Report for

City of Mount Vernon, Ohio

Anaerobic Digestion Needs Assessment

STATE OF OHIO
ANTHONY JOSEPH AKLES
69080
REGISTERED PROFESSIONAL ENGINEER

Anthony J. Akles, P.E.
Nov. 15, 2017

Prepared by:

STRAND ASSOCIATES, INC.®
629 Washington Street
Columbus, IN 47201
www.strand.com

November 2017

STRAND ASSOCIATES®

TABLE OF CONTENTS

Page No.
or Following

SECTION 1–INTRODUCTION

1.01	Purpose and Scope	1-1
1.02	Related Studies, Reports, and Drawings	1-1
1.03	Definitions	1-2

SECTION 2–EXISTING TREATMENT FACILITIES

2.01	Existing WWTP Facilities	2-1
2.02	Current Flows and Loadings	2-1
2.03	Current Biosolids Production	2-2
2.04	Operations Review	2-4

SECTION 3–FUTURE CONDITIONS

3.01	Population and Growth Projections	3-1
3.02	Projected Flows and Loadings	3-1
3.03	Future Biosolids Production	3-2

SECTION 4–EVALUATION OF ALTERNATIVES

4.01	Anaerobic Digester and Sludge Storage Cover Alternatives	4-1
4.02	Monetary and Nonmonetary Analysis of Cover Alternatives	4-5
4.03	Anaerobic Digester Mixing Alternatives	4-7
4.04	Monetary and Nonmonetary Analysis of Mixing Alternatives	4-8
4.05	Sludge Storage Capacity	4-9
4.06	Miscellaneous Improvements	4-10

SECTION 5–RECOMMENDATIONS

5.01	Recommended Alternatives	5-1
5.02	Recommended Next Steps	5-2

TABLE OF CONTENTS Continued

Page No.
or Following

TABLES

2.01-1	Mount Vernon WWTP Design Capacities	2-1
2.02-1	Average Influent Flows and Loadings	2-2
2.02-2	Per Capita Influent Flows and Loadings	2-2
2.03-1	Summary of Biosolids Production	2-3
2.03-2	Average Anaerobic Digester vs Data	2-4
2.03-3	Biosolids Production	2-4
3.01-1	Historical Population for Mount Vernon	3-1
3.02-1	Flow and Load Projections	3-1
3.03-1	Summary of Future Biosolids Production	3-3
4.01-1	Digester Cover Alternatives	4-2
4.02-1	Summary of Cover Technology Present Worth	4-6
4.04-1	Summary of Mixing Technology Present Worth	4-9
4.05-1	Additional Sludge Storage OPCC	4-10
4.06-1	Existing Digester Gas Handling Equipment	4-12
4.06-2	Gas Handling Equipment OPCC	4-14
4.06-3	FOG Modification OPCC	4-15
5.01-1	Complete Project OPCC	5-2
5.01-2	Complete WWTp Modifications	5-3

FIGURES

1.01-1	WWTP Location Map	1-1
2.01-1	WWTP Site Plan	2-1
4.01-1	Cover Alternatives Schematic	4-1
4.01-2	Floating Gas Holder Cover	4-4
4.01-3	Membrane Gas Holder Cover	4-5
4.03-1	Evoqua JETMIX® Vortex Mixing System	4-7
4.04-2	Linear Motion Mixer	4-8
4.04-3	Roof Mounted Draft Tube Mixers	4-9
4.05-1	Proposed Sludge Storage Tank Site Plan	4-10
4.06-1	Proposed FOG SRS By-Pass Pipeline	4-14
4.06-2	FOG Grease SRS By-Pass Pipeline (Modified)	4-14

APPENDICES

APPENDIX A–EVOQUA INSPECTION REPORT
APPENDIX B–NET PRESENT WORTH OF ALTERNATIVES
APPENDIX C–DIGESTER GAS SAFETY EQUIPMENT

SECTION 1
INTRODUCTION

This section describes the purpose and scope of the report and location of the study area. It also summarizes previous and related studies and reports that were used to describe the existing facilities. A list of abbreviations is provided as an aid to the reader.

1.01 PURPOSE AND SCOPE

The City of Mount Vernon, Ohio (City) owns wastewater conveyance and treatment facilities that provide service to the City's residents, businesses, and industries. The wastewater treatment plant (WWTP) is permitted to treat an average daily flow of 5.0 million gallons per day (mgd) and is located at 3 Cougar Drive, Mount Vernon, Ohio, Knox County, and discharges to the Kokosing River. The location of the WWTP is shown in Figure 1.01-1.

The purpose of this report is to assess the current condition of the existing anaerobic digesters and sludge storage tanks. Alternatives will be evaluated for:

1. Anaerobic digester and sludge storage tank cover technologies.
2. Anaerobic digester mixing technologies.
3. Evaluation of current and future anaerobic digester and sludge storage capacity.
4. Replacement of digester gas handling equipment.
5. Facility modifications to accommodate fats, oils, and grease (FOG).

Additionally, Evoqua Water Technologies (Evoqua) performed an on-site evaluation of the anaerobic digester and sludge storage tank covers and appurtenances. Based on this condition assessment, detailed in Appendix A, potential effects to the biosolids production because of forthcoming phosphorus discharge limits, and future flow projections; alternatives will be evaluated for each of the above-mentioned processes.

Although this report will evaluate improvements for mesophilic digestion, consideration for the possible future implementation of temperature-phased anaerobic digestion (TPAD) may be given during the design process. TPAD is a two-stage process, with the initial stage operated at thermophilic temperatures (131°F). Compared to conventional digestion, TPAD typically achieves additional volatile solids (VS) reduction and biogas production, and also achieves Class A biosolids under most operating conditions.

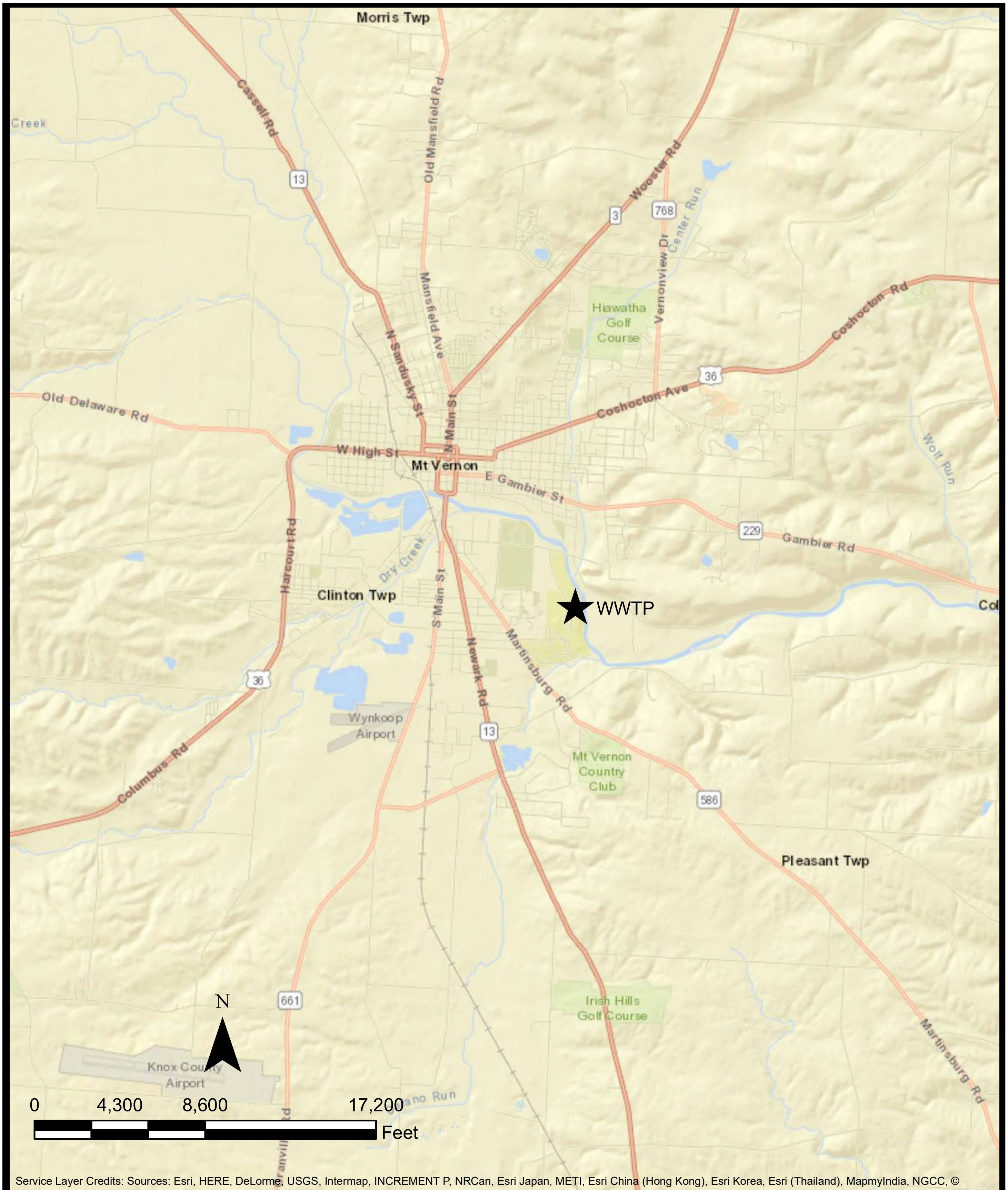
1.02 RELATED STUDIES, REPORTS, AND DRAWINGS

A. *Wastewater Treatment Plant Operations and Maintenance Manual*, prepared by Malcolm Pirnie/Arcadis, October 2014.

B. *Wastewater Treatment Plant Upgrades*, prepared by Malcolm Pirnie, September 2010.

C. *Wastewater Treatment Plant Operating Plan*, prepared by Malcolm Pirnie, July 2009.

D. *Septage Receiving Station Preliminary Study*, prepared by Floyd Browne Group, December 2007.



Path: S:\COL\4900--4999\4962\005\Data\GIS\Task 3\Figure 1.mxd

User: scottw

Date: 10/26/2017

Time: 10:06:00 AM

WWTP LOCATION MAP

ANAEROBIC DIGESTION NEEDS ASSESSMENT
MT. VERNON, OHIO

STRAND ASSOCIATES®

FIGURE 1.01-1
4962.005

E. *Wastewater Treatment Plant Influent Screenings and Aeration Facilities*, prepared by BBS Corporation, 2005.

F. *Wastewater Treatment Plant Master Plan*, prepared by Finkbeiner, Pettis & Strout, Inc., August 2003.

G. *Wastewater Treatment Plant Improvements–Solids Handling Facilities*, prepared by Finbeiner, Pettis & Strout, Inc., 1990.

1.03 DEFINITIONS

The following abbreviations are provided as an aid to the reader:

CBOD	carbonaceous biochemical oxygen demand
City	Mount Vernon, Ohio
CPR	Chemical phosphorus removal
Evoqua	Evoqua Water Technologies
GPD	gallons per day
hp	horsepower
HVAC	heating, ventilation, and air conditioning
lb/day	pounds per day
mg/L	milligrams per liter
MGD	million gallons per day
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administration Code
PRS	Primary Clarifier Sludge
TPAD	temperature-phased anaerobic digestion
TSS	total suspended solids
VS	volatile solids
VSR	volatile solids reduction
WAS	waste activated sludge
WWTP	wastewater treatment plant

SECTION 2
EXISTING TREATMENT FACILITIES

2.01 EXISTING WWTP FACILITIES

The original Mount Vernon WWTP was built in 1952. Since then the WWTP has undergone several modifications to its headworks, secondary treatment processes, disinfection facilities, and solids handling infrastructure. The current WWTP is rated for 5.0 mgd and the forward flow treatment train includes raw wastewater screening, primary pumping, aerated grit removal, primary settling, secondary pumping, contact stabilization activated sludge, secondary clarification, chlorination, and dechlorination.

The Mount Vernon WWTP produces Class B biosolids for land application. Biosolids processing includes single-stage mesophilic anaerobic digestion of primary sludge, aerobic digestion and gravity belt thickening of waste activated sludge (WAS), and sludge holding before disposal by land application. Currently, the WWTP operates the anaerobic digesters in parallel with one being mixed (Digester No. 2) and the other being nonmixed (Digester No. 1). Both aerobic and anaerobic sludge is pumped to the sludge holding tanks before disposal. Although not currently used significantly, the WWTP has the ability to burn digester gas with its boiler. Table 2.01-1 contains the WWTP's current rated design capacities. Figure 2.01-1 shows a site plan of the WWTP.

	Rated Capacity[1]
Flows	
Design Average	5.0 mgd
Peak Hourly	12.5 mgd
BOD Load	5,421 lb/day
TSS Load	5,004 lb/day

[1]based on 2005 plant improvements

Table 2.01-1 Mount Vernon WWTP Design Capacities

2.02 CURRENT FLOWS AND LOADINGS

The current average influent flows and loadings from 2015 to present are shown in Table 2.02-1. The influent carbonaceous biochemical oxygen demand (CBOD) and total suspended solids (TSS) loadings averaged 3,444 and 4,018 pounds per day (lb/day), respectively. The WWTP is currently loaded at about 64 percent of the CBOD capacity and at about 80 percent of the TSS capacity. It should be noted that the average influent CBOD and TSS concentrations of 163 milligrams per liter (mg/L) and 181 mg/L exceed the design values (according the 2005 drawings by BBS Corporation) by 125 percent and 150 percent, respectively. This may result in the WWTP reaching the design loading criteria before reaching the design flow criteria.

