CITY OF ROLLA

Rolla, Missouri

Final

Preliminary Engineering Report

Southeast, Vichy Road, and Southwest Wastewater Treatment Plants, and Collection System

February 2018

HDR

Old Archer Group, P.C. dba: ARCHER-ELGIN engineering ▪ surveying ▪ architecture

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Executive Summary

A Preliminary Engineering Report was developed for the City of Rolla to address the capacity and ability to meet anticipated future regulatory requirements at the Southeast WWTP, Vichy Road WWTP, and Southwest WWTP over a 20 year planning period. A detailed capacity evaluation was completed for each WWTP. A review of influent flow and analytical data was used to establish existing flows and loadings, and detailed population, flow and loading projections for the 20 year planning period were developed. An analysis of improvements needed in order to achieve projected future capacity and regulatory requirements was completed for each WWTP. The recommended improvement alternatives have been split into two phases for each WWTP. Each phase is presented in Table I below.

Table I. Summary of Probable Project Costs for Preferred Alternatives

Vichy Road WWTP Summary(1)		Phase 1- Disinfection and Ammonia Removal (2)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
New Vichy Road 0.5 MGD WWTP	**$9,605,000**	**$7,847,000**	**$1,763,000**

(1)Alternative 1 (new Vichy Road WWTP in lieu of pumping Vichy Road flows to the Southwest WWTP)
(2)Peak flow disinfection

Southeast WWTP Summary(1)		Phase 1- Disinfection and Ammonia Removal (2)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
Add Peak Flow Disinfection, Ammonia Removal, Replace West Plant and Nutrient Removal Improvements	**$27,593,000**	**$16,949,000**	**$10,646,000**

(1)Phasing Alternative 1 (addition of a second oxidation ditch, third secondary clarifier, and expansion of existing sludge lagoon during Phase 1)
(2)Peak flow disinfection

Southwest WWTP Summary(1)		Phase 1- Disinfection (2)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
Southwest WWTP Improvements	**$3,843,000**	**$2,081,000**	**$1,763,000**

(1)Alternative 1 (Southwest WWTP flows only; no Vichy Road flows)
(2)Peak flow disinfection

The City intends to finance a Phase 1 project of $25,000,000. This Phase 1 project was outlined in order to meet the most immediate needs regarding peak flow disinfection and ammonia removal for the Southeast and Vichy Road WWTPs. The Southwest WWTP improvements are a lower priority due to the WWTPs ability to treat near term projected flows, and thus is not included in the proposed Phase 1 project. The Phase 1 project costs and proposed project schedule are summarized in the Table II and Table III, respectively.

Table II. Summary of Probable Project Costs for Initial Phase 1 Project

Item	Southeast WWTP	Vichy Road WWTP	Total Cost
Phase 1	**$16,949,000**	**$7,847,000**	**$24,796,000**

Table III. Southeast and Vichy Road WWTP Phase 1 Proposed Project Schedule

Item	Date
Begin Vichy Road Site Selection	September 2017
SRF Application	November 2017
Begin Facility Plan and Design	March 2018
Bond Election	November 2018
Design Complete	March 2019
MDNR Approval	June 2019
Advertise Bids	June 2019
Open Bids	July 2019
Notice to Proceed	September 2019
Complete Vichy Road WWTP(1)	June 2021
Complete Southeast WWTP(1)	September 2021

(1)Beyond compliance date of May 2021. Extension to be negotiated.

1 Introduction

1.1 Background

The City of Rolla is located in Phelps County in central Missouri. The City had a population of 20,019 in the 2016 US Census Bureau estimates. The Missouri University of Science and Technology (formerly known as the University of Missouri-Rolla) is located in Rolla and had an enrollment of 7,941 in 2016. The City's wastewater is treated at three wastewater treatment plants (WWTPs): the Southeast WWTP, Vichy Road WWTP, and the Southwest WWTP. These WWTPs are owned and operated by the City, and are shown in Figure 1-1.

The Southeast WWTP consists of two facilities that will be referred to in this report as the West Plant and the East Plant. The West Plant was developed in a number of discrete phases beginning in the mid-1950s. The facility consists of preliminary, primary, and secondary treatment with anaerobic digestion of sludge. The West Plant process train has had numerous modifications since the original construction. The East Plant was originally constructed in 2000-2001 and consisted of preliminary and secondary treatment. In 2012, ultraviolet disinfection was added to accommodate new disinfection requirements and additional improvements were made to consolidate West and East Plant flows. The Southeast WWTP has a permitted capacity of 4.765 MGD.

Prior to 1970, the Vichy Road WWTP consisted of an activated sludge facility. In 1970, primary treatment was added, and between 1970 and 1996, a stormwater clarifier was added. In 1996, improvements were made to include new influent screening, a nitrifying trickling filter and secondary clarifier. The Vichy Road WWTP has a permitted capacity of 0.40 MGD.

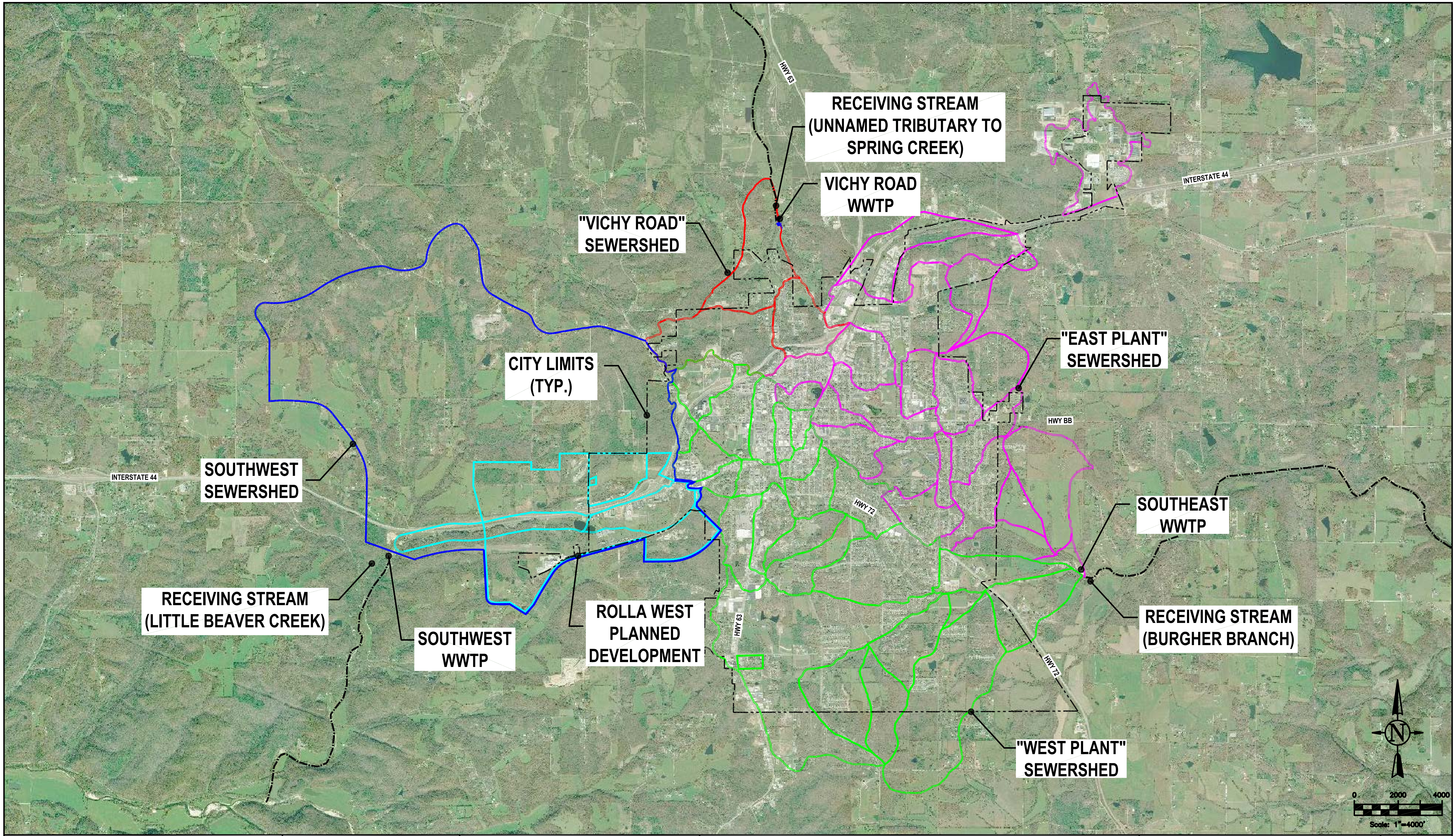
The Southwest WWTP was constructed in 2007 and consists of preliminary treatment, secondary treatment, and disinfection. Space was provided on the site to expand the secondary treatment to accommodate future growth. The Southwest WWTP has a permitted capacity of 1 MGD.

1.2 Purpose

The purpose of this report is to address the capacity and ability to meet anticipated future regulatory requirements at the Southeast WWTP, Vichy Road WWTP, and Southwest WWTP over a 20 year planning period. This is a conceptual level report which shall specifically provide the following for each WWTP:

- A capacity evaluation of individual unit processes, and summary of the existing layout, process flow diagram, and hydraulic profile.
- A review of influent flow and analytical data to establish the existing flows and loadings.
- Detailed population, flow, and load projections for the 20 year planning period.
- A review of existing effluent limits and projection of future effluent limits.

- An analysis of improvements to achieve projected future capacity and regulatory requirements.
- A development of opinions of probable costs associated with each improvement.
- A recommendation of the selected improvements and scheduling for each WWTP.



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City of ROLLA

CITY OF ROLLA, MO ROLLA WASTEWATER TREATMENT PLANT PER	PROJECT NO. 154630
ROLLA WWTP LOCATIONS	DRAWING NO. 1-1

2 Existing Facilities

The following subsections give an overview of each WWTP's unit processes and respective capacities. A detailed capacity evaluation for each WWTP is included in Appendix A.

2.1 Southeast WWTP

The Southeast WWTP is located in the southeast part of the City, approximately two-thirds of a mile east of Highway 72, and is the largest of the City's WWTPs. The permitted capacity of the Southeast WWTP is 4.765 MGD. The existing layout and process flow diagram are shown in Figures 2-1 and 2-2, respectively. The dry weather and wet weather hydraulic profiles are shown in Figures 2-3, 2-4, and 2-5. The Southeast WWTP consists of two facilities, referred to in this report as the West Plant and the East Plant. Dry weather flows from each plant combine and discharge at Outfall No. 001, to Burgher Branch Creek. Dry weather flows can be transferred between the West and East Plants at the direction of City personnel to optimize the facilities' treatment capabilities. Flow is transferred from the West to the East Plant by gravity, and can be pumped from the East to the West Plant via forcemain. The West and East Plant treatment trains each include a peak flow clarifier (Outfall No. 002 and 003, respectively) which currently receive and discharge wet weather flows greater than the treatment capacities of the plants. Outfall No. 002 discharges to Dutro Carter Creek while Outfall No. 003 discharges to Burger Branch Creek.

A detailed capacity evaluation is included in Appendix A.

2.1.1 West Plant

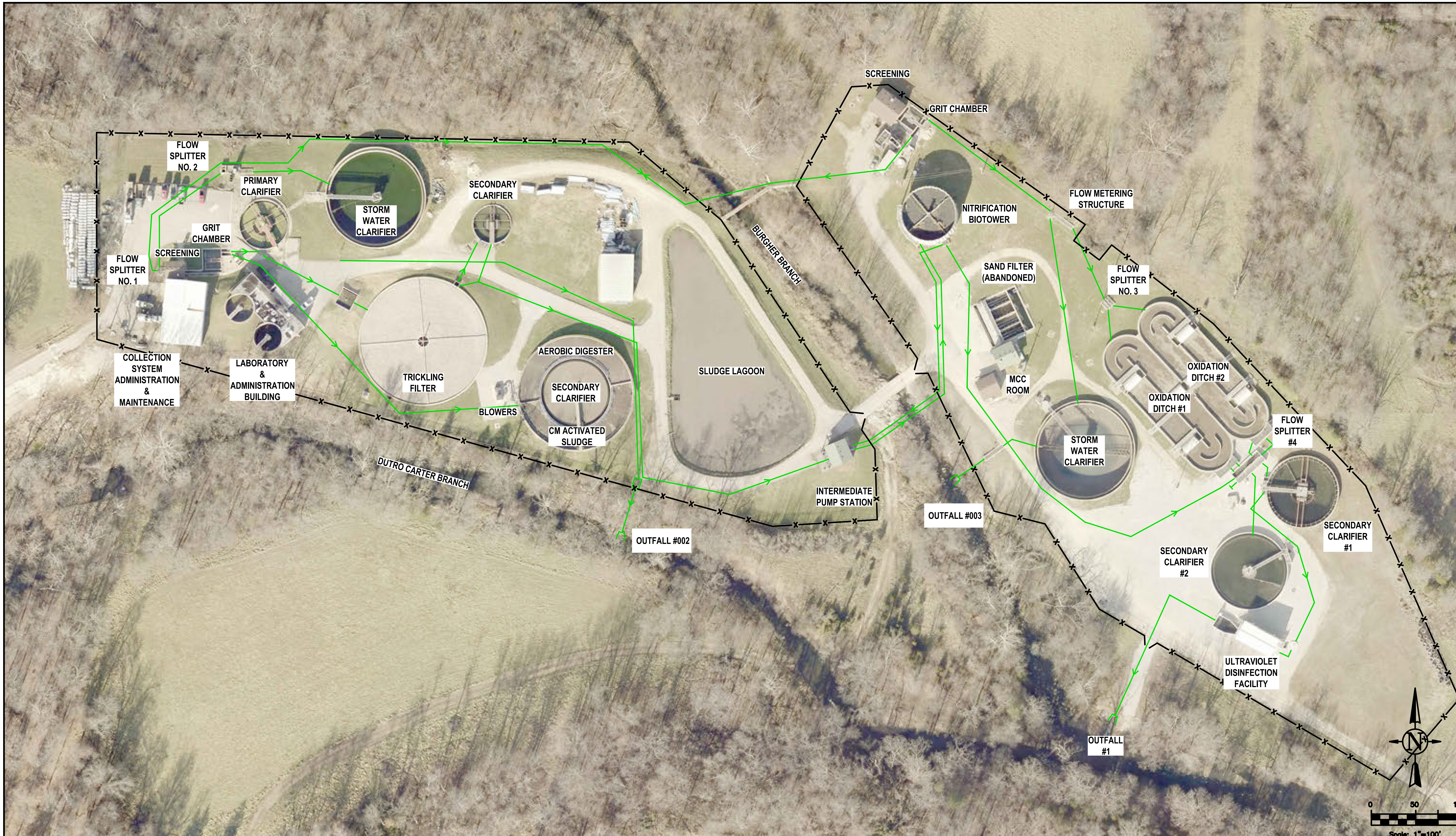
The West Plant headworks consists of a mechanical fine screen and grit chamber. Flow from the headworks is typically split to an activated sludge treatment unit (Walker Process Unit) which includes an aerobic tank, aerobic digester and secondary clarifier. Flow can also be split from the headworks to a parallel treatment train which includes a primary clarifier, trickling filter, and secondary clarifier. Flow from either treatment train is pumped to the East Plant where it is combined with East Plant mixed liquor immediately downstream of the oxidation ditches. Wet weather flow is split prior to the West Plant headworks, and flows through a wet weather screening and measurement structure followed by a peak flow clarifier before discharging to Outfall No. 002. The nitrification biotower and sand filters are no longer in use.

A sludge lagoon, located on the West Plant, is utilized to store biosolids prior to land application.

2.1.2 East Plant

The East Plant headworks consists of a mechanical fine screen and grit chamber. Flow travels from the headworks to a flow measurement and diversion structure. Dry weather flow then travels to Oxidation Ditch No. 1 and 2, Secondary Clarifier No. 1 and 2, and ultraviolet disinfection before discharging through Outfall No. 001. A RAS pump station is utilized at the WWTP.

Wet weather flow is split from the flow measurement and diversion structure to a peak flow clarifier before discharging to Outfall No. 003.



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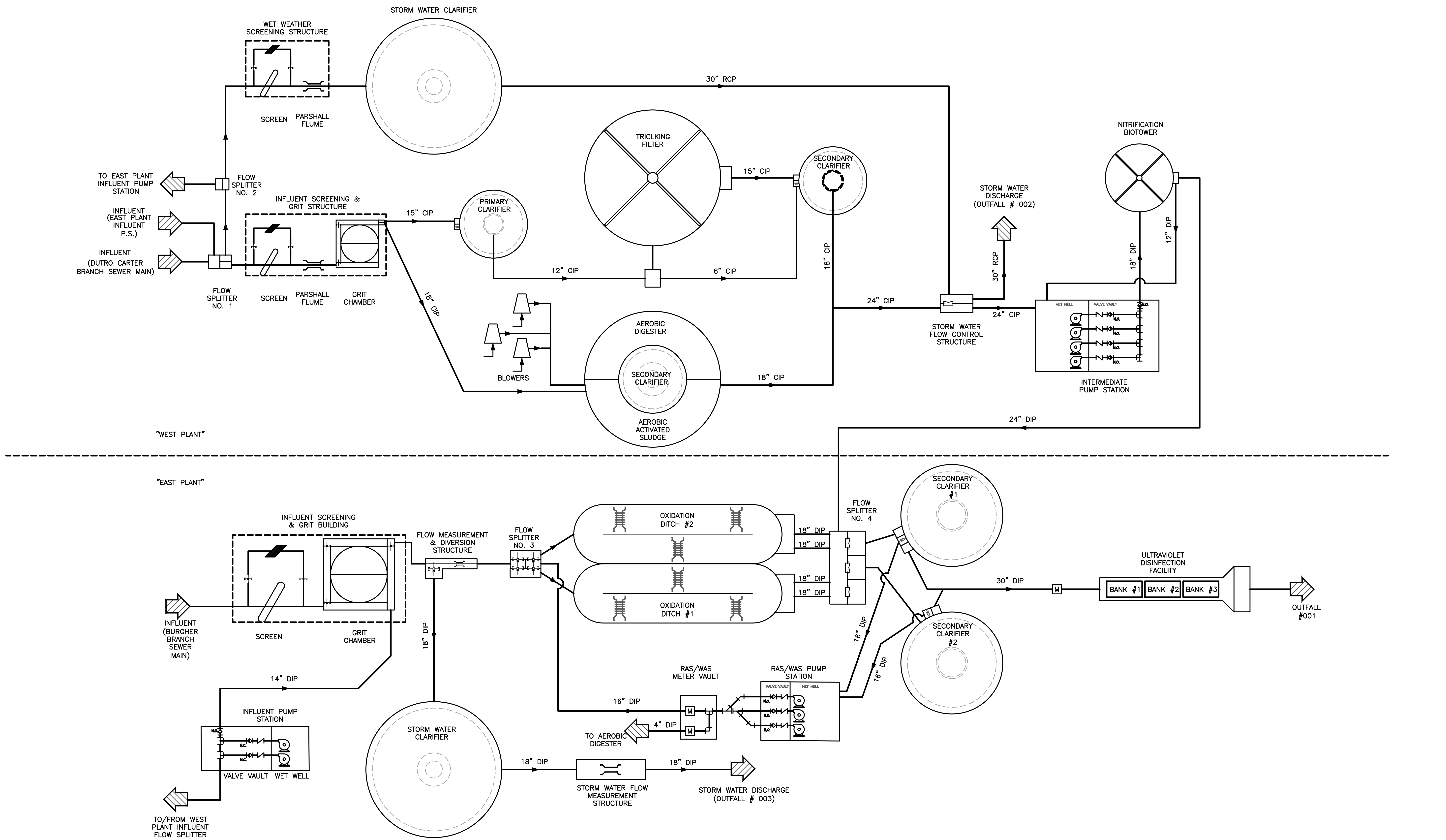
ROLLA WASTEWATER TREATMENT PLANT PER

EXISTING SOUTHEAST WWTP LAYOUT

PROJECT NO. 154630

DRAWING NO. 2-1



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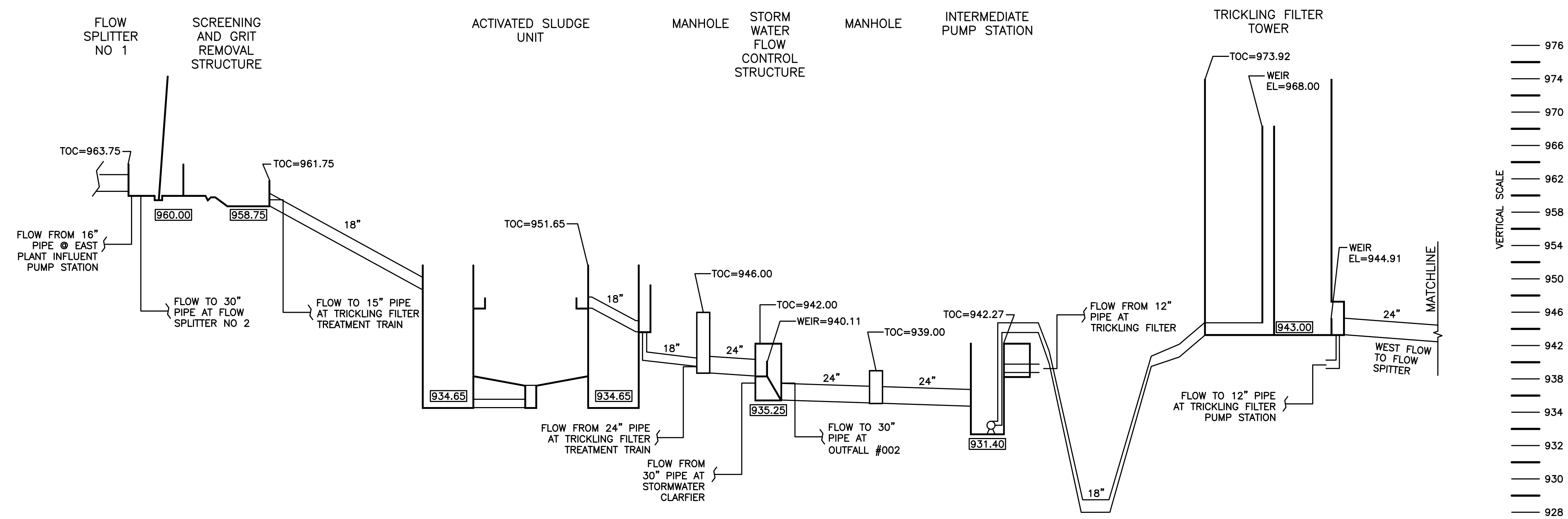
ROLLA WASTEWATER TREATMENT PLANT PER

EXISTING SOUTHEAST WWTP PROCESS FLOW DIAGRAM

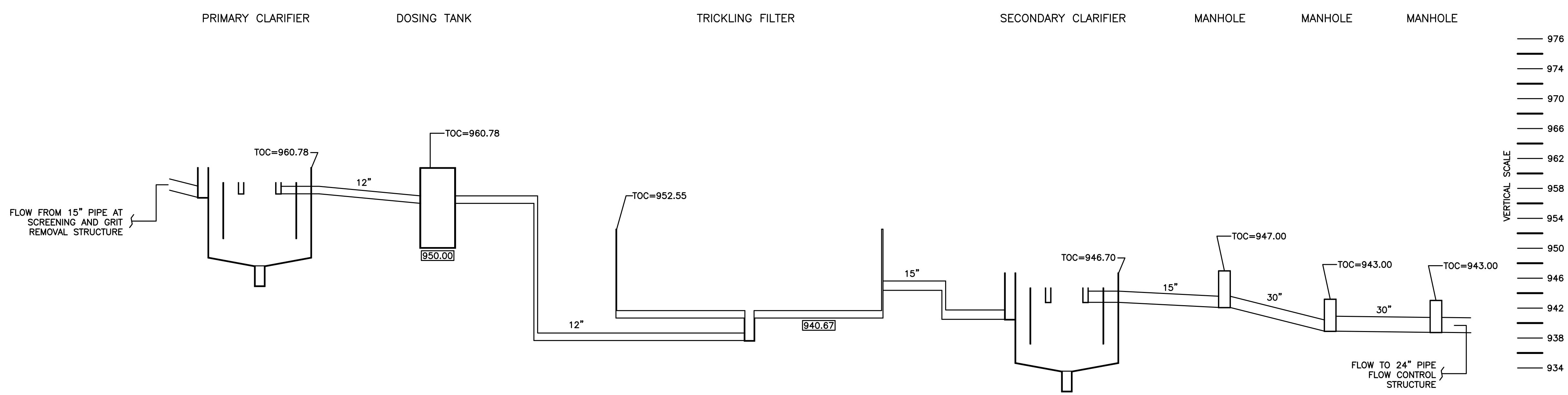
PROJECT NO. 154630

DRAWING NO. 2-2

WEST PLANT – ACTIVATED SLUDGE UNIT



WEST PLANT – TRICKLING FILTER



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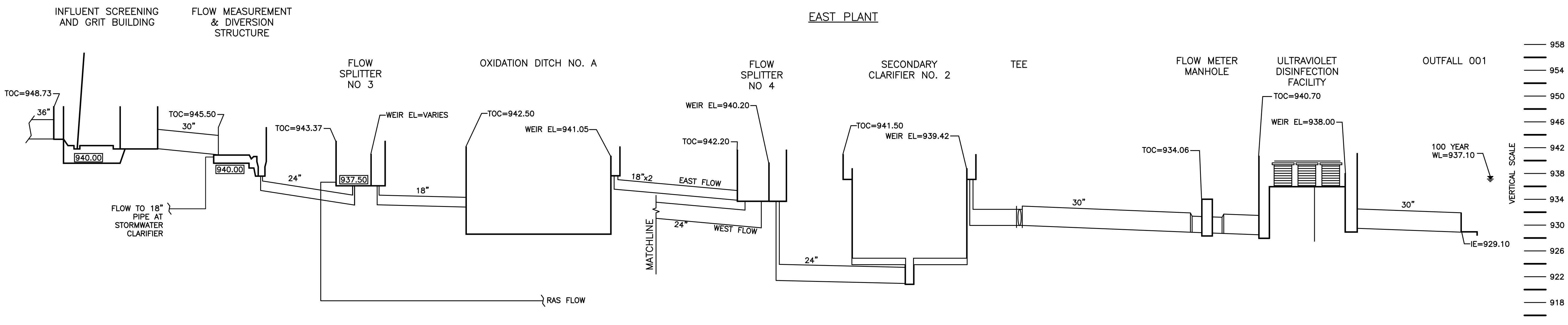
ROLLA WASTEWATER TREATMENT PLANT PER

EXISTING SOUTHEAST WWTP WEST PLANT DRY WEATHER HYDRAULIC PROFILE

PROJECT NO. 154630

DRAWING NO. 2-3



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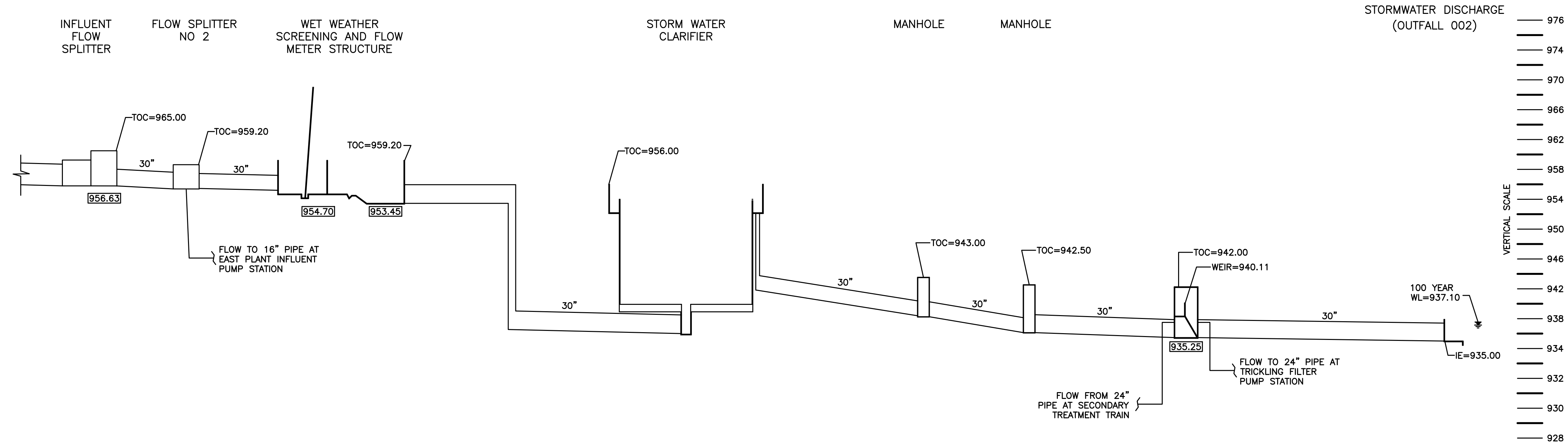
ROLLA WASTEWATER TREATMENT PLANT PER

EXISTING SOUTHEAST WWTP
EAST PLANT DRY WEATHER
HYDRAULIC PROFILE

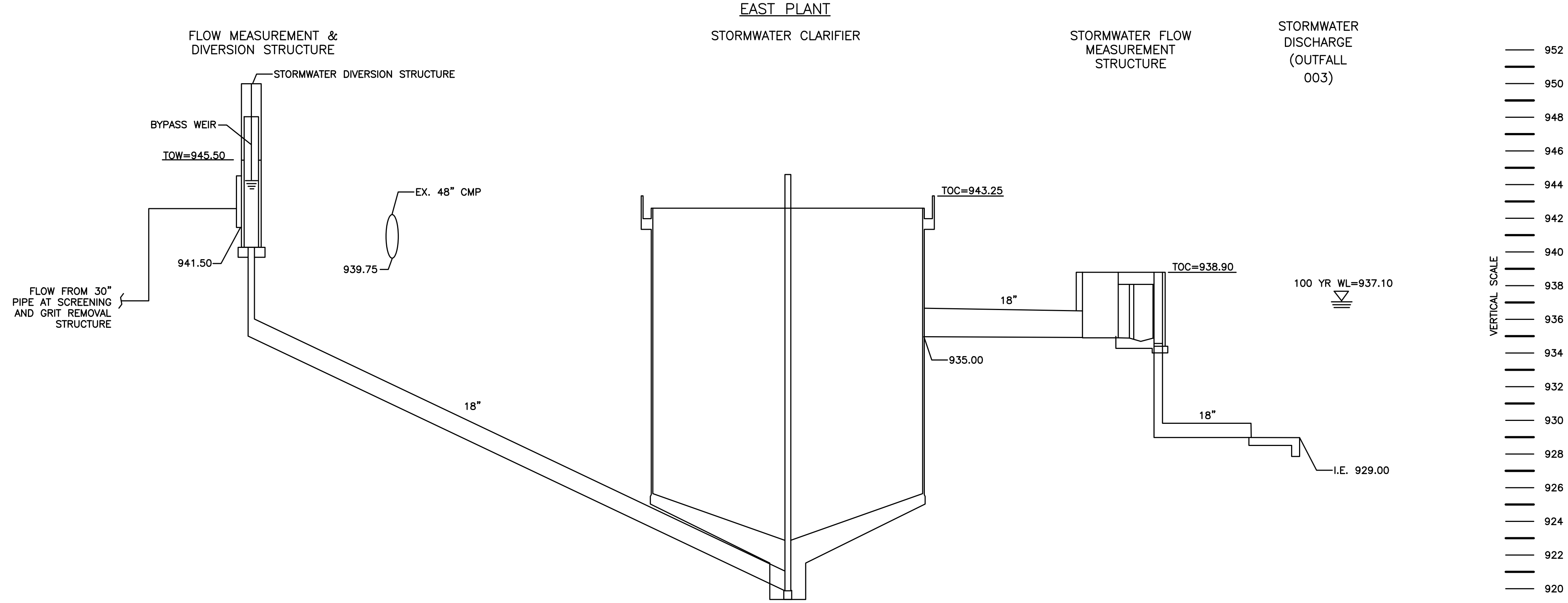
PROJECT NO. 154630

DRAWING NO. 2-4

WEST PLANT



EAST PLANT



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EXISTING SOUTHEAST WWTP
WET WEATHER HYDRAULIC PROFILE
HYDRAULIC PROFILE

PROJECT NO. 154630

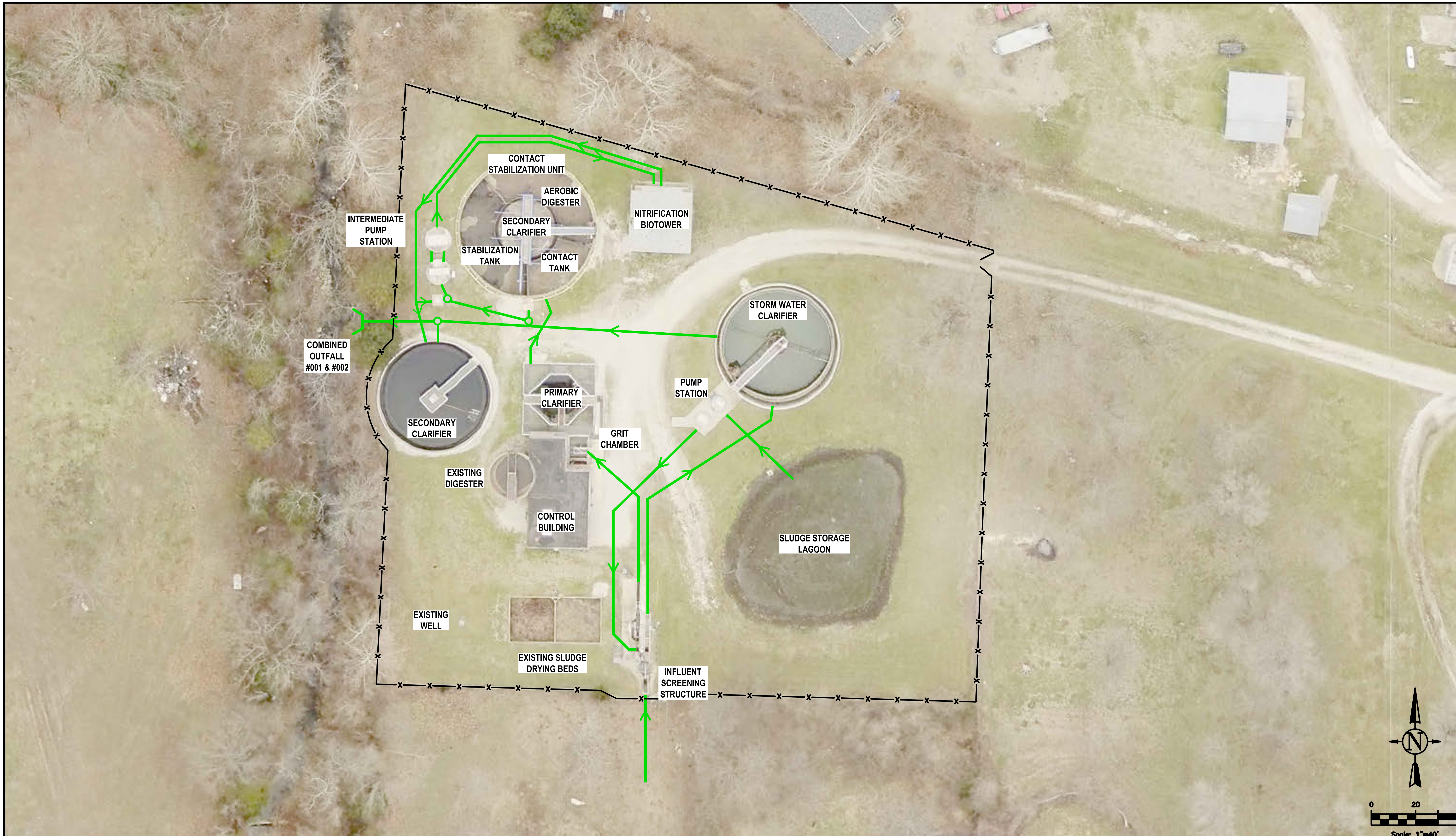
DRAWING NO. 2-5

2.2 Vichy Road WWTP

The Vichy Road WWTP is located in the northwest part of the City, approximately 500 feet west of Vienna Road. The permitted capacity of the Vichy Road WWTP is 0.40 MGD. The existing layout, process flow diagram, and hydraulic profile are shown in Figures 2-6, 2-7, and 2-8, respectively. Flow at the Vichy Road WWTP passes through a screening channel and grit chamber, and then to a primary clarifier. From there it enters the activated sludge treatment unit, and then is pumped to the trickling filter tower before flowing to the final clarifier. After the final clarifier, flow travels to a junction manhole, combining with flow from the peak flow clarifier during wet weather periods. A sludge lagoon is utilized to store biosolids prior to land application.

Wet weather flows greater than the treatment capacity of the plant are split to a peak flow clarifier. During wet weather periods, the flow from the peak flow clarifier is combined with the dry weather flow treated at the plant and discharged together at the combined outfall pipe located at Outfall 001 to an unnamed tributary of Spring Creek. Although there is a single physical outfall pipe, the dry weather and wet weather flows are treated as two separate outfalls in the permit. Flow from the peak flow clarifier is monitored and recorded separately from the dry weather plant, and is listed in the permit as Outfall 002.

A detailed capacity evaluation is included in Appendix A.



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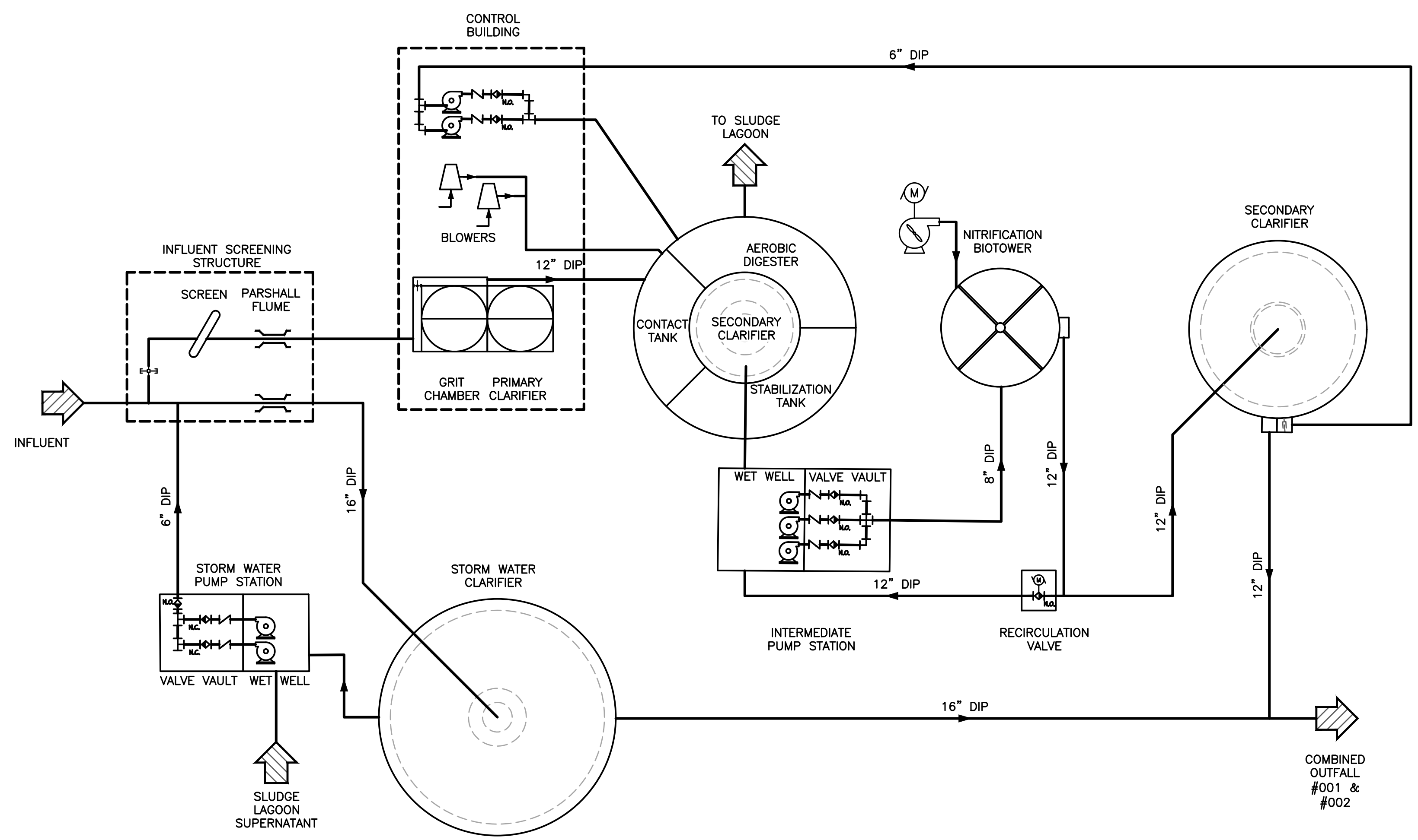
ROLLA WASTEWATER
TREATMENT PLANT PER

EXISTING VICHY ROAD WWTP
LAYOUT

PROJECT NO. 154630

DRAWING NO. 2-6



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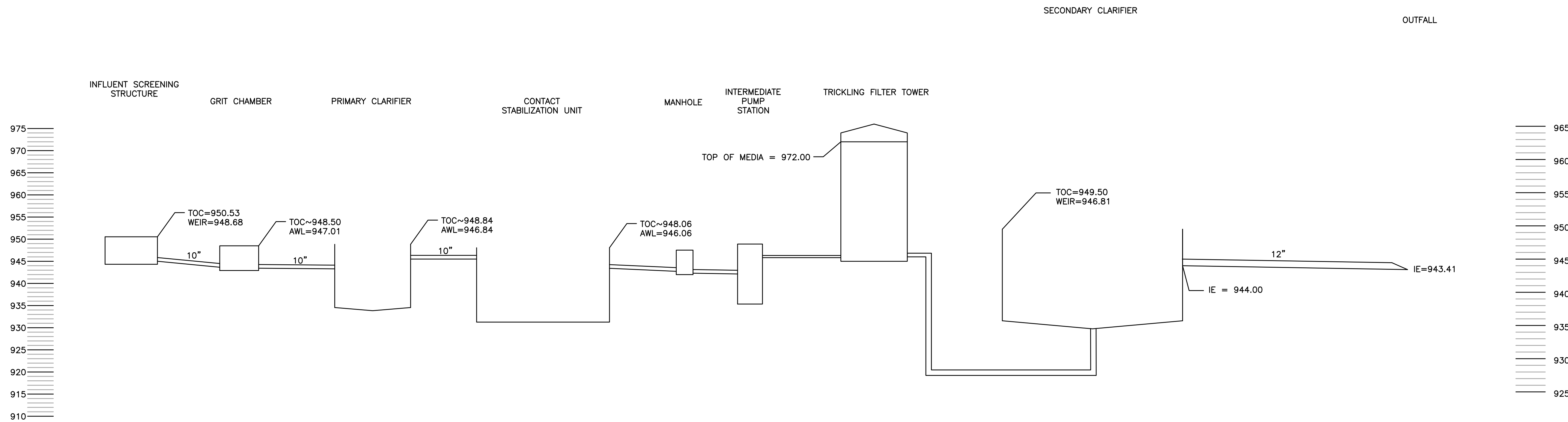
EXISTING VICHY ROAD WWTP
PROCESS FLOW DIAGRAM

PROJECT NO. 154630

DRAWING NO. 2-7



* OBSERVED. FLOOD RATE MAP DOES NOT EXIST FOR THIS AREA.

TOC = TOP OF CONCRETE
IE = INVERT ELEVATION

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ROLLA WASTEWATER
TREATMENT PLANT PER

EXISTING VICHY ROAD WWTP
HYDRAULIC PROFILE

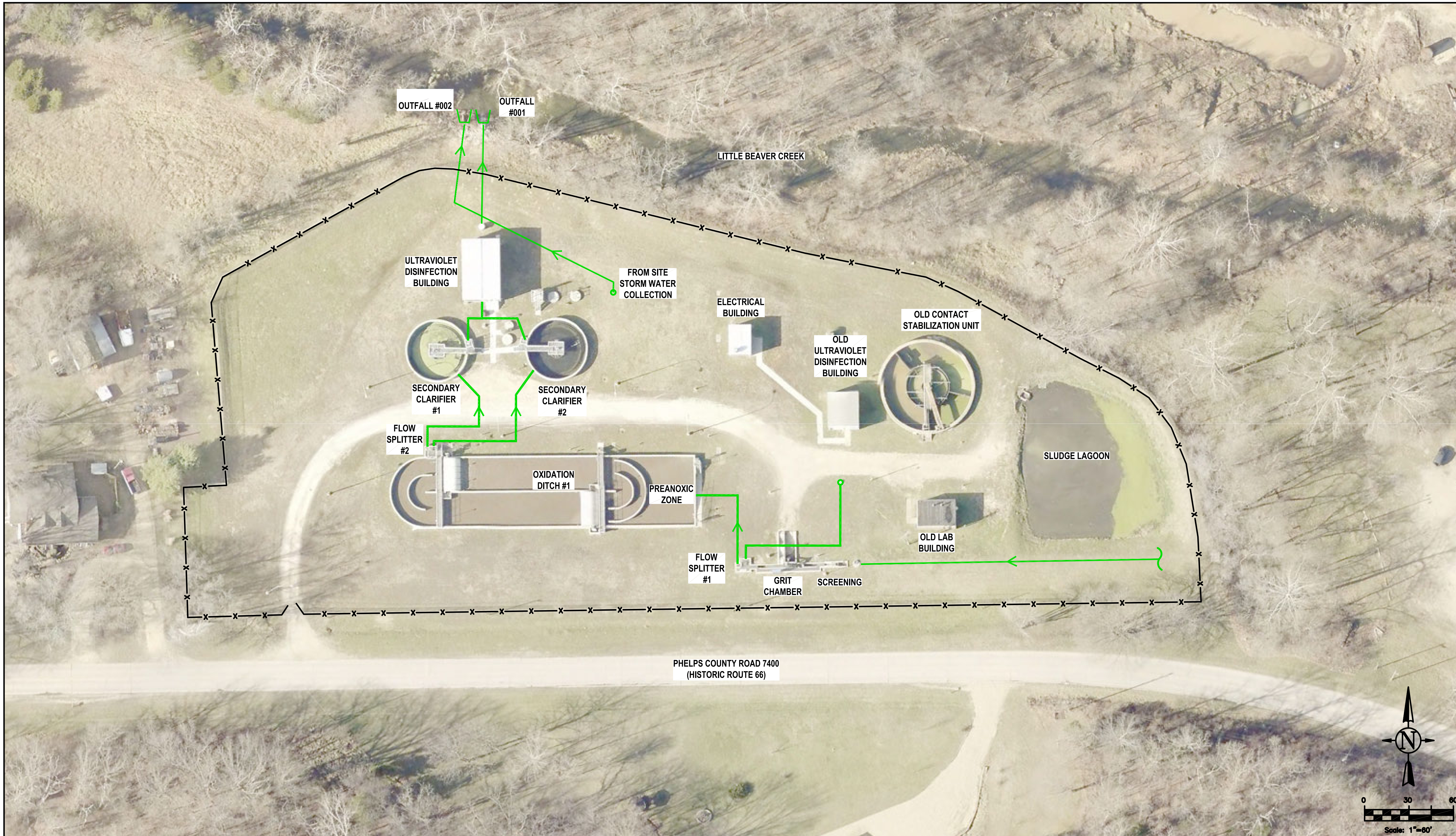
PROJECT NO. 154630

DRAWING NO. 2-8

2.3 Southwest WWTP

The Southwest WWTP is located in the southwest part of the City, approximately 800 feet south of Highway 44. The permitted capacity of the Southwest WWTP is 1.0 MGD. The existing layout, process flow diagram, and hydraulic profile are shown in Figures 2-9, 2-10, and 2-11, respectively. Flow at the Southwest WWTP travels through a mechanical fine screen and grit chamber followed by an anoxic zone in the oxidation ditch. After the oxidation ditch, flow enters two secondary clarifiers and ultraviolet disinfection before discharging through Outfall 001 to Little Beaver Creek. Wet weather flows are currently processed through the WWTP as no peak flow treatment has been constructed at the WWTP. A RAS pump station and scum pump station are utilized at the WWTP. The contact stabilization tank is no longer in use. A sludge lagoon is utilized to store biosolids prior to land application.

A detailed capacity evaluation is included in Appendix A.



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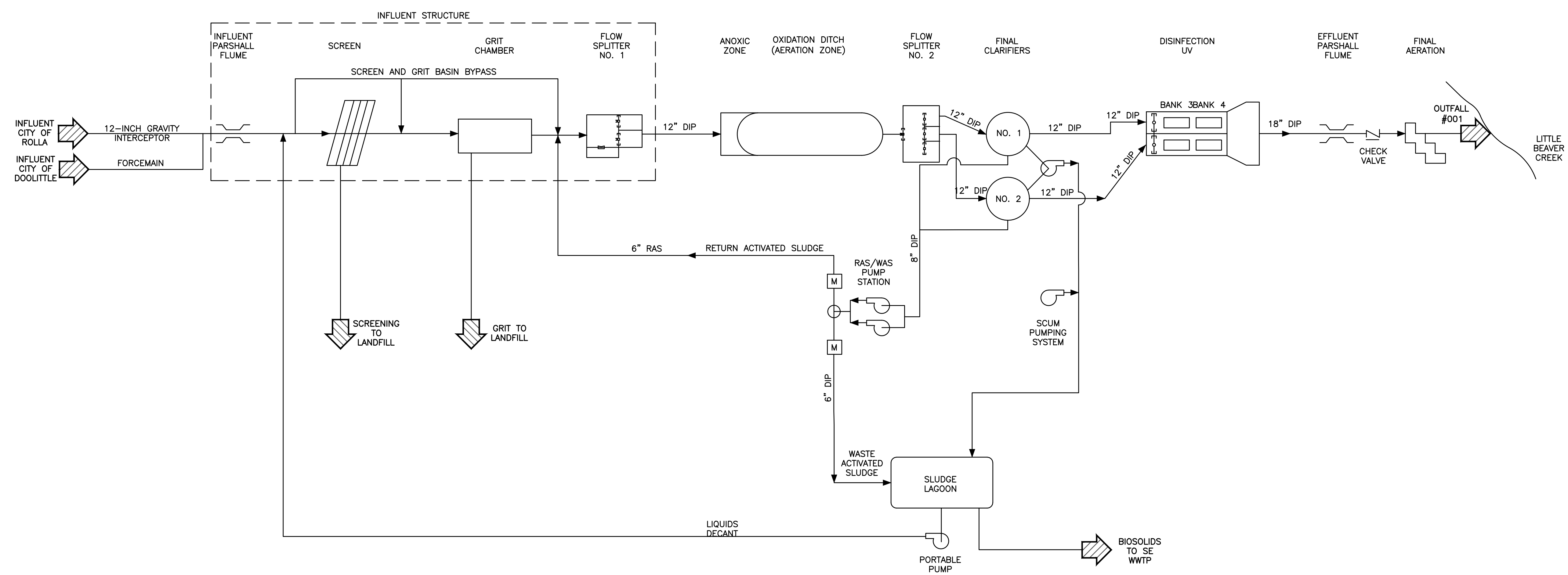
TREATMENT PLANT PER

PROJECT NO.
154630

EXISTING SOUTHWEST WWTP
LAYOUT

DRAWING NO.
2-9



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CM Archer Group, P.C. dba:
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engineering ■ surveying ■ architecture
Corporate Authority:
CM Archer Group, P.C.: E: 2003023612-D, LS: 2004017577-D, A-2016017179
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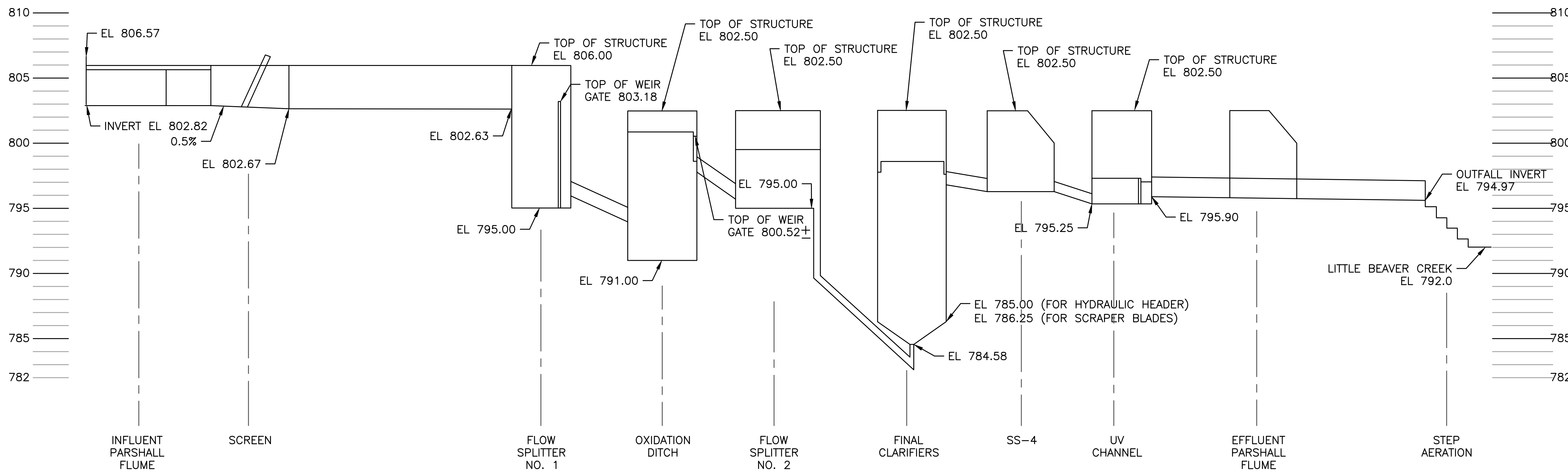
City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER TREATMENT PLANT PER

EXISTING SOUTHWEST WWTP
PROCESS FLOW DIAGRAM

PROJECT NO. 154630

DRAWING NO. 2-10



EXISTING HYDRAULIC PROFILE

DRAWING FILE NAME: 11129910 – Rolla Wastewater System		PROJECT NO.: 11129910	
DATE LAST SAVED: 9–18–17	PLOT SCALE: 1:1	DATE/TIME PLOTTED: 9–18–17	
FILES ATTACHED:	DESIGNED BY: CD/KAC	DRAWN BY: CgL	CHECKED BY: CD/KAC
ATTACHED FILE NAMES:			

HDR ENGINEERING, INC.
MO. STATE CERTIFICATE
OF AUTHORITY #000856
3741 NE TROON DRIVE
LEE'S SUMMIT, MO. 64064

CM Archer Group, P.C. dba:

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City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER
TREATMENT PLANT PER

EXISTING SOUTHWEST WWTP
HYDRAULIC PROFILE

PROJECT NO. 154630

DRAWING NO. 2-11

2.4 Sanitary Sewer Collection System

The City's collection system is divided into three discrete sewersheds which drain to their respective WWTPs, as shown previously in Figure 1-1. The Southeast WWTP sewershed has an area of 7,267 acres and covers the majority of the area currently developed within the city limits. This area includes the downtown commercial district, industrial areas located in the northern extent of the City, and the Missouri University of Science and Technology. Burger Branch Creek is the receiving stream of the sewershed. The time of concentration for the watershed is approximately four hours as determined in the Bypass Elimination Plan. Gravity pipe within the collection system ranges from 6 inches to 42 inches, and collection system materials include vitrified clay pipe (VCP), lined VCP, polyvinyl chloride (PVC) pipe, reinforced concrete pipe, and others (ductile iron pipe, truss pipe, etc.). The collection system consists of approximately 20,780 feet of forcemain and 624,872 feet of gravity sewer.

The Vichy Road WWTP sewershed is located in the northern extent of the city limits, due west of the intersection of US Highway 63 and Interstate 44. The sewershed has an area of 747 acres and serves predominantly residential developments. The receiving stream of the sewershed is an unnamed tributary of Spring Creek. The time of concentration for the sewershed is approximately 2.5 hours. Gravity pipe within the collection system ranges from 6 inches to 21 inches, and collection system materials include VCP, lined VCP, and PVC pipe. The collection system consists of approximately 46,270 feet of gravity sewer.

The Southwest WWTP sewershed is located in the southwestern extent of the City. Much of the sewershed is currently undeveloped; however extensive growth associated with the proposed Rolla West development is anticipated within the project planning period. The projected area of the sewershed is 4,227 acres. The receiving stream of the sewershed is Little Beaver Creek. Gravity pipe within the collection system ranges from 8 inches to 15 inches, and collection system materials predominantly include VCP and PVC pipe. The collection system consists of approximately 5,610 feet of forcemain and 33,480 feet of gravity sewer.

A detailed collection system summary is presented in Appendix B.

3 Population, Flow, and Load Projections

For the purposes of this planning effort, a design period of 20 years is employed resulting in a design year of 2037. Project populations are used to subsequently estimate future average and peak daily flows as well as pollutant loads to the WWTP. These projections are then used to help establish new design criteria or confirm existing design criteria for plant upgrades. A detailed population, flow and load analysis is presented in Appendix C.

3.1 Population Projections

United States Census Bureau historical data was used to project the City's population over the 20 year planning period shown in Table 3-1. The average annual percentage increase in the City's population over the planning period is 1.57%. This average annual percentage increase is comparable to historic population growth trends in both the City of Rolla and Phelps County, Missouri.

Table 3-1. Population Projection for City of Rolla During Project Planning Period

Year	Population
2016[1]	20,019
2027	24,246
2037	28,724

(1) US Census Bureau.

It should be noted that the Missouri University of Science and Technology main campus is located within the City limits and had a total student population of 7,941 in 2016. This student population is not likely accounted for in the census population counts and is not accounted for in Table 3-1. An annual growth rate of two percent will be assumed for the student population.

3.1.1 Southeast and Vichy Road WWTPs

For both the Southeast and Vichy Road WWTPs it was assumed that the population would increase 1.57% annually (2% annually for Missouri S&T) and would be directly proportional to the relative area of the sewershed contributing to flows at each respective WWTP. Table 3-2 details the relative area for each sewershed and population projections during the project planning period.

Table 3-2. Southeast and Vichy Road Population Projections During Project Planning Period

Year	Relative Sewershed Area		Census Population Count		Missouri S&T Student Population	
	SE WWTP	**Vichy WWTP**	**SE WWTP**	**Vichy WWTP**	**SE WWTP**	**Vichy WWTP**
2016	91%	9%	18,197	1,822	7,226	715
2027			22,040	2,206	8,808	872
2037			26,110	2,614	10,738	1,063

3.1.2 Southwest WWTP

The Southwest WWTP serves a small number of Rolla residences, the Town of Doolittle, one significant industrial user and numerous commercial and business facilities. The residential population for the users from Rolla and Doolittle were projected to increase at a rate of 1.57% annually over the 20 year planning period. Review of the current development and master planning for the Rolla West Development was conducted in an effort to estimate the current and future population associated with commercial and industrial developments within the sewershed. It was assumed that:

- 70 percent of the total land area would be available for development over the 20 year planning period.
- By 2027, half of the developable land will be fully developed.
- By 2037, all of the developable land will be fully developed.

Population equivalents were utilized to quantify the impacts of the projected development within the sewershed. Population projections for the Southwest WWTP sewershed are shown in Table 3-3.

Table 3-3. Southwest Population Projection During Project Planning Period

Year	Rolla Contribution		Doolittle Contribution	Total
	Residential	**Population Equivalent**		
2016	663	1,575	436	2,674
2027	774	2,558	509	3,841
2037	905	3,225	595	4,725

3.2 Flow and Loading Projections

Influent flow and analytical data was reviewed and analyzed to determine the existing flows and loadings for the Southeast, Vichy Road and Southwest WWTPs as shown in Appendix D. The population projections were used to project the 2027 and 2037 average daily flow and mass loadings, assuming that the calculated 2016 per capita flow and loading would remain constant during the planning period. The historically observed peaking factors were applied to the projected values to obtain the appropriate design criteria (maximum month, maximum day, etc.).

It should be noted that influent ammonia, total kjeldahl nitrogen, and total phosphorus data was only available for February and March 2017.

3.2.1 Southeast WWTP Flow and Loading Projections

Based on influent flow data, the Southeast WWTP average daily flow is 2.85 MGD. Influent wastewater flows are split between the West Plant and the East Plant. Currently, flows received by each plant cannot be measured separately thus they were scaled based on the plant sewershed area in relation to the total. It was estimated that the flow split is approximately 1.55 MGD to the West Plant and approximately 1.30 MGD to the East Plant though, based on operator knowledge, the flow split widely varies but typically a greater percentage flows to the East Plant.

The flow corresponded to a per capita wastewater production of 112 gpd based on the aggregate census and Missouri S&T population. The average daily BOD, TSS, ammonia, TKN, and TP mass loadings were determined to be 2,821 pounds per day (lb/d), 2,787 lb/d, 389 lb/d, 778 lb/d, and 88 lb/d, respectively. These mass loadings corresponded with per capita mass loads of 0.11 pound per capita per day (ppcd), 0.11 ppcd, 0.02 ppcd, 0.03 ppcd, and 0.003 ppcd, respectively. A summary of the flow and loading data is presented in Table 3-4.

Table 3-4. Flow and Loading Projections for the Southeast WWTP

	Average Day	Max Month Average Day	Max Day	Peak Hour Flow
2017				
Flow:	2.85	7.58	21.0	41.8
Flow (East Plant):	1.30	3.45	9.6	19.0
Flow (West Plant):	1.55	4.12	11.4	22.8
BOD (mg/L):	118.7	196.3	198.5	
BOD (lb/d):	2,821	4,665	4,717	
TSS (mg/L):	117.3	173.1	199.4	
TSS (lb/d):	2,787	4,114	4,738	
NH3-N (mg/L):	16.4	*	28.9	
NH3-N (lb/d):	389.4	*	687.9	
TKN (mg/L):	32.7	*	57.9	
TKN (lb/d):	778	*	1,376	
TP (mg/L):	3.69	*	6.41	
TP (lb/d):	87.7	*	152.3	
2027 Projection				
Flow:	3.46	9.20	25.5	41.8
Flow (East Plant):	1.58	4.20	11.6	19.0
Flow (West Plant):	1.88	5.00	13.9	22.8
BOD (mg/L):	118.7	196.3	198.5	
BOD (lb/d):	3,424	5,662	5,725	
TSS (mg/L):	117.3	173.1	199.4	
TSS (lb/d):	3,383	4,994	5,751	
NH3-N (mg/L):	16.4	*	28.9	
NH3-N (lb/d):	473	*	835.1	
TKN (mg/L):	32.7	*	57.9	
TKN (lb/d):	944	*	1,670	
TP (mg/L):	3.69	*	6.41	
TP (lb/d):	106.3	*	184.6	
2037 Projection				
Flow:	4.13	11.0	30.4	41.8
Flow (East Plant):	1.89	5.01	13.8	19.0
Flow (West Plant):	2.25	5.99	16.6	22.8
BOD (mg/L):	118.7	196.3	198.5	
BOD (lb/d):	4,089	6,762	6,838	
TSS (mg/L):	117.3	173.1	199.4	
TSS (lb/d):	4,040	5,964	6,868	
NH3-N (mg/L):	16.4	*	28.9	
NH3-N (lb/d):	564.9	*	996.8	
TKN (mg/L):	32.7	*	57.9	
TKN (lb/d):	1,128	*	1,995	
TP (mg/L):	3.69	*	6.41	
TP (lb/d):	126.9	*	220.1	

*Influent ammonia, total kjeldahl nitrogen, and total phosphorus data was only available for February and March 2017.

3.2.2 Vichy Road WWTP Flow and Loading Projections

Based on influent flow data, the Vichy Road WWTP average daily flow is 0.311 MGD. The flow corresponded to a per capita wastewater production of 123 gpd based on the aggregate census and Missouri S&T population. The average daily BOD, TSS, ammonia, TKN, and TP mass loadings were determined to be 415 lb/d, 294 lb/d, 44 lb/d, 99 lb/d, and 13 lb/d, respectively. These mass loadings corresponded with per capita mass loads of 0.16 ppcd, 0.12 ppcd, 0.02 ppcd, 0.04 ppcd, and 0.005 ppcd, respectively. A summary of the flow and loading data is presented in Table 3-5.

Table 3-5. Flow and Loading Projections for the Vichy Road WWTP

	Average Day	Max Month Average Day	Max Day	Peak Hour Flow
2017				
Flow:	0.311	0.567	1.50	3.62
BOD (mg/L):	160	292	540	
BOD (lb/d):	415	758	1,400	
TSS (mg/L):	113	440	1,427	
TSS (lb/d):	294	1,142	3,700	
NH3-N (mg/L):	16.9	*	32.2	
NH3-N (lb/d):	43.8	*	83.6	
TKN (mg/L):	38.0	*	72.6	
TKN (lb/d):	98.6	*	188	
TP (mg/L):	4.90	*	9.09	
TP (lb/d):	12.7	*	23.6	
2027 Projection				
Flow:	0.377	0.687	1.82	3.62
BOD (mg/L):	160	292	540	
BOD (lb/d):	504	921	1,700	
TSS (mg/L):	113	440	1,427	
TSS (lb/d):	358	1,391	4,505	
NH3-N (mg/L):	16.9	*	32.2	
NH3-N (lb/d):	53.1	*	101	
TKN (mg/L):	38.0	*	72.6	
TKN (lb/d):	120	*	228	
TP (mg/L):	4.90	*	9.09	
TP (lb/d):	15.4	*	28.7	
2037 Projection				
Flow:	0.451	0.822	2.18	3.62
BOD (mg/L):	160.0	292.2	539.8	
BOD (lb/d):	602	1,100	2,030	
TSS (mg/L):	113.3	440.3	1,427	
TSS (lb/d):	428	1,663	5,386	
NH3-N (mg/L):	16.9	*	32.2	
NH3-N (lb/d):	63.6	*	121	
TKN (mg/L):	38.0	*	72.6	
TKN (lb/d):	143	*	273	
TP (mg/L):	4.90	*	9.09	
TP (lb/d):	18.4	*	34.2	

*Influent ammonia, total kjeldahl nitrogen, and total phosphorus data was only available for February and March 2017.

3.2.3 Southwest WWTP Flow and Loading Projections

Based on influent flow data, the Southwest WWTP average daily flow is 0.181 MGD. For the purposes of design, a per capita wastewater production rate of 85 gpd was assumed which is reflective of per capita flows observed in the Southeast and Vichy Road WWTP sewersheds during summer months when the Missouri S&T student population is not is residence. This wastewater production rate was applied to the population counts projected during the project planning period, and the per capita loading was assumed to remain constant during the planning period. The average daily BOD, TSS, ammonia, TKN, and TP mass loadings were determined to be 415 lb/d, 294 lb/d, 44 lb/d, 99 lb/d, and 39 lb/d, respectively. These mass loadings corresponded with per capita mass loads of 0.16 ppcd, 0.12 ppcd, 0.02 ppcd, 0.04 ppcd, and 0.02 ppcd, respectively. The currently observed peaking factors were not applied to the projected values as they appear to be influenced by the small size of the sewershed and the current nature of the observed development. An average peaking factor between the Southeast and Vichy Road WWTPs was used. A summary of the flow and loading data is presented in Table 3-6.

Table 3-6. Flow and Loading Projections for the Southwest WWTP

	Average Day	Max Month Average Day	Max Day	Peak Hour Flow
2017				
Flow:	0.181	1.204	2.10	2.31
BOD (mg/L):	129.8	475.6	993.6	
BOD (lb/d):	196	718	1,500	
TSS (mg/L):	194.8	612.8	3,643	
TSS (lb/d):	294	925	5,500	
NH3-N (mg/L):	12.3	*	22.2	
NH3-N (lb/d):	18.6	*	33.5	
TKN (mg/L):	24.5	*	44.5	
TKN (lb/d):	37.0	*	67.2	
TP (mg/L):	3.58	*	6.41	
TP (lb/d):	5.40	*	9.68	
2027 Projection				
Flow:	0.338	1.204	2.10	2.26
BOD (mg/L):	239.8	419.7	604.8	
BOD (lb/d):	676.0	1,183	1,705	
TSS (mg/L):	282.0	756.0	2,013.5	
TSS (lb/d):	795.0	2,131	5,676	
NH3-N (mg/L):	25.5	*	46.9	
NH3-N (lb/d):	72.0	*	132.3	
TKN (mg/L):	50.8	*	93.4	
TKN (lb/d):	143.2	*	263.2	
TP (mg/L):	8.48	*	15.3	
TP (lb/d):	23.9	*	43.0	
2037 Projection				
Flow:	0.402	1.405	2.45	2.70
BOD (mg/L):	239.8	419.7	604.8	
BOD (lb/d):	803.0	1,405	2,026	
TSS (mg/L):	282.0	756.0	2,013.5	
TSS (lb/d):	945.0	2,533	6,747	
NH3-N (mg/L):	25.5	*	46.9	
NH3-N (lb/d):	85.5	*	157.2	
TKN (mg/L):	50.8	*	93.4	
TKN (lb/d):	170.1	*	312.7	
TP (mg/L):	8.48	*	15.3	
TP (lb/d):	28.4	*	51.0	

*Influent ammonia, total kjeldahl nitrogen, and total phosphorus data was only available for February and March 2017.

4 Discharge Limits

4.1 Existing and Projected Limits

The existing effluent limits for the Southeast, Vichy Road, and Southwest WWTPs are presented in Table 4-1. No changes are anticipated for BOD and TSS during the next permit cycle, which is expected to begin in 2018 for all three WWTPs. During the 2018 cycle, the Missouri Department of Natural Resources (MDNR) may make minor changes to ammonia limits to reflect variability observed in recent monitoring data and disinfection will be required for the Vichy Road WWTP. MDNR will likely grant at least a three year schedule of compliance before disinfection limits must be achieved. Nutrient limits will likely not be included in 2018.

During the 2023 permit cycle, BOD, TSS, and disinfection limits are not likely to change. However, ammonia limits will become more stringent if MDNR revises the criteria to protect the freshwater mussels. MDNR may implement nutrient limits as early as the 2023 permit cycle, although the exact timing is currently unclear. When MDNR does choose to implement nutrient limits, they will likely include an extended (5 to 10 year) schedule of compliance.

The City currently has a Voluntary Compliance Agreement (VCA) with MDNR as part of a Bypass Elimination Plan (BEP). This VCA essentially grants the City a 5 year period, renewable for an additional 5 years, to reduce I/I or develop flow management strategies so that Outfalls 002 and 003 at Southeast WWTP, and Outfall 002 at Vichy Road WWTP can be eliminated. A condition of the VCA is that disinfection at these peak flow outfalls will not be required during the term of the VCA. When the VCA expires in May 2021, the wet weather outfalls must be eliminated and peak flow disinfection will be required. Targeted compliance dates for each WWTP have been summarized in Tables 4-2, 4-3, and 4-4.

The BEP was developed to present the best course for elimination of bypasses at the Southeast and Vichy Road WWTPs. At the time the BEP was developed, it was the position of the Environmental Protection Agency (EPA) Region 7 that blending was not permitted. However, under Iowa League of Cities v. EPA (March 25, 2013) it was determined that blending at WWTPs is permissible.

Table 4-1. Existing Limits for the Southeast, Vichy Road and Southwest WWTPs

Facility	BOD (mg/L)	TSS (mg/L)	Ammonia (Summer) (mg/L)		Ammonia (Winter) (mg/L)		Disinfection	TN (mg/L)	TP (mg/L)
			Daily Maximum	Monthly Average	Daily Maximum	Monthly Average			
Southeast WWTP	10	30	3.5	1.4	7.3	2.9	Yes	NA	NA
Vichy Road WWTP	30	30	4.4	1.4	7.8	2.9	No	NA	NA
Southwest WWTP	10	15	5.9	1.2	12.1	2.4	Yes	NA	NA

TN- Total Nitrogen
TP- Total Phosphorus
NA- Not Applicable

Table 4-2. Southeast WWTP Targeted Compliance Dates

Item	Date
Next Permit Renewal	April 2018
Voluntary Compliance Agreement Expires	May 2021
Eliminate Wet Weather Outfalls and Add Peak Flow Disinfection(1)	May 2021
Second Permit Renewal	April 2023
More Stringent Ammonia Limits	April 2026
Nutrient Limits	To Be Determined

(1)Bypass Elimination Plan

Table 4-3. Vichy Road WWTP Targeted Compliance Dates

Item	Date
Next Permit Renewal	October 2018
Voluntary Compliance Agreement Expires	May 2021
Eliminate Wet Weather Outfalls and Add Peak Flow Disinfection(1)	May 2021
Disinfection(2)	October 2021
Second Permit Renewal	October 2023
More Stringent Ammonia Limits	October 2026
Nutrient Limits	To Be Determined

(1)Bypass Elimination Plan
(2)NPDES Permit

Table 4-4. Southwest WWTP Targeted Compliance Dates

Item	Date
Next Permit Renewal	September 2018
Voluntary Compliance Agreement Expires	May 2021
Wet Weather Disinfection(1)	May 2021
Second Permit Renewal	September 2023
More Stringent Ammonia Limits	September 2026
Nutrient Limits	To Be Determined

(1)For future consideration if wet weather flow exceeds dry weather treatment capacity then a wet weather train has to be added.

4.2 Impact on Effluent Ammonia Values Resulting from Blending

When the VCA's for the Southeast and Vichy Road WWTPs expire in May 2021, wet weather outfalls will be eliminated, and the wet weather flows will be disinfected prior to blending at Outfall 001 for each WWTP. The blended effluent must be able to achieve permitted discharge limits. Wet weather flows will be treated by screening, disinfection and clarification, but these processes will not be able to achieve ammonia or nutrient removal. Ammonia has instantaneous and average limits that must be achieved. During a blending event, the instantaneous ammonia limit would be critical. Nutrients limits are typically rolling averages and thus would not be critical during a blending event. Though the Southwest WWTP does not have a VCA, an ammonia blending evaluation was performed for future consideration if wet weather flows were to exceed the dry weather treatment capacity.

The following sections detail the assumptions and analysis completed to estimate the effluent blended quality.

4.2.1 Southeast WWTP

A mass balance was used to estimate the blended effluent ammonia concentration at Outfall 001. The current average day influent ammonia concentration of 16.4 mg/L was used for flows up to the projected 2037 average daily flow (ADF) of 4.25 MGD. Note that influent ammonia data was only available from February and March 2017. It was assumed that future improvements to the WWTP will be able to achieve complete ammonia degradation. Furthermore, it is presumed that this degradation of ammonia can be maintained up to flows of 8.5 MGD or twice the ADF through the plant. Flows exceeding 8.5 MGD were assumed to travel to the peak flow clarifier where no ammonia degradation would occur. The peak hour flow of 42 MGD was assumed to be the peak influent flow thus up to 33.5 MGD (42 MGD – 8.5 MGD) could divert to the peak flow clarifier. Flows from the peak flow clarifier would then be blended with treated flow from the mechanical plant.

Figure 4-1 presents the estimated blended ammonia concentration at the average day ammonia influent concentration 16.4 mg/L. The estimated ammonia concentration peaks at approximately 2.04 mg/L at 18 MGD which is below the current summer and winter daily maximum ammonia limits.

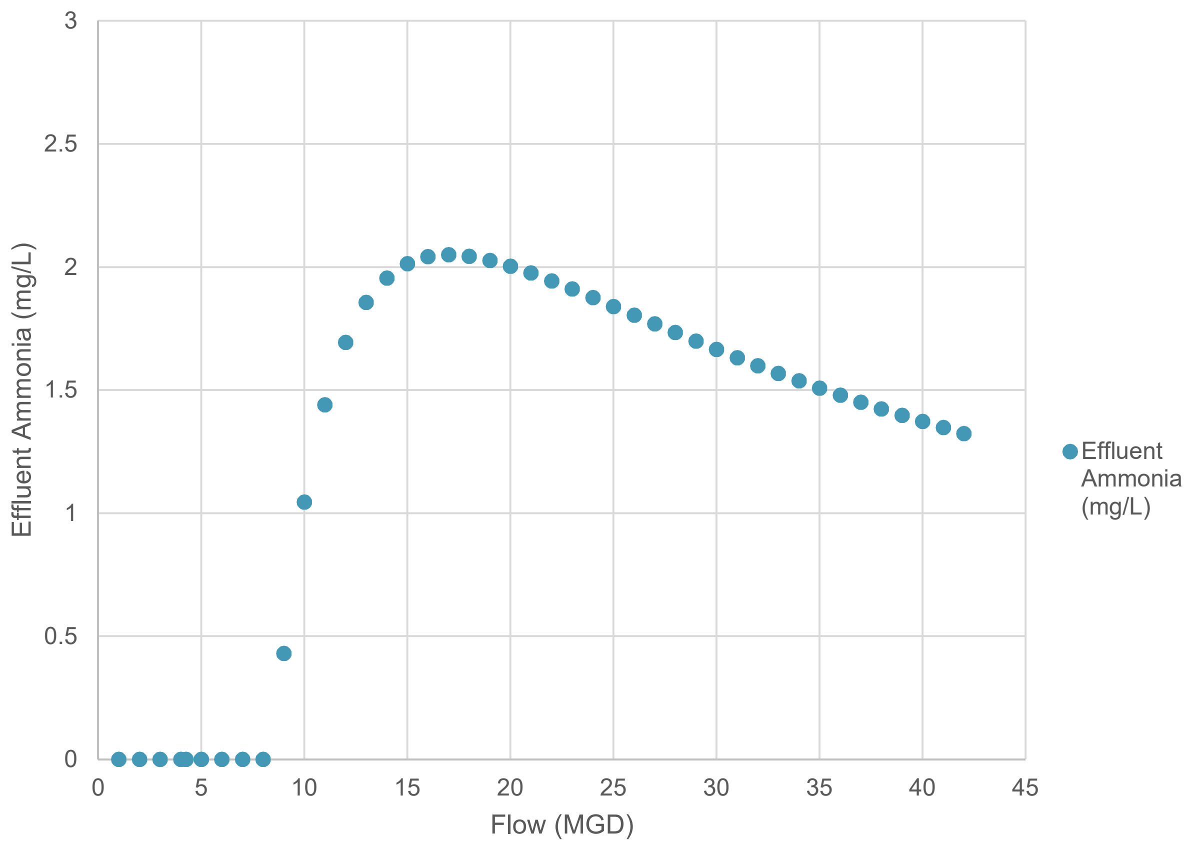


Figure 4-1. Southeast WWTP Ammonia Blending at Average Day Ammonia Influent Concentration and 2037 Projected ADF

Figure 4-2 presents the estimated blended ammonia concentration assuming a maximum day ammonia influent concentration of 24.6 mg/L (1.5 times average day concentration). The estimated ammonia concentration peaks at approximately 3.08 mg/L at 17 MGD which is below the current summer and winter daily maximum ammonia limits.

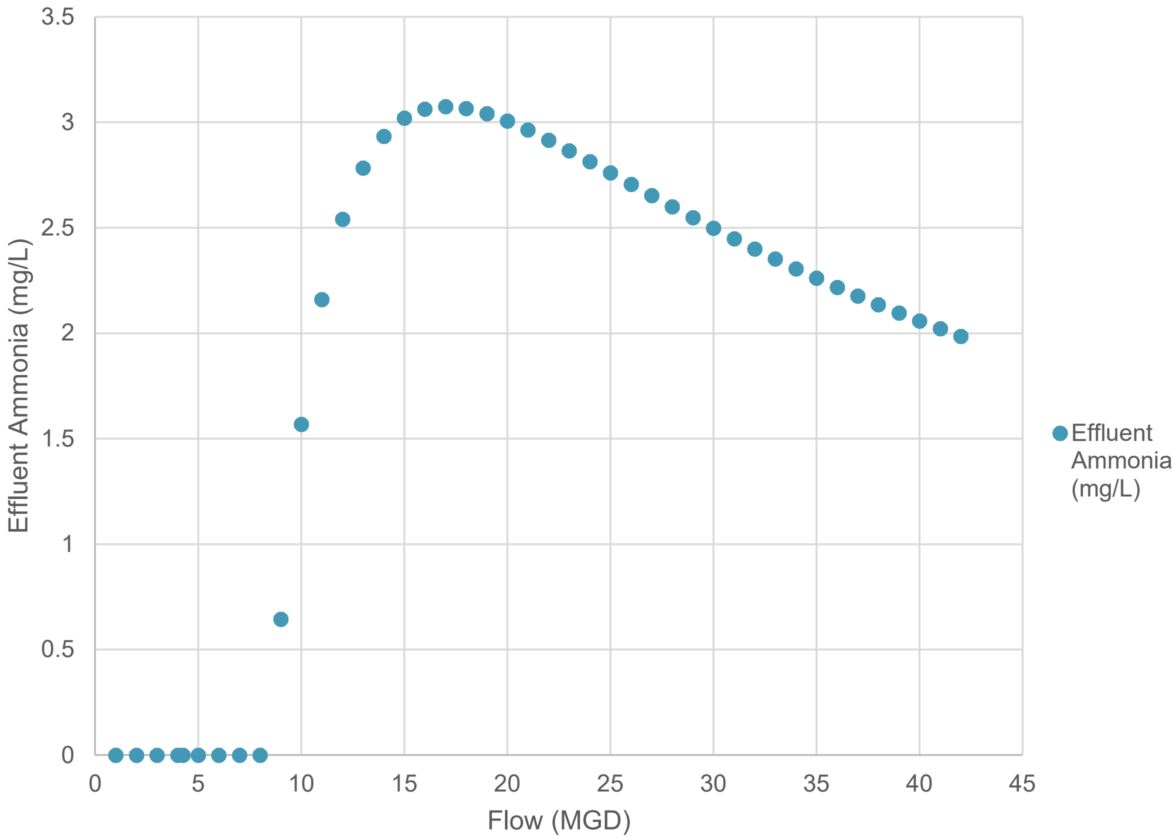


Figure 4-2. Southeast WWTP Ammonia Blending at Maximum Day Ammonia Influent Concentration and 2037 Projected ADF

4.2.2 Vichy Road WWTP

The same methodology used for the Southeast WWTP was used for the Vichy Road WWTP to estimate the blended effluent ammonia concentration at Outfall 001. The current average day influent ammonia concentration of 16.9 mg/L was used for flows up to the projected 2037 average daily flow (ADF) of 0.5 MGD. It was assumed that complete degradation of ammonia can be maintained up to flows of 1 MGD or twice the ADF through the plant. Flows exceeding 1 MGD were assumed to travel to the peak flow clarifier where no ammonia degradation would occur. The peak hour flow of 5 MGD was assumed to be the peak influent flow thus up to 4 MGD (5 MGD – 1 MGD) could divert to the peak flow clarifier. Flows from the peak flow clarifier would then be blended with treated flow from the mechanical plant.

Figure 4-3 presents the estimated blended ammonia concentration at the average day ammonia influent concentration 16.9 mg/L. The estimated ammonia concentration peaks at approximately 2.11 mg/L at 2 MGD which is below the current summer and winter daily maximum ammonia limits.

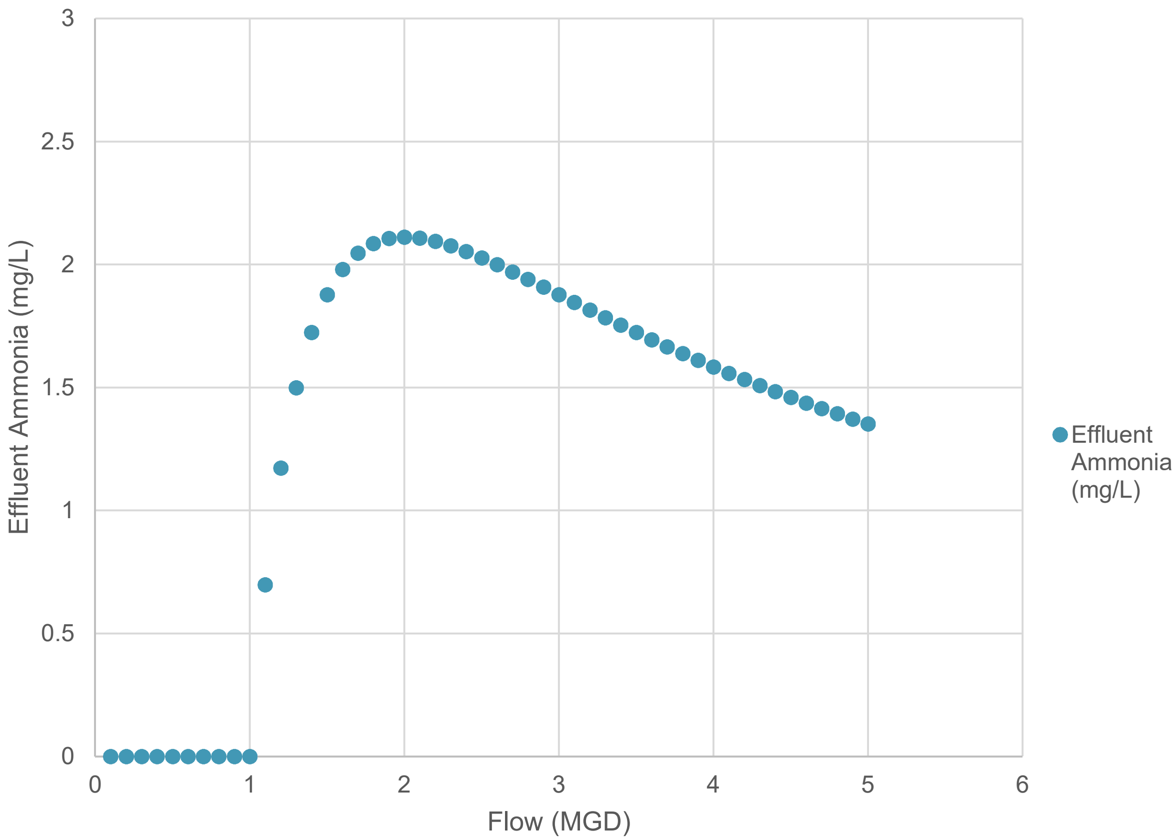


Figure 4-3. Vichy Road WWTP Ammonia Blending at Average Day Ammonia Influent Concentration and 2037 Projected ADF

Figure 4-4 presents the estimated blended ammonia concentration assuming a maximum day ammonia influent concentration of 25.35 mg/L (1.5 times average day concentration). The estimated ammonia concentration peaks at approximately 3.17 mg/L at 2 MGD which is below the current summer and winter daily maximum ammonia limits.

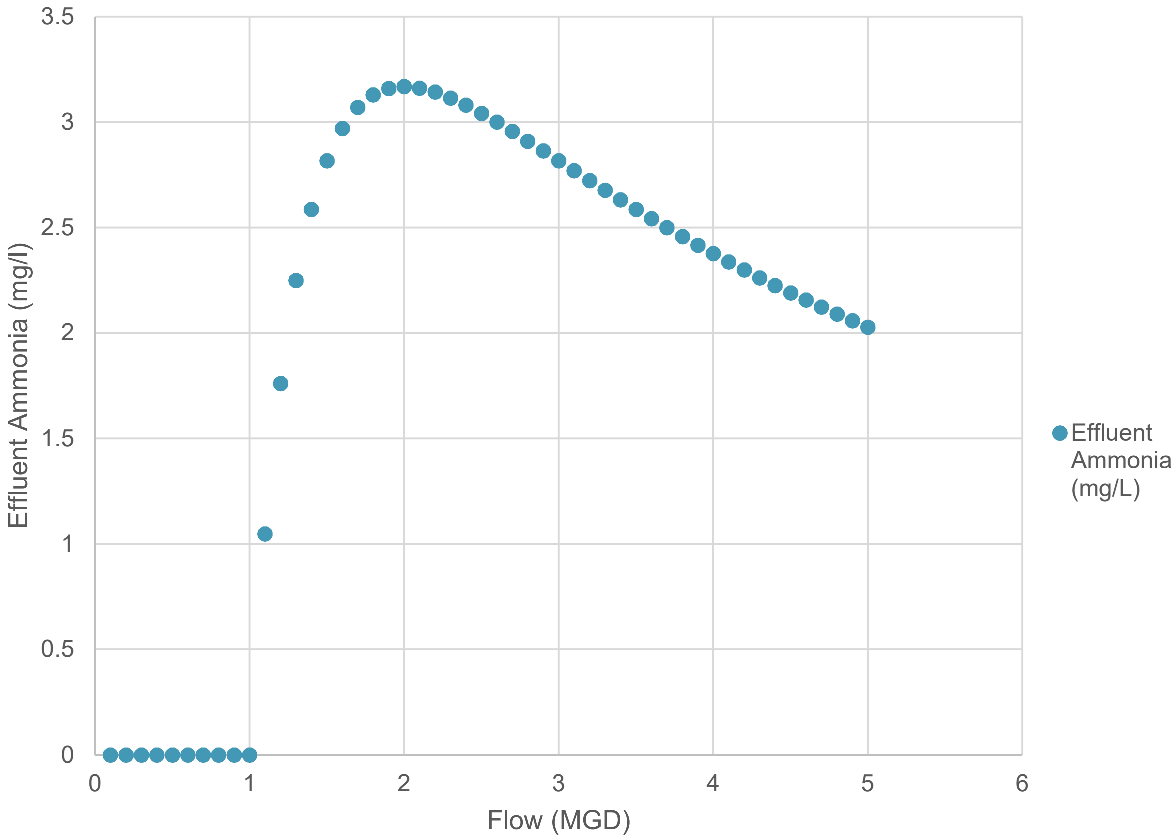


Figure 4-4. Vichy Road WWTP Ammonia Blending at Maximum Day Ammonia Influent Concentration and 2037 Projected ADF

4.2.3 Southwest WWTP

This evaluation was completed for future consideration if wet weather flows were to exceed the dry weather treatment capacity and a wet weather treatment train was brought online. The same methodology used for the Southeast WWTP was used for the Southwest WWTP to estimate the blended effluent ammonia concentration at Outfall 001. The current average day influent ammonia concentration of 12.3 mg/L was used for flows up to the projected 2037 average daily flow (ADF) of 0.5 MGD. It was assumed that complete degradation of ammonia can be maintained up to flows of 1 MGD or twice the ADF through the plant. Flows exceeding 1 MGD were assumed to travel to the peak flow clarifier where no ammonia degradation would occur. The peak hour flow of 5 MGD was assumed to be the peak influent flow thus up to 4 MGD (5 MGD – 1 MGD) could divert to the peak flow clarifier. Flows from the peak flow clarifier would then be blended with treated flow from the mechanical plant.

Figure 4-5 presents the estimated blended ammonia concentration at the average day ammonia influent concentration 12.3 mg/L. The estimated ammonia concentration peaks at approximately 1.53 mg/L at 2 MGD which is below the current summer and winter daily maximum ammonia limits.

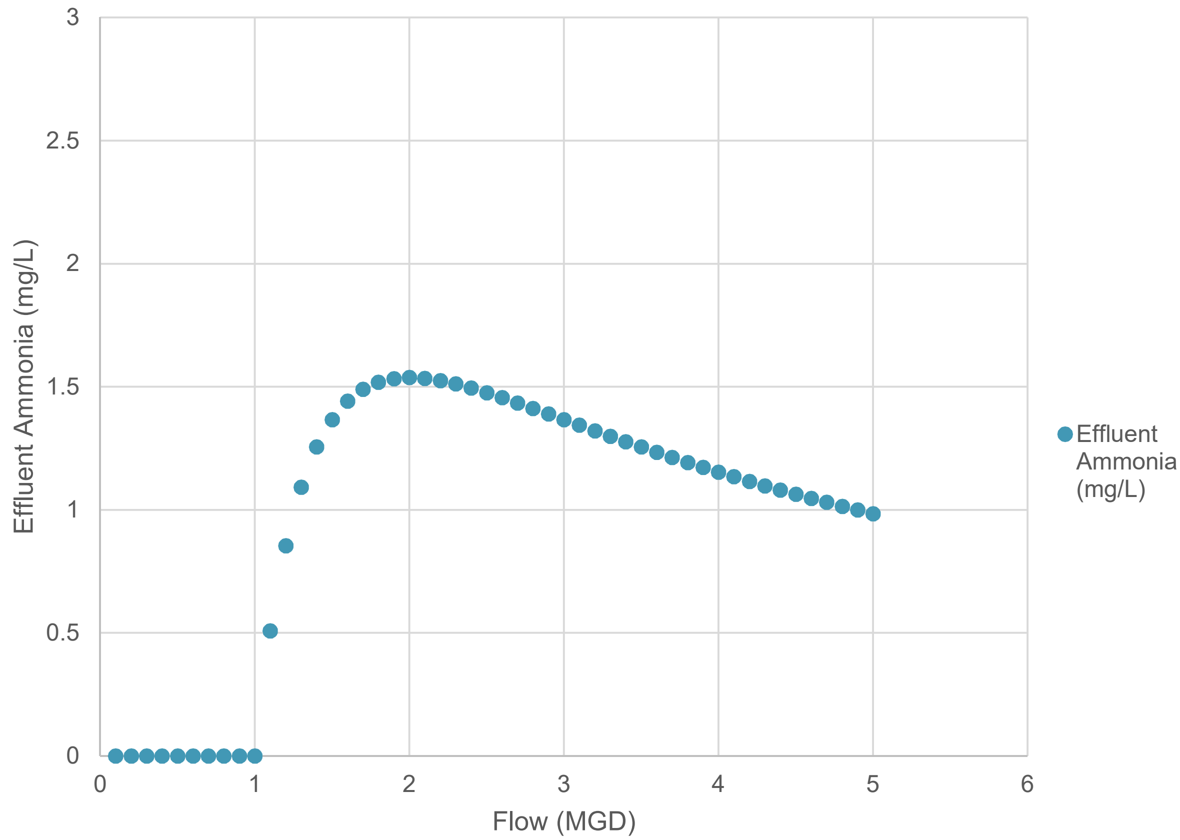


Figure 4-5. Southwest WWTP Ammonia Blending at Average Day Ammonia Influent Concentration and 2037 Projected ADF

Figure 4-6 presents the estimated blended ammonia concentration assuming a maximum day ammonia influent concentration of 18.45 mg/L (1.5 times average day concentration). The estimated ammonia concentration peaks at approximately 2.31 mg/L at 2 MGD which is below the current summer and winter daily maximum ammonia limits.

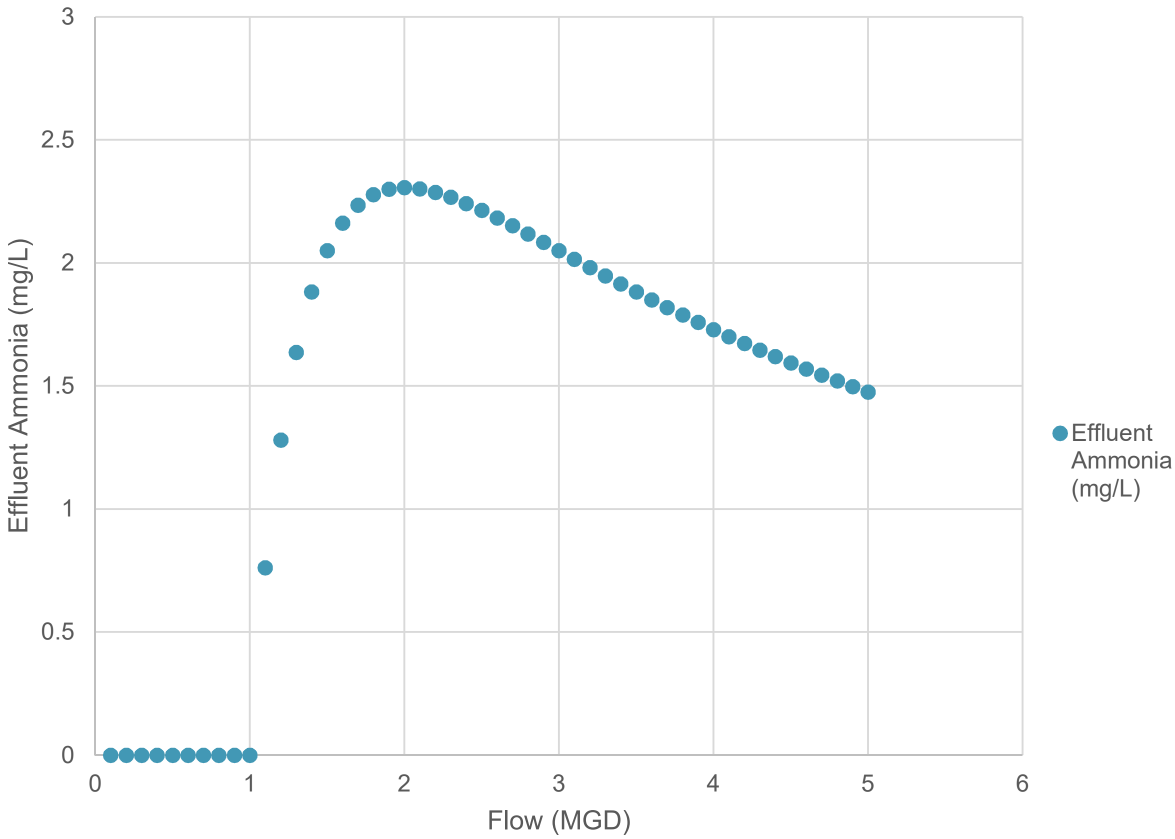


Figure 4-6. Southwest WWTP Ammonia Blending at Maximum Day Ammonia Influent Concentration and 2037 Projected ADF

4.2.4 Ammonia Blending Summary

As described in Section 4.1, ammonia limits are anticipated to become more stringent by the 2023 permit cycle if MDNR revises the criteria to protect the freshwater mussels. It is recommended that the peak ammonia concentrations, presented above, be taken under consideration during future permitting.

5 Wastewater Treatment Plant Improvements

5.1 Southeast WWTP

Based on the capacity evaluations and future projections, the Southeast WWTP will need improvements in order to handle the projected future capacity and regulatory requirements over the 20 year project planning period. These improvements have been split into specific phases to align with the projected capacity and regulatory requirements. Opinions of probable project costs were developed for each phase.

5.1.1 Phase 1 – Peak Flow Disinfection and Ammonia Removal

Phase 1 addresses near term compliance dates for the addition of peak flow disinfection and the elimination of wet weather outfalls (May 2021), and more stringent ammonia removal requirements (April 2026). At the West Plant, upgrades to the flow splitting will be included to handle the dry and wet weather flows as described below:

- Wet weather flows will be handled by an additional peak flow screening and measurement structure that will be added parallel to the existing structure. The peak flow screen will be a mechanical coarse screen with a bypass channel.
- After screening, the wet weather flow will travel to the existing peak flow clarifier. The peak flow clarifier mechanism is currently damaged and will be removed.
- A new chemical building will be added in order to house sodium hypochorite, sodium bisulfite and ferric chloride, and their associated chemical pumping equipment. Hypochorite and ferric will be added before the peak flow clarifier for disinfection and enhanced coagulation/settling, and bisulfite will be added after the peak flow clarifier for dechlorination. The chemical building was sized and priced to include the addition of ferric equipment though the addition of ferric may not be needed initially and will be investigated further in the final design. Chemical storage tanks with double wall containment were assumed to be placed outside the chemical building.
- After disinfection, peak flows will be blended with plant flow at Outfall 001 and Outfall 002 will no longer be used. The Outfall 001 structure will be upgraded to handle the increased flow.

At the East Plant, upgrades to the flow splitting will be included to handle the dry and wet weather flows as described below:

- Wet weather flows will be split before the existing headworks and will be handled by a new peak flow screening and measurement structure. The peak flow screen will be a mechanical coarse screen with a bypass channel.
- After screening, the wet weather flow will travel to the existing peak flow clarifier. Hypochorite and ferric chloride will be added before the peak flow clarifier for disinfection, and bisulfite will be added after the peak flow clarifier for dechlorination. Again, the addition of ferric may not be needed initially and will be investigated further in the final design.

- After disinfection, peak flows will be blended with plant flow at Outfall 001 and Outfall 003 will no longer be used.

Two alternatives were evaluated for the dry weather flow improvements included in Phase 1. Improvements that are common to each alternative are described below:

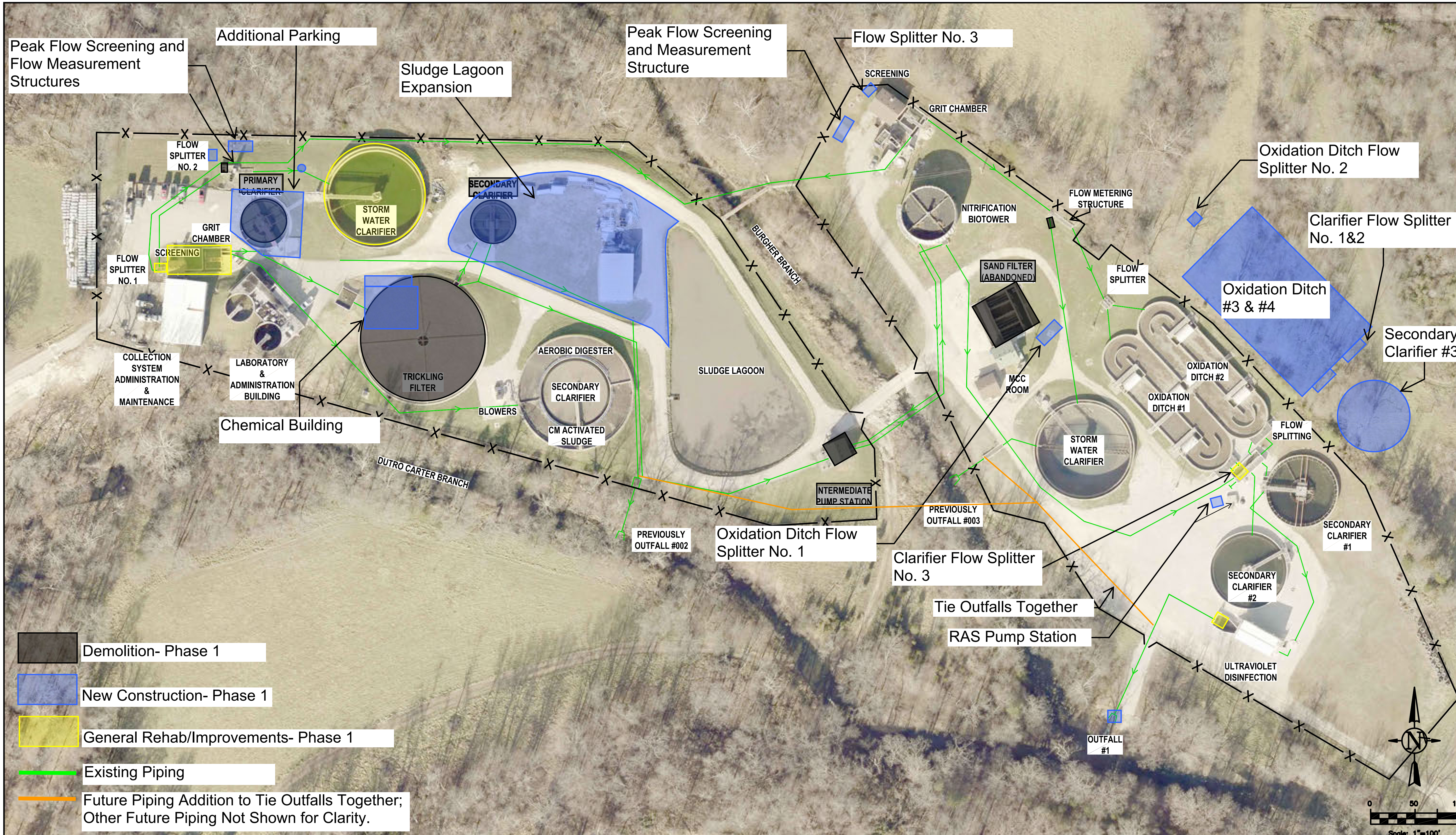
- West Plant dry weather flows will enter the existing headworks through Flow Splitter No. 1. Improvements to the headworks include rehabilitation of the mechanical fine screen, epoxy lining the main channel, and grit chamber rehabilitation, as needed. The existing sludge lagoon will be expanded to the west to accommodate future loadings.
- The East Plant dry weather flows will continue to enter the existing headworks. No upgrades to the headworks are anticipated. Launder covers will be added to Clarifier No. 2 to prevent algae growth. Flow will be treated by the existing ultraviolet disinfection system which does not need upgraded. An additional wet well will be added next to the existing RAS lift station to increase the capacity.
- The following unit processes are no longer needed and will be demolished: primary clarifier, trickling filter, and secondary clarifier (West Plant).
- An asphalt parking area will be constructed in the former primary clarifier location as requested by the City operator.

5.1.2 Phasing Alternative 1 Phase 1

Two alternatives were evaluated for the dry weather flow improvements included in Phase 1. Alternative 1 includes the following:

- Dry weather flow from the west headworks and east headworks will travel to the new Oxidation Ditch Flow Splitter No. 1 and then to the new Oxidation Ditches No. 3 and No. 4 which will be constructed northeast of the existing oxidation ditches. The new oxidation ditches were estimated to be the same size and configuration as the existing ditches.
- Flow from the oxidation ditches will continue to the existing Secondary Clarifiers No. 1 and No. 2, and an additional clarifier, Clarifier No. 3, will be constructed. Clarifier No. 3 will not be brought online until necessitated by future flows.
- The existing walker unit will continue to be used for aerobic digestion.

The estimated probable project cost for Phasing Alternative 1 Phase 1 is $16,949,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-1 and Figure 5-2.



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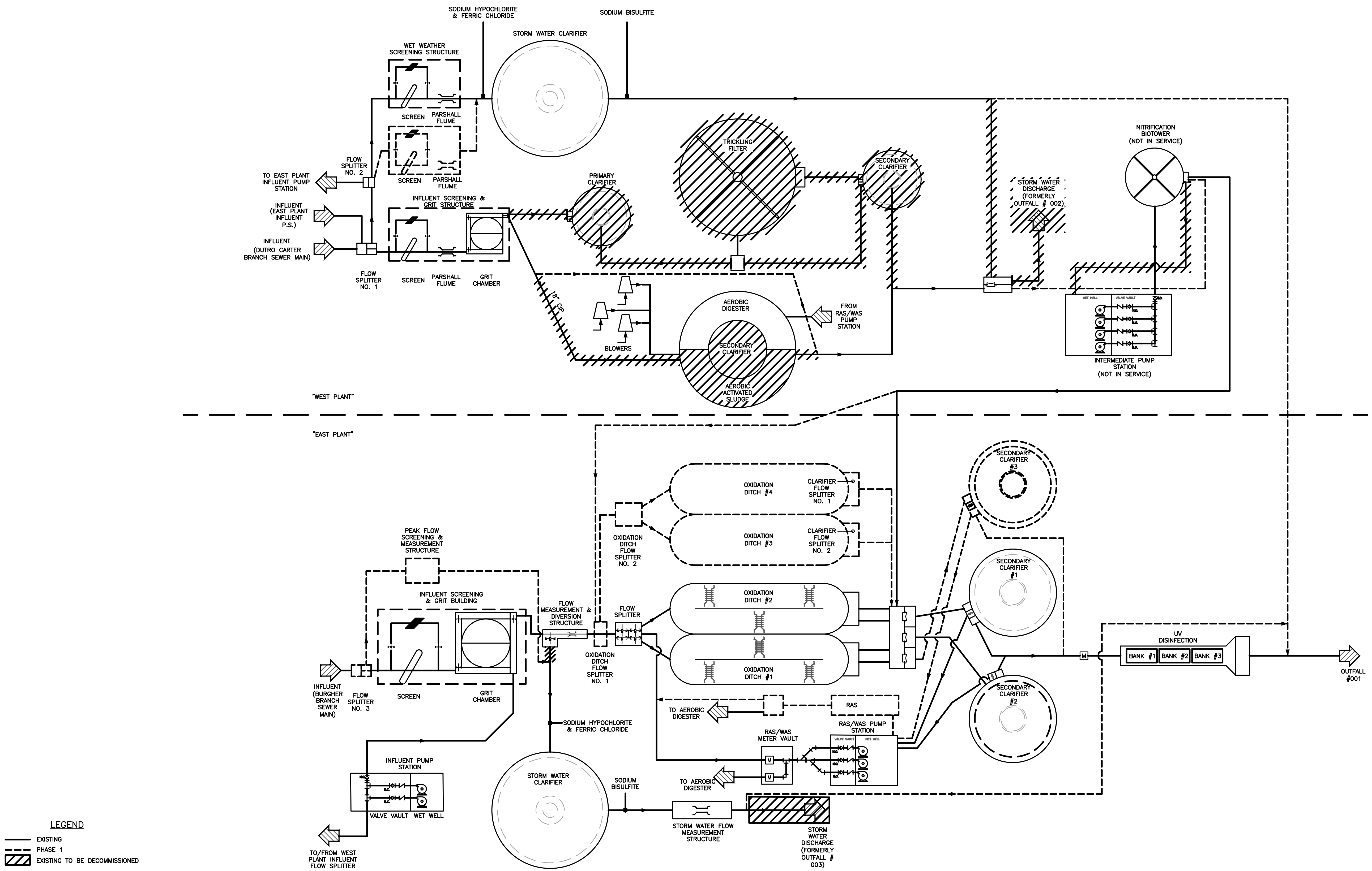

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FUTURE PROCESS FLOW DIAGRAM
PHASING ALTERNATIVE 1 PHASE 1

PROJECT NO. 154630

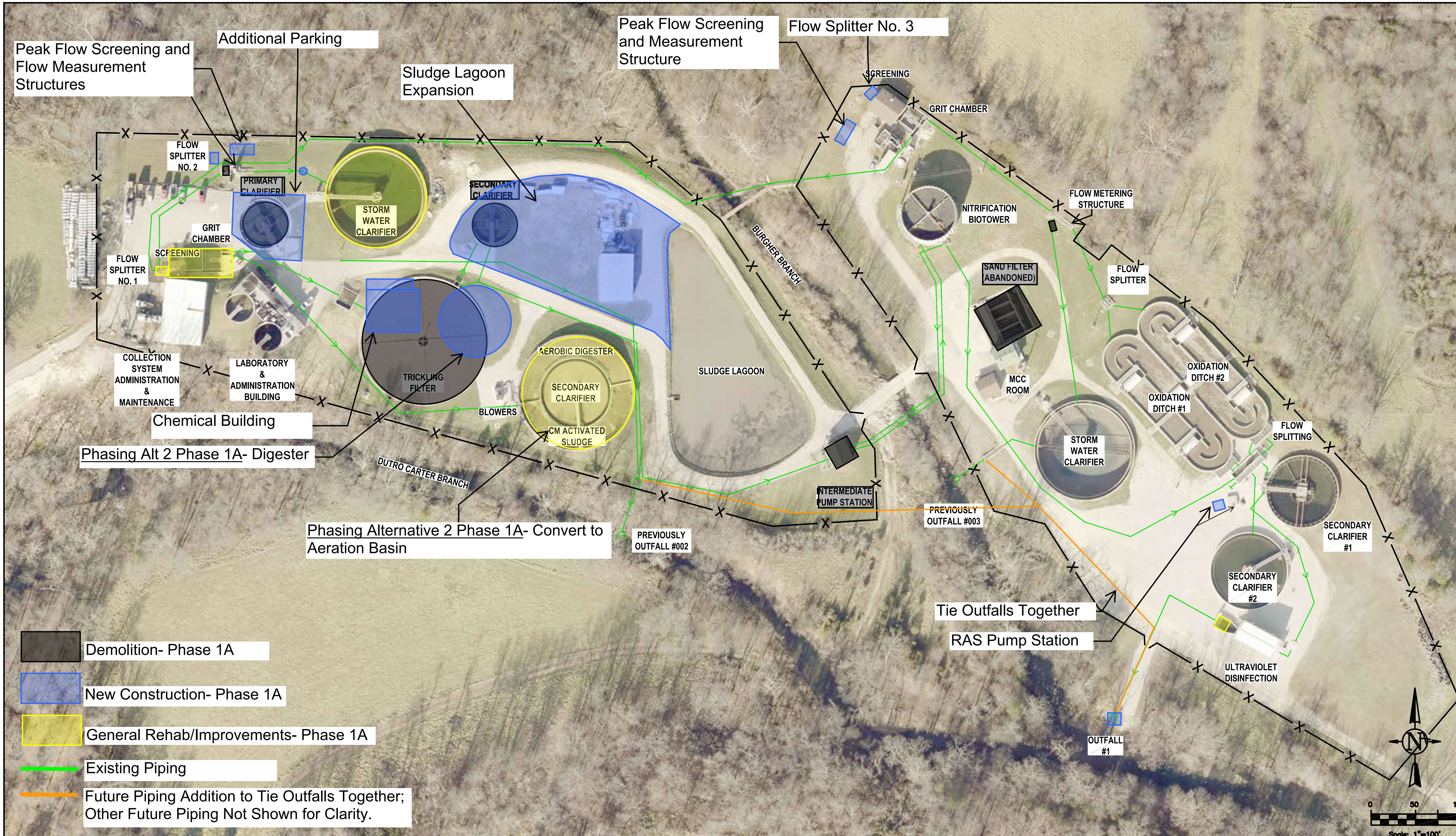
DRAWING NO. 5-2

5.1.3 Phasing Alternative 2 Phase 1A

Two alternatives were evaluated for the dry weather flow improvements included in Phase 1. Alternative 2 splits Phase 1 into two sub-phases (1A and 1B) and was evaluated in order to provide a lower up front cost for peak flow disinfection and ammonia removal. Phase 1A can provide ammonia removal for an estimated 10-13 years until the existing clarifiers become overloaded (approximately 3.7 MGD) at which point Phase 1B will be constructed to increase capacity. Phase 1A is described below:

- Dry weather flow from the west headworks will split to the existing walker unit and the existing oxidation ditches.
- The existing walker unit will be converted to an aeration basin to increase the aeration capacity of the WWTP, and a new digester will be constructed.
- A portion of the waste activated sludge (WAS) flow from the oxidation ditches will be split to the walker unit to provide the biology for ammonia removal.
- Dry weather flow from the east headworks will travel to the existing oxidation ditches. After aeration, the flow will continue to the existing secondary clarifiers and ultraviolet disinfection.

The estimated probable project cost for Phasing Alternative 2 Phase 1A is $11,477,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-3 and Figure 5-4.



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FUTURE LAYOUT
PHASING ALTERNATIVE 2 PHASE 1A

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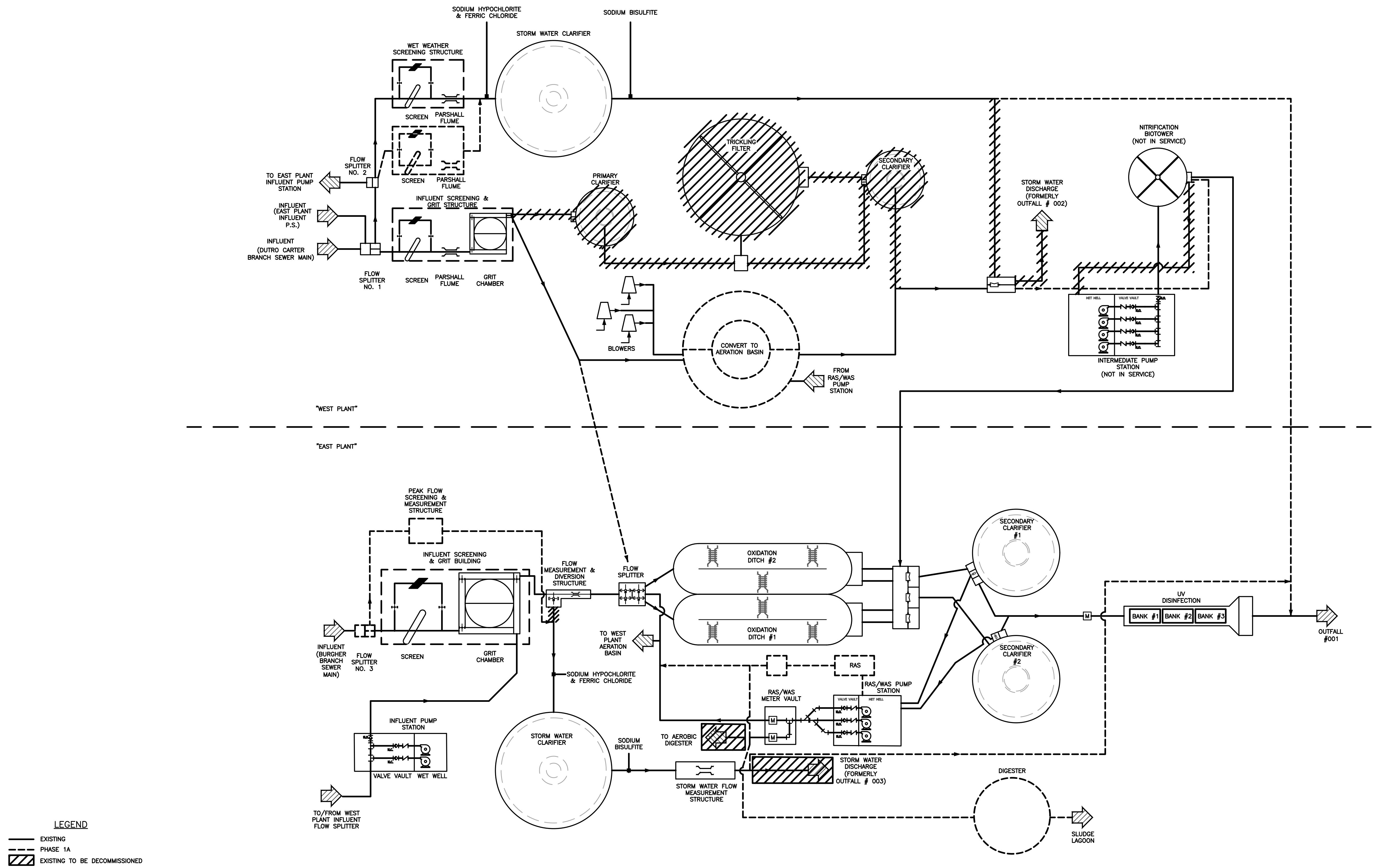

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PHASING ALTERNATIVE 2 PHASE 1A

PROJECT NO.
154630

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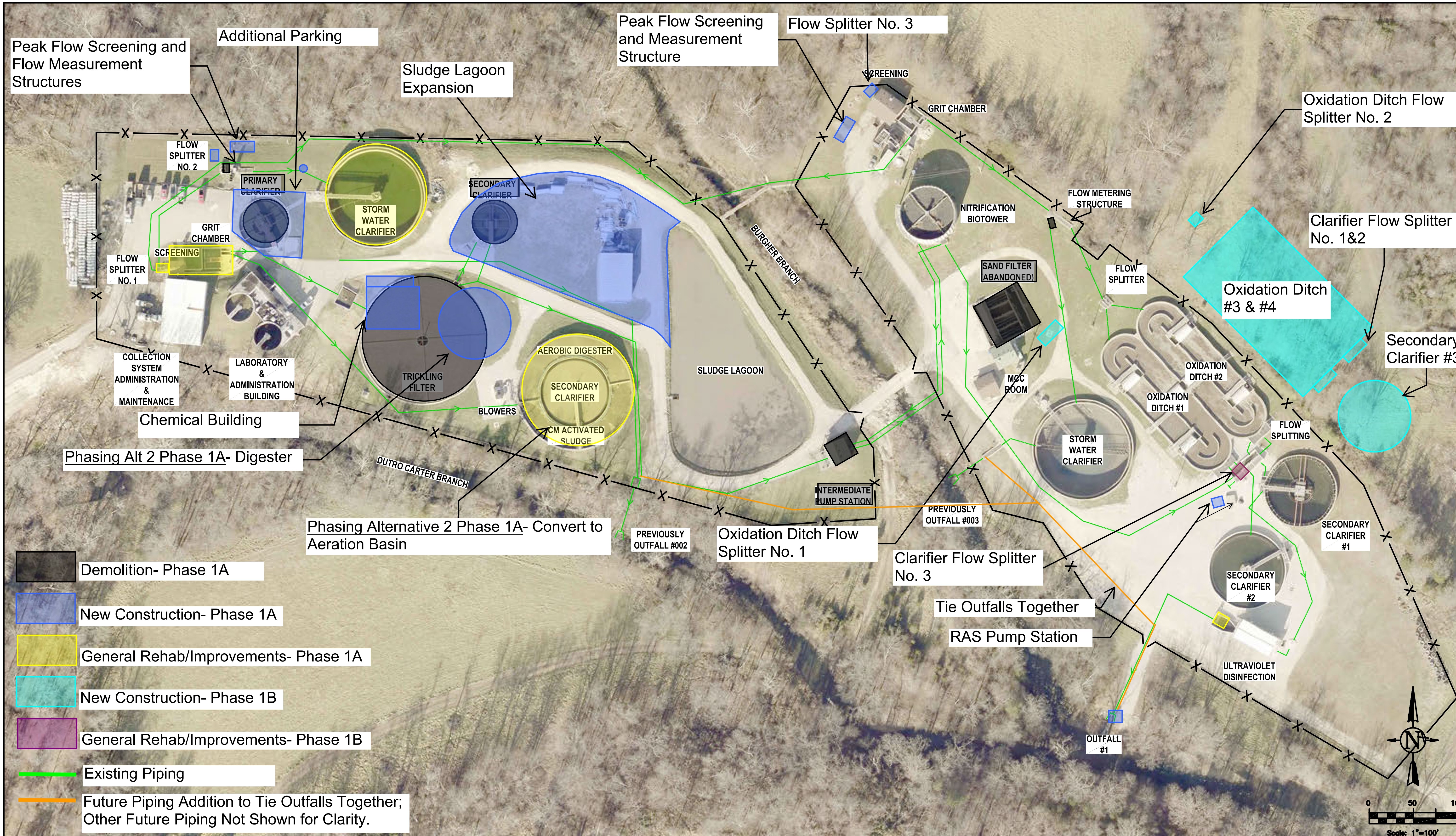
5.1.4 Phasing Alternative 2 Phase 1B

Phase 1B increases the WWTP capacity by constructing Oxidation Ditches No.3 and No. 4 along with an additional clarifier, Clarifier No. 3. Since the exact timing of nutrient limits is currently unclear, it is difficult to determine whether this phase would need to occur within the same timeframe as nutrient removal (Phase 2).

The estimated probable project cost for Phasing Alternative 2 Phase 1B is $10,066,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-5 and Figure 5-6.



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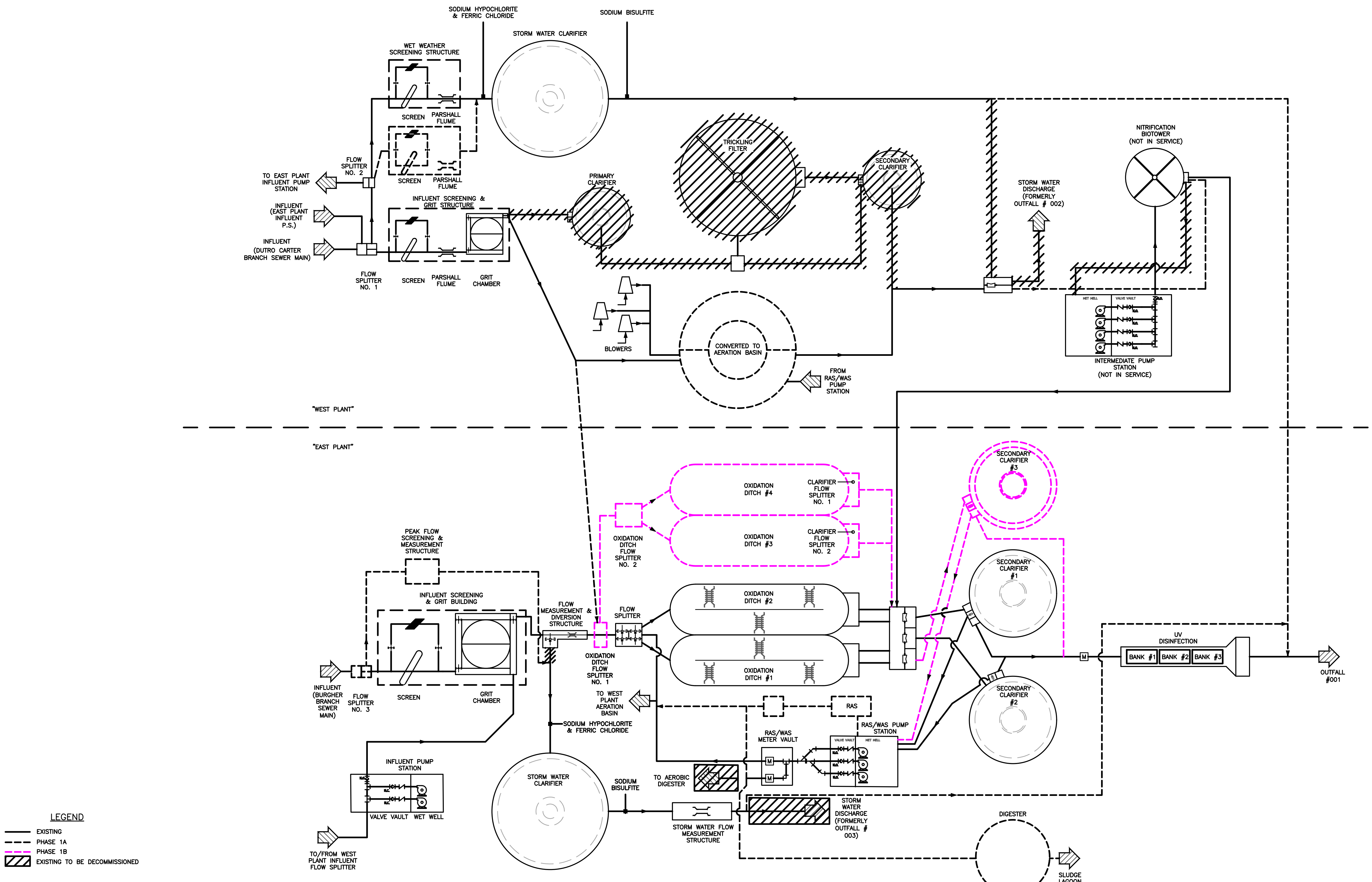

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PROJECT NO. 154630

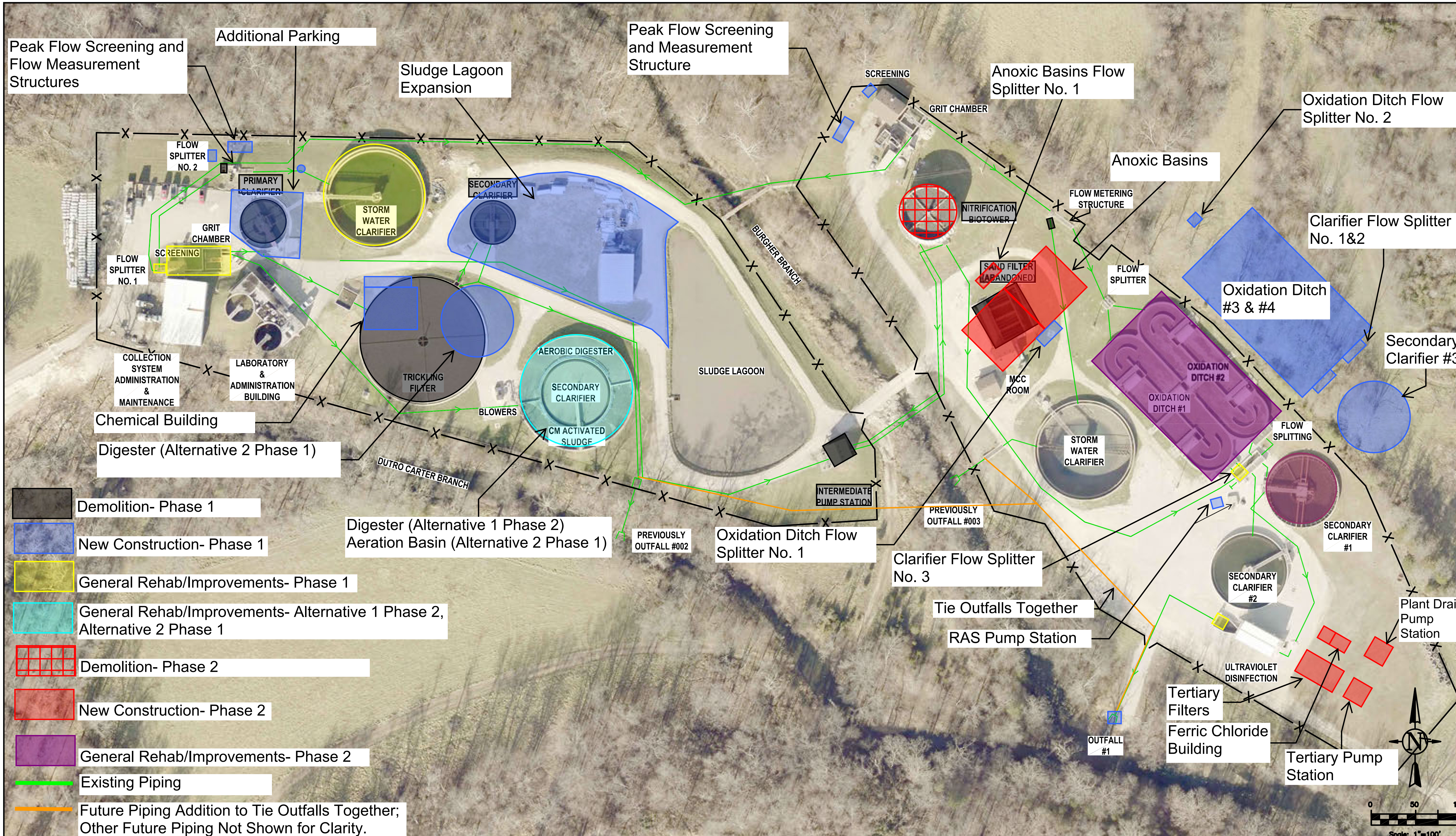
DRAWING NO. 5-6

5.1.5 Phase 2 – Nutrient Removal

Phase 2 addresses nutrient removal which will need to be included within the 20 year project planning period though it is unknown at this time when nutrient limits will be required. In order to achieve nutrient removal the following processes will be added: anoxic basins, a tertiary pump station, tertiary filtration, and a ferric building. The Phase 2 process is described below:

- Dry weather flow from the west headworks and east headworks will travel to the new Anoxic Basins No. 1 and No. 2 followed by the existing Oxidation Ditches No. 1, No. 2, No. 3 and No. 4.
- Flow from the existing oxidation ditches will continue to existing Secondary Clarifiers No. 1, No. 2, and No. 3.
- From the existing clarifiers, a new tertiary pump station will be used to pump flow through the new tertiary filters. Ferric will be added in between the tertiary pump station and the tertiary filters to enhance particle formation and phosphorus removal.
- The following additional items would also occur during this phase: demolition of the nitrifying biotower, dissolved oxygen control and integration for the oxidation ditches, replacement of the existing Clarifier No. 1 mechanism, and construction of a plant drain lift station.

The estimated probable project cost for Phase 2 is $10,646,000 if Phasing Alternative 1 is pursued and $10,019,000 if Phasing Alternative 2 is pursued. This is due to the fact that the walker unit would need to be converted to a digester to add digestion capacity under Phasing Alternative 1 whereas a new digester will have already been constructed under Phasing Alternative 2. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-7 and Figure 5-8.



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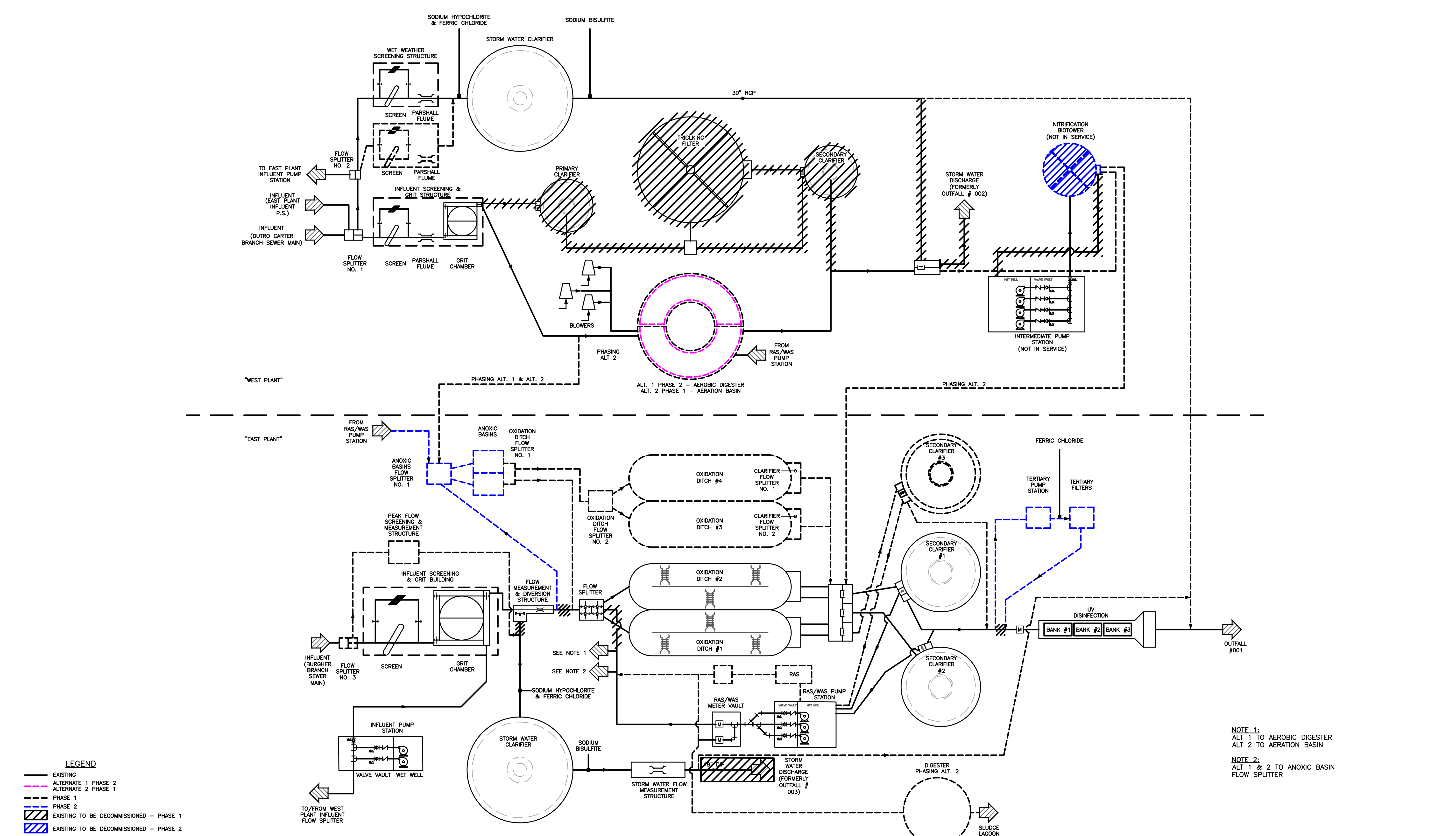

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SOUTHEAST
FUTURE PROCESS FLOW DIAGRAM
PHASE 2

PROJECT NO. 154630

DRAWING NO. 5-8

5.1.6 Southeast WWTP Improvements Summary

Table 5-1 summarizes the probable project costs for the Southeast WWTP. Based on the evaluation above, the City indicated that construction of additional oxidation ditches upfront is the preferred alternative (Phasing Alternative 1) and will be considered herein.

Table 5-1. Southeast WWTP Summary of Probable Costs

Phasing Alternative 1		Phase 1- Disinfection and Ammonia Removal [(1)]	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
Add Peak Flow Disinfection, Ammonia Removal, Replace West Plant and Nutrient Removal Improvements	**$27,593,000**	**$16,949,000**	**$10,646,000**

Phasing Alternative 2		Phase 1A - Disinfection and Ammonia Removal [(2)]	Phase 1B- Replace West Plant	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**	**Total Cost**
Add Peak Flow Disinfection, Ammonia Removal, Replace West Plant and Nutrient Removal Improvements	**$31,550,000**	**$11,477,000**	**$10,066,000**	**$10,019,000**

[(1)]Peak flow disinfection; add Oxidation Ditch

[(2)]Peak flow disinfection; Convert Walker Unit to Aeration Basin and add Digester

5.2 Vichy Road and Southwest WWTPs Alternatives

Based on the capacity evaluations and future projections, the Vichy Road and Southwest WWTPs will need improvements in order to handle the projected future capacity and regulatory requirements over the 20 year project planning period. Two different alternatives were evaluated regarding the treatment of Vichy Road WWTP flows. Each alternative was split into specific phases to align with the projected capacity and regulatory requirements. Opinions of probable project costs were developed for each phase.

5.2.1 Alternative 1 Phase 1 – Peak Flow Disinfection at Southwest Plant and New Vichy Road WWTP

Alternative 1 evaluated keeping the existing Southwest WWTP and constructing a new Vichy Road WWTP. Phase 1 addresses near term compliance dates for the addition of peak flow disinfection and the elimination of wet weather outfalls (May 2021). Southwest WWTP improvements are described below:

- Wet weather flows will be split by a new flow splitter (Flow Splitter No. 3) to a new peak flow screening and measurement structure. The peak flow screen will be a mechanical coarse screen with a bypass channel.
- After screening, the wet weather flow will travel to the existing walker unit which will be converted to a peak flow clarifier.
- A new chemical building will be added in order to house sodium hypochorite, sodium bisulfite and ferric chloride, and their associated chemical pumping equipment. Hypochorite and ferric will be added before the peak flow clarifier for disinfection and enhanced coagulation/settling, and bisulfite will be added after the peak flow clarifier for dechlorination. The chemical building was sized and priced to include the addition of ferric equipment though the addition of ferric may not be needed initially and will be investigated further in the final design. Chemical storage tanks with double wall containment were assumed to be placed outside the chemical building.
- After disinfection, peak flows will be blended with plant flow at Outfall 001. The Outfall 001 structure will be upgraded to handle the increased flow.
- Mixing improvements for the existing oxidation ditch and launder covers for the existing secondary clarifiers were also included in Phase 1.

The estimated probable project cost for the Southwest WWTP Alternative 1 Phase 1 is $2,081,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-9 and Figure 5-10, respectively.

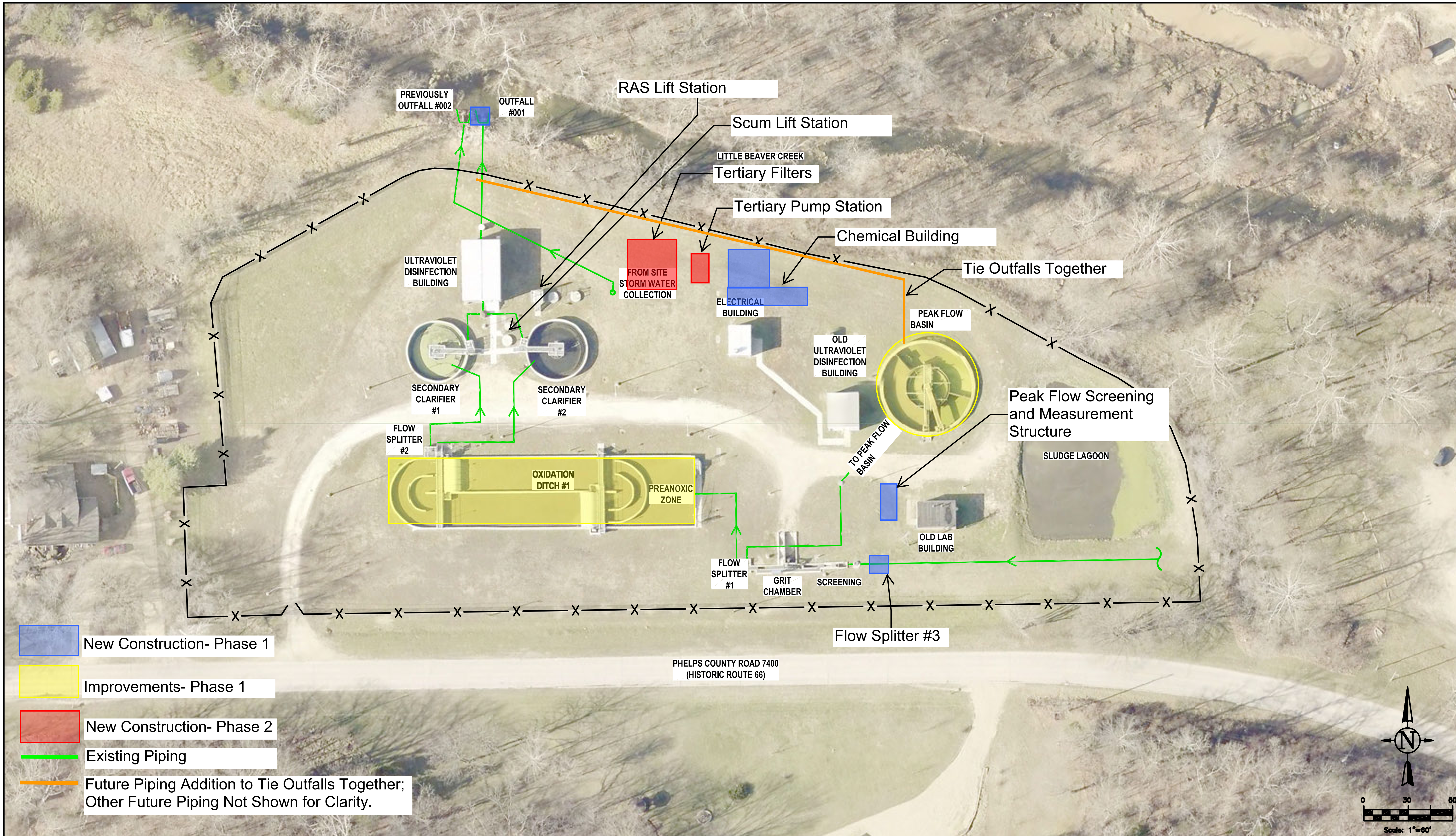
A new Vichy Road WWTP with 0.5 MGD capacity and peak flow disinfection facilities will be constructed on a new site contiguous with the existing Vichy Road WWTP as described below:

- Wet weather flows will be treated by the same facilities as described above for the Southwest WWTP which include the following: influent splitter structure, mechanical coarse screen with a bypass channel, peak flow clarifier and chemical storage building.

- Dry weather facilities will be the same as the existing Southwest WWTP which include the following unit processes: influent screening, grit chamber, oxidation ditch, two secondary clarifiers, ultraviolet disinfection, RAS pump station, and sludge lagoon.

The estimated probable project cost for the new Vichy Road WWTP Alternative 1 Phase 1 is $7,847,000. The probable project cost was developed using the construction cost of the Southwest WWTP scaled from 2008 to 2017 dollars and addition of the peak flow disinfection facilities. A detailed cost estimate is presented in Appendix E, and a process flow diagram is shown in Figure 5-11.

The estimated probable project cost for the Southwest WWTP and new Vichy Road WWTP Alternative 1 Phase 1 is $9,928,000.



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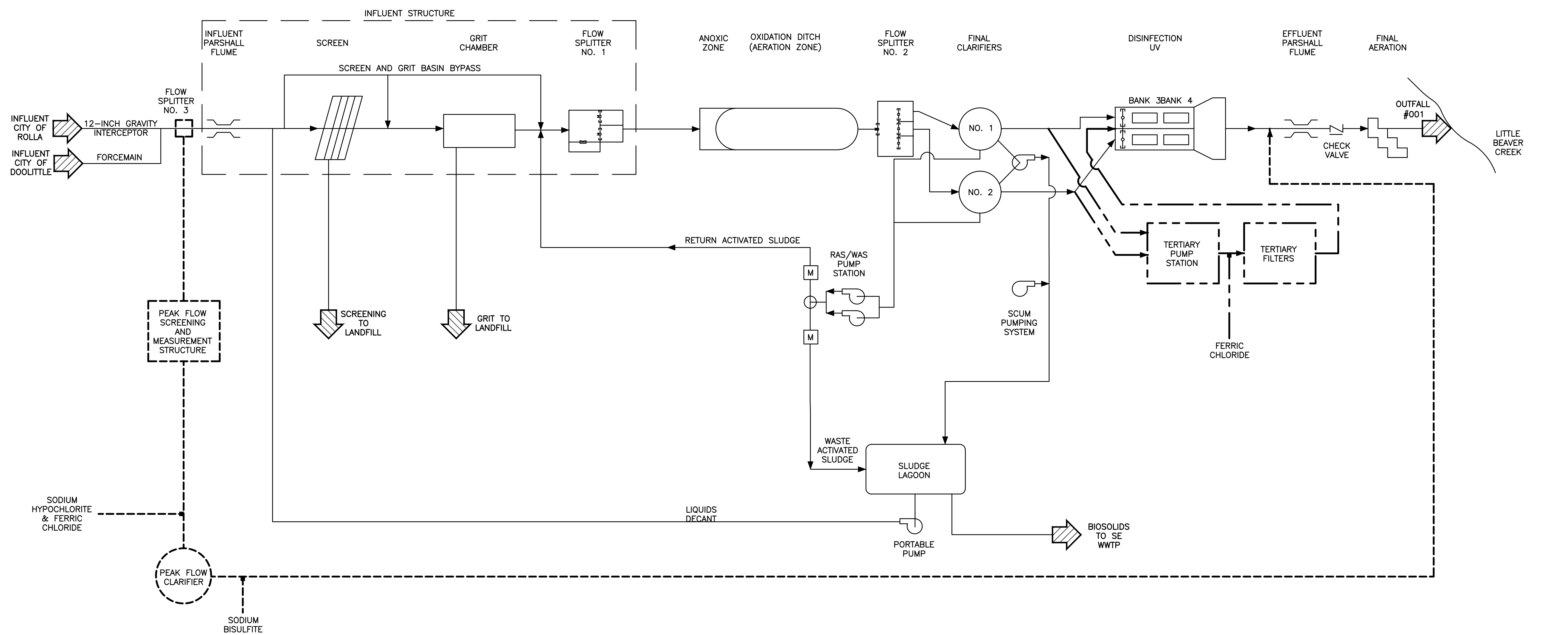
PROJECT NO. 154630

SOUTHWEST FUTURE LAYOUT ALTERNATIVE 1 PHASE 1 AND PHASE 2

DRAWING NO. 5-9



LEGEND

EXISTING
PHASE 1
PHASE 2

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engineering ■ surveying ■ architecture
Corporate Authority:
CM Archer Group, P.C.: E: 2003023612-D, LS: 2004017577-D, A-2016017179
Archer-Elgin Surveying & Engineering, LLC: E: 2011024038, LS: 2011025471, A-2012014618
310 East 6th Street; Rolla, Missouri 65401 ■ Phone: 573-364-6362 Fax: 573-364-4782 ■ www.archer-elgin.com

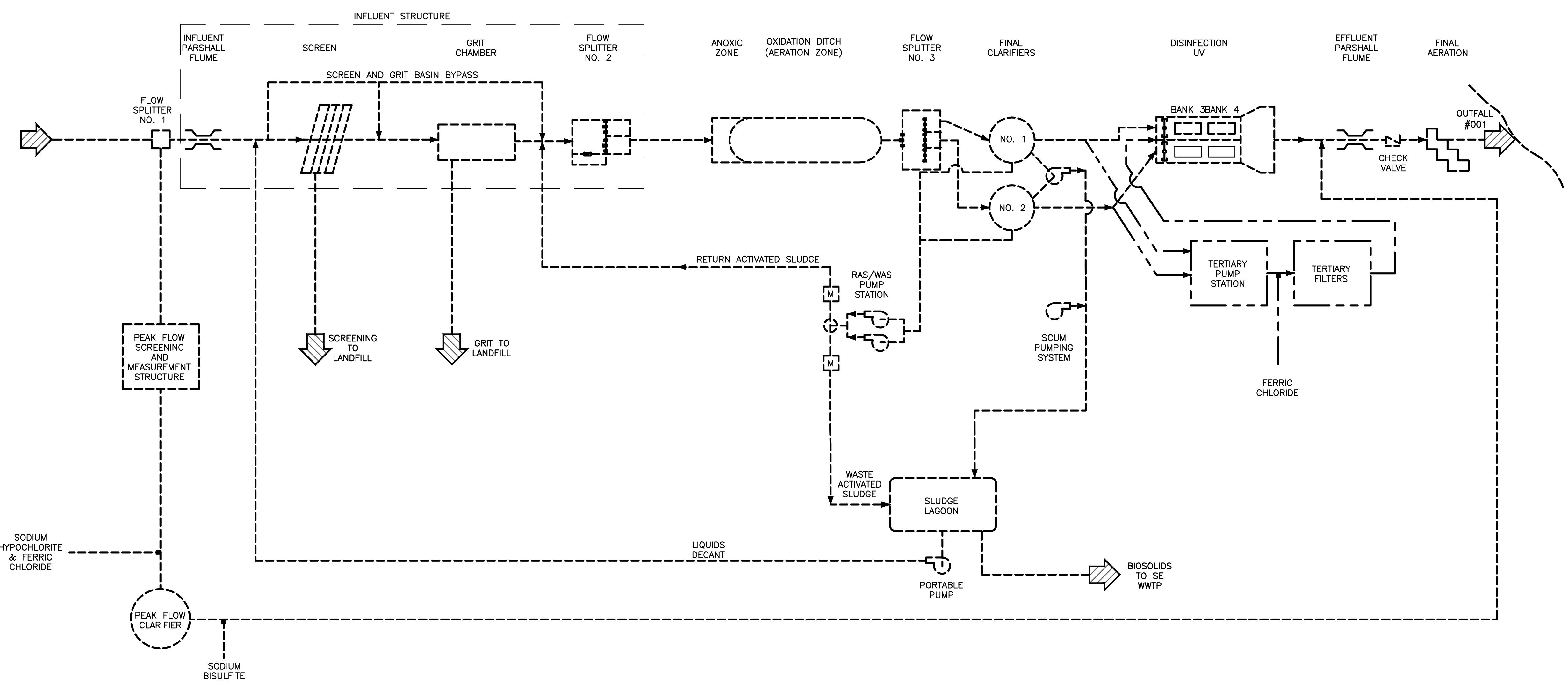
City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER TREATMENT PLANT PER

SOUTHWEST
FUTURE PROCESS FLOW DIAGRAM
ALTERNATIVE 1 PHASE 1 AND PHASE 2

PROJECT NO. 154630

DRAWING NO. 5-10



LEGEND

PHASE 1
PHASE 2

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City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER
TREATMENT PLANT PER

VICHY ROAD
FUTURE PROCESS FLOW DIAGRAM
ALTERNATIVE 1 PHASE 1 AND PHASE 2

PROJECT NO. 154630

DRAWING NO. 5-11

5.2.2 Alternative 1 Phase 2 –Nutrient Removal at Southwest Plant and New Vichy Road WWTP

Phase 2 addresses nutrient removal which will need to be included within the 20 year project planning period though it is unknown at this time when nutrient limits will be required. In order to achieve nutrient removal the following processes will be added to both the existing Southwest and new Vichy Road WWTPs: tertiary pump station and tertiary filtration.

- A tertiary pump station will be used to pump flow from the secondary clarifiers through the new tertiary filters.
- Ferric will be added in between the tertiary pump station and the tertiary filters.

The estimated probable project cost for Alternative 1 Phase 2 is the same for both WWTPs. The estimated probable project cost for each WWTP is $1,763,000 for a total cost of $3,526,000 for Alternative 1 Phase 2. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-9 and Figure 5-10 for the Southwest WWTP, and a process flow diagram is shown in Figure 5-11 for the new Vichy Road WWTP.

5.2.3 Alternative 2 Phase 1 – Pump Vichy Road to Southwest WWTP, Expand Southwest WWTP Capacity, and Add Peak Flow Disinfection

Alternative 2 evaluated decommissioning the existing Vichy Road WWTP, constructing a new pump station to pump the Vichy Road flows to the Southwest WWTP, and expanding the Southwest WWTP. Phase 1 addresses near term compliance dates for the addition of peak flow disinfection and the elimination of wet weather outfalls (May 2021).

Figure 5-12 shows the new Vichy Road pump station location and alignment alternatives for the forcemain to convey Vichy Road flows to the existing Southwest WWTP as described below:

- Alignment Alternative 1 is the recommended forcemain alignment due to its shorter length and lower high point elevation. Alternative 1 has a length of approximately 26,000 feet and maximum elevation of 1,162 feet.
- The forcemain and pumps will carry the projected 2037 average daily flow of 0.451 MGD and a peak flow of 3.62 MGD. There will be two forcemains: one for average daily flow and one for the peak hour flow. The average daily flow forcemain and pumps will have an approximate duty point of 500 gpm at 270 feet total dynamic head (TDH), and the peak flow forcemain and pumps will be have an approximate duty point of 2,250 gpm at 266 feet TDH.
- Flows in excess of the pump station capacity will pass through a manual bar screen and the existing stormwater clarifier prior to being sent to a two million gallon stormwater storage basin as shown in Figure 5-13.

Pump station conceptual drawings are shown in Appendix F along with a detailed evaluation of pumping Vichy Road flows to the Southwest WWTP. The estimated probable project cost for the new forcemain and pump station to replace the existing Vichy Road WWTP is $7,946,000 as shown in Appendix E and Appendix F.

In order to treat the projected wet weather flows from Vichy Road, the Southwest WWTP will be expanded as described below:

- Wet weather facilities include: influent splitter structure, mechanical coarse screen with a bypass channel, peak flow splitter structure, two peak flow clarifiers and chemical storage building.
- The existing walker unit will be converted to a peak flow clarifier and an additional peak flow clarifier will be constructed.
- Hypochlorite and ferric will be added to wet weather flows similar to Alternative 1 Phase 1.

In order to treat the projected dry weather flows from Vichy Road, the dry weather treatment train will be expanded as described below:

- Dry weather expansion includes: an additional oxidation ditch (Oxidation Ditch No. 2), secondary clarifier (Clarifier No. 3), upgraded ultraviolet disinfection, and upgraded RAS lift station.
- After disinfection, peak flows will be blended with plant flow at Outfall 001. The Outfall 001 structure will be upgraded to handle the increased flow.
- Mixing improvements for the existing oxidation ditch and launder covers for the existing secondary clarifiers were also included in Phase 1.

The estimated probable project cost to expand the Southwest WWTP to accommodate projected Vichy Road flows is $6,407,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-14 and Figure 5-15, respectively.

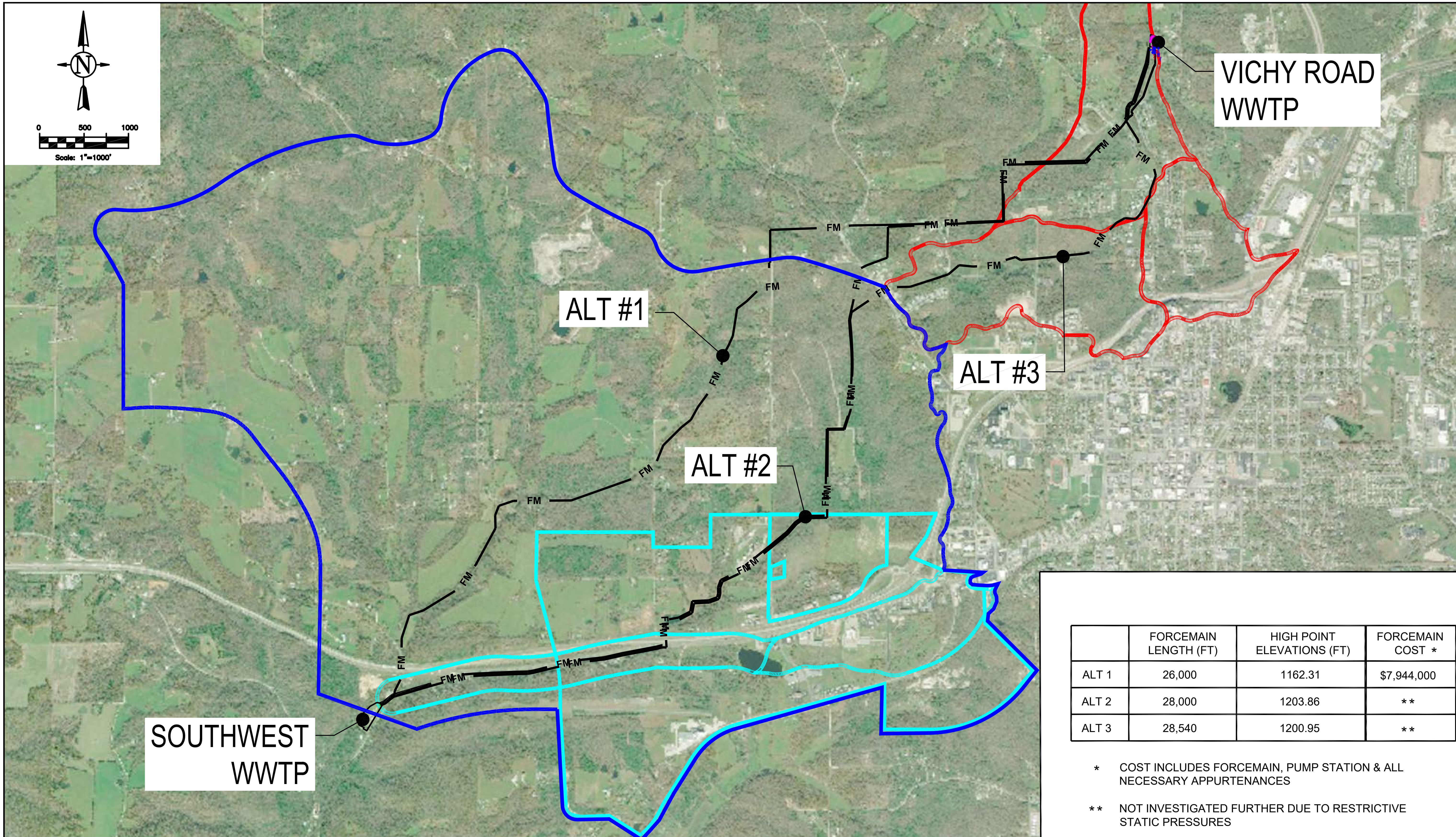
The estimated probable project cost for Alternative 2 Phase 1 is $14,353,000.

5.2.4 Alternative 2 Phase 2 –Add Nutrient Removal Improvements to Expanded Southwest WWTP

Phase 2 addresses nutrient removal at the Southwest WWTP after it has been expanded to handle the projected Vichy Road flows. In order to achieve nutrient removal, a tertiary pump station and tertiary filtration will be added to the expanded Southwest WWTP as described below:

- A tertiary pump station will be used to pump flow from the secondary clarifiers through the new tertiary filters.
- Ferric will be added in between the tertiary pump station and the tertiary filters.

The estimated probable project cost for Alternative 2 Phase 2 is $2,456,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown in Figure 5-14 and Figure 5-15, respectively.



	FORCEMAIN LENGTH (FT)	HIGH POINT ELEVATIONS (FT)	FORCEMAIN COST *
ALT 1	26,000	1162.31	$7,944,000
ALT 2	28,000	1203.86	**
ALT 3	28,540	1200.95	**

* COST INCLUDES FORCEMAIN, PUMP STATION & ALL NECESSARY APPURTENANCES

** NOT INVESTIGATED FURTHER DUE TO RESTRICTIVE STATIC PRESSURES

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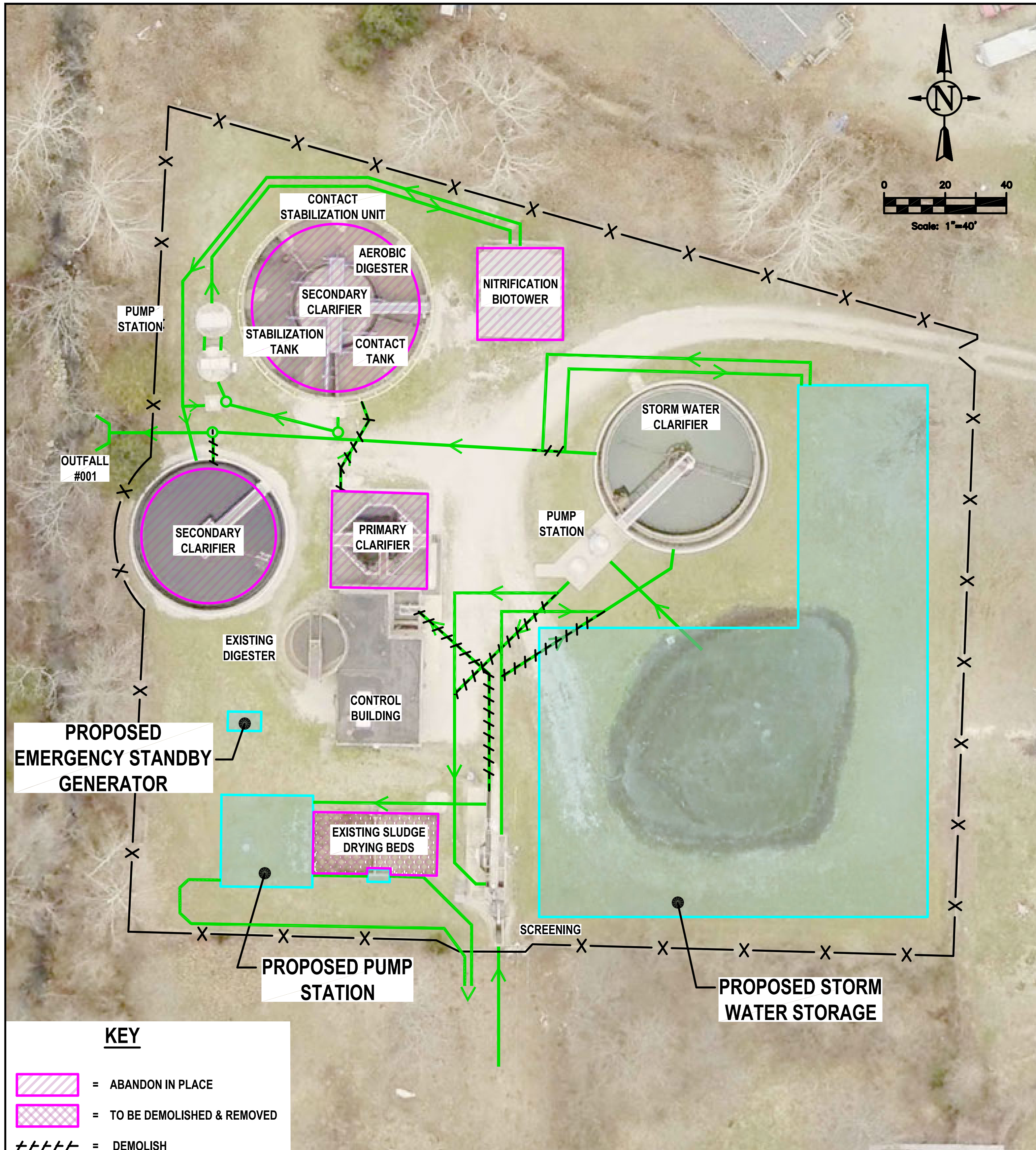
City of ROLLA

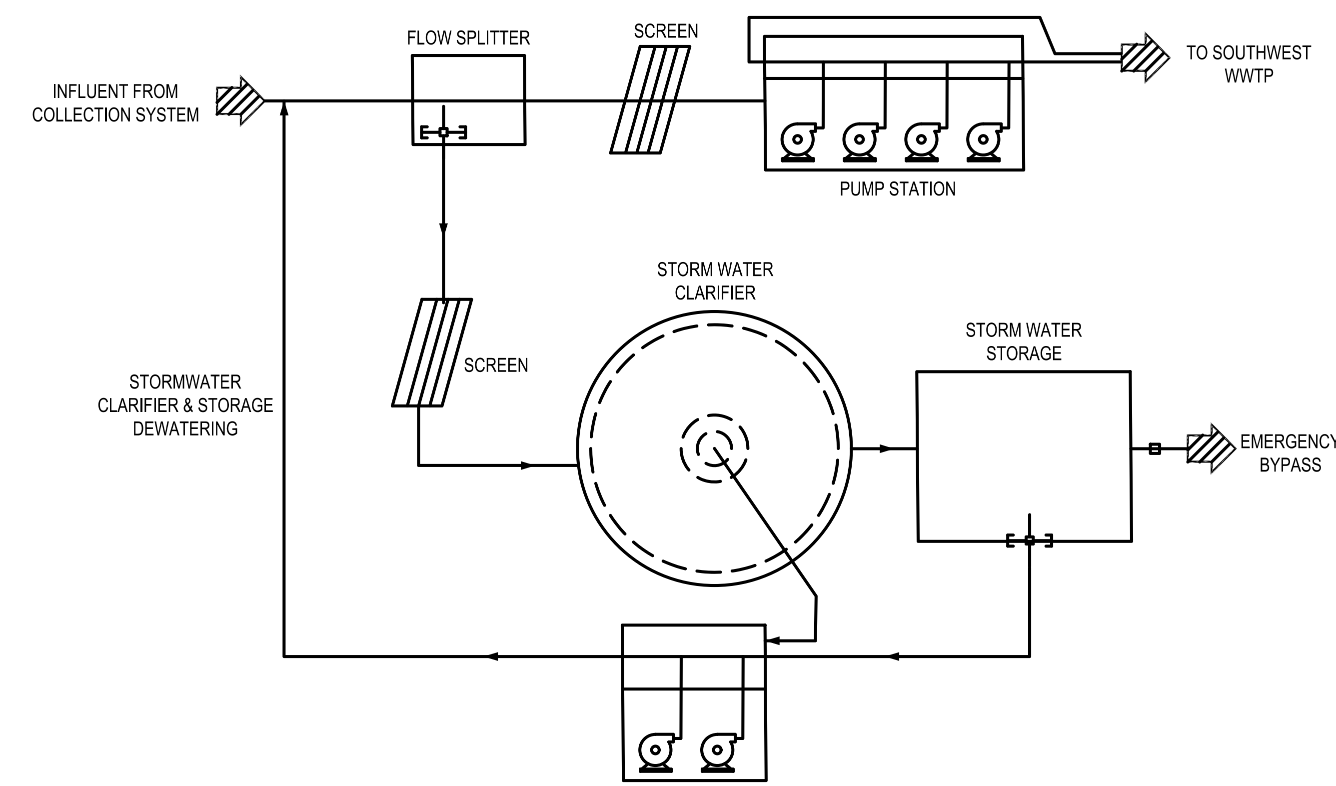
CITY OF ROLLA, MO
ROLLA WASTEWATER
TREATMENT PLANT PER

VICHY ROAD
PUMP STATION FORCEMAIN
ALIGNMENT ALTERNATIVES

PROJECT NO. 154630

DRAWING NO. 5-12





PROPOSED FLOW DIAGRAM

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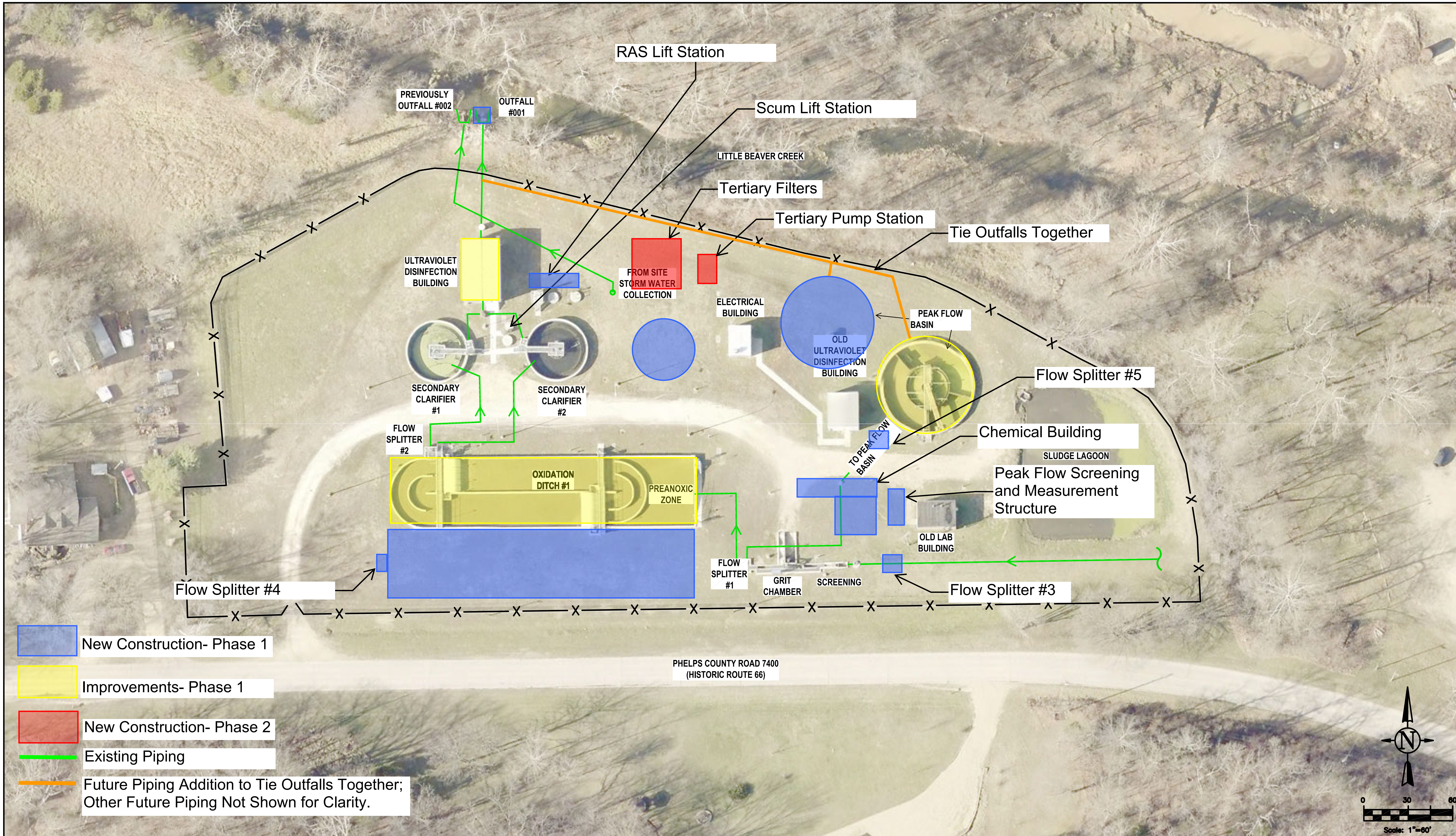
City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER TREATMENT PLANT PER

VICHY ROAD
FUTURE LAYOUT AND PROCESS FLOW DIAGRAM
ALTERNATIVE 2 PHASE 1

PROJECT NO. 154630

DRAWING NO. 5-13



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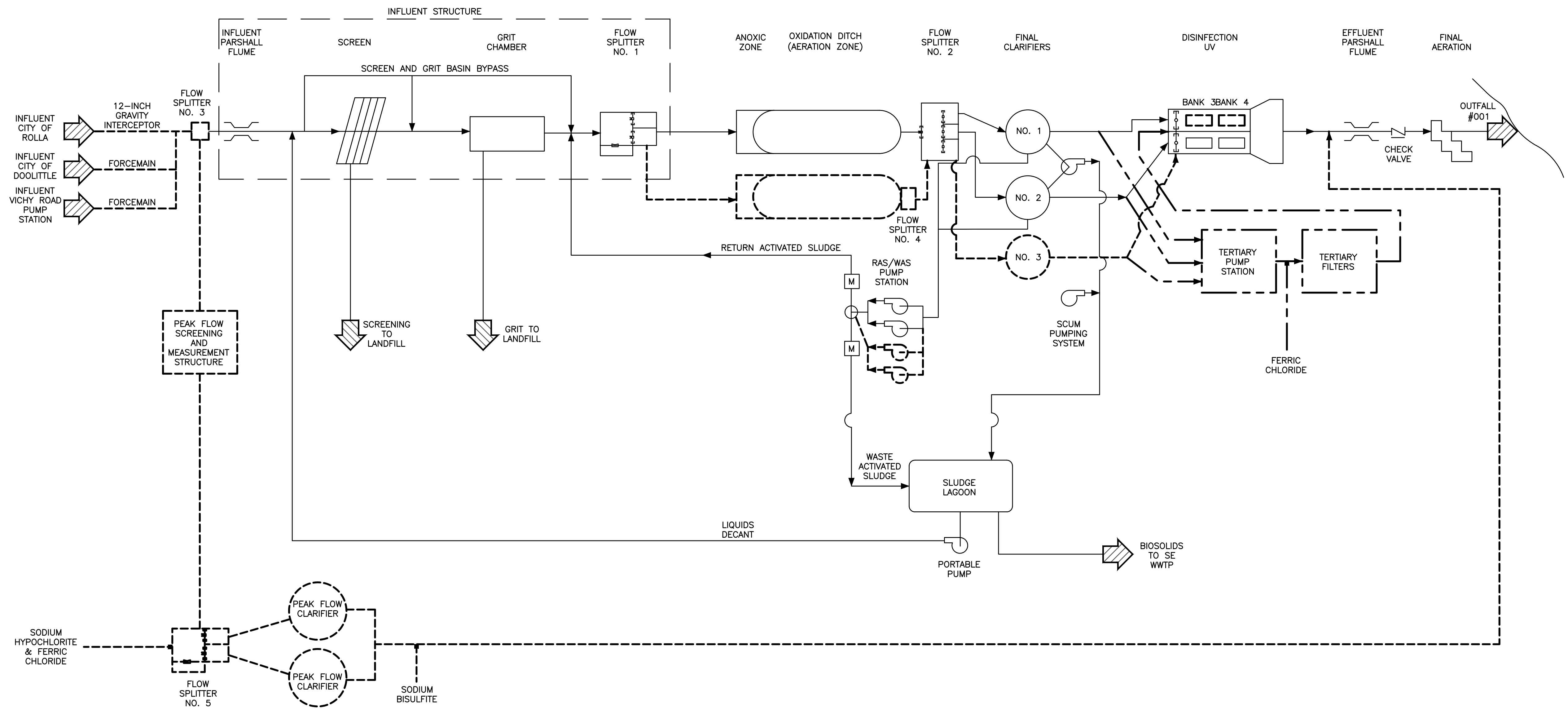
ROLLA WASTEWATER TREATMENT PLANT PER

SOUTHWEST FUTURE LAYOUT
ALTERNATIVE 2 PHASE 1 AND PHASE 2

PROJECT NO. 154630

DRAWING NO. 5-14



LEGEND

- PHASE 1
- PHASE 2
- EXISTING

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City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER TREATMENT PLANT PER

PROJECT NO. 154630

SOUTHWEST
FUTURE PROCESS FLOW DIAGRAM
ALTERNATIVE 2 PHASE 1 AND PHASE 2

DRAWING NO. 5-15

5.2.5 Vichy Road and Southwest WWTP Alternatives Summary

Table 5-2 summarizes the probable project costs for each alternative along with each phase. Based on this evaluation, the lower cost and preferred alternative is to construct a new Vichy Road WWTP (Alternative 1) instead of pumping Vichy Road flows to the Southwest WWTP.

Table 5-2. Vichy Road and Southwest WWTP Alternatives Summary of Probable Costs

Alternative 1- Peak Flow Disinfection and Nutrient Removal at Southwest WWTP and New Vichy Road 0.5 MGD WWTP		Phase 1- Disinfection and Ammonia(1)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
SW Plant Improvements Total	$3,843,000	$2,081,000	$1,763,000
New Vichy Road 0.5 MGD WWTP Total	$9,605,000	$7,847,000	$1,763,000
Alternative 1 Total	**$13,448,000**	**$9,928,000**	**$3,526,000**
Alternative 2- Pump Vichy Road to Southwest WWTP, Expand Southwest WWTP, and add Disinfection and Nutrient Removal Improvements			
Expansion of SW WWTP Total	$8,859,000	$6,407,000	$2,456,000
Vichy Road Forcemain and Pump Station Total	$7,946,000	$7,946,000	
Alternative 2 Total	**$16,805,000**	**$14,353,000**	**$2,456,000**

(1) Peak flow disinfection

5.3 Vichy Road WWTP Summary

Based on the capacity evaluations and future projections, the Vichy Road WWTP will need improvements in order to handle the projected future capacity and regulatory requirements over the 20 year project planning period. As previously described in Section 5.2 (Alternative 1), two different alternatives were evaluated regarding the treatment of Vichy Road WWTP flows. Based on this evaluation, a new Vichy Road 0.5 MGD WWTP is the preferred alternative (Alternative 1). The construction of a new Vichy Road WWTP will be split into specific phases to align with the projected capacity and regulatory requirements. Opinions of probable project costs were developed for each phase.

5.3.1 Phase 1 – Peak Flow Disinfection and Ammonia Removal

Phase 1 addresses near term compliance dates for the addition of peak flow disinfection and the elimination of wet weather outfalls (May 2021) at the WWTP. A full description of this phase is presented in Section 5.2.1. The estimated probable project cost for this phase is $7,847,000. The probable project cost was developed using the construction cost of the Southwest WWTP scaled from 2008 to 2017 dollars and addition of the peak flow disinfection facilities. A detailed cost estimate is presented in Appendix E, and a process flow diagram is shown above in Figure 5-11.

5.3.2 Phase 2 – Nutrient Removal

Phase 2 addresses nutrient removal which will need to be included within the 20 year project planning period though it is unknown at this time when nutrient limits will be required. A full description of the improvements needed for nutrient removal is presented in Section 5.2.2. The estimated probable project cost for this phase is $1,763,000. A detailed cost estimate is presented in Appendix E, and a process flow diagram is shown above in Figure 5-11.

5.4 Southwest WWTP Summary

As previously described in Section 5.3, the Southwest WWTP will not be expanded to accept the flows from Vichy Road. Based on the capacity evaluations and future projections for the Southwest WWTP, the WWTP will need improvements in order to handle the projected future capacity and regulatory requirements over the 20 year project planning period. These improvements have been split into specific phases to align with the projected capacity and regulatory requirements. Opinions of probable project costs were developed for each phase.

5.4.1 Phase 1 – Peak Flow Disinfection

Phase 1 addresses near term compliance dates for the addition of peak flow disinfection (May 2021) at the WWTP. A full description of this phase is presented in Section 5.2.1. The estimated probable project cost for this phase is $2,081,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown above in Figure 5-9 and Figure 5-10, respectively.

5.4.2 Phase 2 – Nutrient Removal

Phase 2 addresses nutrient removal which will need to be included within the 20 year project planning period though it is unknown at this time when nutrient limits will be required. A full description of the improvements needed for nutrient removal is presented in Section 5.2.2. The estimated probable project cost for this phase is $1,763,000. A detailed cost estimate is presented in Appendix E, and layout and process flow diagrams are shown above in Figure 5-9 and Figure 5-10, respectively.

6 Cost Summary

6.1 Phase 1 and 2 Cost Summary- All WWTPs

Opinions of probable project cost have been prepared for the improvements previously discussed. The estimates have been prepared through reference to other similar projects. All costs are presented in 2017 dollars, and should be escalated to the mid-point of construction once a schedule has been established. Table 6-1 presents a summary of the probable project costs for the preferred alternatives as indicated by the City. A detailed cost estimate is presented in Appendix E.

Table 6-1. Summary of Probable Project Costs for Preferred Alternatives

Vichy Road WWTP Summary(1)		Phase 1- Disinfection and Ammonia Removal (2)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
New Vichy Road 0.5 MGD WWTP	**$9,605,000**	**$7,847,000**	**$1,763,000**

(1)Alternative 1 (new Vichy Road WWTP in lieu of pumping Vichy Road flows to the Southwest WWTP)
(2)Peak flow disinfection

Southeast WWTP Summary(1)		Phase 1- Disinfection and Ammonia Removal (2)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
Add Peak Flow Disinfection, Ammonia Removal, Replace West Plant and Nutrient Removal Improvements	**$27,593,000**	**$16,949,000**	**$10,646,000**

(1)Phasing Alternative 1 (addition of a second oxidation ditch, third secondary clarifier, and expansion of existing sludge lagoon during Phase 1)
(2)Peak flow disinfection

Southwest WWTP Summary(1)		Phase 1- Disinfection (2)	Phase 2- Nutrient Removal
Item	**Total Cost**	**Total Cost**	**Total Cost**
Southwest WWTP Improvements	**$3,843,000**	**$2,081,000**	**$1,763,000**

(1)Alternative 1 (Southwest WWTP flows only; no Vichy Road flows)
(2)Peak flow disinfection

6.2 Initial Project Cost Summary

An initial Phase 1 project was outlined in order to meet the most immediate needs regarding peak flow disinfection and ammonia removal for the Southeast and Vichy Road WWTPs. Table 6-2 presents probable project costs for the initial Phase 1 project. The

Southwest WWTP improvements are a lower priority due to the WWTPs ability to treat near term projected flows, and thus is not included in the initial project below.

Table 6-2. Summary of Probable Project Costs for Initial Phase 1 Project

Item	Southeast WWTP	Vichy Road WWTP	Total Cost
Phase 1	**$16,949,000**	**$7,847,000**	**$24,796,000**

7 Financing and Implementation

7.1 Financing and Impact on Ratepayers

The City is in the process of revising their sewer user charge to include the establishment of a Sewer Availability Fee (SAF). The SAF is intended to cover the fixed cost associated with operating the sewer collection system. In addition to the SAF, a volumetric rate will cover the treatment cost per 1,000 gallons of usage.

The City intends to finance the Phase 1 improvements through either the MDNR State Revolving Fund or through private market Certificates of Participation. Revenues from the above described rate structure will provide the debt service for the selected financing. The proposed rate structure will be gradually implemented over the next four years such that the rate will be sufficient to cover full debt service upon construction completion in 2021. It is anticipated that some interim financing will be necessary to fund engineering design and property acquisition prior to permanent financing.

7.2 Schedule

As previously described in Section 6, an initial Phase 1 project was outlined for the Southeast and Vichy Road WWTPs. Table 7-1 presents the proposed Phase 1 project schedule. The Southwest WWTP improvements are a lower priority due to the WWTPs ability to treat near term projected flows, and thus is not included in the proposed project schedule below.

Table 7-1. Southeast and Vichy Road WWTP Phase 1 Proposed Project Schedule

Item	Date
Begin Vichy Road Site Selection	September 2017
SRF Application	November 2017
Begin Facility Plan and Design	March 2018
Bond Election	November 2018
Design Complete	March 2019
MDNR Approval	June 2019
Advertise Bids	June 2019
Open Bids	July 2019
Notice to Proceed	September 2019
Complete Vichy Road WWTP(1)	June 2021
Complete Southeast WWTP(1)	September 2021

(1)Beyond compliance date of May 2021. Extension to be negotiated.

Appendix A
Capacity Evaluation Design Memorandums

DESIGN MEMORANDUM

To:	File
From:	Ken Campbell, P.E.
Date:	May 2, 2017
Subject:	Rolla SE WWTP Capacity Evaluation

“West Plant” Capacity Analysis

Background:

The “West Plant” was developed in a number of discrete phases. First, a facility was constructed on the west bank of the Burgher Branch in the mid-1950s. The facility consisted of preliminary, primary and secondary treatment with anaerobic digestion of sludge. Secondary treatment consisted of a low rate trickling filter with rock media. In 1968, a suspended growth process was added due east of the trickling filter. The secondary treatment process was configured such that the trickling filter could be run in parallel or series with the Walker Process Unit that was installed. The Walker Process Unit consisted of aerobic tank, aerobic digester and secondary clarifier. In the early 1990s, a nitrification biotower and tertiary depth filtration process was installed on the east bank of the Burgher Branch to provide for nitrification. In 2000, construction of the “East Plant” was performed, during which the headworks and wet weather processes in the “West Plant” were upgraded. New screening equipment was installed for both the dry weather and wet weather treatment trains. A new flow diversion structure was constructed on the “West Plant” wet weather treatment train which provided for the redirection of influent flows from the “West Plant” to the “East Plant” for treatment. In 2012, a disinfection process was installed at the facility. During this project, the “West Plant” flow through the sand filter was removed. Flow was redirected around that facility and combined with “East Plant” mixed liquor immediately downstream of the “East Plant” oxidation ditches.

The permitted capacity of the entire facility (MO-0050652) is 4.765 MGD. The capacity for the West Plant was determined to be 2.64 MGD (WVP FP 1998).

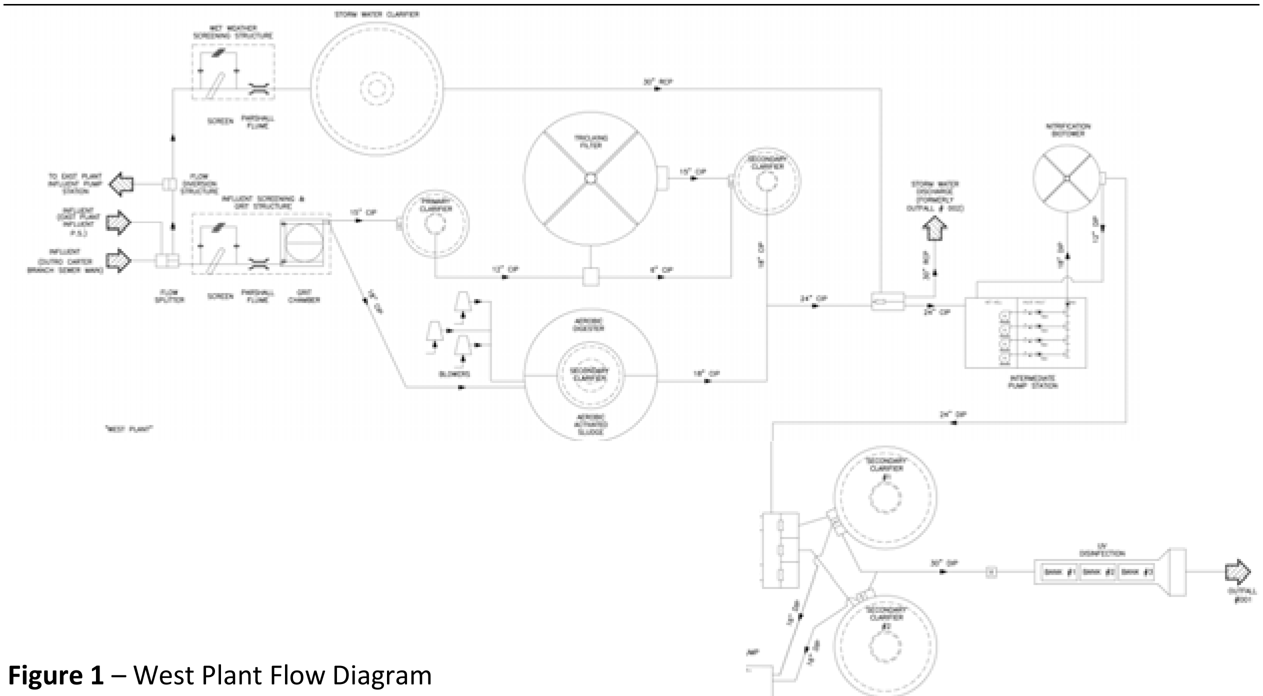

Figure 1 – West Plant Flow Diagram

Headworks Facility:

Screening: Mehcanical fine screen with 3/8” openings = 5.0 MGD (WVP O&M 2001)
Manual bar screen: -1 ½” x ¼” aluminum bar @ 1” cts.
(WVP 1970) - 45° Installation
-2’-9” channel depth

Grit Removal: 18’-0” x 18’-4” rectangular horizontal flow grit chamber (WVP 1970)
Effective depth = 1’-3”

Cross-sectional area, A_{CS} = (18’-4”)(1’-3”) = 22.9167 ft^2
Surface area, AS = (18’-4)(18’-0”) = 330 ft^2

Volume = 3,085 gal
Allowable hydraulic retention time, HRT_{allow} = 45 s *(M/E 5th Ed., T5-16)*

Q_{PHF} = Volume/HRT_{allow} = 3,085 gal / 45 s
= 68.55 gal s^{-1}
= 5.92 mgd

V_{PHF} = Q_{PHF} / A_{CS}
= 4,113 gpm / 22.9167 ft^2
= 0.4 fps

SOR $= QPHF / A_S$
$= (4{,}113\ gpm) / (330\ ft^2)$
$= 1.67\ ft^3 / ft^2\ min$

<u>Trickling Filter:</u>

Primary Clarifier: Primary clarifier diameter = 54'=0"
Primary clarifier SWD = 8'-0"

$SOR_{PHF} = 1{,}500\ gpd\ ft^2$ *(TSS T72.2)*
$SOR_{ADF} = 800\ gpd\ ft^2$ *(TSS T72.2)*

$$Q_{PHF} = (1{,}500\ gpd\ ft^{-2})\left[\frac{(54\ ft)^2}{4}\pi\right] = 3.44\ mgd$$

$$Q_{ADF} = (800\ gpd\ ft^{-2})\left[\frac{(54\ ft)^2}{4}\pi\right] = 1.83\ mgd$$

Trickling Filter: Trickling filter diameter = 142'-0" (WVP FP 1990)
Trickling filter surface area = $15{,}836.77\ ft^2$
Trickling filter SWD = 6'-0" (WVP FP 1990)

Media = Rock; 3 to 4" nominal diameter;
specific surface area = $15\ ft^2/ft^3$*; void space = 55*% (M/E 5th Ed., F9-2)

Media volume = *(TF surface area)(TF SWD)(Media void space)*
$= (15837\ ft^2)(6\ ft)(0.55)$
$= 52{,}262\ ft^3$

Ventilation = Natural draft

Hydraulic Loading Rate = $100\ gpd\ ft^{-2}$ *(M/E 5th Ed., F9-1)*
(slow rate, BOD Removal, wastewater load only)

Organic Loading Rate = $20\ lbs\ BOD\ 1000\ ft^{-3}$ *(M/E 5th Ed., F9-1)*

Recirculation Ratio = 1.0 *(M/E 5th Ed., F9-1)*

$$Q_{TF1} = (HLR)(SA) = (100\ gpd\ ft^{-2})(15{,}837\ ft^2) = 1{,}583{,}700\ gpd$$

$$ML_{BOD} = (OLR)(V_{media}) = (20\ lbs\ 1000\ ft^{-3})(52.262\ 1{,}000\ ft^3) = 1{,}045\ lbs\ d^{-1}$$

Secondary Clarifier: Secondary clarifier diameter = 42'-0" (WVP FP 1990)
Secondary clarifier SWD = 8'-0"
Secondary clarifier surface area = $1{,}385.44\ ft^2$

SOR_{PHF} = 706.8 gpd ft^{-2} *(M/E 5th Ed., F9-12)*
SOR_{ADF} = 353.4 gpd ft^{-2} *(M/E 5th Ed., F9-12)*

Q_{PHF} = (SOR_{PHF})(SC surface area) = (706.8 gpd ft^{-2})(1,385.44 ft^2) = 979,179 gpd
Q_{ADF} = (SOR_{ADF})(SC surface area) = (353.4 gpd ft^{-2})(1,385.44 ft^2) = 489,589 gpd

Secondary Treatment – Activated Sludge Unit:

Design Q_{ADF} = 1.8 MGD (WP O&M 1972)
Design QMD = 4.5 MGD (WP O&M 1972)

Design ML_{BOD} = 3,060 lbs BOD d^{-1} (WP O&M 1972)

Aeration Tank: Tank Volume = 451,313 gallons (WP O&M 1972)

$$Ex.VL = \frac{3{,}060\ lbs\ BOD\ d^{-1}}{60{,}336\ ft^3} = 50.7\ lbs\ BOD\ d^{-1}\ 1{,}000\ ft^{-3}$$

$$Ex.F/M = \frac{3{,}060\ lbs\ BOD\ d^{-1}}{(0.451\ MGal)(3{,}000\ mg\ L^{-1})(8.34\ \ lbs/(MGal\ mg\ L^{-1})} = 0.27\ d^{-1}$$

$$HRT = \frac{0.451\ MGal}{1.8\ MGD} = 0.25\ d = 6.0\ hrs$$

Air Delivery = 3,188 CFM (WP O&M 1972)

Secondary Clarifier: Tank Dia. = 77.5 ft (WVP 1970, 1992)
Tank Sidewater Depth = 15.0 ft

Weir length = 219.91

$$Ex.\ SOR_{ADF} = \frac{1{,}800{,}000\ gpd}{\left[\frac{(77.5\ ft)^2}{4}\pi\right]} = 381.6\ gpd\ ft^{-2}$$

$$Ex.SOR_{MD} = \frac{4{,}500{,}000\ gpd}{\left[\frac{(77.5\ ft)^2}{4}\pi\right]} = 953.93\ gpd\ ft^{-2}$$

$$Ex.\ SLR = \frac{1.8\ mgd(2.5 + 1.0)(3{,}000\ mg\ L^{-1})(8.34\ \ lbs/(MGal\ mg\ L^{-1}))}{\left[\frac{(77.5\ ft)^2}{4}\pi\right]} = 33.41\ lbs\ d^{-1}\ ft^{-2}$$

$$Ex.\ WLR = \frac{4{,}500{,}000\ gpd}{(219.91\ ft)} = 20{,}462.78\ gpd\ ft^{-1}$$

Aerobic Digester: Volume = 60,336 ft^3 (3.2 ft^3 per capita) (Walker O&M 1972)
Air Delivery = 1,180 CFM (20 cfm per 1000 ft^3) (Walker O&M 1972)

Intermediate Pump Station:

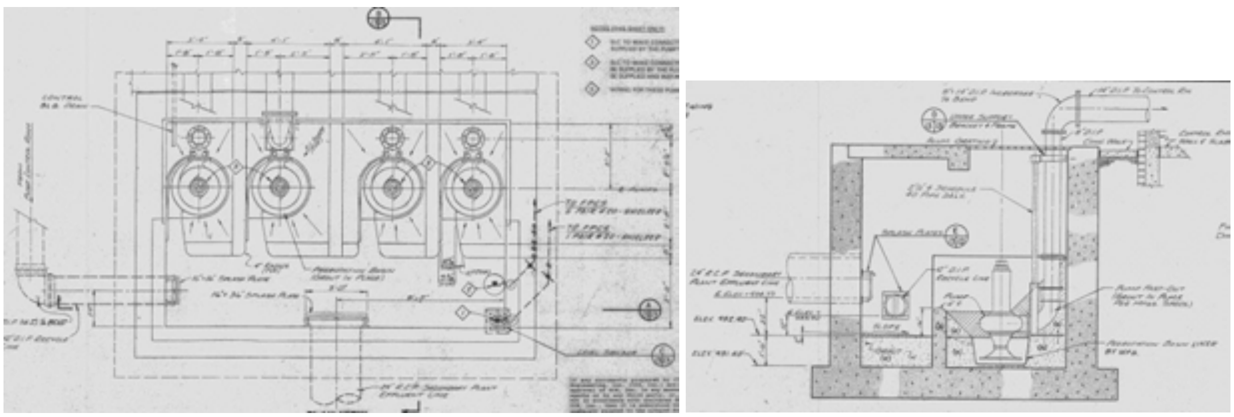

Figure 2 – Intermediate Pump Station – Plan and Typical Section (WVP 1992)

Number of Firm Pumps = 3 (WVP FP 1990)
Number of Standby Pumps = 1 (WVP FP 1990)
One (1) pump hydraulic capacity = 1,620 gpm (WVP FP 1990)
= 2.33 MGD
Three (3) pump hydraulic capacity = 4,860 gpm (WVP FP 1990)
= 7.0 MGD

Rated Head = 42 ft TDH (WVP FP 1990)

Nitrification Biotower: Diameter = 60.0 ft (WVP FP 1990)
Media Depth = 20.0 ft (WVP FP 1990)
Volume = 56,520 ft3 (WVP FP 1990)

Design media loading rate: BOD = 11.69 lbs 1,000 ft^{-3} (WVP FP 1990)
Ammonia = 5.84 lbs 1,000 ft^{-3} (WVP FP 1990)

Minimum Hydraulic Loading = 0.5 gpm ft^2 (WVP FP 1990)
= 1,413 gpm (WVP FP 1990)

Maximum Hydraulic Loading *= 1.72 gpm ft^2*
= 4,860 gpm (WVP FP 1990)

Influent BOD = 30 mg L^{-1} (WVP FP 1990)

Influent NH3-N = 15 mg L^{-1}	(WVP FP 1990)
Effluent BOD = 10 mg L^{-1}	(WVP FP 1990)
Effluent NH3-N = 2.0 mg L^{-1} (Summer)	(WVP FP 1990)
= 3.3 mg L^{-1} (Winter)	(WVP FP 1990)

<u>"West Plant" Wet Weather Treatment Train</u>

Flow enters the West Plant via the 24" Dutro Carter Branch Interceptor. Flow passes into the Influent Flow Splitter which redirects flow in excess of the West Plant capacity to a wet weather treatment train. Flow splitting is accomplished via a modulating weir gate.

Immediately downstream of the Influent Flow splitter is the Flow Diversion Structure which allows flows from the West Plant to be diverted and conveyed by gravity to the East Plant. This diversion structure was designed to split a maximum of 5.0 MGD to the East Plant. Flows in excess of 5.0 MGD are conveyed to a Wet Weather Screening Channel.

Flow sent to the Wet Weather Screening Channel passes through a mechanical screen where coarse solids are removed. The mechanical screen was rated to accommodate a peak flow of 13 MGD. The flowrate is measured downstream of the screen with an 18" Parshall flume.

The flow then passes to the Stormwater Clarifier (SC) for BOD and TSS removal via a 30 in DIP. Discharge from the SC is conveyed to a flow diversion structure and subsequently discharged to the Dutro Carter Branch. The Love Branch discharge was previously permitted as Outfall #002. Based on facility planning documentation and construction plan data, it would appear that the high water level for the West Plant SC is 954.00 ft. The top of structure is 956.00 ft.

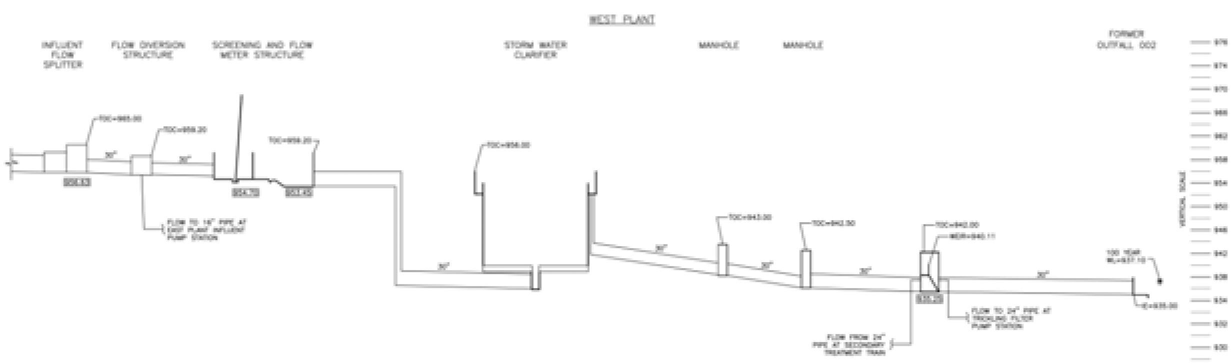

Figure 3 – Hydraulic Profile for "West Plant" Wet Weather Treatment Train

Flow Diversion Structure: Design Capacity = 5.0 MGD	(WVP O&M 2001)
Wet Weather Screening Channel:	
Mechanical Screen: Max. Hydraulic Capacity = 13.0 MGD	(WVP O&M 2001)
Parshall Flume, 18": Max Hydraulic Capacity = 15.87 MGD	*(Isco)*
Stormwater Clarifier:	
Diameter: 110.0 ft	(WVP 1992, 2000)
Sidewater Depth: 10 ft	

Surface area = 9,503.32 ft^2
Volume = 710, 848.2 gal

Weir Length = 314.16 ft

Max Cap, SOR = (2,000 gpd ft^2)(9,503.32 ft^2) = 19.00 MGD (TSS T72.2)
Max Cap, WLR = (30,000 gpd ft^{-1})(314.16 ft) = 9.43 MGD (TSS 74.43)

HRT @ Max Cap, SOR = 0.90 hrs
HRT @ Max Cap, WLR = 1.81 hrs

<u>"East Plant" Capacity Analysis</u>

<u>Background:</u>
The "East Plant" is located on the east bank of the Burgher Branch in Rolla, Missouri. The facility receives flow from both the Love Branch and Burgher Branch sanitary sewer mains. Flow from the Love Branch sewer main is diverted at the headworks of the "West Plant" and sent to the "East Plant" for treatment via an inverted siphon present beneath the Burgher Branch.

The East Plant was originally constructed in 2000-2001. It consisted of preliminary and secondary treatment. Preliminary treatment included screening with mechanical fine screens and grit removal with a horizontal flow grit chamber. Secondary treatment consisted of two oxidation ditches and one secondary clarifier. The anticipated total capacity of the East and West Plants was 4.25 MGD. Both the East and West Plants were assumed to have a design capacity of 2.125 MGD. The maximum hourly dry weather flow to each facility was determined to be 5.0 MGD. The maximum wetweather flow capacity at each plant was 18 MGD. Design influent BOD and TSS concentrations were taken to be 132 and 146 mg L^{-1}, respectively.

Improvements to the facility were made in 2012 to accommodate new disinfection requirements for the facility. Improvements included the consolidation of East and West Plant flows, construction of a new secondary clarifier, and Ultraviolet disinfection process.

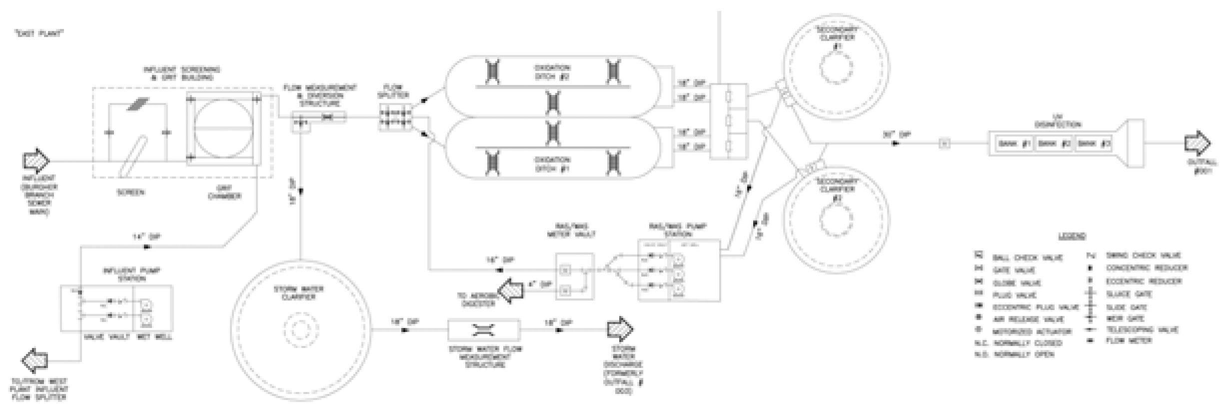

Figure 4 – East Plant Flow Diagram

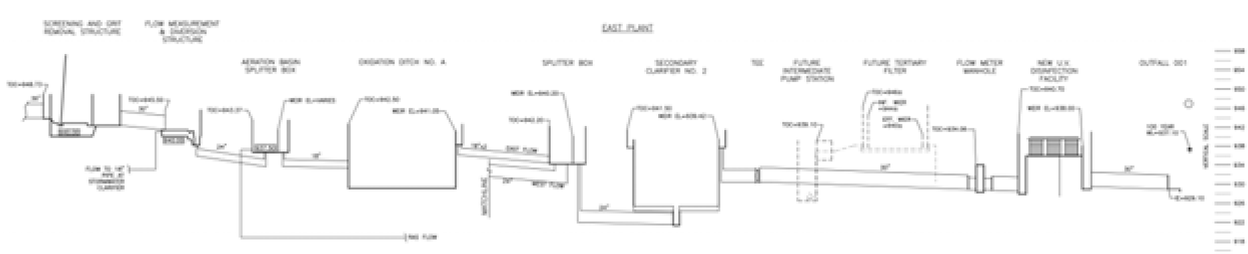

Figure 5 – East Plant Dry Weather Hydraulic Profile: Headworks to Flow Diversion Structure

Headworks Facility:

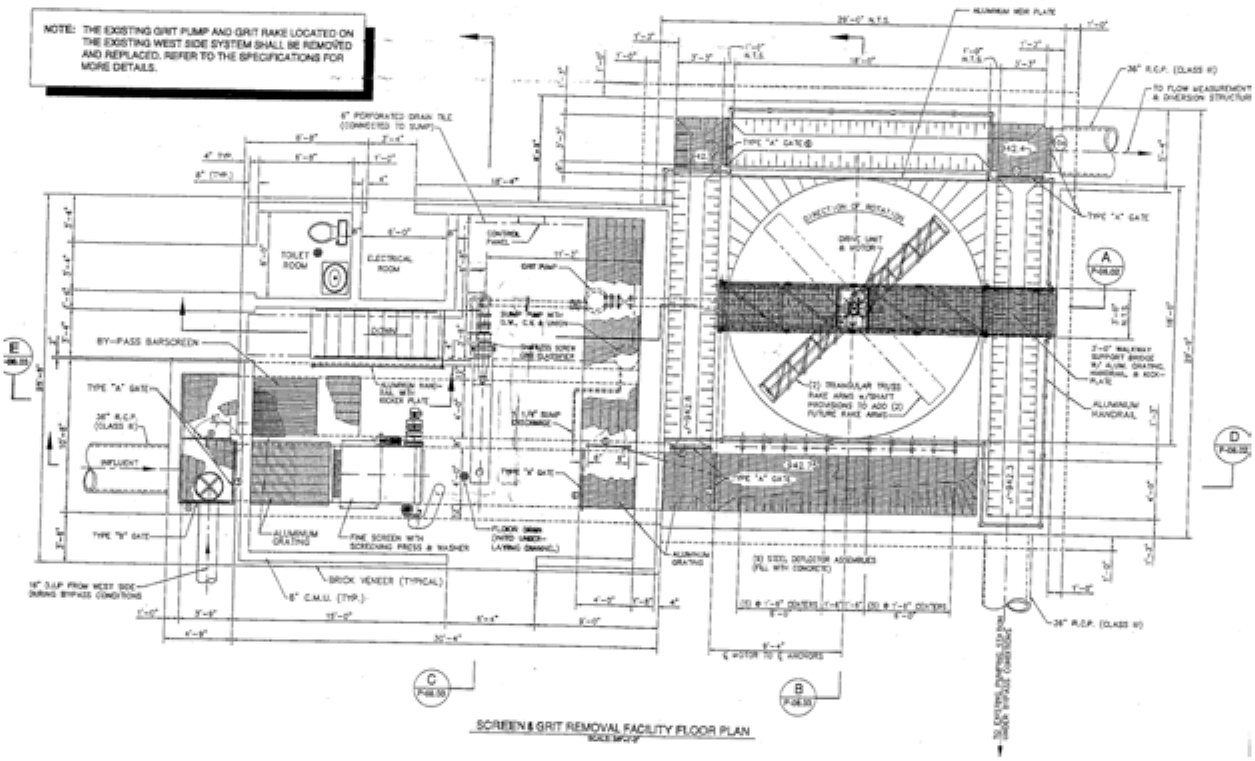

Figure 6 – East Plant Headworks Facility Plan

Screening:	Fine Screen with 3/8" openings = 18.0 MGD	(WVP O&M 2001)
	Channel width = 4 ft	(WVP 2000)
	Channel depth = 6.5 ft	(WVP 2000)
Grit Removal:	Horizontal flow grit chamber	(WVP O&M 2001)
	Tank size: 18 ft by 18 ft	(WVP O&M 2001)
	Tank surface area = 324 ft^2	(WVP O&M 2001)
	Surface overflow rate/Anticipated grit removal:	
	At 2.125 MGD = 6,559 gpd ft^2 / 225 mesh	(WVP O&M 2001)
	At 5.0 MGD = 15,432 gpd ft^2 / 225 mesh	(WVP O&M 2001)
	At 18 MGD = 55,555 gpd ft^2 / 225 mesh	(WVP O&M 2001)
	Grit pump = 200 gpm at 40 ft TDH	(WVP O&M 2001)

Grit Classification: Vortex-style grit separator.

Flow Measurement and Diversion Structure:

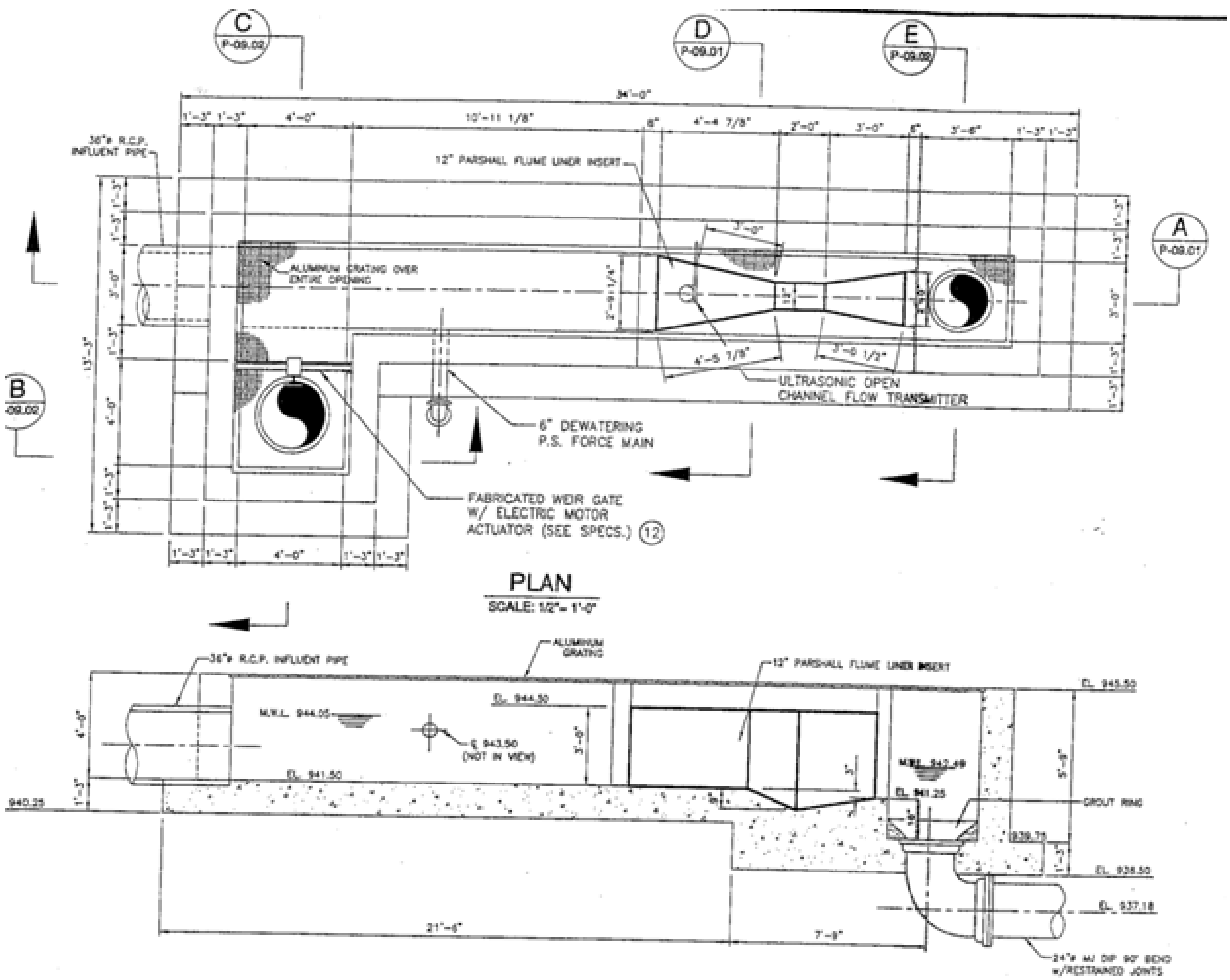

Figure 7 – Flow Measurement and Diversion Structure: Plan and Longitudinal Section

The flow measurement and diversion structure was designed to convey 5.0 MGD to the secondary treatment process. Any flows in excess of 5.0 MGD were to be diverted and conveyed to the Stormwater Tank

Parshall Flume, 12 inch: 10.43 MGD (Max)		*(Isco)*
Stormwater Tank Flow Diversion:	4 ft wide weir gate	(WVP 2000)
	Bottom of weir travel = 941.50	(WVP 2000)
	Top of weir travel = 943.50	(WVP 2000)
	Design WSE = 944.05	(WVP 2000)
	Max capacity at design WSE = 35.1 MGD	

Secondary Treatment – Oxidation Ditch:

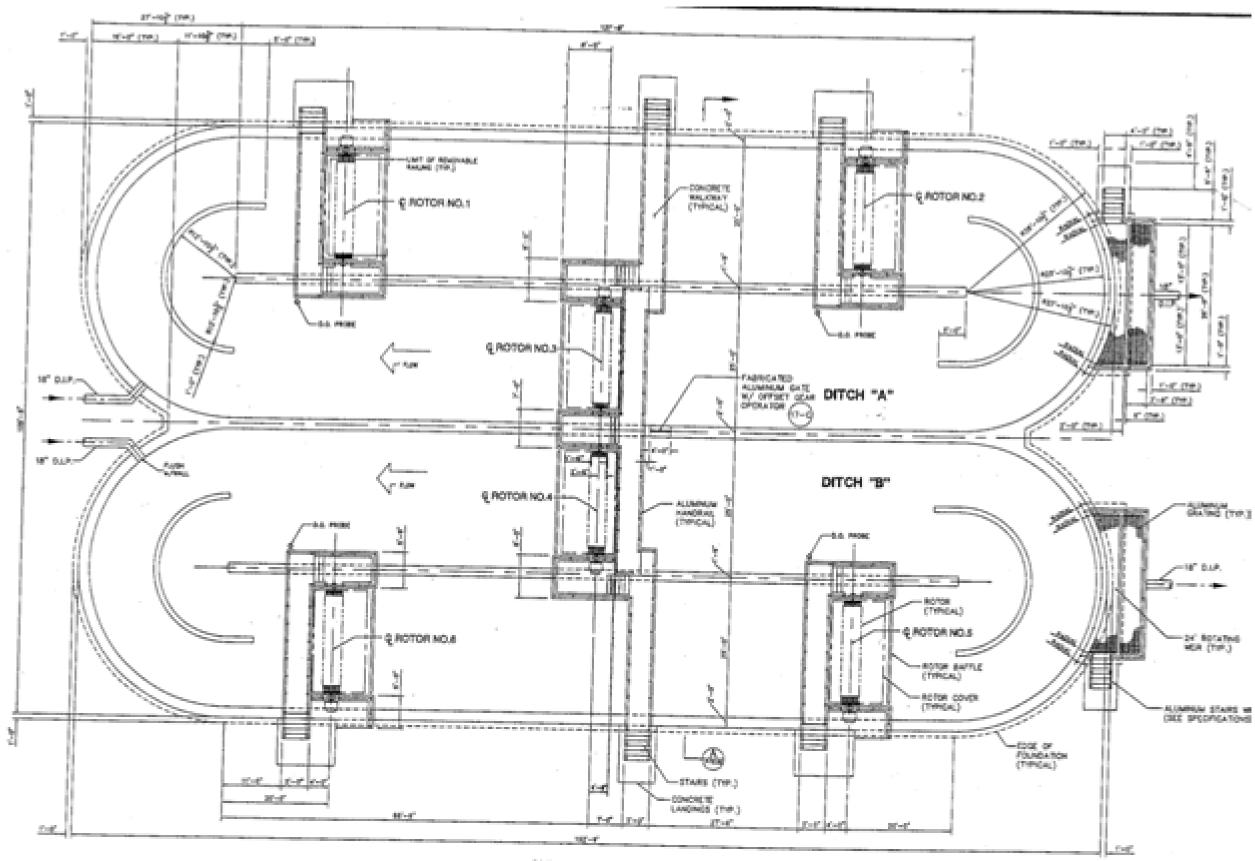

Figure 8 – Oxidation Ditch: Plan

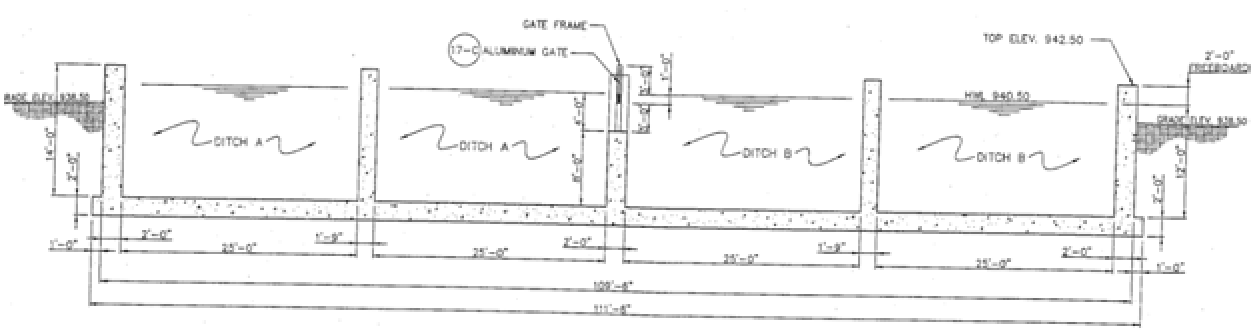

Figure 9 – Oxidation Ditch: Typical Transvers Section

Number of ditches = 2 (WVP 2000)

Ditch Length = 188 ft	(WVP O&M 2001)
Ditch Width = 25 ft	(WVP O&M 2001)
Ditch Sidewater Depth = 12 ft	(WVP O&M 2001)
Ditch volume = 798,200 gallons	(WVP O&M 2001)
Total aeration basin volume = 1,596,400 gallons	(WVP O&M 2001)
Design organic loading = 11.0 lbs cBOD per 1,000 ft^3	(WVP O&M 2001)
Hydraulic Retention Time = 18.00 hrs	(WVP O&M 2001)
Number of Rotors = 6	(WVP O&M 2001)
Rotor Length = 18 ft	(WVP O&M 2001)

Secondary Treatment – Secondary Clarifiers:

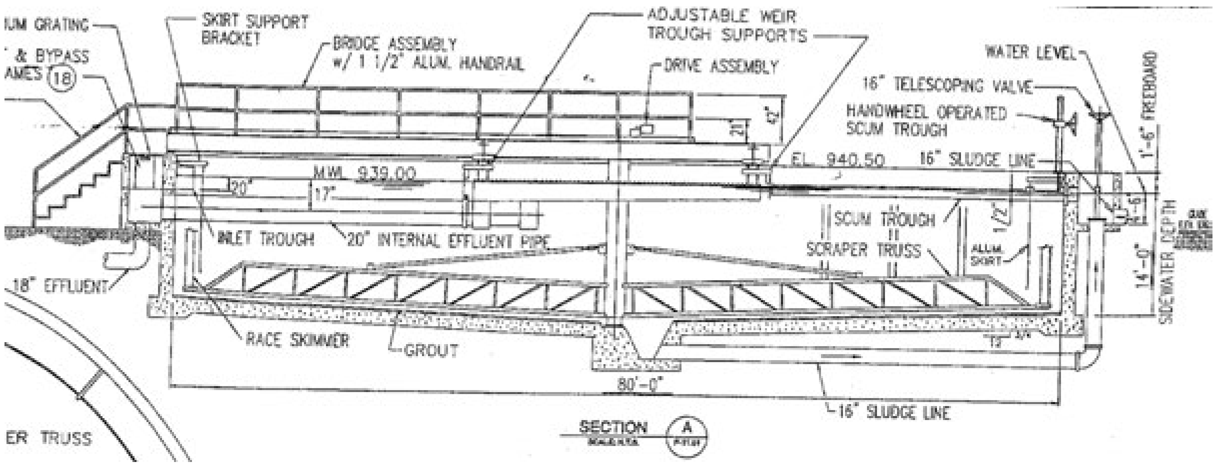

Figure 10 – Clarifier #1 typical Section

Note: Existing conditions are that secondary clarifier effluent from the "West Plant" are blended with the east plant mixed liquor, resulting in a reduced solids loading on the clarifiers. For future conditions, it was anticipated that a third clarifier would be required at the facility. Mixed liquor from a new treatment train would be blended with mixed liquor from the existing secondary treatment train resulting in normal solids loading rate.

Secondary Clarifier #1:	Diameter = 80.0 ft	(HDR 2012/2014)
	Surface Area = 5026.55 ft^2	(HDR 2012/2014)
	Sidewater Depth = 14.0 ft	(HDR 2012/2014)
	Weir Length = 232 ft	
	SOR_{ADF} = 468 gpd ft^{-2} (Existing)	(HDR 2012/2014)
	= 312 gpd ft-2 (Future)	(HDR 2012/2014)
	SOR_{MD} = 981 gpd ft^{-2} (Existing)	(HDR 2012/2014)
	= 655 gpd ft-2 (Future)	(HDR 2012/2014)
	SLR = 21.6 lbs d^{-1} ft^2 (Existing)	(HDR 2012/2014)
	= 32.8 lbs d^{-1} ft^2 (Future)	(HDR 2012/2014)
	WLR_{MD} = 21,271 gpd ft^{-1} (Existing)	(HDR 2012/2014)
	= 14,181 gpd ft^{-1} (Future)	(HDR 2012/2014)

Future Condition Assumptions: Q_{ADF} = 4.7 MGD
Q_{PHF} = 10.0 MGD
MLSS = 3,500 mg L^{-1}
R = 150%

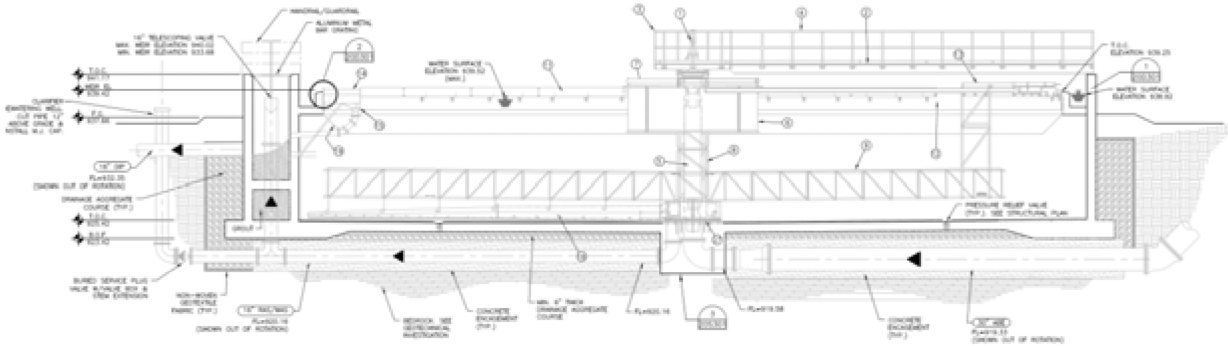

Figure 11 – Clarifier #2 typical Section

Secondary Clarifier #2: Diameter = 85.33 ft (HDR 2012/2014)
Sidewater Depth = 14.0 ft (HDR 2012/2014)
Weir Length = 251.3 ft (HDR 2012/2014)

SOR_{ADF} = 410 gpd ft^{-2} (Existing) (HDR 2012/2014)
= 273 gpd ft^{-2} (Future) (HDR 2012/2014)

SOR_{MD} = 863 gpd ft^{-2} (Existing) (HDR 2012/2014)
= 575 gpd ft^{-2} (Future) (HDR 2012/2014)

SLR = 21.6 lbs d^{-1} ft^2 (Existing) (HDR 2012/2014)
= 25.2 lbs d^{-1} ft^2 (Future) (HDR 2012/2014)

WLR_{MD} = 21,552 gpd ft^{-1} (Existing) (HDR 2012/2014)
= 14,181 gpd ft^{-1} (Future) (HDR 2012/2014)

Future Condition Assumptions: Q_{ADF} = 4.7 MGD
Q_{PHF} = 10.0 MGD
MLSS = 3,500 mg L^{-1}
R = 150%

<u>Secondary Treatment – RAS/WAS Pump Station:</u>

Number of pumps = 3
Pump Rated Capacity = 1,100 gpm
Pump Rated Head = 20 ft TDH
Pump Motor Power = 10 Hp

Disinfection – Ultraviolet Disinfection:

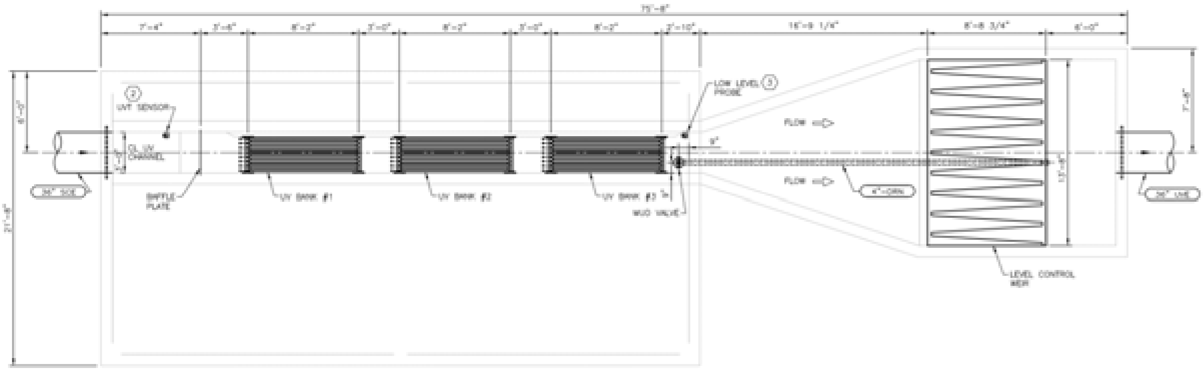

Figure 12 – Ultraviolet Disinfection Process - Plan

Peak Flow = 10.0 MGD
Average Daily Flow = 4.7 MGD

TSS ≤ 30 mg L^{-1}
Design Transmittance = 60% at 253.7 nm
Dose – T1 phage = 17.5 mJ cm^{-2}

Firm Banks = 2
Standby Banks =1

<u>"East Plant" Wet Weather Treatnment Train</u>

Flow enters the East Plant via the 36" Burgher Branch Interceptor. It passes through a screening and grit removal facility and is conveyed to the Flow Measurement and Diversion Structure. The screening facility consists of a continuous belt, perforated plate screen rated having a capacity of 18 MGD. The grit removal facility consists of a horizontal flow chamber rated to remove grit of 55 mesh or greater at 18 MGD. Flow in excess of the rated secondary treatment plant capacity are split at the Flow Measurement and Diversion Structure and sent to a SC. Flows are split via a motorized weir gate that can be modulated to control the amount of flow diverted to the SC.

The SC has a 105 ft diameter and an 11 ft sidewater depth. The SC was designed to provide a SOR of 1500 gpd ft^{-2} and a weir loading rate of 39,400 gpd ft^{-1}. The high-water elevation for the East Plant SC is 941.25. The top of structure is 943.25. During planning and design of disinfection improvements for the SE WWTP in 2012, the top of structure was surveyed and determined to be 943.78 ft.

Effluent from the SC is conveyed to a Flow Measurement Structure. The flow measurement structure contains an 18 in Parshall Flume. The structure discharges to the Burgher Branch. The discharge was previously permitted as Outfall #003.

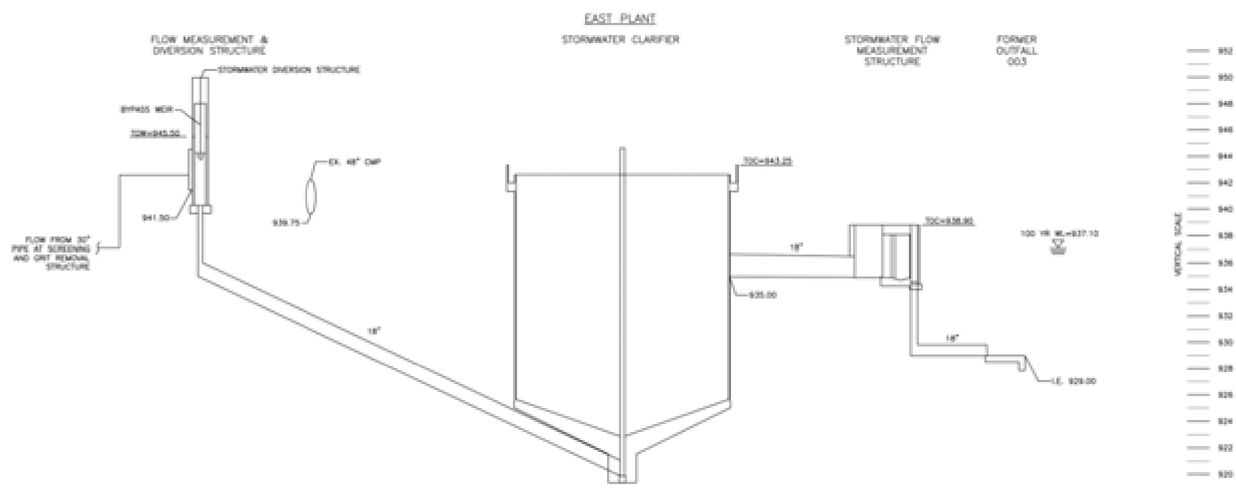

Figure 13 – East Plant Wet Weather Hydraulic Profile: Headworks to Flow Diversion Structure

Stormwater Clarifier:

Diameter = 105.00 ft	(WVP O&M 2001)
Sidewater Depth = 11.0 ft	(WVP O&M 2001)
Surface area = 8,659.01 ft^2	
Volume = 700,000 gal	(WVP O&M 2001)
Weir Length = 330.0 ft	(WVP O&M 2001)
Max Cap, SOR = (1,500 gpd ft^{-2})(8,659.01 ft^2) = 13.0 MGD	(WVP O&M 2001)

Max Cap, WLR = (39,400 gpd ft^{-1})(330.0 ft) = 13.0 MGD (WVP O&M 2001)

HRT @ Max Cap = 1.29 hrs

Storm Water Flow Measurement Structure:

Parshall Flume, 18" = 15.87 MGD *(Isco)*

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DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: May 4, 2017
Subject: Vichy Road WWTP Capacity Evaluation

Background

Prior to 1970, the Vichy Road WWTP (VR WWTP) consisted of an activated sludge plant. The facility was upgraded in 1970. The existing preliminary treatment process were not modified. The existing secondary treatment process was converted to provide primary treatment. A new Walker Process Sparjair contact stabilization activated sludge reactor and aerobic digester were constructed at the site. Between 1970 and 1996, a new storm water clarifier was constructed at the facility to ameliorate adverse effects of stormwater inflow and infiltration on the liquid treatment train performance. In 1996, the facility was improved to incorporate a new nitrifying trickling filter. Other improvements performed during this project included the installation of new influent screening and flow splitting and a new secondary clarifier to remove trickling filter solids from the liquid treatment train prior to discharge from the site.

The VR WWTP is currently permitted to treat (MO-0047031) a design flow of 0.40 MGD.

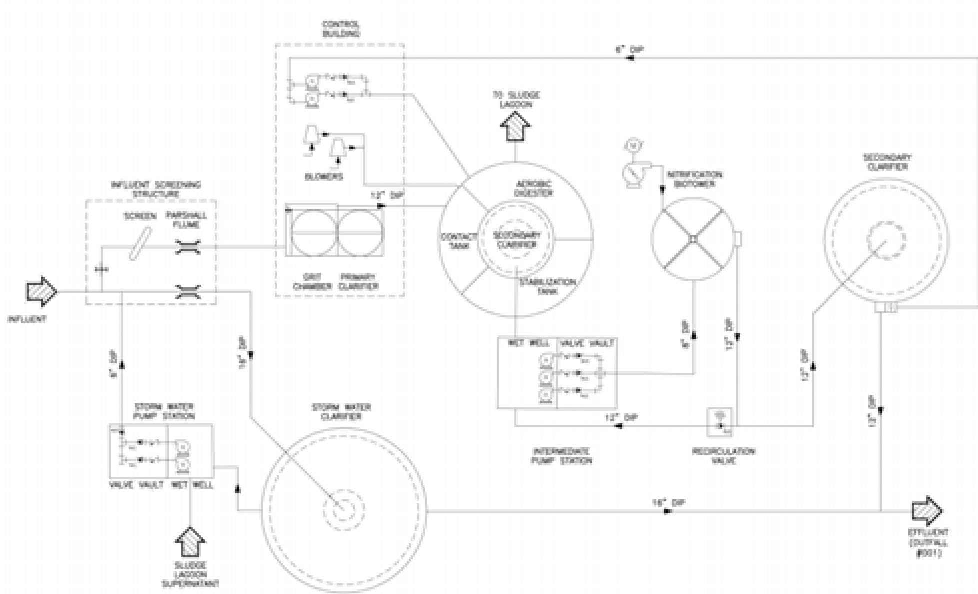

Figure 1 – Vichy Road WWTP Flow Diagram

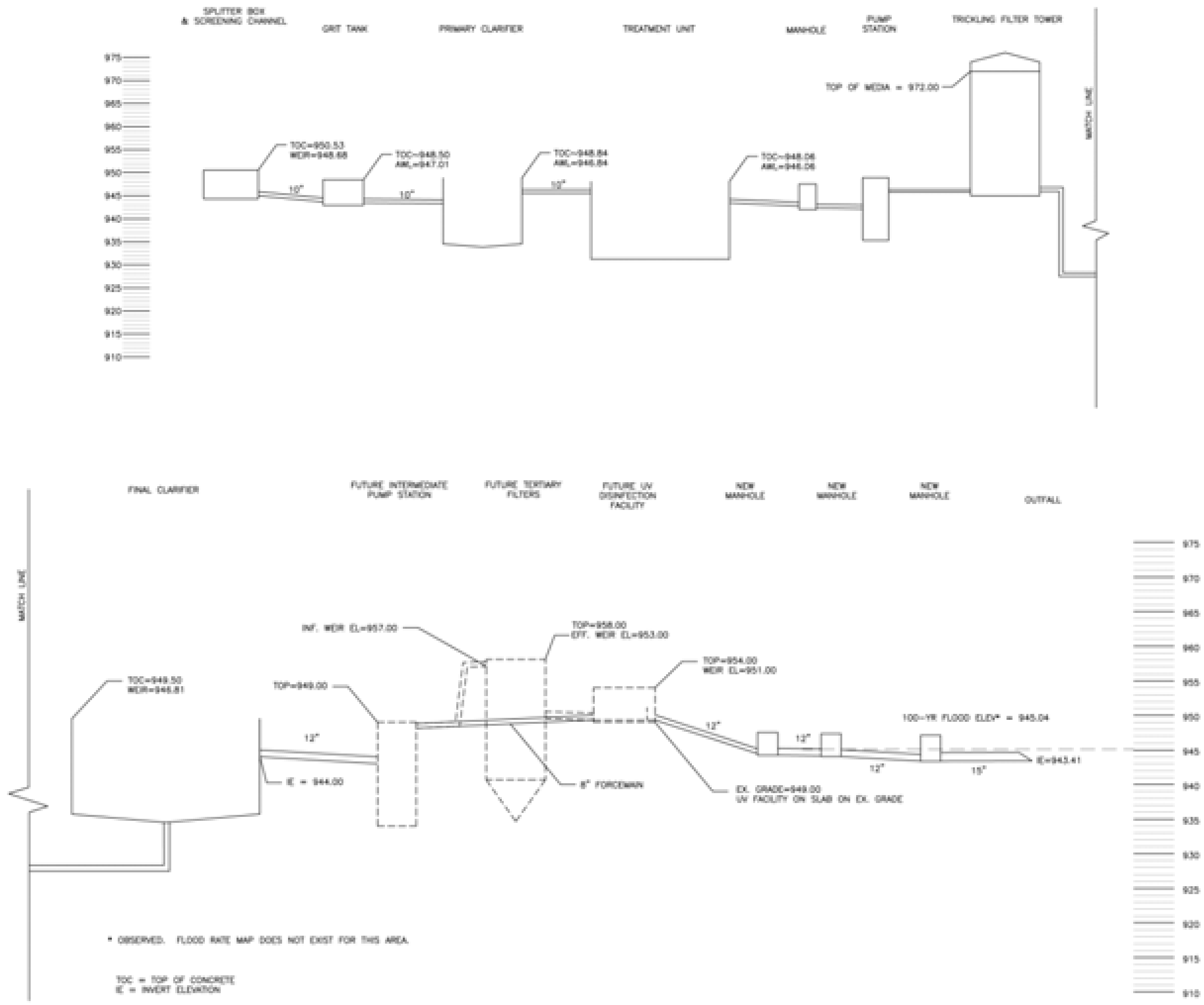

Figure 2 – Vichy Road WWTP Hydraulic Profile

Walker Process Sparjair Contact Stabilization Unit

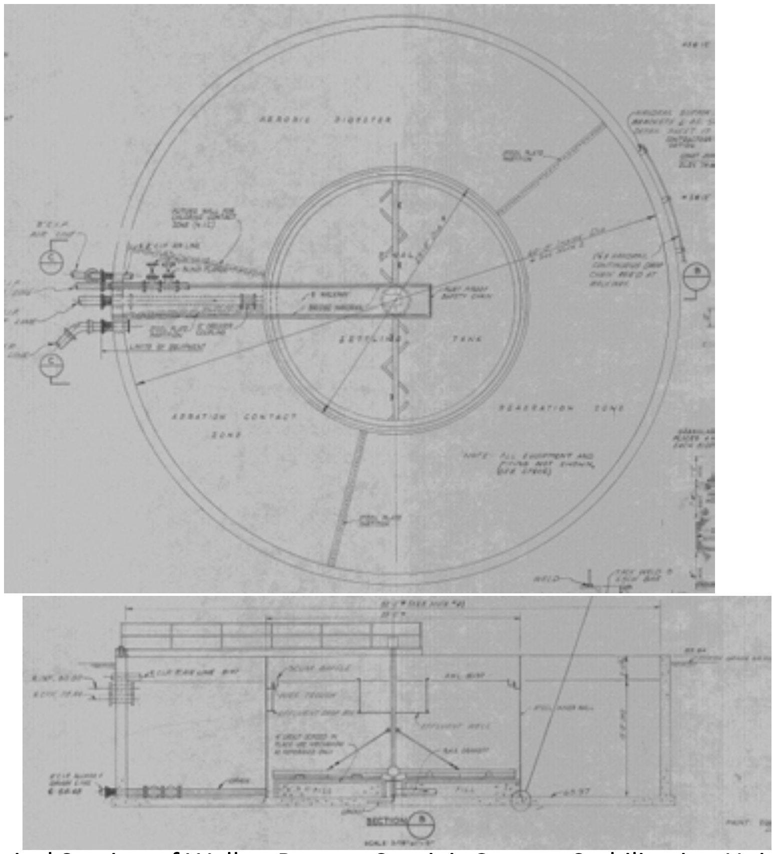

Figure 3 – Plan and Typical Section of Walker Process Sparjair Contact Stabilization Unit

Specified Flow Capacity = 0.40 mgd (WP 1969)

Secondary Treatment – Contact Stabilization Unit (CSU) Sedimentation Tank:

Diameter = 29.0 ft (WVP 1970)

Sidewater depth = 12.0 ft (WVP 1970)

Surface area = 660.52 ft^2

Volume = 59,288.28 gal

Weir length = 75.40 ft

SOR_{ave} = 618 gpd ft^{-2} (WP 1969)

SOR_{PHF} = 1,000 gpd ft^{-2} *(TSS 72.232)*

SLR = 40 lbs d ft^{-2} *(TSS 72.232)*

HRT_{ave} = 3.5 hr (WP 1969)

Max Cap @ SOR_{ave} = (618 gpd ft^{-2})(660.52 ft^2) = 408,201.40 gpd
Max Cap @ SOR_{PHF} = (1,000 gpd ft^{-2})(660.52 ft^2) = 660,520 gpd

Secondary Treatment – CSU Aeration Tank:

Contact Aeration Vol, V_{CA} = 6,590 ft^3	(WP 1969)
Contact Aeration Airflow Rate, AFR_{CA} = 157 SCFM	(WP 1969)
Reaeration Vol, V_{RA} = 13,100 ft^3	(WP 1969)
RAS Recycle Ratio, R = 100 %	(WP 1969)
RAS = 280.0 gpm	(WP 1969)
Hydraulic Retention Time, HRT_{ave+R} = 5.83 hr	(WP 1969)
Reaeration Airflow Rate, AFR_{RA} = 315 SCFM	(WP 1969)
Total air/lb BOD = 1,000 ft^3 lb^{-1}	(WP 1969)

<u>CSU - Aerobic Digester:</u>

Volumetric loading = 3.18 ft^3 percapita	(WP 1969)
Vol, V_{AD} = 12,700 ft^3	(WP 1969)
Air Delivery, AFR_{AD} = 254 SCFM	(WP 1969)

Nitrification Biotower:

Trickling Filter Pump Station:

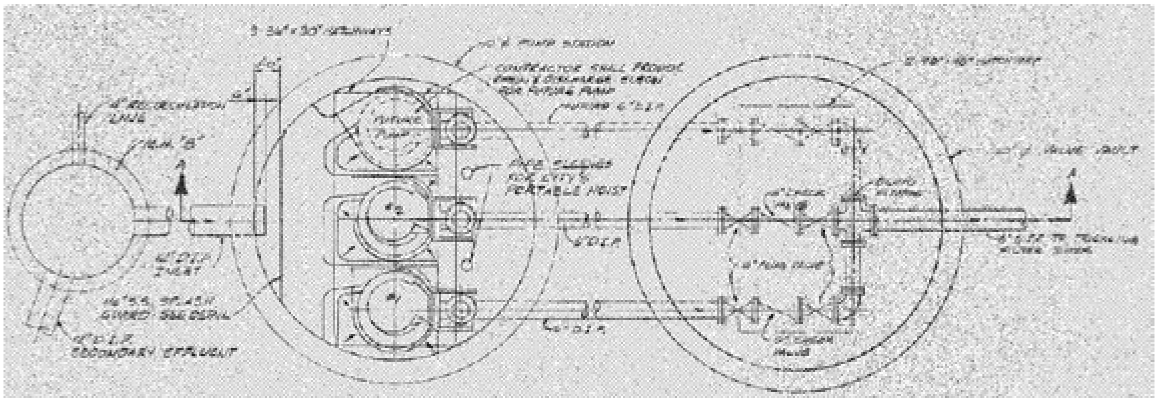

Figure 4– Trickling Filter Pump Station Plan

One pump capacity = x.xx gpm
Two pump capacity, parallel operation = x.xx gpm

Trickling Filter:

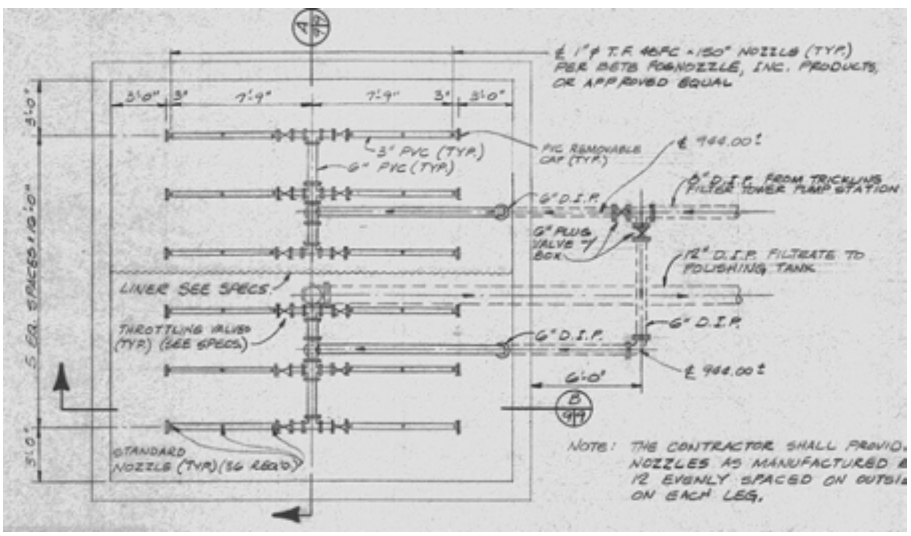

Figure 5 – Trickling Filter Plan

Filter surface area = 484.0 ft^2	(WVP 1996)
Filter height = 20.0 ft	(WVP 1996)
Filter media volume = 9,680 ft^3	(WVP 1996)
Filter media = 60° cross flow, specific surface area = 30 ft^2 ft^{-3}	(Assumed)
Total hydraulic loading (THL) rate = 2,160 gpd ft^{-2}	(MOP8 T13.26)
Recirculation ratio = 1.5	

Filter capacity, average daily flow = (THL)(Filter surface area) / (1.0 +R)
= (2,160 ft^{-2})(484.0 ft^2) / (1.0 + 1.5)
= 418,176 gpd

Ammonia-nitrogen loading rate = 0.5 lbs NH_3-N d^{-1} 1,000 ft^{-2} *(MOP8 T13.26)*
Media surface area = (Filter media volume)(Specific surface area)
= (9,680 ft3)(30 ft^2 ft^{-3})
= 290,400 ft^2

Filter capacity, max day NH_3-Nloading = (NL)(Media surface area)
= (0.5 lbs NH_3-N d^{-1} 1,000 ft^{-2})(290,400 ft^2/1000)
= 145.2 lbs d^{-1}

Forced air ventilation

Final Clarifier:

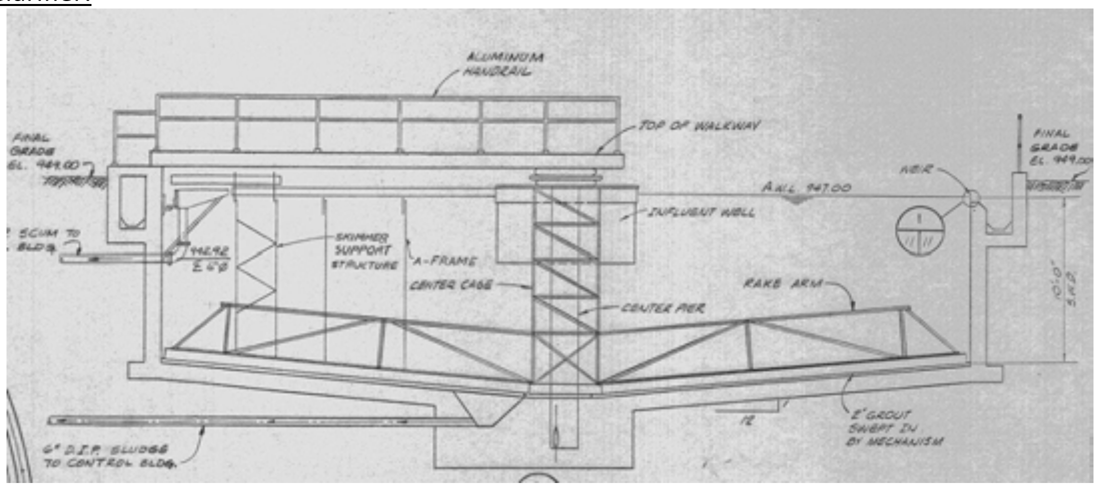

Figure 6 – Final Clarifier Typical Section

Diameter = 45.0 ft (WVP 1996)
Side water depth = 10.0 ft (WP 1969)

No recycled flows *(WP 1969)*

Surface area = 1,590.43 ft2
Volume = 118,964.26 gal

Weir Length = 141.37 ft

SOR_{ave} = 471 gpd ft^{-2} *(M/E 5th Ed, F9-12)*
SOR_{PHF} = 978 gpd ft^{-2} *(M/E 5th Ed, F9-12)*
WLR = 20,000 gpd ft^{-1} *(TSS72.43)*

Max Cap @ SOR_{ave} = (500 gpd ft^{-2})(1,590.43 ft^2) = 795,215 gpd
Max Cap @ SOR_{PHF} = (1,000 gpd ft^{-2})(1,590.43 ft^2) = 1,590,430 gpd

Max Cap @ WLR = (20,000 gpd ft^{-1})(141.37 ft) = 2,827,400 gpd

Stormwater Clarifier:

Diameter = 50.0 ft (WVP 1996)
Side water depth = 10.0 ft (Assumed)

Surface area = 1,963.5 ft2
Volume = 146,869.8 gal

Weir Length = 138.23 ft

SOR_{ave} = 1,000 gpd ft^{-2} (TSS T72.21)
SOR_{PHF} = 2,000 gpd ft^{-2} (TSS T72.21)
WLR = 20,000 gpd ft^{-1} (TSS T72.43)

Max Cap @ SOR_{ave} = (1,000 gpd ft^{-2})(1,963.5 ft^2) = 1,963,500 gpd
Max Cap @ SOR_{PHF} = (2,000 gpd ft^{-2})(1,963.5 ft^2) = 3,927,000 gpd
Max Cap @ WLR = (20,000 gpd ft^{-1})(138.2 ft) = 2,764,000 gpd

References:

1. Sparjair Contact Stabilization Plant Specifications, Walker Process Equipment, 1969
2. Sewerage Improvements: Division “C - Sewage Treatment Facilities, WVP, Inc., 1970
3. Vichy Road Wastewater Treatment Plant Improvements, WVP, Inc., 1996

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DESIGN MEMORANDUM

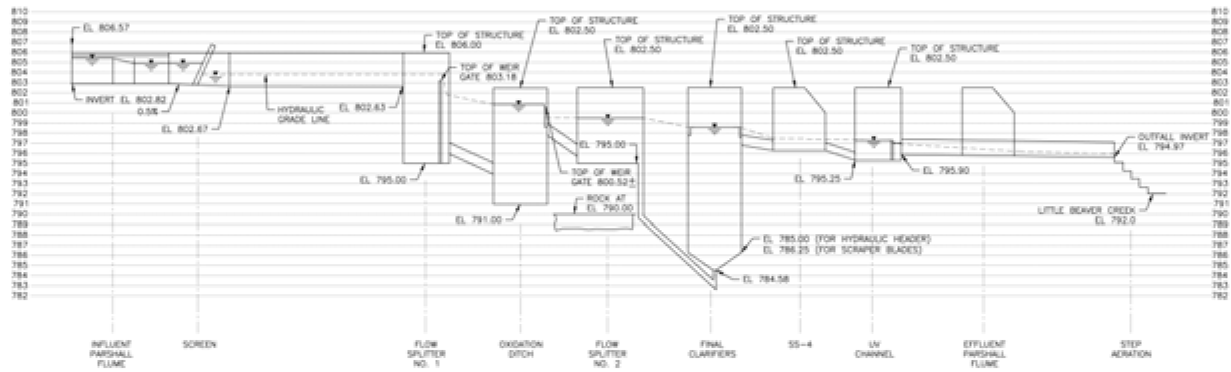
To: File
From: Ken Campbell, P.E.
Date: May 4, 2017
Subject: Capacity Assessment for Existing Southwest Wastewater Treatment Plant

Background

The Southwest Wastewater Treatment Plant (SW WWTP) was constructed in 2007. It consists of the following unit processes: preliminary treatment; secondary treatment; and disinfection. Preliminary treatment involves removal of coarse solids by single mechanical fine screen. Secondary treatment consists of a suspended growth process with biological nutrient removal. An oxidation ditch with a preannoxic zone was constructed, with internal recycle being achieved via circulation of mixed liquor through the main ditch channel. Two secondary clarifiers were constructed to provide liquid solids separations. An ultraviolet disinfection process was selected for inactivation of pathogens present in secondary clarifier effluent.

Accommodations were made in the initial design of the facility to accommodate future growth. Room on the site was provided for a second oxidation ditch and third secondary clarifier. Construction of these units would effectively double the capacity of the facility. It was also planned that the existing contact stabilization tank could be converted and utilized as a peak flow clarifier in the future. All process piping necessary to implement these future improvements to the facility were installed during construction of the existing facility.

The permitted capacity of the SW WWTP (**MO-0047023**) is 1.0 MGD.



EXISTING HYDRAULIC PROFILE
NOTE: Q = PEAK HOUR FLOW

Figure 1 – Hydraulic Profile

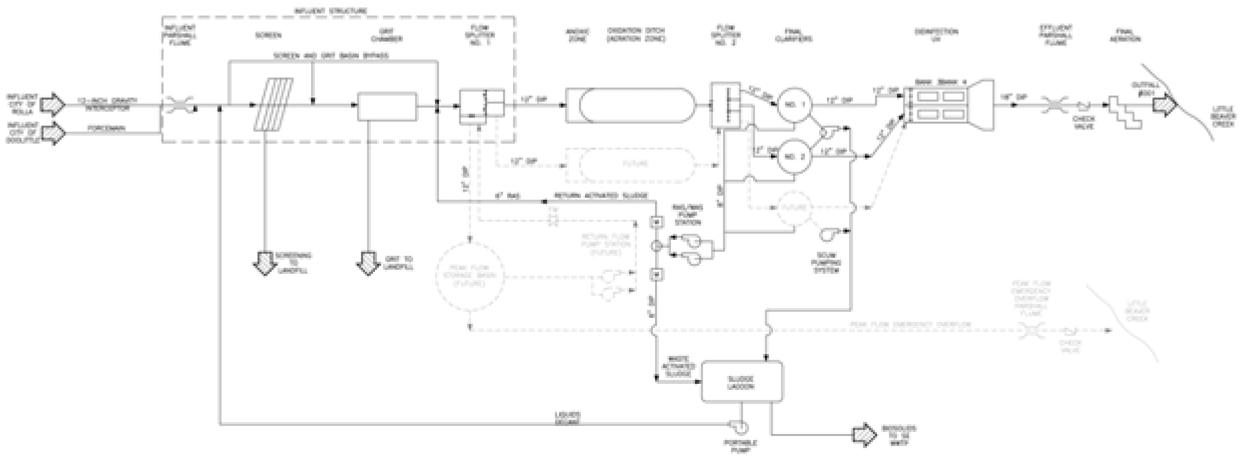


Figure 2 – Flow Diagram

Influent Structure

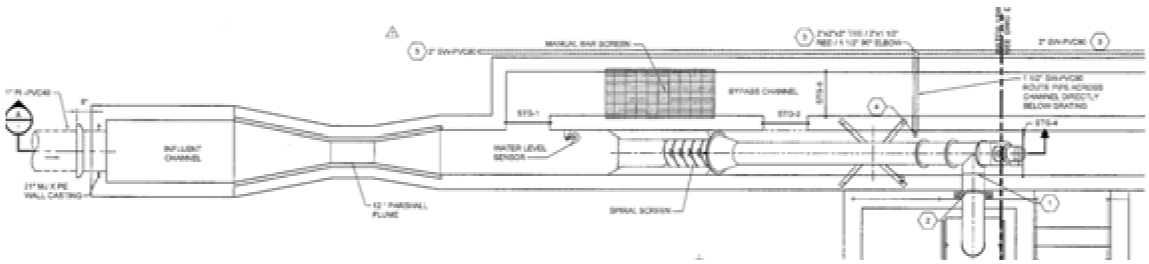


Figure 3– Influent Structure - Plan

Parshall Flume, 12 " :	*Peak Flow Capacity = 10.43 MGD*		*(Isco)*
Parkson Hycor Spiral Screen:	Peak Flow Capacity = 3.6 MGD		(B&M FP 2005)
Flow Splitter No. 1:	Oxidation Ditch #1:	2 ft wide weir gate	(B&M 2008)
		Top of weir travel = 803.18	(B&M 2008)
		Bottom of weir travel = 802.63	(B&M 2008)
		Max capacity at design WSE ≈ 5.1 MGD	
	Oxidation Ditch #2;	2 ft wide weir gate (Future)	(B&M 2008)
		Top of weir travel = 803.18	(B&M 2008)
		Bottom of weir travel = 802.63	(B&M 2008)
		Max capacity at design WSE ≈ 5.1 MGD	
	Peak Flow Clarifier:	2 ft wide contracted weir	(B&M 2008)
		End contraction length = 2 ft	(B&M 2008)
		Weir Crest = 803.78	(B&M 2008)
		Weir Height = 0.234 ft	(B&M 2008)

Process Piping: 12" DIP, I.D. = 12.64", *V_{max} = 6.39 fps*

Secondary Treatment – Oxidation Ditch

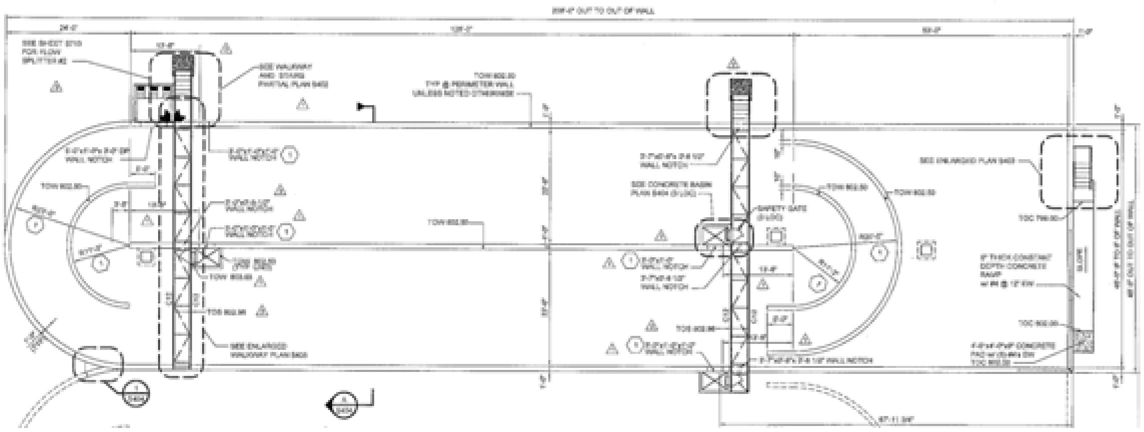


Figure 4 – Oxidation Ditch – Plan

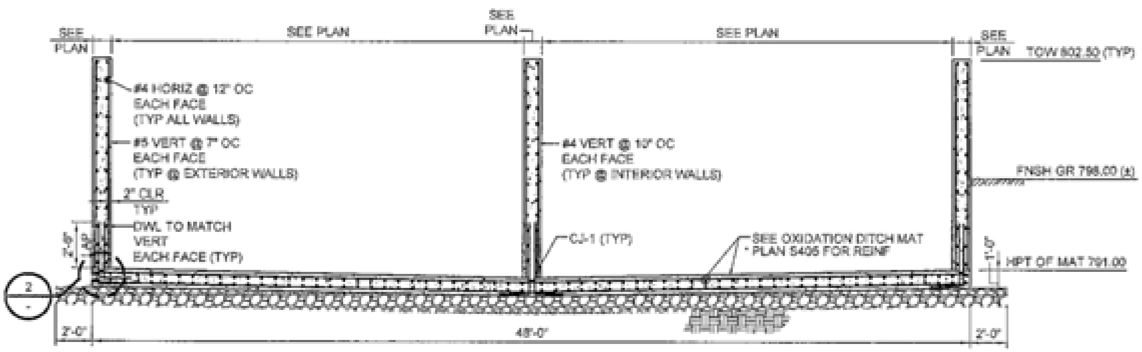


Figure 5 – Oxidation Ditch – Typical Section

Peak Flow Capacity = 3.6 MGD (B&M FP 2005)
Average Flow Capacity = 1.0 MGD (B&M FP 2005)

Anoxic Basin volume = 135,364 gallons (B&M 2008)
Aerobic Basin Volume = 552,455 gallons (B&M 2008)

Ex. Design ML_{BOD} = 1,430 lbs BOD d^{-1} (B&M FP 2005)
Ex. Design ML_{TSS} = 1,430 lbs TSS d^{-1} (B&M FP 2005)

$$Des.VL = \frac{1{,}430\ lbs\ BOD\ d^{-1}}{91{,}954\ ft^3} = 15.55\ lbs\ BOD\ d^{-1}\ 1{,}000\ ft^{-3}$$

$$Des.F/M = \frac{1{,}430\ lbs\ BOD\ d^{-1}}{(0.688\ MGal)(3{,}000\ mg\ L^{-1})(8.34\ \ lbs/(MGal\ mg\ L^{-1})} = 0.083\ d^{-1}$$

$$HRT = \frac{0.688\ MGal}{1.0\ MGD} = 0.688\ d = 16.50\ hrs$$

Oxidation Ditch Rotors:	Number of Rotors = 2		(B&M 2008)
	Rotor Length = 22’ -6”		(B&M 2008)
	Rotor Power = 50 Hp		(B&M 2008)
Flow Splitter No. 2 :	Ditch Level Control:	5 ft wide weir gate	(B&M 2008)
		Top of weir travel = 802.50	(B&M 2008)
		Bottom of weir travel = 799.50	(B&M 2008)
		Max. hydraulic capacity at design WSE = 15.0 MGD	
	Stop Gate #1:	1.5-ft wide stop gate	(B&M 2008)
	Stop Gate #2;	1.5-ft wide stop gate	(B&M 2008)
	Stop Gate #3:	1.5-ft wide weir gate (Future)	(B&M 2008)
RAS/WAS Pumps:	Number of pumps = 2		(B&M 2008)
	Pump rated power = 7.5 Hp (existing), 10.0 Hp (future)		(B&M 2008)
	RAS/WAS force main diameter = 6”		(B&M 2008)

Secondary Treatment – Clarifiers

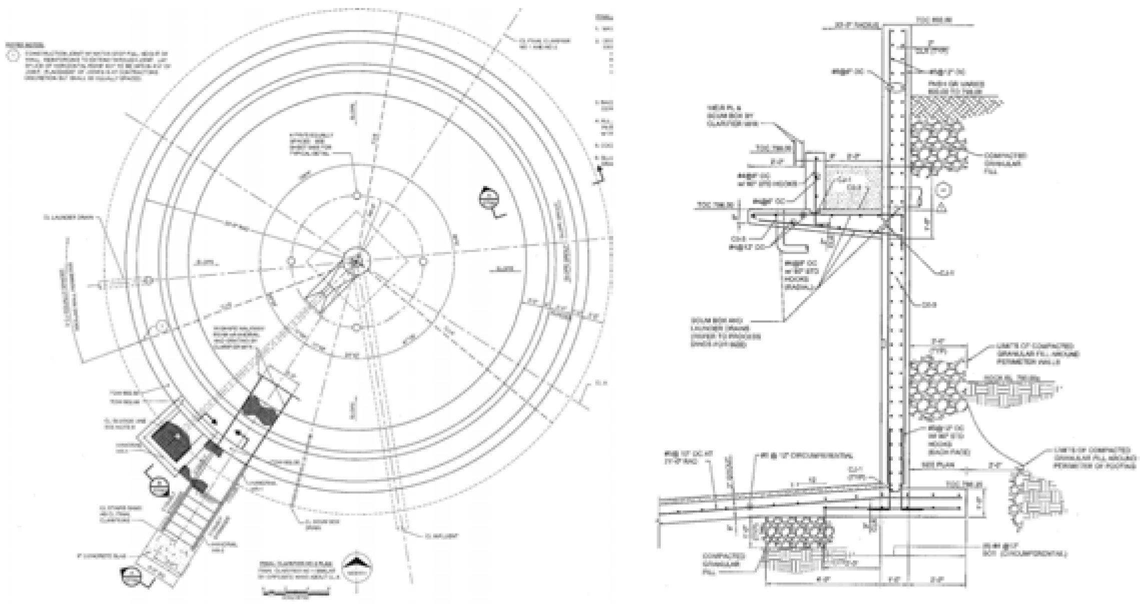


Figure 6 – Secondary Clarifier – Plan and Typical Section

Peak Flow Capacity = 2.4 MGD (B&M FP 2005)
Average Flow Capacity = 1.0 MGD (B&M FP 2005)

# of Clarifiers = 2 (B&M FP 2005)
Diameter = 40.0 ft (B&M FP 2005)
Surface Area = 1,256.64 ft^2
Weir Length = 108.89 ft

Recycle Ratio, R = 150 %
MLSS = 3,000 mg L^{-1}

$$Ex.\ SOR_{ADF} = \frac{1{,}000{,}000\ gpd}{2\left[\frac{(40.0\ ft)^2}{4}\pi\right]} = 397.89\ gpd\ ft^{-2}$$

$$Ex.SOR_{PHF} = \frac{2{,}400{,}000\ gpd}{2\left[\frac{(40.0\ ft)^2}{4}\pi\right]} = 954.93\ gpd\ ft^{-2}$$

$$Ex.\ SLR = \frac{1\ mgd(2.4+1.5)(3{,}000\ mg\ L^{-1})(8.34\ \ lbs/(MGal\ mg\ L^{-1}))}{2\left[\frac{(40.0\ ft)^2}{4}\pi\right]} = 35.84\ lbs\ d^{-1}\ ft^{-2}$$

$$Ex.\ WLR = \frac{2{,}400{,}000\ gpd}{2(108.89\ ft)} = 11{,}020\ gpd\ ft^{-1}$$

Disinfection

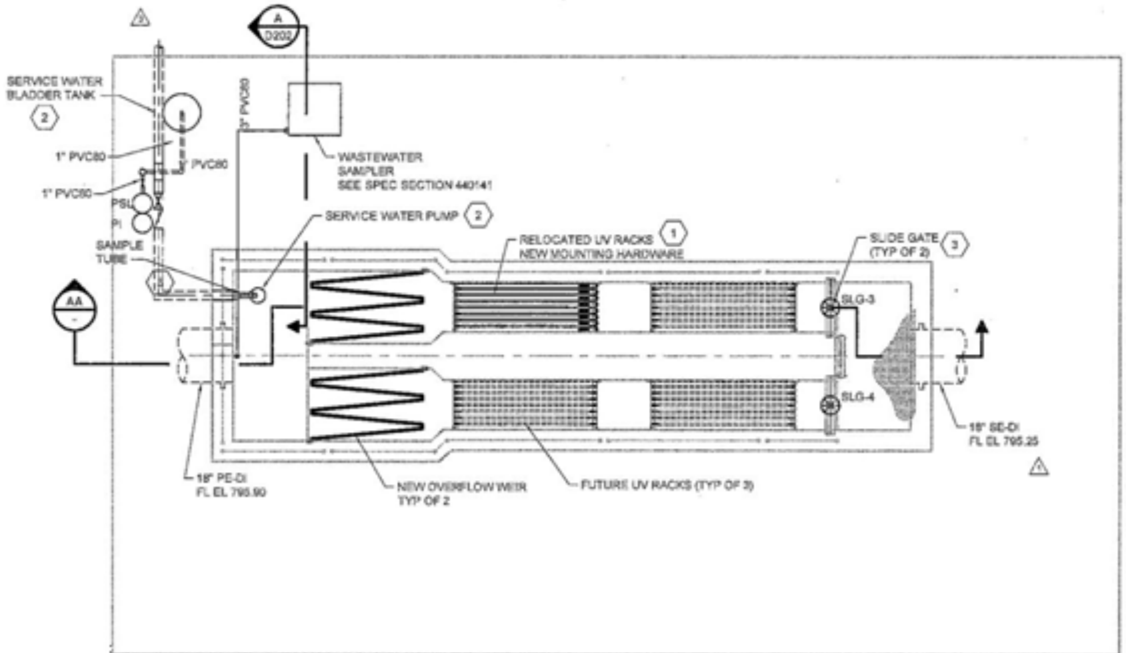


Figure 7 – UV Disinfection Building – Plan

Model = Trojan PTP UV3000

Peak Flow Capacity = 1.4 MGD	(B&M FP 2005)
Average Day Capacity = 0.4 MGD	(B&M FP 2005)

Note: It was planned (B&M FP 2005) that one unit/bank would be installed in 2014 which would increase the capacity of the process to 2.4 MGD. A third installation was planned for 2020, which would further increase the capacity of the process to 3.8 MGD.

References:

1. Wastewater Facility Plan: Southwest Wastewater Treatment Plant, Burns & McDonnell, March 2005

2. Southwest Wastewater Treatment Plant: Record Drawings, Burns & McDonnell, May 2008

3. UV3000PTP Operations and Maintenance Manual, Trojan Technologies

Appendix B
Sanitary Sewer Collection System Summary Design Memorandum

DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: August 8, 2017
Subject: Rolla WWTP Preliminary Engineering Report
Sanitary Sewer Collection System Summary

Th City of Rolla's collection system is divided into three discrete sewersheds, which each drain to their own respective wastewater water treatment plants (WWTPs).

The Southeast (SE) WWTP sewershed covers the majority of the area contained within the currently developed city limits, including the downtown commercial district, industrial areas located in the northern extent of the City and the Missouri University of Science and Technology (MST). The total area of the sewershed is 7,267 acres and has been further subdivided to incorporate discrete sewersheds for the "West Plant" and "East Plant" sanitary sewer trunk mains feeding the SE WWTP. Analysis performed for the Bypass Elimination Plan (HDR, Inc. April 2012) revealed that the approximate time of concentration for this sewershed was 4 hours. The collection system contained within the sewershed is comprised of a conglomerate of pipe sizes ranging from 1.5 inch force main to 42 inch diameter trunk main. The collection system materials include vitrified clay pipe (VCP), lined VCP, polyvinyl chloride (PVC) pipe, reinforce concrete pipe (RCP), and others (ductile iron pipe, truss pipe, etc.) Table 1 summarizes the attributes associated with the SE WWTP sewershed based on data obtained from City maintained graphical information system (GIS) mapping. Figure 1 details the extent of the sewershed and locations of the SE WWTP and receiving stream.

Table 1 – Southeast WWTP Collection System Summary

Nominal Diameter, in	Type	Total Length, ft	Material Type, %			
			Clay	Lined	PVC	RCP
1.5	Force Main	2,383.3	--	--	100.0	--
2	Force Main	5,610.7	--	--	100.0	--
4	Force Main	8,104.2	--	--	100.0	--
6	Force Main	4,683.6	--	--	100.0	--
6	Gravity	38,582.3	70.6	8.0	21.4	--
8	Gravity	504,143.0	42.3	4.9	52.6	--
10	Gravity	8,287.5	47.1	2.3	49.2	--
12	Gravity	22,099.9	69.2	2.4	28.42	--
15	Gravity	11,361.7	44.5	--	65.5	--
18	Gravity	10,824.2	44.3	--	53.1	2.7
21	Gravity	1,744.6	73.9	--	26.1	--
24	Gravity	5,206.2	12.9	--	16.2	71.0
30	Gravity	7,416.5	4.5	--	3.2	92.3
36	Gravity	9,567.0	--	--	6.4	93.6
42	Gravity	5,643.8	--	--	12.9	87.2

The Vichy Road (VR) WWTP sewershed is located in the northern extent of the City's limits, due west of the intersection of US Highway 63 and Interstate 44. The sewershed has an area of 747 acres and serves predominantly residential developments. It also receives flow from a residence hall owned and operated by MST. Based on a review of the sewershed collection system hydraulics, it would appear that its time of concentration is approximately 2.5 hours. The collection system contained within the sewershed is comprised of a conglomerate of pipe sizes ranging from 6 inch gravity to 21 inch gravity sewer lines. The collection system pipe materials include VCP, lined VCP, and PVC. Table 2 summarizes attributes associated with the VR WWTP sewershed based on data obtained from the City's GIS mapping. Figure 2 details the extent of the sewershed and locations of the VR WWTP and its receiving stream.

Table 2 – Vichy Road WWTP Collection System Summary

Nominal Diameter, in	Type	Total Length, ft	Material Type, %			
			Clay	Lined	PVC	RCP
6	Gravity	549.6	--	--	--	--
8	Gravity	38,851.0	33.0	6.7	59.6	--
10	Gravity	2,366.7	54.8	10.8	34.5	--
18	Gravity	1,940.8	35.9	--	64.1	--
21	Gravity	2,561.5	--	--	100.0	--

The Southwest (SW) WWTP sewershed is located in the southwestern extent of the City. It serves residential and commercial developments currently located there. Much of the sewershed is currently undeveloped; however the anticipates extensive growth associated with the proposed Rolla West development within the project planning period. The projected area of the sewershed is 4,227 acres. The collection system contained with the sewershed is comprised of a conglomerate of pipes sizes, ranging from 2 inch force main to 15 inch gravity main sewer. The collection system materials consist predominantly of VCP and PVC pipe. Table 3 summarizes attributes associated with the VR WWTP sewershed based on data obtained from the City's GIS mapping. Figure 3 details the extent of the sewershed and location of the SW WWTP and its receiving stream.

Table 3 – Southwest WWTP Collection System Summary

Nominal Diameter, in	Type	Total Length, ft	Material Type, %			
			Clay	Lined	PVC	RCP
2	Force Main	5,610.7	--	--	100.0	--
8	Gravity	25,956.1	29.3	--	70.7	--
10	Gravity	1,664.0	24.0	--	76.0	--
12	Gravity	5,310.0	80.1	--	19.9	--
15	Gravity	5,49.4	--	--	100.0	--

Appendix C

Population, Flow, and Loading Projections

Design Memorandum

DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: May 4, 2017
Subject: Rolla WWTP PER Population Projections

Background

Historic population data was obtained from the U.S. Census Bureau for a time period ranging from 1870 through 2010. The US Census Bureau projection for the current year was also utilized. Table 1 summarizes the available Census Bureau data for both the City of Rolla and Phelps County, Missouri. Both regression and curvilinear analyses were performed to rationally analyze the available data. Based on the analyses and discussions with City of Rolla officials regarding projected economic growth, a reasonable projection of the City's population was made.

Table 1 – U.S. Census Bureau Data for the City of Rolla and Phelps County Missouri: 1870 – present.

Year	Population Count	
	City of Rolla	Phelps County, Missouri
1870	1,354	--
1880	1,582	--
1890	1,592	12,636
1900	1,600	14,194
1910	2,261	15,796
1920	2,077	14,941
1930	3,670	15,308
1940	5,141	17,437
1950	9,354	21,504
1960	11,132	25,396
1970	13,245	29,481
1980	12,298	33,633
1990	14,090	35,248
2000	16,367	39,825
2010	19,569	45,156
2016	20,019	44,794

Analysis of Available Data

The regression analysis was performed by fitting linear and exponential functions to the available population data utilizing the least squares method. Generally, the linear model is applicable for communities experiencing slower, steady growth, whereas the exponential model is applicable for communities experiencing rapid growth. Based on the regression analysis, it was observed that the exponential model did a better job of describing the City's population with respect to time, as evidenced by a larger coefficient of determination (R^2). The exponential model was then utilized to project the total city population for 2027 and 2037. The projected 2027 and 2037 populations were determined to be 33,796 and 41,818, respectively.

A curvilinear analysis was utilized which compares the population growth in the City of Rolla to the population growth rates in numerous other cities having similar historical population trends. For this project, populations for the City of Rolla were compared to historical population data for the following cities in Missouri: Cape Girardeau, Cape Girardeau County; Columbia, