3/8% RESID	5 3/8% NET	TOTAL PRESENT WORTH AT 7% EXPEND	TOTAL PRESENT WORTH AT 7% RESID	7% NET	TOTAL PRESENT WORTH AT 10% EXPEND	TOTAL PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	387	398	349	390	391	2006	2183	2380	2517	2716	4527	4696	4865	5034	52039	9839	6013	6431	6501	6612	6655	7139	272681	0	56736	0	56736	38185	0	38185	21359	0	21359
SOURCE PACILITIES	35	0	0	0	0	9	9	9	9	408	414	423	428	432	766	775	792	805	818	972	1147	1374	1465	1606	1683	1754	48755	0	10633	0	10633	7209	0	7209	3749	0	3749
SEWERS	50	0	0	0	329	329	329	329	329	574	574	574	574	574	782	786	794	802	810	964	1082	1214	1289	1380	1380	1380	42535	0	11003	0	11003	7029	0	7029	4702	0	4702
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	616	620	627	632	638	640	642	19659	0	4092	0	4092	2750	0	2750	1355	0	1355
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	0	105	105	105	105	409	0	0	0	0	1357	1473	1545	1590	1651	1673	1686	50178	0	10000	0	10000	6519	0	6519	3138	0	3138
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1828	1872	2157	2236	2316	2346	2383	75300	0	15605	0	15605	10433	0	10433	5209	0	5209
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	1	1	1	1	1	5	146	146	1447	1322	2552	3672	3747	3828	3872	2357	2236	2316	2346	2383	75300	0	1376	0	1376	926	0	926
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	14	14	14	14	14	14	14	14	14	17	17	28	28	28	0	868	0	868	526	0	526	261	0	261
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	19	19	55	60	65	70	75	87	97	125	125	149	132	132	3888	0	796	0	796	526	0	526	261	0	261
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	400	400	400	428	428	604	650	696	742	788	963	894	897	918	939	947	943	32721	0	7772	0	7772	5412	0	5412	2979	0	2979
LAND PURCHASE & PREP	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	9	91	91	510	527	544	594	578	605	612	710	717	744	769	748	23817	0	5126	0	5126	3438	0	3438	1751	0	1751
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	9	9	115	116	117	118	119	131	132	144	149	157	154	159	5028	0	1088	0	1088	730	0	730	373	0	373
SLUDGE MANAGEMENT	39	0	0	0	0	0	0	0	0	0	0	0	0	9	9	532	540	550	557	566	574	567	620	644	668	672	677	21875	0	4749	0	4749	3211	0	3211	1645	0	1645
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	9	9	103	116	129	142	155	175	183	203	203	203	210	210	6453	0	1408	0	1408	957	0	957	470	0	470
TOTAL		0	0	0	725	726	727	726	730	3494	3677	3860	4356	4530	10000	10708	10825	11042	12059	19969	14849	16238	16568	17084	17476	0	561313	0	127216	0	0	87315	0	0	46875	0	0
PW (BEGIN PER) 5 3/8		0	0	0	687	653	649	691	695	3115	3488	3666	4138	4301	9494	9697	10279	10960	11964	26157	26537	72362	71905	73786	75442	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (8/72) 5 3/8%		0	0	0	687	654	630	634	640	2180	2176	2169	2326	2296	4920	4856	4887	4702	4703	24011	15512	16271	12756	12156	7523	0	0	1284428	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PER) 7%		0	0	0	677	634	614	679	680	2681	3265	3433	3608	4071	6262	9349	9523	10317	10899	11260	9501	9738	8733	6926	7182	71821	77032	0	0	0	0	0	0	0	0	0	0	0
PW (8/72) 7%		0	0	0	653	617	594	624	624	1900	1867	1831	1934	1885	3980	3899	3869	3827	3569	17985	13844	10097	7410	5643	3581	0	0	0	0	0	0	88120	0	0	0	0	0	0
PW (BEGIN PER) 10%		0	0	0	659	660	660	662	664	3172	3547	3950	4470	4326	9068	9276	9473	10352	10962	24316	24566	64042	64502	64924	65224	201	6678	0	0	0	0	0	0	0	0	0	0	0
PW (8/72) 10%		0	0	0	645	650	610	373	540	1481	1419	1351	1389	1316	2630	2619	2559	2265	2170	6777	6663	4350	2778	1724	1144	0	0	0	0	0	0	0	0	0	0	0	0	0

TOTAL STORMWATER FOR ALL SOURCES FOR PLAN C

- - - - - - ANNUAL CAPITAL COSTS AT 7% IN $1,000 - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	10% NET
PLANTS	35	0	0	0	1399	1613	1827	2043	2259	4910	5167	5372	5586	5788	9876	9458	10126	10329	10516	2C044	2C195	21878	21992	21993	22480	19660											
EXPAND TO LEVEL 1	25	0	0	0	0	3	7	11	15	19	28	38	47	56	66	80	96	106	121	134	144	153	157	159	95	39	59										
EXPAND TO LEVEL 2	25	0	0	0	0	9	19	29	39	48	58	68	78	88	99	119	141	162	184	205	227	245	262	236	157	121	122										
SLUDGE FACILITIES	35	0	0	0	0	116	116	116	116	116	242	242	242	242	242	242	242	242	242	242	242	242	242	242	242	116	116										
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SEWERS	50	0	0	0	0373	0373	0373	0373	0373	02211	10211	10211	10211	10211	15429	15429	15429	15429	15429	19763	18293	22313	22313	22313	22313	22313											
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
DETENTION BASINS	50	0	0	0	0	0836	0836	0836	0836	0836	0836	11400	11400	11400	11400	11400	11400	11400	11400	16724	17425	16724	16224	16823	16867	16867	17525	17525	17525	17525	17525	17525	17525	17525			
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	816	816	816	816	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	1506	1506	1506	1506	4230	7170	7170	7170	7170	7170	7170	7170	7170	7170	7170	7170	7170											
AERATED LAGOONS	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	622	1098	1161	1193	1161	1161	1163										
SECONDARY PUMPING	33	0	0	0	0	0	0	0	0	0	0	0	0	0	359	359	471	471	471	471	471	471	355	355	1C05	1005	1CC5	1C06									
FORCE MAINS	50	0	0	0	0	96	0	0	0	0	4	4	4	191	191	178	196	196	196	196	196	196	261	261	392	392	392	392	392	392	392	392	392	392	392	392	392
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	277	277	789	789	789	789	789	789	789	1247	1247	1784	1784	1784	1910	1910	1910	1910	1910	1910	1910	1910	1910	1910
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	66	222	222	222	222	222	222	222	357	251	3C4	358	367	367	367	367	367	367	367	367	367	367	367
LAND PURCHASE & PREP	50	534	534	534	534	534	534	534	534	534	534	534	534	616	616	1347	1347	1347	1347	1347	1347	1347	1475	1477	1524	1484	1843	1843	1843	1843	1843	1843	1843	1843	1843	1843	1843
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	90	90	838	838	838	838	838	965	971	1104	1117	1150	1154	1154	1154	1154	1154	1154	1154	1154	1154	1154	1154	1154
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	67	67	657	657	657	657	657	657	657	744	744	842	779	885	885	885	885	885	885	885	885	885	885	885
SLUDGE MANAGEMENT	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	322	322	322	322	322	322	322	368	368	375	375	390	390	390	390	390	390	390	390	390	390	390
MISCELLANEOUS	33	0	0	0	0	0	0	0	0	0	0	0	0	14	14	161	161	161	161	161	161	161	272	294	317	318	317	318	318	318	318	318	318	318	318	318	318
5 3/8% CRF		634	634	634	12644	12934	12926	12915	15111	26207	26422	25273	26975	32664	43758	44222	44233	44631	44816	57617	53592	63866	63953	63547	62535	62532											
7 % CRF		539	539	539	15279	15503	15731	15960	18516	29721	29977	31131	33271	39467	51492	54231	54434	54711	54932	70644	70867	78163	78426	78518	77297	76765											
10 % CRF		757	757	757	21967	21654	23561	22269	25573	44133	44483	43042	44834	55581	76477	75317	75375	75983	76290	97413	93764	108359	108159	107473	106492	105612											

- - - - - TOTAL ANNUAL CAPITAL COSTS IN $1,000 - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL		634	634	634	12644	12934	12926	12915	15111	26207	26422	25273	26975	32664	43758	44222	44233	44631	44816	57617	53592	63866	63953	63547	62535	62532											
TOTAL ANNUAL O&M		0	0	0	725	726	727	726	730	3494	3677	3860	4356	4530	10000	10708	10825	11042	12059	19969	14849	16238	16568	17084	17476	0											
TOTAL ANNUAL COSTS		634	634	634	13369	13660	13653	13641	15841	29701	30099	29133	31331	37194	53758	54930	55058	55673	56875	77586	68441	80104	80521	80631	80011	62532											

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL		539	539	539	15279	15503	15731	15960	18516	29721	29977	31131	33271	39467	51492	54231	54434	54711	54932	70644	70867	78163	78426	78518	77297	76765											
TOTAL ANNUAL O&M		0	0	0	725	726	727	726	730	3494	3677	3860	4356	4530	10000	10708	10825	11042	12059	19969	14849	16238	16568	17084	17476	0											
TOTAL ANNUAL COSTS		539	539	539	16004	16229	16457	16686	19246	33215	33654	34991	37627	43997	61492	64939	65259	65753	66991	90613	85716	94401	94994	95602	94773	76765											

CAPITAL RECOVERY FACTOR AT 10 %

TOTAL ANNUAL CAPITAL		757	757	757	21967	21654	23561	22269	25573	44133	44483	43042	44834	55581	76477	75317	75375	75983	76290	97413	93764	108359	108159	107473	106492	105612											
TOTAL ANNUAL O&M		0	0	0	725	726	727	726	730	3494	3677	3860	4356	4530	10000	10708	10825	11042	12059	19969	14849	16238	16568	17084	17476	0											
TOTAL ANNUAL COSTS		757	757	757	22692	22380	24288	22995	26303	47627	48160	46902	49190	60111	86477	86025	86200	87025	88349	117382	108613	124597	124727	124557	123968	105612											

TOTAL WASTEWATER AND STORMWATER FOR PLAN C

PLAN C

- - - - - - CAPITAL COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	2000	TOTAL EXPEN	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEN	PRESENT WORTH AT 5 3/8% RESID	PR 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PR 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PR 10% NET
PLANTS	35	0	0	0	78304	27602	27602	27602	27602	44093	30735	29227	27719	26211	58940	35211	33703	32195	30687	29179	27671	26163	24655	23147	21639	15065	577844	43151	414767	15065	399701	155987	8307	147680	96147	5123	91024
EXPAND TO LEVEL 1	25	0	0	0	82665	45	47	45	45	1156	109	109	109	109	324	368	368	368	368	368	368	368	368	368	368	368	89616	6716	72244	960	71284	43291	722	42569	21187	536	20651
EXPAND TO LEVEL 2	25	0	0	0	0	113	113	113	113	113	115	115	115	115	115	22251	251	251	251	251	251	251	251	251	251	251	48145	3620	45451	1049	44402	12117	436	11681	5696	212	5484
SLUDGE FACILITIES	35	0	0	0	48445	0	0	0	0	2617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51062	3954	44451	676	43775	11594	325	11269	4923	163	4760
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11703	0	0	0	0	0	0	0	0	0	0	23032	1783	9756	931	8824	2221	448	2772	1340	115	1225
SEWERS	50	0	0	0	1318647	0	0	0	0	0	0	0	0	0	0	12478	0	0	0	0	41838	0	0	0	0	0	1372963	106345	219178	7731	211446	157464	11731	145733	59757	5164	54593
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	29369	0	0	0	0	0	0	0	0	0	0	25998	0	0	0	0	0	53867	15733	2869C	1274	27516	24182	813	23369	17411	541	16870
DETENTION BASINS	50	0	0	0	944930	0	0	0	0	63960	0	0	0	0	0	67005	0	0	0	0	9369	0	0	0	0	0	2441335	91638	1826212	4140	1564832	1440392	20112	1244062	1220668	529	1220139
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	2748	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2748	0	1918	0	1918	1726	0	1726	1419	0	1419
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	69814	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	470474	120567	267014	9798	248016	227625	4717	222538	169639	2209	167430
AERATED LAGOONS	30	0	0	0	0	132625	0	0	0	0	0	0	0	0	0	0	0	0	0	72940	16466	19000	25	0	12625	0	198610	16314	95318	2961	92378	54073	2372	51701	30833	1338	29495
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	12	0	0	0	0	4425	0	24000	0	0	0	11015	0	3025	0	904	4484	24000	72442	32186	23369	8817	14552	11295	1994	9301	8321	1121	7200
FORCE MAINS	50	0	0	0	0	0	387	0	0	68	0	0	0	0	9002	0	240	0	0	0	904	0	0	0	1824	0	12427	3745	6744	303	6441	5711	148	5563	5265	57	5208
STORAGE RESERVOIRS	50	0	0	0	0	0	2287	0	0	0	0	0	0	0	18604	0	61345	0	0	0	25804	0	0	0	22151	0	119349	46665	50039	3778	46261	40018	1819	38217	27478	966	27002
RESERVOIR AER & CL	10	0	0	0	0	0	532	0	0	0	0	0	0	0	4139	0	3534	0	0	0	10243	0	12378	0	13802	0	13836	58644	11908	1470F	11238	23382	2C813	542	20271	6137	138	6197
LAND PURCHASE & PREP	52	34686	0	0	0	0	784	0	0	0	0	0	0	0	5886	0	62888	0	517	0	4853	1574	4915	5243	3511	2743	0	65719	62652	51098	7532	44566	45101	1428	43674	36553	925	35628
IRRIGATION SYSTEMS	33	0	0	0	0	0	513	0	0	0	0	0	0	0	5284	0	56260	0	462	0	0	0	0	0	0	0	62719	2888	44472	1819	42653	32726	1717	31009	23376	1745	21631
DRAINAGE SYSTEMS	50	0	0	0	0	0	337	0	0	0	0	0	0	0	3611	0	38170	0	378	0	0	0	0	0	0	0	42496	1955	3972	2455	2565	2640	0	71355	26781	33260	4907	31273	27127	988	26140	24543	247	24295
SLUDGE MANAGEMENT	35	0	3004	0	9200	2452	0	1189	0	2704	0	0	0	0	0	3885	342	0	0	0	2868	1139	11239	0	3848	11457	4700	61527	23757	29713	5927	23786	22389	928	21461	17849	287	17561
MISCELLANEOUS	35	0	0	0	0	1363	0	0	0	0	961	0	0	0	10926	0	0	0	0	0	8184	1681	1851	515	597	1432	26941	96029	14316	12926	1159	11766	10090	558	9532	6772	143	6629
TOTAL			9686	3004	0466734	26917	2946	4139	7562720	7219	3299	5504	5149	4793	4437	4082	3726	3371	3015	2660	2304	1948	1593	1237	882	526	3958842	267713	2839390	3C437102	2398	2C437102	2398	2C27C515	443535	1365178	48310	1296868	1167648	32690	1134958	907928	8493	899434
PW (1/72) 5 3/8			9686	2850	3180267	25237	2268	9021	5240891	3615	3256	5258	5197	5057	4704	4313	3784	3378	3015	2660	2304	1948	1593	1237	882	526	3527548	74271	17456	1893	15564	17586	0	0	0	0	0	0	0	0	0
PW (1/72) 7 %			9686	2808	2762902	19C31	2130	2756	3711593	2046	3194	4794	4611	4232	3873	3514	3C84	2731	2428	2147	1928	1587	1350	1C39	7C3	447	2C	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (1/72) 10 %			9686	2730	2533995	17C10	1829	2336	3679%	9677	1398	21246	4822	4454	4096	3737	3379	3021	2683	2360	2073	1772	1482	1C99	757	457	2712	1C86	2172	0	0	0	0	0	0	0	0	0	0	0

- - - - - - O & M COSTS IN $1000 FOR WASTEWATER - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPENS	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPENS	PRESENT WORTH AT 5 3/8% RESID	PR 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PR 7% NET	PRESENT WORTH AT 10% EXPENS	PRESENT WORTH AT 10% RESID	PR 10% NET
PLANTS	35	27407	28122	29818	31180	31422	30208	30773	31338	32520	32162	31804	31446	31088	25871	26465	27257	28049	28841	29596	27216	27105	27058	27044	27033	27372	1162345	0	605161	0	582573	0	382573	0	284150	0	284150
SLUDGE FACILITIES	35	3616	3522	3627	3751	3805	3763	3810	3857	4322	4357	4392	4427	4462	3191	3411	3629	3647	3665	3295	3563	3625	3714	3674	3672	2127	135244	0	97337	0	97337	47521	0	47521	35560	0	35560
SEWERS	50	0	0	0	0	961	987	613	639	676	0	976	976	976	976	1085	1215	1243	1271	1300	1480	1562	1716	1716	1716	1716	37053	0	17053	0	17053	12426	0	12426	7512	0	7512
TEMPORARY PUMPS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	246	369	369	369	1119	1869	2772	2376	2196	2398	2609	3037	3074	3114	3147	3181	3265	3228	110891	0	25600	0	25600	17606	0	17606	9620	0	9620
AERATED LAGOONS	30	0	0	0	0	0	676	694	712	731	767	767	821	858	894	967	1045	1072	1100	1127	1426	1505	1654	1716	1716	1716	1716	83590	0	43590	0	43590	41522	0	41522	20373	0	20373
SECONDARY PUMPING	35	0	0	0	0	0	0	40	42	44	46	48	48	48	472	492	8512	8586	8660	9063	9303	9815	10715	11123	11523	11872	12129	875472	0	81211	0	81211	54489	0	54489	27840	0	27840
FORCE MAINS	50	0	0	0	0	0	0	4	4	4	4	4	4	4	58	58	58	58	58	58	58	59	60	62	62	73	73	73	2535	0	596	0	596	413	0	413	224	0	224
STORAGE RESERVOIRS	50	0	0	0	0	0	0	11	11	11	11	11	11	11	104	104	310	315	321	328	331	402	414	426	523	581	585	590	17377	0	3653	0	3653	2461	0	2461	1262	0	1262
RESERVOIR AER & CL	10	0	0	0	0	0	0	34	35	35	436	438	438	438	447	449	1444	1461	1478	1496	1845	1970	2091	2159	2240	2401	2491	2524	79331	0	17885	0	17885	12239	0	12239	6507	0	6507
LAND PURCHASE & PREP	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	31	31	32	32	33	33	33	293	297	2953	3021	3089	3155	3221	3225	3346	3605	3730	3823	3955	3986	126721	0	27670	0	27670	18861	0	18861	9867	0	9867
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	8	8	8	8	8	8	8	64	64	686	647	690	691	692	733	773	823	855	898	911	914	28437	0	6296	0	6296	4261	0	4261	2181	0	2181
SLUDGE MANAGEMENT	35	0	791	860	1291	1346	1442	1500	1559	1618	1676	1735	1794	1853	1730	1774	2276	2151	2236	2280	2329	1418	1910	1849	1944	2036	2129	2258	84554	0	20483	0	20483	20613	0	20613	13684	0	13684
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	103	119	129	160	195	195	195	195	203	203	210	210	210	4653	0	1408	0	1408	937	0	937	470	0	470
TOTAL			30823	32835	36105	36737	37615	36861	37537	38561	41110	42044	42503	42729	42C20	42764	43890	43948	44042	44021	43948	44C73	44C96	44C74	44C75	44C52	44C62	4C1330	0	1245.644	74675	1170969	968.52	592.62	376.00	0	2511835	0	2511835
PW (BEGIN PER) 5 3/8			29238	31159	32168	31432	35315	34930	35455	36578	38975	37715	36529	35178	34529	33C42	32454	32717	32714	32755	32230	31712	29865	28255	26792	25385	24C28	23785	23C54	22C62	0	0	0	0	0	0	0	0	0
PW (1/72) 5 3/8			29191	29584	29159	29783	28579	26968	26040	25359	25612	24198	22497	22593	21671	20864	20161	19151	18211	22C02	19478	16391	13178	10816	9021	27393	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PERI TE			28805	30643	31065	30333	33144	32616	35135	35588	38410	38126	37923	36933	40011	37416	44344	42076	42449	42953	42532	42C62	41C65	39C32	37C22	35C85	34C88	32C46	31C55	0	0	0	0	0	0	0	0	0	0
PW (1/72) 7E			28819	28486	27825	28036	26413	24568	23410	22430	22363	21746	19276	19276	18744	17772	16787	16195	15422	18782	16759	13823	10618	8427	6854	20743	0	0	0	0	0	0	0	0	0	0	0	0	0
PW (BEGIN PERI 10E			28003	29023	30504	29704	31202	31402	34166	35068	37307	37110	36782	36762	38918	36097	43110	40784	40973	41455	41758	40973	39C33	37C12	35C11	33C27	32C35	30C11	29C19	1225	37645	0	0	0	0	0	0	0	0	0
PW (1/72) 10E			28018	27121	25612	25091	23370	22789	19277	17998	17430	15766	14204	13496	12420	11372	12401	11656	10898	10191	9265	7526C	5477C	3977	2929	1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- - - - - - ANNUAL CAPITAL COSTS AT 7E IN $1000 - - - - - -

ITEM	LIFE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000	2005	2010	2015	2020	TOTAL EXPEND	TOTAL RESID	PRESENT WORTH AT 5 3/8% EXPEND	PRESENT WORTH AT 5 3/8% RESID	PR 5 3/8% NET	PRESENT WORTH AT 7% EXPEND	PRESENT WORTH AT 7% RESID	PR 7% NET	PRESENT WORTH AT 10% EXPEND	PRESENT WORTH AT 10% RESID	PR 10% NET
PLANTS	35	0	0	0	6029	5763	5498	5233	4969	8469	5903	5614	5325	5036	11321	6764	6475	6187	5898	5609	5321	5026	4738	4449	4160	2894	111011	8293	79763	2894	76869	29708	1596	28113	18483	984	17499
EXPAND TO LEVEL 1	25	0	0	0	6521	6527	6471	6534	6532	6532	6567	6567	6567	6567	6476	6490	6490	6490	6490	6490	6731	6763	6774	6763	6768	6763	1C1C2	755	9C1C3	6768	9C1C3	6731	111	655	655	0	655
EXPAND TO LEVEL 2	25	0	0	0	0	16	16	16	16	16	16	16	16	16	16	3188	36	36	36	36	2011	2033	2034	2C78	2078	2078	2C78	2078	2C78	2078	2C78	2078	2C78	2078	2C78	2078	2C78	2078	2C78
SLUDGE FACILITIES	35	0	0	0	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703	1703
SLUDGE FAC. EXP.	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEWERS	50	0	0	0	9478	9478	9478	9478	9478	9478	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069	14069
SEWER EXPANSION	50	0	0	0	0	0	0	0	0	0	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114	2114
DETENTION BASINS	40	0	0	0	6834	6834	6834	6834	6834	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405	11405
BASIN EXPANSION	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEMPORARY PUMPS	4	0	0	0	0	0	0	819	819	819	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2457	0	1714	0	1714	1543	0	1543	1268	0	1268
SHAFTS & TUNNELS	50	0	0	0	0	0	0	0	0	5026	5026	5026	5026	5026	18865	33908	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808	33808
AERATED LAGOONS	30	0	0	0	0	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931	931
SECONDARY PUMPING	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORCE MAINS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STORAGE RESERVOIRS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESERVOIR AER & CL	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAND PURCHASE & PREP	52	647	647	647	647	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294	1294
IRRIGATION SYSTEMS	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAINAGE SYSTEMS	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLUDGE MANAGEMENT	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 3/8% CRF			561	748	748	28329	28053	27783	27514	27248	47468	47627	51323	51980	45111	41264	41111	40964	40817	40671	40527	39811	39C99	38C99	38C99	38C99	38C99	1C2C68	7C27	1C2C68	7C27	0	1C2C68	7C27	0	1C2C68	7C27	0
7 % CRF			697	922	922	36196	35832	35478	35125	34773	59338	59538	64154	64975	56389	51580	51389	51205	51021	50839	50659	49764	48874	47984	47984	47984	47984	1277585	8784	1277585	8784	0	1277585	8784	0	1277585	8784	0
10 % CRF			974	1284	1284	46597	46237	45830	45479	45122	76259	76500	79503	79928	69613	63767	63531	63295	63059	62824	62588	61483	60378	59273	59273	59273	59273	1578431	10854	1578431	10854	0	1578431	10854	0	1578431	10854	0

- - - - - - TOTAL ANNUAL CAPITAL COSTS IN $1000 - - - - - -

CAPITAL RECOVERY FACTOR AT 5 3/8%

TOTAL ANNUAL CAPITAL			561	748	748	28329	28053	27783	27514	27248	47468	47627	51323	51980	45111	41264	41111	40964	40817	40671	40527	39811	39C99	38C99	38C99	38C99	38C99	1C2C68	7C27	1C2C68	7C27	0	1C2C68	7C27	0	1C2C68	7C27	0
TOTAL ANNUAL O&M			30823	32835	36105	36737	37615	36861	37537	38561	41110	42044	42503	42729	42C20	42764	43890	43948	44042	44021	43948	44C73	44C96	44C74	44C75	44C52	44C62	4C1330	0	1245644	74675	1170969	968.52	592.62	376.00	0	2511835	0	2511835
TOTAL ANNUAL COSTS			31384	33583	36853	65066	65668	64644	65051	65809	88578	89671	93826	94709	87131	84028	85001	84912	84859	84692	84475	83884	83C95	82C73	82C74	82C51	82C62	5C3398	7C27	2423712	81702	1288033	1C47.21	592.62	454.59	0	4090003	0	4090003

CAPITAL RECOVERY FACTOR AT 7 %

TOTAL ANNUAL CAPITAL			697	922	922	36196	35832	35478	35125	34773	59338	59538	64154	64975	56389	51580	51389	51205	51021	50839	50659	49764	48874	47984	47984	47984	47984	1277585	8784	1277585	8784	0	1277585	8784	0	1277585	8784	0
TOTAL ANNUAL O&M			30823	32835	36105	36737	37615	36861	37537	38561	41110	42044	42503	42729	42C20	42764	43890	43948	44042	44021	43948	44C73	44C96	44C74	44C75	44C52	44C62	4C1330	0	1245644	74675	1170969	968.52	592.62	376.00	0	2511835	0	2511835
TOTAL ANNUAL COSTS			31520	33757	37027	72933	73447	72339	72662	73334	100448	101582	106657	107704	98409	94344	95279	95153	95063	94860	94607	93837	92970	92058	92059	92036	92046	5417915	16811	3523

BIBLIOGRAPHY

1. Allaway, W. H. 1968. Agronomic controls over the environmental cycling of trace elements. Advances in Agronomy, 20: 135-274.

2. Chapman, H. D. 1966. Diagnostic criteria for plants and soils. University of California, Division of Agricultural Sciences, Riverside, California.

3. Childers, N. F. 1941. The toxicity of certain spray chemicals to the roots of apple, grape, rye and corn. Proc. American Society of Horticultural Scientists, 38: 157.

4. Cox, W. J., and D. W. Rains. 1972. Effect of lime on lead uptake by five plant species. J. Environ. Q. 1: 167-169.

5. Cunningham, I. J. 1957. Parenteral administration of copper as cerate to cattle and sheep. New Zealand Vet. Journ. 5: 9-16.

6. Fujimoto, G. and G. D. Sherman. 1950. Cobalt content of typical soils and plants of the Hawaiian Islands. Agron. Journ. 42: 577-581.

7. Ellis, B. G. and B. D. Knezek. 1972. Micronutrients in Agriculture (J. J. Mortredt, P. M. Giordano, and W. L. Lindsay, eds.), Soil Sci. Soc. Amer., Inc., Madison, Wisc.

8. John, M. K., H. H. Chuck, and C. J. Van Laerhoven. 1972. Cadmium contamination of soil and its uptake by oats. Environmental Science and Technology, 6: 555-557.

9. Johnson, Clarence C. 1966. Diagnostic Criteria for Plants and Soils (H. D. Chapman, ed.) University of California, Div. of Agr. Sci., Riverside, California, pp. 286-301.

10. Knezek, B. D. 1973. Personal communication.

11. Lagerwerff, J. V. 1972. Lead, mercury, and cadmium as environmental contaminants. Micronutrients in Agriculture. (J. J. Mortvedt, P. M. Giordano, and W. L. Lindsay, eds.), Soil Sci. Soc. Amer., Inc., Madison, Wisc.

12. Liebig, G. J. 1966. Diagnostic Criteria for Plants and Soils, (H. D. Chapman, ed.), University of California, Div. of Agr. Sci., Riverside, California.

13. Meek, B. D. 1973. Personal communication to Dr. Burns Sabey.

14. Melton, J. R., B. G. Ellis, and E. C. Doll. 1970. Zinc, phosphorous and lime interactions with yield and zinc uptake by phaseolus vulgaris. Soil Sci. Soc. Amer. Proc. 34: 91-93.

BIBLIOGRAPHY (Continued)

15. Mitchell, Robert L. 1964. Trace elements. (Bear, F. E., ed.) Chemistry of the soil, Reinhold Publishing Corp., New York, N.Y., pp. 320-368.

16. Murrmann, R. P. and F. R. 1972. Role of soil chemical processes in land reclamation of waste water applied to land. (Reed, S. coordinator) Waste water management by disposal on the land. Special Report 171, CRREL Corps of Engineers; Hanover, New Hampshire. pp. 49-76.

17. Pratt, P.F. 1966. Diagnostic criteria for plants and soils. (H. D. Chapman, ed.) Univ. of California, Div. of Agr. Sci. Riverside, California. pp. 136-141.

18. Reuther, W. and C. K. Labanauskas. 1966. Diagnostic criteria for plants and soils, (H. D. Chapman, ed.) Univ. of California, Div. of Agr. Sci. Riverside, California. pp. 157-179.

19. Rhoades, J. D., R. D. Ingralson, and J. T. Hatcher. 1970. Adsorption of boron by ferromagnesian minerals and magnesium hydroxide. Soil Sci., Soc. Amer. Proc. 34: 938-941.

20. Rogers, L.H., O. E. Gall, L. W. Gaddum, and R. M. Bamette. 1939. Distribution of macro- and microelements in some soils of peninsular Florida. Florida Univ. Agr. Expt. Sta. Bull. 341.

21. Sabey, B. R. and W. E. Hart. 1973. Land application of metro Denver municipal sewage sludge. Final Report, Colorado State University, Agricultural Experiment Station.

22. Sauchelli, V. 1969. Trace elements in agriculture. Van Nostrand Reinhold Co. New York, N. Y.

23. Smith, E. G. 1943. Changes produced in growth, reproduction, blood, and urine in rats by ingestion and oral administration of cobalt salts. Iowa State Coll. Jorn. Sci. 18: 87-88.

24. Soane, B. D. and D. H. Saunder. 1959. Nickel and chromium toxicity of serpentine soils in Southern Rhodesia. Soil Sci. 88: 322-330.

25. Swaine, D. J. 1951. The distribution of trace elements in soils. Thesis. University Aberdeen Scotland. 265 p.

26. Swaine, D. J. 1955. The trace element content of soils. Commonwealth Bur. Soil Sci. Tech. Comm. No. 48. Herald Printing Works, Coney St. York (England)

27. Traynor, M. F. and B. D. Knezek. 1972. Personal communication.

BIBLIOGRAPHY (Continued)

28. Turner, M. A. and R. H. Rust. 1971. Effects of chromium on growth and mineral nutrition of soybeans. Soil Sci. Soc. Amer. Proc. 35: 755-758.

29. Vanselow, A. P. 1966. Silver. Diagnostic criteria for plants and soils. (H. D. Chapman, ed.) Univ. of Calif., Div. of Agr. Sci. Riverside, California. pp. 405-408

30. Vanselow, A. P. 1966. Cobalt. Diagnostic criteria for plants and soils. (H. D. Chapman) Univ. of Calif., Div. of Agr. Sci. Riverside, California. pp. 142-156.

31. Vanselow, A. P. and G. R. Bradford. 1960. Data on lead content of citrus and soils. (Unpublished data)

32. Virande, R., B. D. Knezek, J. Davis, E. Doll, and J. Melton. 1968. Field and laboratory studies with zinc and iron fertilization of peas, beans, corn, and potatoes in 1967. A Bull. Mich. Agr. Expt. Sta. 50: 625-636.

33. Wallihan, E. F. 1966. Diagnostic criteria for plants and soils. (H. D. Chapman, ed.) Univ. of Calif., Div. of Agr. Sci. Riverside, California. pp. 203-212.

34. Wilkins, D. A. 1957. A technique for measurement of lead tolerance in plants. Nature. 180: 37-38.

35. Schwab, G. O. and J. L. Foress. 1967. Tile flow and surface runoff from drainage systems with corn and grass cover. Trans. of the ASAE. (Vol. 10, No. 4) pp. 492-496.

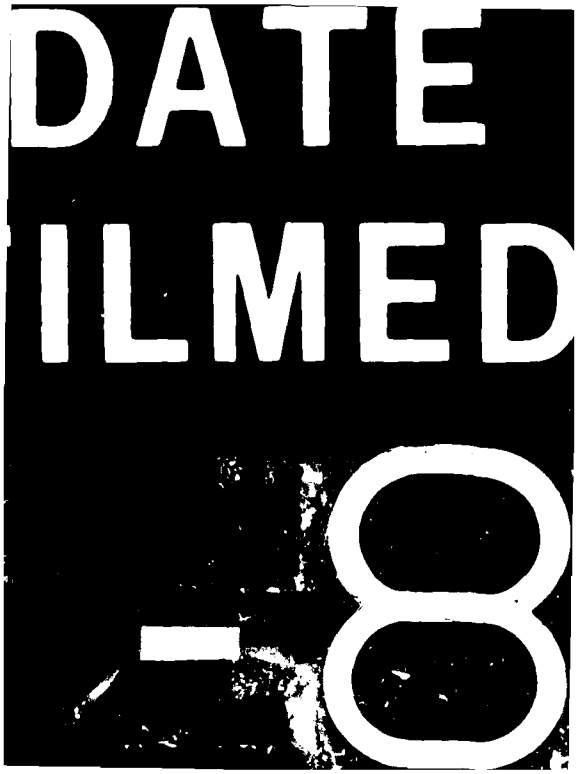
36. Schwab, G. O, et al. Tile and surface drainage of clay soils. Hydrologic performance with grass cover. Research Bulletin 935. Dept. of Agr. Eng. and Agron. Ohio Agricultural Experiment Station. Wooster, Ohio. April, 1963.

37. Condon, Francis J. March, 1973. Treatment of urban runoff. APWA Reporter. Vol. 4, No. 3, p. 8.

38. Herbicidal Handbook of the Weed Society of American. 2nd edition, 1970.

39. Ecological effects of pesticides on non-target species. Published by the Executive Office of the President. June, 1971.

40. Thorne and Peterson. Irrigated soils. 2nd Edition. January 12, 1954.


DATE
ILMED
-8