WASTE WATER TREATMENT PLANT SITE PLAN

ANAEROBIC DIGESTION NEEDS ASSESSMENT
MT. VERNON, OHIO

STRAND ASSOCIATES®

FIGURE 2.01-1
4962.005

Path: S:\COL\4900--4999\4962\005\Data\GIS\Task 3\Figure 2.mxd User: scottw Date: 10/26/2017 Time: 10:03:24 AM

Year	Influent Flow (mgd)	Influent CBOD (mg/L)	Influent CBOD Loading (lb/day)	Influent TSS (mg/L)	Influent TSS (lb/day)
2015	2.81	165	3,124	179	3,768
2016	2.63	178	3,577	193	3,903
2017	3.29	146	3,632	172	4,382
3-Year Average	2.91	163	3,444	181	4,018
Design Capacity	5	130	5,421	120	5,004
Percent of Design Capacity	58%		64%		80%

Table 2.02-1 Average Influent Flows and Loadings

Flow to the Mount Vernon WWTP is largely comprised of residential wastewater. The estimated per capita residential flows and loadings are summarized in Table 2.02-2. These values are within typical ranges for municipal wastewater.

	Flow/Loading	Unit
3-Year Average Influent Flow	2.91	mgd
3-Year Average Population[1]	16,700	
Percent Residential	95%	
Per Capita Flow	166	gpd
Influent BOD Per Capita Loading	0.196	pcd
Influent TSS Per Capita Loading	0.229	pcd

[1]Source: United States Census Bureau

Table 2.02-2 Per Capita Influent Flows and Loadings

2.03 CURRENT BIOSOLIDS PRODUCTION

The current average sludge loading, biosolids production, and hydraulic retention values are shown in Table 2.03-1. Reported biosolids production is based on values provided by WWTP personnel from January 2015 to August 2017. A digester volume (each) of 241,290 gallons was used to calculate loadings. A sludge storage volume (each) of 377,000 gallons was used to calculate sludge storage capacity. According to the Ohio Administrative Code (OAC) Chapter 3745-40-10, facility storage of sewage sludge or biosolids shall be in place to provide 120 days of storage for the design capacity of the treatment works. Clarification to this Code has recently been provided that notes the 120 days of facility storage shall be dedicated to storage, not treatment.

	Flow/Loading	Unit
Anaerobic Digesters		
Anaerobic Digester Volume (total)	482,580	gal
Anaerobic Digester Volume (total)	64,516	cu. ft.
Primary Sludge (to anaerobic digesters)[1]	15,440	gpd
Solids Concentration[2]	2.0	%
Sludge Storage Tanks		
Sludge Storage Volume (total)	754,030	gal
Anaerobic Sludge (to sludge storage)	2,440	gpd
Thickened Digested WAS (to sludge storage)[1]	2,140	gpd
Average Sludge Flow to Storage Tanks	4,580	gpd
Percent Total Solids (sludge loadout)[1]	3.72	%
Hydraulic Retention Time		
Anaerobic Digesters (total)	31	day
Sludge Storage Tanks (total)	165	day

[1]Based on data provided by plant staff.
[2]Calculated based on mass balance and 70% solids capture in primary clarifiers.

Table 2.03-1 Summary of Biosolids Production

Performance data for the solids capture and resulting volatile solids (VS) concentration in the primary clarifier sludge (PRS) are not currently monitored by the WWTP staff. Literature and experience with similar domestic WWTPs indicates that PRS typically has the following characteristics:

- PRS capture is typically between 50 to 75 percent of influent TSS
- VS is typically 60 to 85 percent of total solids

For the purposes of this report, it is assumed that the primary clarifiers capture 70 percent of the influent TSS and that the corresponding solids are 75 percent volatile. Based on these assumptions, the resulting average VS loading to the anaerobic digesters from January 2015 to August 2017 was 2,109 lb/day. With two digesters in use, the volumetric VS loading is 32.7 pounds per thousand cubic foot per day (lb/1,000 ft^3-d). Ten States Standards allows for a VS loading of up to 80 lb/1,000 ft^3-d for completely mixed anaerobic digesters and up to 40 lb/1,000 ft^3-d for moderately mixed anaerobic digesters.

WWTP data indicated a three-year average VS concentration in the digested sludge to be 60.8 percent. Assuming an average VS loading of 75 percent results in a three-year average VS reduction of 48.3 percent between January 2015 and August 2017. According to Title 40, Part 503 of the Code of Federal Regulations, vector attraction reduction requirements can be met by reducing the mass of VS in sewage sludge by a minimum of 38 percent. Table 2.03-2 summarizes the average VS loadings to and destruction in the anaerobic digesters.

Year	VS to Anaerobic Digester (%)[2]	VS Loading (lb/day)[1]	VS in Digested Sludge (%)[2]	VS Reduction (%)
2015	83.2%	2,194	64.9%	62.5%
2016	85.0%	2,323	68.6%	61.5%
2017	84.1%	2,581	68.4%	59.2%
3–Year Average	84.1%	2,366	67.3%	61.1%

[1]Assumes 70% solids capture in primary clarifiers.
[2]Based on data provided by plant staff.

Table 2.03-2 Average Anaerobic Digester VS Data

Following digestion, the liquid biosolids are stored in the sludge storage tanks before disposal by land application. Table 2.03-3 outlines the quantities of bioslids that were produced from January 2015 to August 2017.

Year	Anaerobic Sludge (gal)	Thickened WAS (gal)	Sludge Loadout (gal)
2015	834,525	826,750	1,783,625
2016	845,440	718,845	1,424,450
2017[1]	655,270	591,815	1,403,225
Annual Average to Sludge Holding	890,667	781,143	1,652,843

[1]Through August 2017

Table 2.03-3 Biosolids Production

2.04 OPERATIONS REVIEW

Currently, sludge from the primary clarifiers is believed to have a relatively low solids concentration, approximately 2.0 percent; thus requiring that a large volume of PRS be pumped from the clarifiers to the anaerobic digesters on a daily basis. If equipment or processes were in place that allowed for a thicker solids concentration in the primary sludge, the anaerobic digester tank volume could be used more efficiently. This would also increase the hydraulic retention time (HRT) and result in better treatment performance. Alternative PRS pumps could be evaluated in the future if additional HRT capacity is needed for the anaerobic digester system.

The dilute PRS that is currently pumped to the unmixed anaerobic digesters also requires that WWTP staff decant large volumes of supernatant to the head of the WWTP on a daily basis. A mass balance of the data provided by WWTP staff suggests that current operations result in the potential recycle of approximately 1,600 pounds of solids per day. This results in decreased treatment performance and negative impacts to the downstream processes. Regardless of the PRS concentration, it is recommended that supernatant is no longer removed from the anaerobic digesters and that the tanks are converted to a completely mixed system to prevent the settling and recycle of solids.

Additionally, digester mixing is important for optimizing sludge stabilization and potential gas production in anaerobic digesters. While pumped sludge recirculation and gas bubble movement produce some mixing within the tank, auxiliary mixing is necessary to prevent stratification and to encourage contact between the organic components and the microorganisms. Adequate mixing intensity is also needed to help entrain and break down foam and grease that would otherwise accumulate within the tank.

SECTION 3
FUTURE CONDITIONS

This section evaluates the potential 20-year flow, loading, and biosolids projection for the City. The projections include an evaluation of potential population growth, addition of chemical phosphorus removal (CPR), and modifications to the biosolids treatment process.

3.01 POPULATION AND GROWTH PROJECTIONS

The historical population of the City was obtained from the United State Census Bureau and is shown in Table 3.01-1. This data indicated that, on average, the population of the City has increased by 0.17 percent annually since the year 2000. The City does not anticipate the population to increase at a rate higher than the historical value. Therefore, assuming population growth is linear, the projected 20-year population of the City will be approximately 17,335 people.

Year	Population[1]	Annual Percent Change
2000	15,742	
2005	15,940	0.25%
2010	17,030	1.37%
2015	16,713	-0.37%
2016	16,620	-0.56%
Average		**0.17%**

[1]Source: United States Census Bureau

Table 3.01-1 Historical Population for Mount Vernon

3.02 PROJECTED FLOWS AND LOADINGS

Based on the projected 2037 population of 17,335 people and the per capita flows and loadings shown in Table 3, the future 2037 flows and loads can be projected. Table 8 summarizes these projected flows and loads.

	Year 2017	Year 2037	Design Capacity[1]	Percent of Design Capacity
Population	16,655	17,335	30,120	58%
Average Flow (mgd)	2.91	3.20	5.0	64%
BOD Load (lb/day)	3,435	3,575	5,421	66%
TSS Load (lb/day)	4,007	4,170	5,004	83%

[1]Based on 2005 design drawings

Table 3.02-1 Flow and Load Projections

3.03 FUTURE BIOSOLIDS PRODUCTION

The phosphorus removal planning report completed for the WWTP recommended the addition of CPR equipment. CPR has been shown to increase sludge production, in the form of fixed solids, by 120 to 150 percent. Therefore, there is the potential for increased loadings to the anaerobic digesters and sludge storage tanks in the near-term due to impending phosphorus limits and long-term because of an increase in population and corresponding influent loadings and CPR impacts. This report assumes an increase in sludge production of 135 percent for CPR in addition to increases from population growth previously described.

Implementing CPR will also increase the solids concentration in the primary sludge. Thereby, potentially decreasing the overall volume of primary sludge that is required to meet the assumed solids capture of 70 percent in the primary clarifiers but increasing the total solids loading to the anaerobic digesters. For the purposes of this report, it is assumed that the PRS solids concentration will increase from an average of 2.1 percent to 3.0 percent once CPR facilities are constructed.

Typical VS reduction for completely mixed anaerobic digesters with a digestion time of 30 days is between 50 to 65 percent. This report assumes an increase in average VS reduction from 48 percent to 55 percent once the new equipment is installed. It is also recommended that no supernatant is recycled from the completely mixed anaerobic digesters. This will eliminate the potential of recycling digested sludge and VS back to the head of the WWTP. Therefore, volume into the anaerobic digesters will equal volume out of the anaerobic digesters when calculating the future HRT of the tanks. In turn, supernatant can then be drawn from the sludge storage tanks before disposal via land application. Typically, digested sludge can be thickened to 4 percent solids, thus increasing the hydraulic retention time of the sludge storage tanks.

Table 3.03-1 provides a summary of potential operations with completely mixed anaerobic digesters, the addition of CPR, and future biosolids production.

It should be noted that the completely mixed system decreases the HRT of the sludge storage tanks when compared to the value shown in Table 2.03-1. This is largely due to the recommended supernatant modifications at the anaerobic digesters. It is believed that these modifications will results in increased treatment efficiency, eliminate the potential for the recycle of VS and digested solids, fewer plant upsets, and provide the WWTP with the ability to receive FOG in the future.

Table 3.03-1 Summary of Future Biosolids Production

	Flow/Loading 2017 (Completely Mixed Anaerobic Digesters)	Flow/Loading 2017 with CPR (Completely Mixed Anaerobic Digesters)	Flow/Loading 2037 (Completely Mixed Anaerobic Digesters)	Flow/Loading 2037 with CPR (Completely Mixed Anaerobic Digesters)
WWTP Influent TSS Loading (lb/day)[1]	4,018	4,018	4,170	4,170
Total Solids Captured by Primary Clarifier (lb/day)[2]	2,812	3,797	2,919	3,941
Volatile Solids Captured by Primary Clarifier (lb/day)[3]	2,109	2,109	2,189	2,189
Solids Concentration in Primary Sludge (%)	2.1%	3.0%	2.1%	3.0%
Primary Sludge Volume (gpd)	15,694	14,831	16,291	15,395
Anaerobic Digester Tanks				
Volume (total, gal)	482,580	482,580	482,580	482,580
VS Loading (lb/1,000 ft^3-d)[2,3]	32.7	32.7	33.9	33.9
Hydraulic Retention Time (day)	31	33	30	31
VS Reduction [2,3]	61%	61%	61%	61%
Sludge Storage Tanks				
Volume (total, gal)	754,030	754,030	754,030	754,030
Anaerobic Sludge				
Total Solids to Sludge Storage (lb/day)[4]	1,524	2,508	1,582	2,604
Percent Solids (%)	1.1%	2.0%	1.1%	2.0%
Volume (gpd)	15,694	14,831	16,291	15,395
Thickened digested WAS (gpd)				
Total Solids to Sludge Storage (lb/day)[4]	1,215	1,215	1,261	1,261
Percent Solids (%)[4]	6.7%	6.7%	6.7%	6.7%
Volume (gpd)	2,125	2,125	2,206	2,206
Total Flow to Sludge Storage (gpd)	17,819	16,956	18,497	17,601
Decant Sludge Storage to 4% Solids	4.0%	4.0%	4.0%	4.0%
Average Daily Sludge Production (gal)	8,025	10,909	8,330	11,324
Hydraulic Retention Time (day)	94	69	91	67

[1]Based on data provided by plant staff.
[2]Assumes 70% solids capture in primary clarifiers.
[3]Assumes primary solids are 75% volatile.
[4]Based on mass balance of existing plant data.

SECTION 4
EVALUATION OF ALTERNATIVES

This section provides an overview of the alternatives considered for the anaerobic digester and sludge storage facilities, gas handling equipment, and modifications that may be required for the WWTP to accommodate FOG. These alternatives were selected based on the existing condition of the facilities, recommendations from Evoqua's on-site inspection, and potential phosphorus limits that may be enforced in the future.

4.01 ANAEROBIC DIGESTER AND SLUDGE STORAGE COVER ALTERNATIVES

Four new cover alternatives and rehabilitation of the existing covers were considered for the anaerobic digesters and sludge storage tanks. These covers were evaluated based on the need to rehabilitate or replace the existing aging equipment, future biosolids production, and the potential for biogas storage in the future. Figure 4.01-1 provides an illustration of the existing digester cover styles (steel floating cover) as well as potential alternative styles that will be considered. A comparison of the advantages and disadvantages of each cover type is shown in Table 4.01-1.

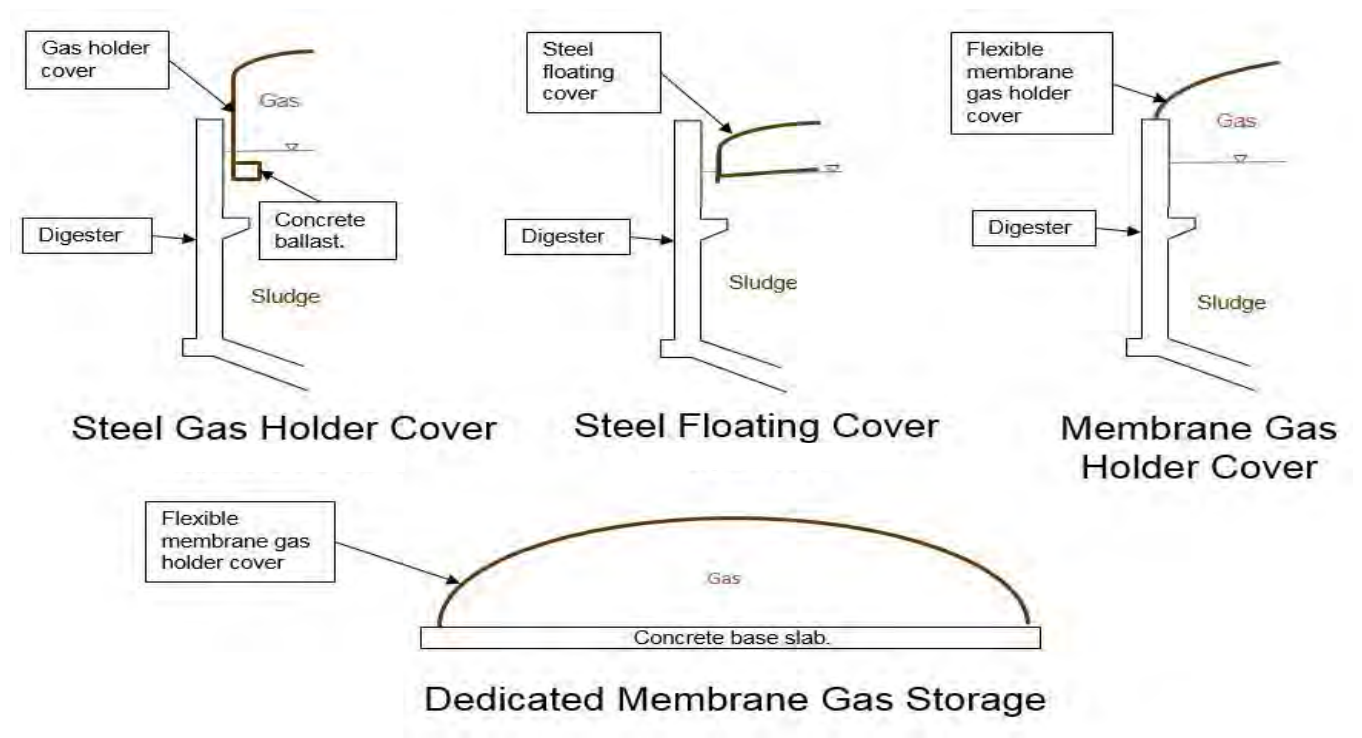


Figure 4.01-1 Cover Alternatives Schematic

Alternative	Advantages	Disadvantages	Cost[1]
Rehabilitation of all Covers	▪ Fewer resources used (better environmental sustainability).	▪ Shorter projected service life as compared to new covers. ▪ Less adaptable to alternative mixing technologies, particularly for linear motion and vertical agitator.	$
New Steel Floating Cover	▪ Longer service life. ▪ Easier to accommodate all mixing technologies. ▪ No increase in maintenance needs.	▪ Longer downtime during construction. ▪ No biogas storage	$$
New Steel Gas-Holding Cover	▪ Increased biogas storage capacity. ▪ Longer service life.	▪ Longer downtime during construction. ▪ Higher cost compared to rehabilitation.	$$$
New Membrane Gas-Holding Cover	▪ Increased biogas storage capacity. ▪ Easier installation than steel covers.	▪ Requires blowers, air piping, and controls. ▪ Requires blower maintenance ▪ Shorter service life than new steel cover	$$
New Membrane Storage Structure	▪ Increased biogas storage capacity. ▪ Biogas storage alternative if non-gas holding covers are rehabilitated.	▪ Requires blowers, air piping, and controls. ▪ Requires blower maintenance. ▪ Shorter service life than a new steel cover. ▪ High capitol cost.	$$$

[1]Capital costs can vary significantly. Cost assumptions were based on past project experience at other facilities.

Table 4.01-1 Digester Cover Alternatives

A. Rehabilitate Existing Covers

There are currently four tanks in the anaerobic digester system at the WWTP. Two of these tanks are used for anaerobic digestion and two are used for sludge storage. Evoqua evaluated the condition of each tank cover in June 2017. According to its report (Appendix A), the anaerobic digester covers are generally in good condition. Proper rehabilitation of these covers will include:

- New pressure release valves
- New antirotation guides
- New sampling well covers
- New rollers and spring shoes
- Replacement of all gaskets and O-rings
- Blast and paint cover exterior

Similarly, Evoqua recommended that the sludge storage tanks receive the following upgrades:

- New pressure release valves
- Blast and paint both interior and exterior of the covers
- Reballasting of covers

Based on discussions with Evoqua, each cover can be either rehabilitated or replaced, whichever is deemed most cost-effective and suitable for future operations. It was noted that none of the existing covers are considered to be gas-holding covers. Because of the age, condition, and corbel location, it was recommended (if gas-holding is desired) to replace the sludge storage tank covers with gas-holding covers.

B. New Steel Gas-Holding Cover

Floating covers are most advantageous for handling variable sludge levels. These covers are designed to adjust to changing conditions when adding and removing solids. Steel floating covers can be designed as either nongas-holding or gas-holding covers. The floating cover rests on top of the liquid or gas surface. There is a gap between the cover and the digester wall, which allows the cover to float up and down with the liquid. The rim skirt is submerged in the liquid, creating a gas seal around the cover. Gas-holding covers require a longer rim skirt to provide a tighter gas seal. In addition, ballast (typically concrete) is attached to the cover rim skirt to help maintain a gas pressure and allow for controlled release of excess gas to the gas flare.

Advantages of the floating steel gas-holding cover are provisions for biogas storage, allowance for variable liquid storage, and allowance for batch feeding. Disadvantages are the annular space provides a potential escape path for foam and odors, there is no scum submergence, and construction costs are higher when compared to a conventional floating steel cover.

The floating gas-holder allows for foam buildup in the gas space of the cover, since there is a large gas/liquid interface. Foam detection and suppression systems can be used to help prevent foam from becoming a serious problem.

The existing location of the corbels in the anaerobic digesters and sludge storage tanks would allow for the installation of new steel gas-holding covers with minimal modifications to the tank structure. This alternative includes rehabilitation of the two digester covers and one of the sludge storage covers with a second sludge storage cover being replaced with a steel gas-holding cover. A floating steel gas-holding cover is shown in Figure 4.01-2.

Figure 4.01-2 Floating Gas Holder Cover

C. Membrane Gas-Holding Cover

Dual membrane gas-holder covers use a dome-shaped membrane system fixed to the top of the digester wall to store biogas. The outer membrane is restrained and the inner membrane moves freely to store biogas. The inner membrane is pressurized by a low pressure compressed air system and the outer membrane is designed to handle all environmental loads (e.g., wind and snow). The space between the two membranes on the cover system is consistently purged with fresh air by dedicated blowers. Two blowers are typically provided for each cover. Only one blower is anticipated to be operating at a time with the other blower providing 100 percent redundancy. The blowers would be designed to run 24 hours a day, 7 days a week. For typical digesters, dual membrane covers can provide approximately three times more biogas storage volume compared to conventional steel gas-holder covers. Additional freeboard can be provided if foam accumulation is anticipated.

Advantages of the dual membrane cover include provisions for a large amount of biogas storage, allowance for variable liquid storage, allowance for batch feeding, a gas tight seal, and somewhat lower construction costs for comparable gas volume in a steel floating gas-holder cover. The dual membrane cover is also not subject to imbalance, which can become an issue with floating covers. Disadvantages include reliance on a compressor system to maintain biogas pressure and the need to replace the membrane approximately every 15 years. This alternative includes rehabilitation of the two digester covers and one of the sludge storage cover being replaced with a membrane. A membrane cover is shown in Figure 4.01-3

Figure 4.01-3 Membrane Gas Holder Cover

D. Membrane Storage Structure

A dedicated membrane storage structure is a potential alternative if the WWTP elects to include non-gas holding covers on the existing anaerobic digester and sludge storage tanks. This option includes a dual membrane cover that would be constructed atop a new concrete slab and would be dedicated for biogas storage. Operation of this system is similar to that of the previously described membrane cover. Currently, WWTP staff are not concerned with the capture and storage of biogas. Therefore, this alternative will not be further evaluated at this time.

4.02 MONETARY AND NONMONETARY ANALYSIS OF COVER ALTERNATIVES

A. Economic Evaluation of Cover Alternatives

A 20-year present worth (monetary) analysis was performed for each cover alternative. Cover rehabilitation's that are common to all alternatives include rehabilitation of two anaerobic digester covers and one sludge storage tank cover. The capital cost associated with this work is $1,041,000.

Assumptions include:

1. 20-year equipment service life for rehabilitated covers and membrane covers.
2. 40-year service life for new gas-holding steel covers.
3. Discount rate of 4.25 percent.
4. Maintenance material costs of 2 percent of equipment cost.
5. Biogas production equal for all gas-holding alternatives.

A summary of the present worth analyses are presented in Table 4.02-1. Additional information for each analysis can be found in Appendix B.

	Capital Cost Common To All Alternatives	Additional Capital Cost[2]	20-Year Total Present Worth
Rehabilitation of All Existing Anaeraobic Digester and Sludge Storage Covers	$1,041,000	$348,000	$1,641,000
New Steel Gas-holding Cover (Vertical Guided Steel Cover)	$1,041,000	$1,071,000	$2,369,000
New Membrane Gas-Holding Cover[1]	$1,041,000	$847,000	$2,220,000

[1]Unit price includes the cost of blowers and associated appurtenances.
[2]Includes the addition of one cover technology on existing sludge storage tank.

Table 4.02-1 Summary of Cover Technology Present Worth

B. <u>Nonmonetary Factors</u>

Several nonmonetary factors could affect the selection of covers for the anaerobic digesters and sludge storage tanks at the Mount Vernon WWTP.

1. Durability

Steel covers (floating and gas holding) are inherently more durable than membrane covers. While equipment lives are usually estimated at a maximum of 20 years, it could be reasonably assumed that a new steel cover with routine maintenance would operate reliably for 30 years or more and that rehabilitation of the existing covers could operate for an additional 20 years. Membrane covers may last for 20 years, but that is the maximum service life estimate. The membrane material may require replacement after 15 to 20 years.

2. Gas Storage

Steel covers are designed to float on top of the liquid level in the digester tanks. Floating covers have short side skirts for stability; gas holding covers have longer side skirts. Steel covers are inherently limited in their gas storage capacity by the tank depth and corbel elevations. Membrane covers are mounted to the top of the tank and provide a half sphere of storage above the tank depth. Membrane covers provide approximately 3 to 4 times more storage than steel gas-holding covers provide.

3. Mixing Systems

Digester mixing can be accomplished with several different types of systems with widely varying operating principles. Some mixing systems are cover mounted and therefore are only compatible with steel floating or steel gas-holding covers. Other systems only require tank wall mounted equipment or penetrations through the tank walls. Cover types must be considered in conjunction with mixing systems.

4.03 ANAEROBIC DIGESTER MIXING ALTERNATIVES

Three mixing alternatives for the two anaerobic digesters were considered based on future biosolids production, the need to replace aging equipment, and the opportunity to maximize digester mixing and subsequent biogas production under future design conditions. Table 4.03-1 summarizes the advantages and disadvantages of each mixing technology.

A. Pumped Mixing

Pumped mixing, an established mixing alternative for anaerobic digesters, has shown reliable success for many years. Digester contents are pulled out of the digester and pumped back in various locations through nozzles to mix the contents. The mixing system for anaerobic digesters Nos. 1 and 2 would be comprised of one 20 horse power (hp) chopper pump and two nozzle assemblies per digester. It is anticipated that the pumps could be housed in the digester building. The chopper pumps will be designed to run intermittently while still maintaining a mixed system. Figure 4.03-1 shows an example vertical pump and dual nozzle layout. Housing these pumps within an existing building will require that a code review be completed. This review will verify that proper HVAC equipment and appurtenances are present to handle the added requirements of the pumps.

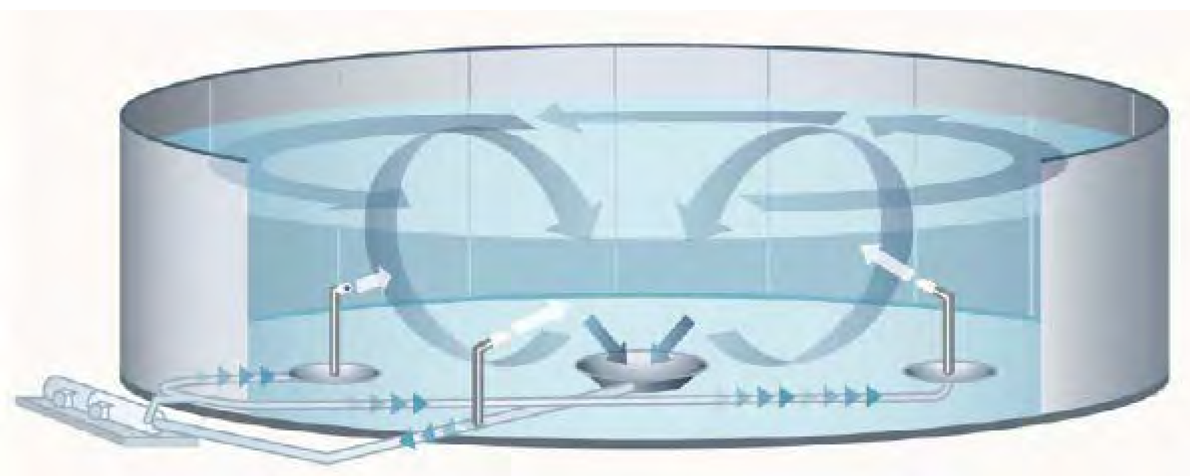


Figure 4.03-1 Evoqua JETMIX® Vortex Mixing System

B. Linear Motion Mixing

The application of linear motion mixing in anaerobic digesters is relatively new, and is marketed as being able to resuspend heavy solids, reduce foaming and scum formation with significantly less power costs in comparison to conventional mixers. The mixer is suspended in the digester from the digester cover. The shaft has a ring-shaped disk at the end that oscillates up and down at about 30 cycles per minute. Because the mixer is suspended from the cover, modifications may be required to the existing sludge and digester gas piping, and possibly to the center ring of each cover for the installation of the mixers at the WWTP. Fewer heating, ventilation, and air-conditioning (HVAC) modifications are anticipated to be required as a result of this mixing alternative since the equipment would be located within or on top of the digester. According to the manufacturer, each digester would require one 7.5 horse power (hp) mixer comprised of an 72-inch disk that vertically oscillates about 1 foot. The linear motion mixers are designed to run 24 hours a day, 7 days a week. Figure 4.04-2 shows an image of a linear motion mixer installed.

Figure 4.04-2 Linear Motion Mixer

C. Roof Mounted Draft Tube Mixing

Draft tube mixing, another traditional mixing alternative for anaerobic digesters, consistently provides adequate mixing and the flexibility to alter mixing dynamics to minimize scum formation. To minimize construction efforts, it is proposed that a roof-mounted system is used at the WWTP. One 7.5 hp roof-mounted draft tube mixer per digester would be required to provide adequate mixing. This alternative would require modifications to the sludge and digester gas piping similar to the Linear Motion Mixing alternative. No HVAC modifications are anticipated to be required with this mixing alternative. It is assumed that the motors for the draft tube mixers would run 24 hours a day, 7 days a week. Figure 4.04-3 shows a graphic of a roof mounted draft tube mixer.

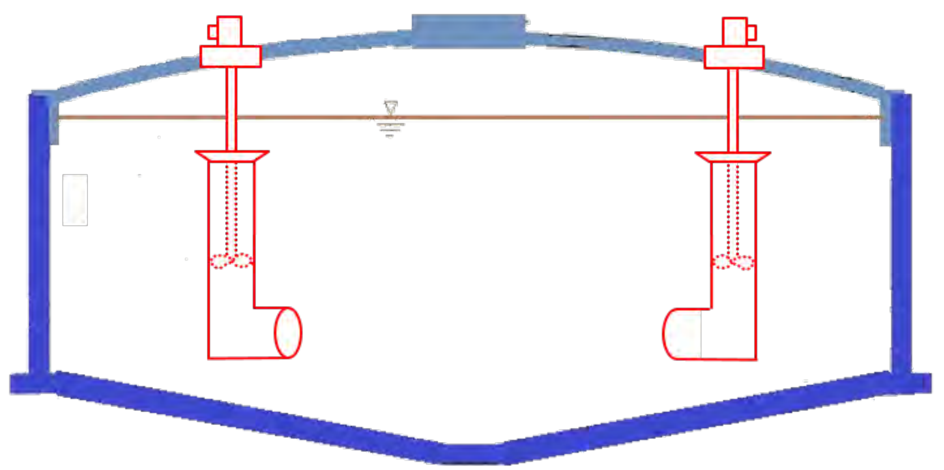


Figure 4.04-3 Roof Mounted Draft Tube Mixers

4.04 MONETARY AND NONMONETARY ANALYSIS OF MIXING ALTERNATIVES

A. <u>Economic Evaluation of Mixer Alternatives</u>

A 20-year present worth (monetary) analysis was performed for each mixer alternative for the two 40-foot primary digesters.

Assumptions include:

1. 20-year equipment service life.
2. Discount rate of 4.25 percent.
3. Maintenance material costs of 2 percent of equipment cost.
4. Biogas production equal for all alternatives.

A summary of the present worth analyses are presented in Table 4.04-1. Additional information for each analysis can be found in Appendix B.

	Initial Equipment Capital Cost	Existing Structure and Equipment Modifications	Operation and Maintenance	GCs, Contingencies, and Technical	20-year Present Worth
Pumped Mixing	$258,000	$50,000	$266,000	$167,000	$741,000
Linear Motion Mixing	$396,000	$150,000	$213,000	$296,000	$1,055,000
Roof Mounted Draft Tube Mixing	$293,000	$150,000	$186,000	$241,000	$870,000

Table 4.04-1 Summary of Mixing Technology Present Worth

B. Nonmonetary Factors

Since the mixing systems need to be operationally compatible with the covers selected, mixing system selection cannot be purely an equipment capital cost decision. Rehabilitation of the floating steel covers for the respective mixer type was included in the 20-year net present worth analysis. These details are presented in Appendix B.

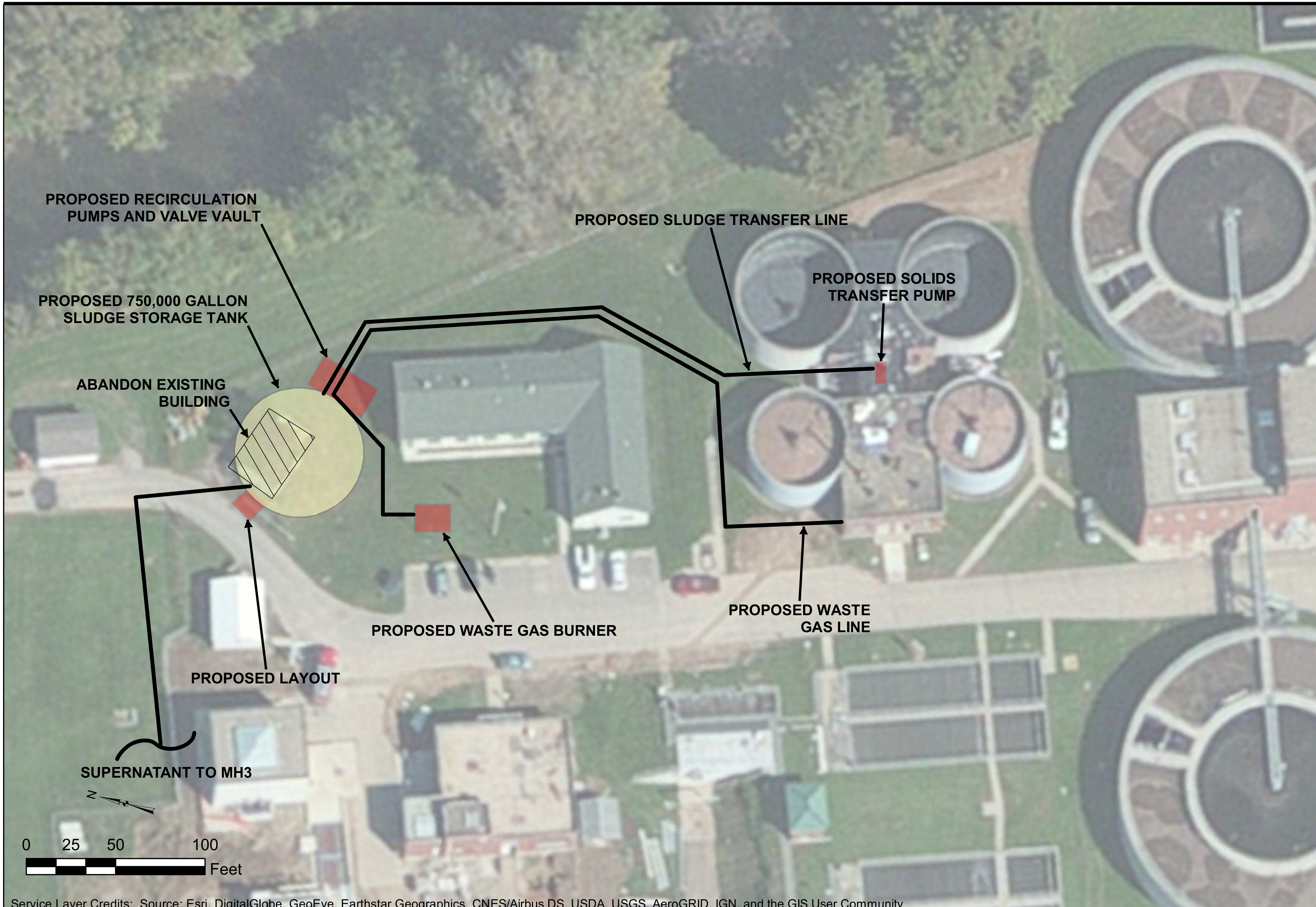
4.05 SLUDGE STORAGE CAPACITY

Table 3.03-1 identified the potential need for additional sludge storage capacity to meet future biosolids storage regulations. Although WWTP staff have indicated that, at this time, the capture and reuse of biogas is not a priority, it is proposed that a new concrete sludge storage tank with a steel gas-holding cover be constructed to provide the WWTP with process flexibility in the future. If the capture of biogas becomes a priority in the future, additional biogas storage could be provided via a dedicated membrane system. To provide 120 days of sludge storage, it is proposed that a new 750,000 gallon tank be constructed. Table 4.05-1 details the opinion of probable construction cost (OPCC) for a new sludge storage tank. Figure 4.05-1 shows the potential location of the sludge storage tank and equipment.

Item	Cost
Concrete Sludge Storage Tank With Steel Gas-Holding Cover	$2,905,000
Sludge Transfer Pump	$15,000
Pumped Recirculation	$50,000
Sludge Loading Pump	$15,000
Subtotal - Equipment and Structure	**$2,985,000**
Interior and Exterior Piping[1] (20%)	$597,000
Subtotal	**$3,582,000**
Electrical and Controls (15%)	$537,000
Subtotal	**$4,119,000**
Contractor's General Conditions (10%)	$411,900
Subtotal - Construction	**$4,530,900**
Technical Services and Contingencies (40%)	$1,812,000
Total OPCC	**$6,342,900**

[1]Includes stainless steel gas piping

Table 4.05-1 Additional Sludge Storage OPCC



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

PROPOSED SLUDGE STORAGE TANK SITE PLAN

PHOSPHORUS REMOVAL PLANNING REPORT
MT. VERNON, OHIO

STRAND ASSOCIATES®

FIGURE 4.05-1
4962.005

Path: S:\COL\4900--4999\4962\005\Data\GIS\Sludge storage tank.mxd User: scottw Date: 11/9/2017 Time: 11:03:32 AM

4.06 MISCELLANEOUS IMPROVEMENTS

A. Foam Control

Several design options are available for detecting and mitigating foaming in anaerobic digesters. These options may include one or more of the following:

1. Radar level detection (operating in combination with liquid level detection devices).
2. Foam-sensing probes.
3. Spray nozzles at the liquid surface of the digesters.
4. Foam suppression chemicals added directly to the digesters.
5. Gas handling equipment such as foam separators.
6. Alternative mixing (e.g., reversing flow through a draft tube mixer).

One or more of these options should be selected for foam detection and suppression. These alternatives can be further evaluated during the design of anaerobic digester improvements. Operating practices can also be used to minimize foaming such as maintaining a uniform loading rate of VS to the digesters.

B. Supernatant Piping Modifications

As previously described in Section 3 of this report, a completely mixed anaerobic digester does not provide the ability to draw supernatant from the tank. To prevent the recycling of VS and digested sludge, it is recommended that the supernatant piping at the digesters be abandoned. Supernatant could then be drawn from the sludge storage tanks and recycled to the head of the WWTP. Based on existing record drawings, it is anticipated that the total OPCC for supernatant modifications would equate to $150,000. These modifications are highlighted in Figure 4.05-1.

C. Digester Gas Handling Equipment

Throughout the WWTP there are currently a total of 28 digester gas handling equipment items installed. This equipment is designed to provide the ability to safely collect and burn the biogas produced during the biological breakdown of organic solids through the anaerobic digestion process for electricity production. The function and purpose of the existing digester gas handling equipment components are detailed in Table 4.06-1 and their location is further highlighted within the figures of Appendix C.

ID No.	DESCRIPTION	FUNCTIONAL PURPOSE
1	3" Pressure-Vacuum Relief, Weighted Diaphragm type	Used to maintain constant upstream pressure, and to provide positive shut-off when the downstream pressure is reduced
2	3" Pressure-Vacuum Relief, Weighted Diaphragm type	
3	3" Pressure-Vacuum Relief, Weighted Diaphragm type	
4	3" Pressure-Vacuum Relief, Weighted Diaphragm type	
5	Sediment Trap with Drip Trap	Collects small debris and moisture that could be present in the gas stream, and removes the likelihood of damage to the downstream equipment and burner
6	Sediment Trap with Drip Trap	
7	Sediment Trap with Drip Trap	
8	Sediment Trap with Drip Trap	
9	Manometer 3. Digesters	Allows for critical pressure recording throughout the system
15	Manometer 2. Waste	
27	Manometer 1. Service	
10	Drip Trap	Manually collects and safely removes condensate from the gas stream traveling through the pipe system
11	Drip Trap	
13	Drip Trap	
14	Drip Trap	
17	Drip Trap	
22	Drip Trap	
24	Drip Trap	
28	Drip Trap	
12	Gas Meter	Records the flow rate of the gas through the gas-train system
23	Gas Meter	
16	Pressure Release Valve	By releasing gas into the atmosphere it reduces the pressure within the fixed system, to avoid an equipment failure
20	Pressure Release Valve	
19	Thermal Shut off Valve	Spring-loaded pressure applied on top and bottom portion of the diaphragm shuts-off fuel supply when a certain temperature is reached
26	Thermal Shut off Valve	
21	Waste Gas Burner	Designed to burn biogas generated in the anaerobic digestion to reduce the occurrence of potential odor nuisance
18	Flame Trap w/ Drip Trap	Regulates and diverts digester gas to the waste gas burner to prevent flame propagation in case of flame flashback
25	Flame Trap w/ Drip Trap	

Table 4.06-1 Existing Digester Gas Handling Equipment

Evoqua's on-site evaluation (Appendix A) noted that, in general, the existing gas handling system appears to be in good condition with the exception of the waste gas burner (Item: 21) and associated piping. Evoqua also noted that the existing covers for the sludge storage tanks are not gas holders and replacement of these covers may be required to efficiently capture potential biogas. The volume of methane gas produced during the digestion process is estimated from the percentage of volatile solids reduction. With a completely mixed anaerobic system, Table 3.03-1 indicates a potential VS reduction of 55 percent. Typically, there is between 12 to 18 ft^3 of methane gas produced for every pound of VS destroyed. Therefore, the City could potentially produce between 13,900 ft^3 and 20,900 ft^3 of methane gas on a daily basis if the system is converted to completely mixed tanks.

Based on the potential gas production estimate, components of the existing handling equipment may require upgrades. Varec Biogas proposed the following modifications:

- Replacement of existing 3-inch PRVs (Items: 1, 2, 3, 4) with two new 6-inch PRVs with flame arrester and sight glass on each tank.
- Installation of new 4-inch sediment and flame traps (Items: 5, 6) on each of the sludge storage tanks.
- Installation of new 8-inch sediment and flame traps (Items: 7, 8) on each of the anaerobic digesters.
- Installation of three new manometers (Items: 9, 15, 27) to measure the pressure of each individual tank.

The scope of this report did not include a detailed site survey of the existing condition of the gas handling equipment. However, a cost opinion for the replacement and modification of the existing equipment was formulated based on record drawings and discussions with the manufacturer of the existing equipment (Varec Biogas). These items are summarized in Table 4.06-2. Pending a condition assessment, replacement of the overall system may not be required and the components listed in Table 4.06-2 may be prioritized by the City.

Table 4.06-2 Gas Handling Equipment OPCC

Item Description	Item Location	Quantity	Unit Price	Cost
6" "All Weather" Relief Valve with Flame Arrester	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	8	$9,500	$76,000
6" Insulating Jacket, Relief Valve and Flame Arrester	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	8	$3,200	$26,000
6" Safety Selector Valve, Rotary Style	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	4	$17,300	$69,000
6" Insulating Jacket for SSV, Safety Selector Valve	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	4	$3,300	$13,000
4" Sediment Trap	Sludge Holding Tank 1, 2	2	$9,400	$19,000
8" Sediment Trap	Digester Tank 1 and 2	2	$15,800	$32,000
Sight Glass	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	4	$1,600	$6,000
Well-Type Manometer	4 on Digesters, Waste, Service	6	$3,000	$18,000
Low Pressure Flame Check	6 Manometer vent Line, Vent line of pressure regulator	7	$300	$2,000
Drip Trap, Manual Operation	Multiple Locations	8	$1,100	$9,000
8" Single Port Back Pressure Regulator, Set Pressure 9" WC	Waste Gas Burner	1	$10,400	$10,000
8" Flame Trap Assembly	Waste Gas Burner, Vertical Installation	1	$13,500	$14,000
8" Insulating Jacket for 450 8", Flame Trap Assembly	Waste Gas Burner	1	$2,800	$3,000
8" Waste Gas Burner & Ignition System, Full Feature Panel	Waste Gas Burner	1	$58,400	$58,000
4" Flame Trap Assembly	Boiler Gas	1	$5,400	$5,000
New Stainless Steel Gas Piping	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	1	$78,000	$78,000
Flow Meters	Digester Tank 1 and 2, Sludge Holding Tank 1 and 2	4	$1,5000	$6,000
			Subtotal–Equipment Cost	**$444,000**
Contractor's General Conditions (10%)		1	$44,000	$44,000
			Subtotal–Construction	**$488,000**
Technical Services and Contingencies (40%)		1	$195,000	$195,000
			Total OPCC	**$683,000**

D. FOG

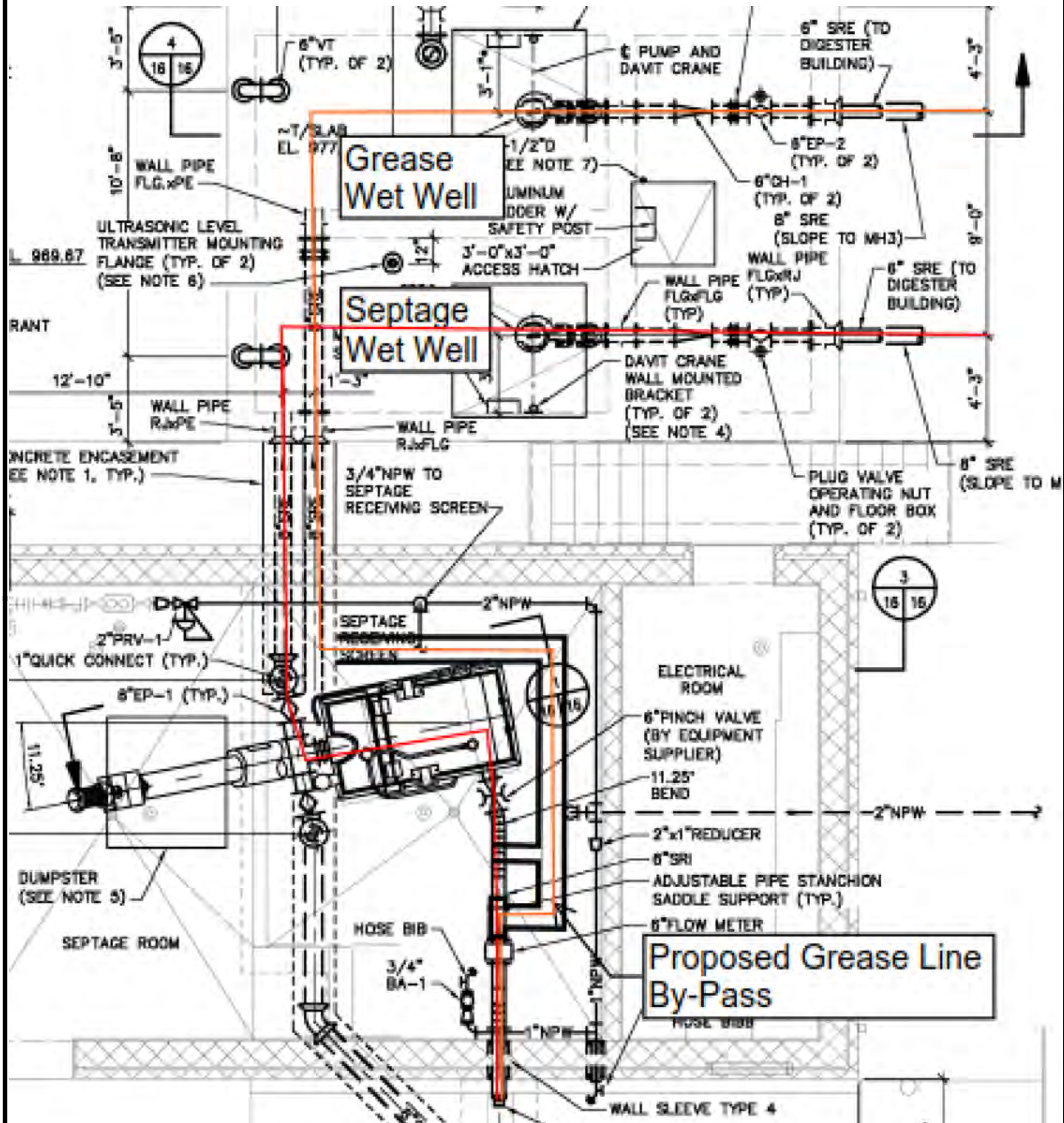
Modifications of the anaerobic digesters to include complete mixing creates an opportunity for the City to accept FOG. Literature suggests that the anaerobic digestion process appears to become more stable when a variety of substrates are codigested causing improved digester performance. The addition of organic substrate (i.e., FOG) directly to the anaerobic digestion system can stimulate biological activity and improve performance in terms of biogas production. Current WWTP operation does not allow for grease to be directly conveyed to the anaerobic digesters. Instead, FOG must pass through the headworks of the facility, potentially blinding the influent screens and piping, and continues through the forward flow processes of the WWTP. Potential benefits of codigesting organic wastes with municipal sludge include:

- Remove organic loadings and nuisance factors from headworks and liquid treatment train.
- Increase use of existing digester capacity.
- Provide a reliable outlet for organic wastes.
- Potential for a new revenue stream for organic wastes.
- Potential to increased volume of biogas.
- Reduce cost of operation, maintenance, and odor control in the liquid treatment train between headworks and final clarifiers.

The existing layout of the septage receiving station provides the potential to construct a parallel FOG receiving connection. The connection could be piped such that FOG bypasses the septage receiving screen (SRS) and discharges directly to one of the two existing septage receiving wet wells. Each of these wells has a capacity of approximately 7,500 gallons. FOG could then be pumped directly to the anaerobic digesters and bypass all forward flow processes. Figures 4.06-1 and 4.06-2 provides a schematic of the proposed modifications to the septage receiving facility. The associated OPCC is detailed in Table 4.06-3

Description	**Unit**	**Quantity**	**Unit Cost**	**Cost**
Septage Receiving Building Modifications	LS	1	$ 5,000	$ 5,000
FOG Bypass Piping & Appurtenances	LF	10	$ 60	$ 600
Gate Valves	EA	4	$ 2,000	$ 8,000
Motor Actuator	EA	4	$ 2,000	$ 8,000
Subtotal–Equipment and Structures				**$ 21,600**
Site Work (5%)	LS	1	$ 1,000	$ 1,000
Yard Piping (5%)	LS	1	$ 1,000	$ 1,000
Electrical (15%)	LS	1	$ 3,000	$ 3,000
Instrumentation and Controls (10%)	LS	1	$ 2,000	$ 2,000
Subtotal				**$ 28,600**
Contractors General Conditions (10%)	LS	1	$ 2,900	$ 2,860
Subtotal–Construction				$ 31,460
Technical Services and Contingencies (40%)	LS	1	$ 12,600	$ 12,600
			Total OPCC	**$ 44,000**

Table 4.06-3 FOG Modifications OPCC



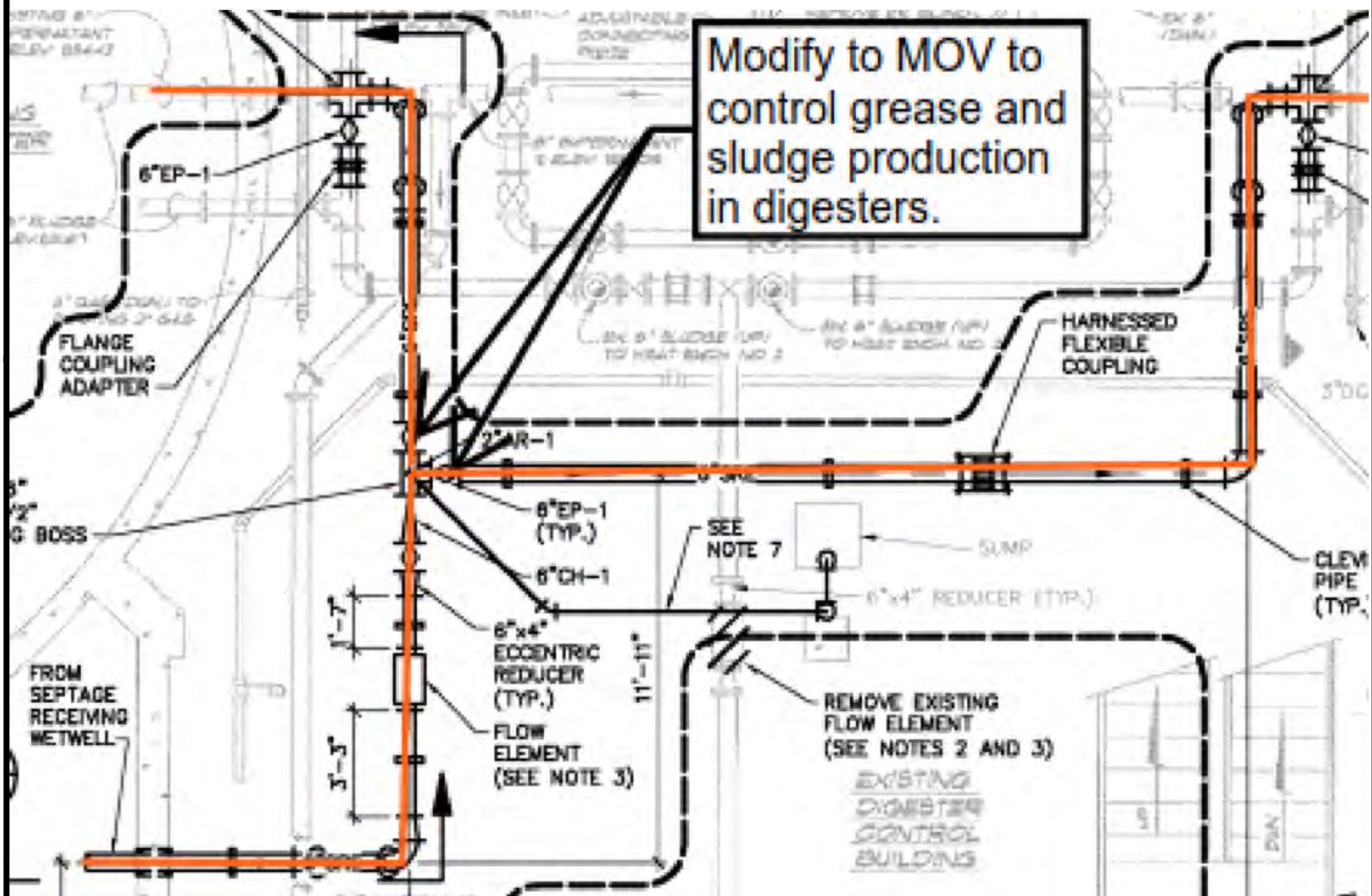
Path: S:\COL\4900--4999\496\2005\Wrd\Task 3 - Anaerobic Digestion\FOG\FOG GREASE SRS BY-PASS PIPELINE1.mxd User: scottw Date: 10/20/2017 Time: 1:48:16 PM

FOG GREASE SRS BY-PASS PIPELINE

ANAEROBIC DIGESTION NEEDS ASSESSMENT
MOUNT VERNON, OHIO

STRAND ASSOCIATES

FIGURE 4.06-1
4962.005



FOG GREASE SRS BY-PASS PIPELINE

ANAEROBIC DIGESTION NEEDS ASSESSMENT
MOUNT VERNON, OHIO

STRAND ASSOCIATES®

FIGURE 4.06-2
4962.005

SECTION 5
RECOMMENDATIONS

5.01 RECOMMENDED ALTERNATIVES

Several alternatives were discussed for the anaerobic digester and sludge storage modifications and improvements to prepare the WWTP for forthcoming phosphorus limits. Based the previously described monetary and nonmonetary analysis, the following alternatives are recommended for the City:

1. Rehabilitation of the existing steel floating covers on both the anaerobic digesters and sludge storage tanks. Rehabilitation of these covers may provide the City with an additional 20 years of service life. However, if gas storage becomes a future priority, the City will need to evaluate potential biogas alternatives.

2. Installation of new jet mixers in each of the anaerobic digesters. The mixers will encourage increased microbial activity within the anaerobic digesters; resulting in a more efficient system and greater VS reduction.

3. Modifications to the supernatant piping of both the anaerobic digesters and sludge storage tanks to reduce the potential of recycling solids.

4. Construction of a new sludge storage tank to provide adequate storage capacity.

5. Evaluation and replacement of existing gas handling equipment as needed, including the construction of a new waste gas burner.

A. <u>Project Costs</u>

This plan is intended to improve the operational and treatment efficiency of the WWTP's biosolids treatment train. The OPCC of each component is detailed in Table 5.01-1.

The Phosphorus Removal Planning Report detailed the necessary WWTP modifications required to meet a discharge phosphorus limit of 1.0 mg/L via CPR. Table 5.01-2 summarizes the OPCC of a complete WWTP upgrade to include phosphorus removal equipment, anaerobic digester improvements, and additional sludge storage capacity.

Item	Description	Capital Cost
1	Rehabilitation of Exiting Anaeraobic Digester and Sludge Storage Covers (Duo Deck Steel Floating Cover)	$720,000
2	Installation of Jet Mix System in Anaerobic Digesters	$245,000
3	Supernatant Piping Modifications	$150,000
4	Sludge Storage Tank and Appurtenances	$3,582,000
5	Complete Replacement of Gas Safety Equipment[1]	$444,000
6	FOG Modifications	$21,600
	Subtotal - Equipment and Structures	**$5,162,600**
	Site Work (5%)	$258,000
	Yard Piping (10%)	$516,000
	Electrical (15%)	$774,000
	Instrumentation and Controls (10%)	$516,000
	Subtotal	**$7,226,600**
	Contractors General Conditions (10%)	$722,660
	Subtotal - Construction	**$7,949,260**
	Technical Services and Contingencies (35%)	2,782,000
	Total OPCC	**10,732,000**

[1]May be prioritized base on detailed assessment and manufacturer recommendations.

Table 5.01-1 Complete Project OPCC

Description	Capital Cost
Chemical Phosphorus Removal	$550,000
Biosolids Treament Upgrades	$10,732,000
Total OPCC	**$11,282,000**

Table 5.01-2 Complete WWTP Modifications

5.02 DATA COLLECTION

In preparation for design, it is recommended that WWTP staff continue and/or begin sampling and monitor the following parameters:

- Primary Clarifier Sludge
  - Solids capture percentage
  - PRS flowrate to anaerobic digesters (gpd)
  - Percent solids of PRS
  - Percent volatile solids of PRS
- Anaerobic Digester
  - Volatile solids reduction (percent)
  - Volume of supernatant (gpd)
  - Percent solids of supernatant
  - Volume of digested sludge to sludge storage tanks (gpd)
- Sludge Storage Tanks
  - Total influent volume (anaerobic and digested WAS) (gpd)
  - Percent solids of influent flow
  - Total sludge loadout
  - Percent solids of disposed sludge
- Biogas
  - Meter current biogas production

APPENDIX A
EVOQUA INSPECTION REPORT

AnDig System Inspection Report
Mt. Vernon, OH

Date of Inspection: June 27, 2017

Purpose of Trip: Evaluate existing Anaerobic Digester Covers.

Representative: BissNuss – Ken Rogozinski (territory representative); The Henry P. Thompson Company – Neil Raymond (territory representative)

Engineer: Kevin Earnest – Strand & Associates

Inspector: Tom Mangione – Evoqua Water Technologies.

Mt. Vernon Personnel: Bill Rutherford, Jason Belcher

General Comments: For an anaerobic digester system to properly operate, there are a few conditions that are necessary.

- Anaerobic describes the absence of oxygen. So the tank needs to be covered to prevent absorption of oxygen from the atmosphere. Additionally, the cover should have the ability to collect and direct the biogas produced by the process.
- It must be well mixed. The retention time for a mesophilic digester is 15 to 20 days, the sludge fed each day must be mixed with the sludge already in the digester.
- It must be maintained at a constant temperature, 95°F for a mesophilic digester. The largest portion of that temp comes from bringing the raw sludge from 55°F (in winter) up to 95°F.
- It should be fed on a regular basis.
- The ability to safely utilize the free bio-methane being produced.

Background: There are four (4) tanks in the anaerobic digester system at Mt. Vernon. Two (2) 40’ diameter tanks that are used as digesters and have duo deck floating covers that were supplied in 1992. Each of these covers also has 2” of insulating concrete on top of the ceiling plates. The ceiling plates, therefore, were not able to be inspected.

Two (2) 50’ diameter tanks that are used for sludge storage and have duo deck floating covers that were supplied in 1986. We were asked by the engineer to inspect the four covers. We inspected the two 40’ covers and one of the 50’ covers.

Observations: Digester #2, which has a PEARTH gas mixing system on it, was inspected first. The very first thing I noticed is that the cover is tilted and belching gas (see MV 1). Jason said that that was because they have the digester gas system isolated. I am not sure why the system was isolated, but later, in the basement, Jason opened the valve that isolated the digester and said that should fixed the belching gas. The waste gas burner was flaring once that valve was opened.

The cover was not centered in the tank, which is a function of the tilting as well as broken spring shoes and rollers that need adjusting. The top of the cover needs a paint job, but is not overly corroded (see MV 2).

The attic space was clean and dry. There were no odors, no moisture at all, there was some very minor surface rust (see MV 3), but nothing at all to worry about. There are no bent or twisted truss members. This cover is 25 years old and the inside of the attic space is great.

Digester #1 is in similar condition. The exterior needs a paint job but the attic space was in great condition. This tank was centered in the tank and the rollers all seemed to move easily. The PVR is cracked (see MV 4).

The attic space was clean and dry and smelled like it was painted just a few weeks ago. There are no bent or twisted truss members and some very minor surface rust (see MV 5).

Sludge Storage Tank #1 was way down in the tank, most likely resting on the corbels. Bill said he was told that we didn't need to inspect that one (see MV 6).

Sludge Storage tank #2 was not in as great shape as the two digesters.

The exterior paint has held up better than the digesters has, not sure if it has been recoated externally in the last 31 years or not, but it looks pretty good. Not great, but not terrible either (see MV 7).

Climbing down into the interior I was greeted with a pile of rusted steel and other debris (see MV 8) which came from the hole in the bottom of the PVR stack (see MV 9). Condensate collects in the bottom of the PVR pot and rusts it out over time. This allows gas to get into the attic space. There were no odors nor any alarms on the air monitor, so I completed my inspection.

Most of the corrosion was on the floor, where condensate would collect and on the roof plates painted seams (see MV 10, 11 and 12).

The trusses look amazingly good considering the environment they are in, not much corrosion, there are no bent or twisted members.

We then looked at the entire gas safety system which looks to be in good shape, with the exception of the Waste Gas Burner vault. One of the biggest culprits to a failing GSE system is drip traps that are not actuated on a regular basis. I was very happy to see that that is not the situation in Mt. Vernon.

A portion of the gas piping was replaced with some sch. 40 PVC in the WGB vault.

The PEARTH gas mixing system was not running when we were there but Jason said they had little if any issues with the PEARTH. So we didn't look at it.

Recommendations: Structurally, all the covers inspected are in great shape and can easily last another 20 years.

On any digester or sludge storage tank, with the gas take off line closed, the PVR should be able to relieve the gas pressure in the digester so that the cover doesn't tip and allow gas to belch out. A tipped cover is never a good thing. The PVR's should be replaced.

In light of the condition of PVR stack on the sludge storage tank, I recommend that all PVR's be moved to the gas dome cover plate. The PVR stack can then be removed and the hole in the roof plate and gas dome be sealed.

I'm not sure the last time the digesters were taken out of service, but the tanks could use a good cleaning and the roof plates could be blasted and painted. The ceiling plates could then be blasted, inspected and recoated.

The sludge storage tank cover will require a bit more. It will need to be blasted and painted both externally and internally. The H2S that is in the attic space, and I should say that the H2S levels at this facility are not high, will just continue to corrode all the steel in the attic space.

While discussing the sludge storage tanks with Jason and Bill, they were both under the impression that these covers are gasholders. They are not. A small gasholder would not be a bad thing at this facility. Even though their boiler is set up to burn digester gas, and the digester valve appears to be open, both Bill and Jason said they don't burn much digester gas in it. With natural gas prices so low, I'm not sure the payback is there for a gasholder, but that's someone else's decision. However, with the corbels on the sludge storage tanks being 25' below the top of the wall, one of those can easily accept a gasholder.

The gas piping in the WGB vault needs to be replaced and I'm not sure how much slope is in that line, but it may need to be replaced back to the building.

Jason did express an interest in mixing Digester #1 to have the flexibility in operation. We discussed Jet Mix hydraulic mixing system.

Looking at the drawings, I notice that the operating pressure of all four covers is exactly the same. Since the sludge storage tanks produce very little if any gas, and are not gasholders, they should weigh slightly more. This will keep the biogas moving towards the boiler or WGB. Some minor re-ballasting should be considered.

APPENDIX B
NET PRESENT WORTH OF ALTERNATIVES

Mount Vernon WWTP
Rehabilitation of Two Anaerobic Digester and
One Sludge Storage Tank Covers

Discount Rate 4.250%

20 year PW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
Rehabilitation of Cover	$ 585,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 585,000					
Piping (5%)	$ 30,000	$ -	20	$ -	$ -	$ -
Electrical (5%)	$ 30,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 30,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 675,000					
Contractor GCs (10%)	$ 68,000					
Total Construction Costs	$ 743,000					
Contingencies and Technical Services (40%)	$ 298,000					
Total Capital Costs	$ 1,041,000			$ -	$ -	$ -
Present Worth of Capital Costs	$ 1,041,000			$ -		$ -
Annual O&M Costs	$ 14,000					
Natural Gas Cost	$ -					
Total O&M Costs	$ 14,000					
Present Worth of O&M	$ 186,000					
Summary of Present Worth						
Capital Cost	$ 1,041,000					
Replacement	$ -					
O&M Cost	$ 186,000					
Salvage Value	$ -					
Total Present Worth	$ 1,227,000					

Note: Costs are fourth quarter 2017 basis and do not include taxes.

Mount Vernon WWTP

Rehabilitation of one Sludg Storge Tank Cover

Discount Rate 4.250%

20 year PW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
Rehabilitation of Cover	$ 195,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 195,000					
Piping (5%)	$ 10,000	$ -	20	$ -	$ -	$ -
Electrical (5%)	$ 10,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 10,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 225,000					
Contractor GCs (10%)	$ 23,000					
Total Construction Costs	$ 248,000					
Contingencies and Technical Services (40%)	$ 100,000					
Total Capital Costs	$ 348,000			$ -	$ -	$ -
Present Worth of Capital Costs	$ 348,000			$ -		$ -
Annual O&M Costs	$ 5,000					
Natural Gas Cost	$ -					
Total O&M Costs	$ 5,000					
Present Worth of O&M	$ 66,000					
Summary of Present Worth						
Capital Cost	$ 348,000					
Replacement	$ -					
O&M Cost	$ 66,000					
Salvage Value	$ -					
Total Present Worth	$ 414,000					

Note: Costs are fourth quarter 2017 basis and do not include taxes.

Mount Vernon WWTP
New Steel Gas-Holding Cover

Discount Rate 4.250%

20 year PW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
New Steel Gas Holder	$ 530,000	$ -	40	$ -	$ 265,000	$ 115,000
Painting	$ 25,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 555,000					
Piping (15%)	$ 84,000	$ -	20	$ -	$ -	$ -
Electrical (5%)	$ 28,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 28,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 695,000					
Contractor GCs (10%)	$ 70,000					
Total Construction Costs	$ 765,000					
Contingencies and Technical Services (40%)	$ 306,000					
Total Capital Costs	$ 1,071,000			$ -	$ 265,000	$ 115,000
Present Worth of Capital Costs	$ 1,071,000			$ -		$ 115,000
Annual O&M Costs	$ 14,000					
Electrical Savings	$ -					
Natural Gas Costs	$ -					
Total O&M Costs	$ 14,000					
Present Worth of O&M	$ 186,000					
Summary of Present Worth						
Capital Cost	$ 1,071,000					
Replacement	$ -					
O&M Cost	$ 186,000					
Salvage Value	$ (115,000)					
Total Present Worth	$ 1,142,000					

Note: Costs are fourth quarter 2017 basis and do not include taxes.

Mount Vernon WWTP
New Membrane Gas-Holding Cover

Discount Rate 4.250%

20 year PW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
New Membrane Cover	$ 390,000	$ -	20	$ -	$ -	$ -
Blower and Appurtanences	$ 50,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 440,000					
Piping (15%)	$ 66,000	$ -	20	$ -	$ -	$ -
Electrical (5%)	$ 22,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 22,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 550,000					
Contractor GCs (10%)	$ 55,000					
Total Construction Costs	$ 605,000					
Contingencies and Technical Services (40%)	$ 242,000					
Total Capital Costs	$ 847,000			$ -	$ -	$ -
Present Worth of Capital Costs	$ 847,000			$ -		$ -
Annual O&M Costs	$ 11,000					
Electrical Savings	$ -					
Natural Gas Costs	$ -					
Total O&M Costs	$ 11,000					
Present Worth of O&M	$ 146,000					
Summary of Present Worth						
Capital Cost	$ 847,000					
Replacement	$ -					
O&M Cost	$ 146,000					
Salvage Value	$ -					
Total Present Worth	$ 993,000					

Note: Costs are fourth quarter 2017 basis and do not include taxes.

Mount Vernon WWTP
Anaerobic Digester Jet Mix System

Discount Rate 4.250%

20 year TPW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
New Jet Mixing Equipment	$ 195,000	$ -	20	$ -	$ -	$ -
Building Modifications	$ 50,000					
Subtotal	$ 245,000					
Piping (10%)	$ 25,000	$ -	20	$ -	$ -	$ -
Electrical (10%)	$ 25,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 13,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 308,000					
Contractor GCs (10%)	$ 31,000					
Total Construction Costs	$ 339,000					
Contingencies and Technical Services (40%)	$ 136,000					
Total Capital Costs	$ 475,000			$ -	$ -	$ -
Present Worth of Capital Costs	$ 475,000			$ -		$ -
Annual O&M Costs	$ 20,000					
Total O&M Costs	$ 20,000					
Present Worth of O&M	$ 266,000					

Summary of Present Worth	
Capital Cost	$ 475,000
Replacement	$ -
O&M Cost	$ 266,000
Salvage Value	$ -
Total Present Worth	$ 741,000

Note: Costs are fourth quarter 2017 basis and do not include taxes.

Mount Vernon WWTP
Anaerobic Digester Linear Motion Mixing System

Discount Rate 4.250%

20 year TPW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
New Linear Motion Mixing Equipment	$ 304,000	$ -	20	$ -	$ -	$ -
Cover Modifications	$ 150,000					
Subtotal	$ 454,000					
Piping (5%)	$ 23,000	$ -	20	$ -	$ -	$ -
Electrical (10%)	$ 46,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 23,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 546,000					
Contractor GCs (10%)	$ 55,000					
Total Construction Costs	$ 601,000					
Contingencies and Technical Services (40%)	$ 241,000					
Total Capital Costs	$ 842,000			$ -	$ -	$ -
Present Worth of Capital Costs	$ 842,000			$ -		$ -
Annual O&M Costs	$ 16,000					
Total O&M Costs	$ 16,000					
Present Worth of O&M	$ 213,000					
Summary of Present Worth Costs						
Capital Cost	$ 842,000					
Replacement	$ -					
O&M Cost	$ 213,000					
Salvage Value	$ -					
Total Present Worth	$ 1,055,000					

Note: Costs are fourth quarter 2017 basis and do not include taxes.

Mount Vernon WWTP
Anaerobic Digester Roof Mounted Draft Tube Mixing System

Discount Rate 4.250%

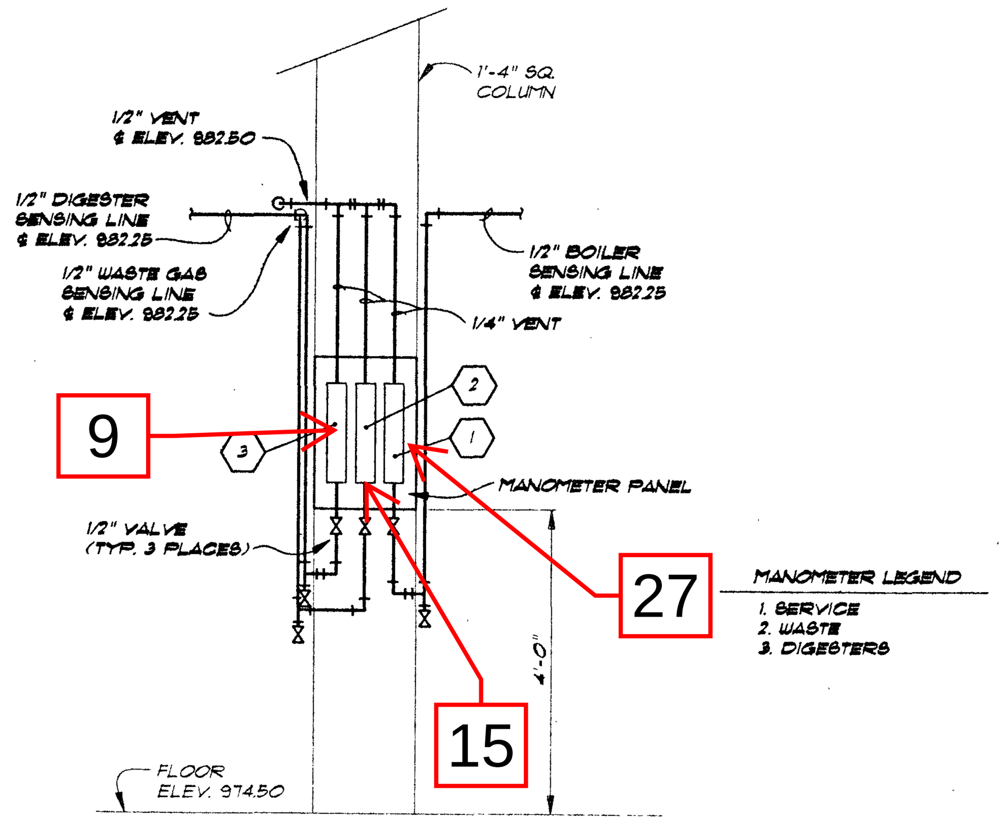
20 year TPW

ITEM	Initial Capital Cost	Future Capital Cost	Service Life	Replacement Cost (P.W.)	20 year Salvage Value	Salvage Value (P.W.)
New Draft Tube Mixers	$ 218,000	$ -	20	$ -	$ -	$ -
Cover Modifications	$ 150,000					
Subtotal	$ 368,000					
Piping (5%)	$ 19,000	$ -	20	$ -	$ -	$ -
Electrical (10%)	$ 37,000	$ -	20	$ -	$ -	$ -
Sitework (5%)	$ 19,000	$ -	20	$ -	$ -	$ -
Subtotal	$ 443,000					
Contractor GCs (10%)	$ 45,000					
Total Construction Costs	$ 488,000					
Contingencies and Technical Services (40%)	$ 196,000					
Total Capital Costs	$ 684,000			$ -	$ -	$ -
Present Worth of Capital Costs	$ 684,000			$ -		$ -
Annual O&M Costs	$ 14,000					
Total O&M Costs	$ 14,000					
Present Worth of O&M	$ 186,000					
Summary of Present Worth Costs						
Capital Cost	$ 684,000					
Replacement	$ -					
O&M Cost	$ 186,000					
Salvage Value	$ -					
Total Present Worth	$ 870,000					

Note: Costs are fourth quarter 2017 basis and do not include taxes.

APPENDIX C
DIGESTER GAS SAFETY EQUIPMENT

2176 A



ELEVATION

MANOMETER PANEL DETAIL

NO SCALE

2

VALVE SCHEDULE						
NO.	TYPE	SIZE	ENDS	RATING	OPERATOR	REMARKS
1	PL	4"	FL	125	LE	DIGESTER GAS
2	PL	4"	FL	125	LE	" "
3	PL	4"	FL	125	LE	" "
4	PL	4"	FL	125	LE	" "
5	PL	4"	FL	125	LE	" "
6	PL	4"	FL	125	LE	DIGESTER GAS

LEGEND FOR VALVE SCHEDULE

VALVES, ETC.

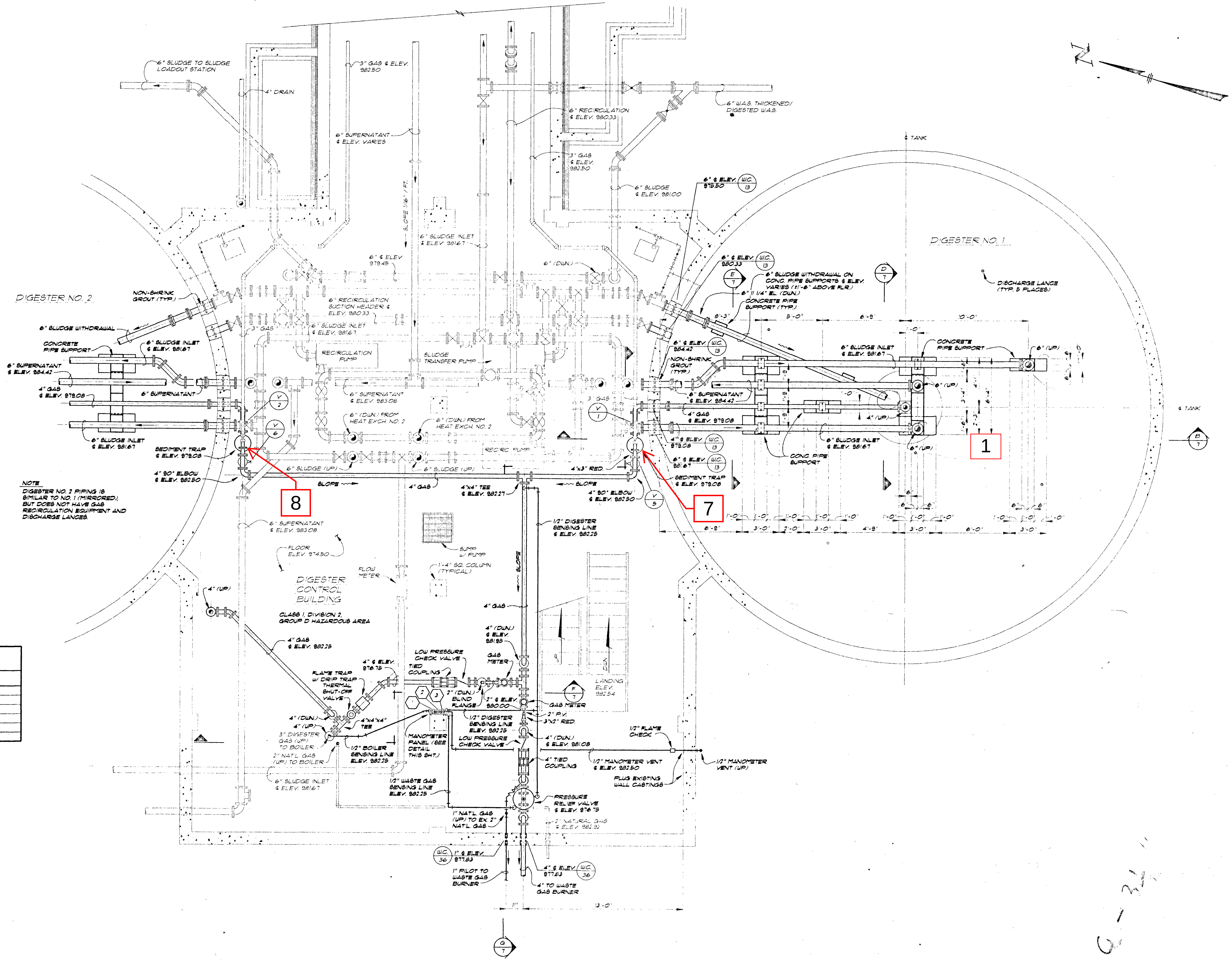
AC AIR CHECK VALVE
AL ALTITUDE VALVE
AN ANGLE VALVE
AR AIR RELEASE VALVE
AV AIR AND VACUUM VALVE
BA BALL VALVE
BF BUTTERFLY VALVE
BK BACKPRESSURE VALVE
BFP BACKFLOW PREVENTER
CK CHECK VALVE
CO CONE VALVE
GA GATE VALVE
GL GLOBE VALVE
HB HOSE BIBB
KG KNIFE GATE VALVE
KN KNIFE VALVE
PD PLUG DRAIN VALVE
PRV PRESSURE RELIEF
PG PRESSURE REGULATOR
PI PINCH VALVE
PL PLUG VALVE
PR PRESSURE REDUCING VALVE
PT PRESSURE TEMPERATURE RELIEF
RF RATE-OF-FLOW CONTROLLER
SC SAMPLING COCK
SO SOLENOID VALVE
SU SURGE VALVE
TE TELESCOPING VALVE
TM TEMPERATURE CONTROL VALVE
WF WALL FAUCET

OPERATOR

CH CHAIN
EM ELECTRIC MOTOR
ES EXTENSION STEM
FB FLOOR BOX
FS FLOOR STAND
GE GEAR
HC HYDRAULIC CYLINDER
HW HANDWHEEL
LE LEVER
LW "L" WRENCH
ON OPERATING NUT
PC PNEUMATIC CYLINDER
PD PNEUMATIC DIAPHRAGM
TW "T" WRENCH
VB VALVE BOX

ENDS

BE BELL
CM COMPRESSION
CS COPPER SWEAT
FL FLANGE
GR GROOVED
LU LUG
MJ MECHANICAL JOINT
SW SOLVENT WELD
TS THREADED (SCREWED)
WB WAFER WITH THRU BOLTING
WE WELDED



SECTIONAL PLAN

1/4"=1'-0"

2176 A

REV. NO.	DESCRIPTION	DATE	BY	APP'D

FINKBEINER, PETTIS & STROUT, LTD.
CONSULTING ENGINEERS
TOLEDO • AKRON
OHIO

SCALE: AS NOTED
DESIGNED BY: D.G.M./D.M.S.
DRAWN BY: C.A.S./R.N.J.
CHECKED BY: R.B.W./G.L.B.

MODIFICATIONS TO CONTROL BUILDING AND DIGESTERS
WASTEWATER TREATMENT PLANT IMPROVEMENTS
MOUNT VERNON, OHIO

STATE OF OHIO
DAVID G. McCALLOPS
51900
REGISTERED PROFESSIONAL ENGINEER

REV. NO.	DESCRIPTION	DATE	BY	APP'D

FINKBEINER, PETTIS & STROUT, LTD.
CONSULTING ENGINEERS
TOLEDO • AKRON
OHIO

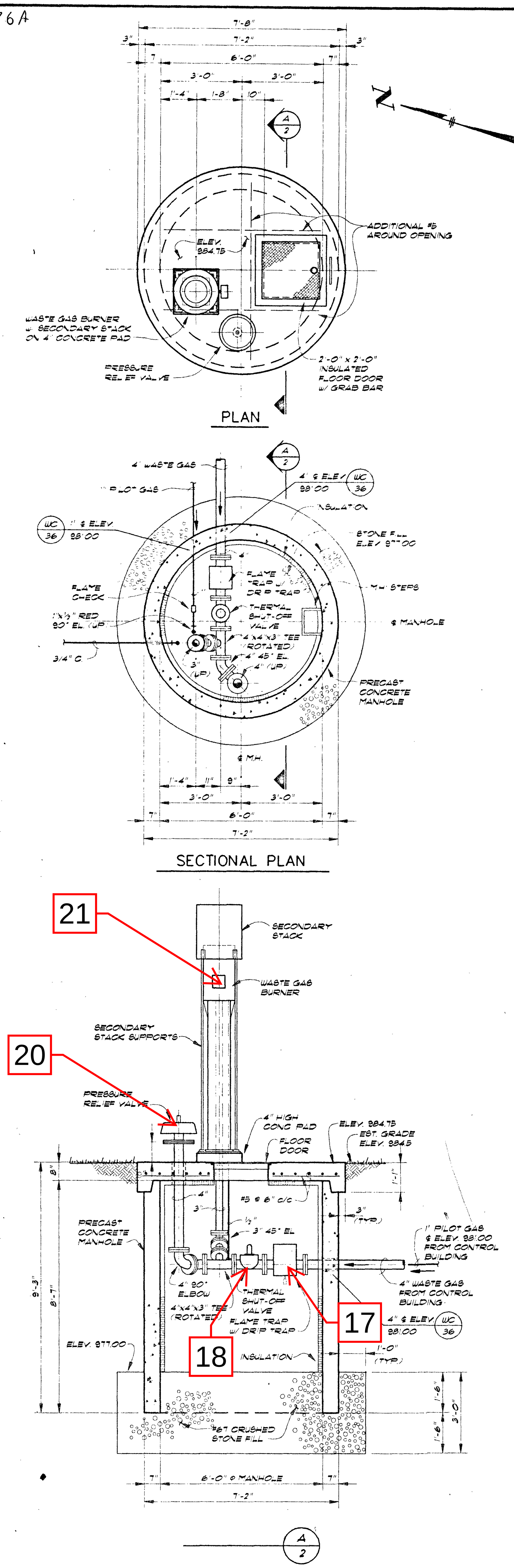
SCALE	1/4" = 1'-0"
DESIGNED BY	D.G.M.
DRAWN BY	D.M.C.
CHECKED BY	R.B.W./G.L.B.

CONTROL BUILDING AND SLUDGE HOLDING TANKS
WASTEWATER TREATMENT PLANT IMPROVEMENTS
MOUNT VERNON, OHIO

PROJECT NUMBER	MTVS 903 B
SECTION	A
DATE	10-31-90
SHEET	7 OF 42

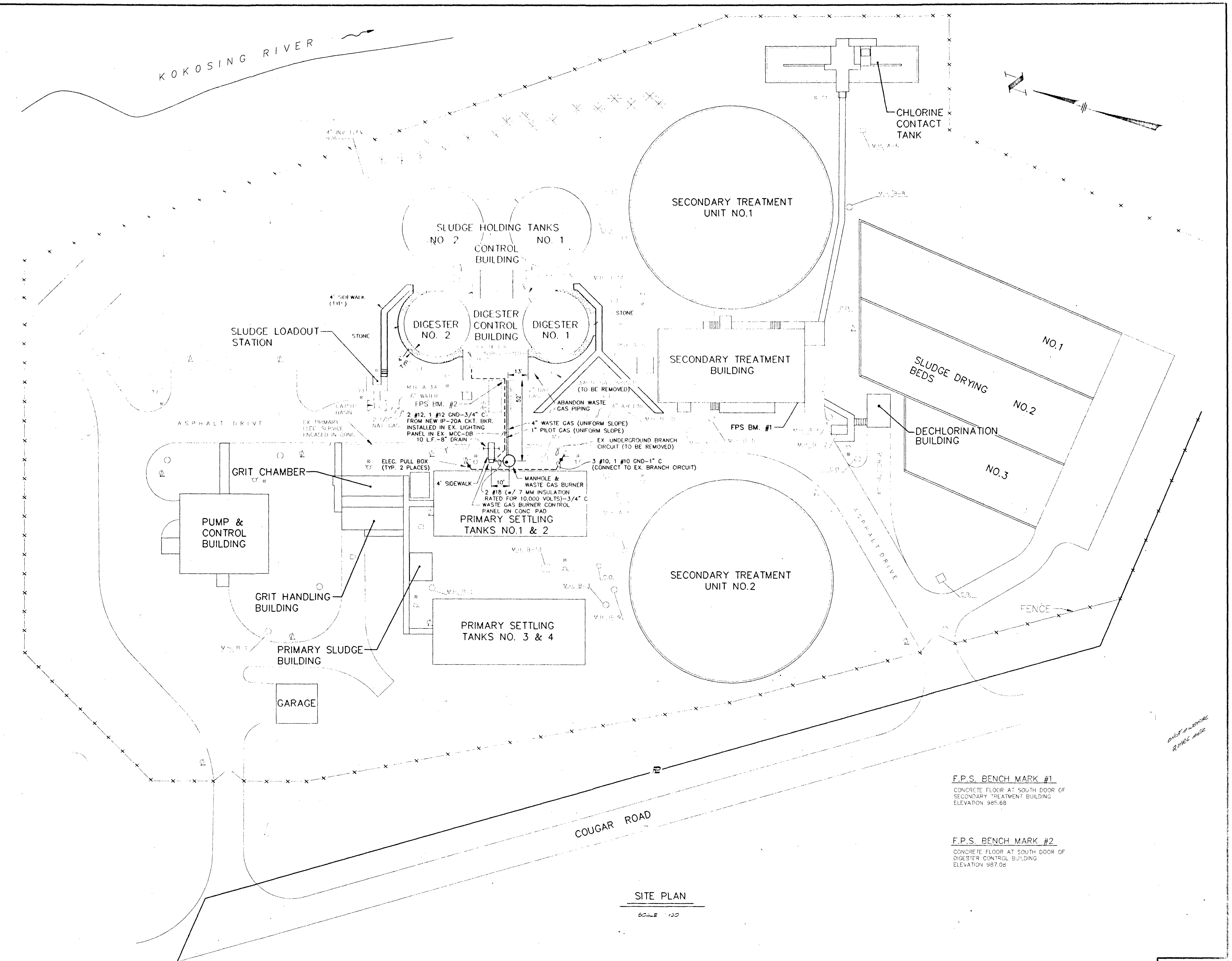
CAD:MTVS903A / 10-29-90

2176A



MANHOLE & WASTE GAS BURNER

SCALE 3/8"=1'-0"



SITE PLAN

SCALE 1"=30'

2176A

REV. NO.	DESCRIPTION	DATE	BY	APP'D

FINKBEINER, PETTIS & STROUT, LTD.
CONSULTING ENGINEERS
TOLEDO • AKRON
OHIO

SCALE: AS NOTED
DESIGNED BY: D.G.M.
DRAWN BY: RNJ/C.A.S.
CHECKED BY: RBW/G.L.B.

SITE PLAN

WASTEWATER TREATMENT PLANT IMPROVEMENTS

MOUNT VERNON, OHIO

CAD NUMBER: MTVSI01A
PROJECT NUMBER: MTVS 107 B
SECTION
DATE: 4-10-92
2 OF 7

2176A

REV. NO.	DESCRIPTION	DATE	BY	APP'D

FINKBEINER, PETTIS & STROUT, LTD.
CONSULTING ENGINEERS
TOLEDO • AKRON
OHIO

SCALE: AS NOTED
DESIGNED BY: D.G.M./D.M.S.
DRAWN BY: C.A.S.
CHECKED BY: R.B.W./G.L.B.

MODIFICATI
CONTROL BUILDING
WASTEWATER
PLANT IMPR
MOUNT VE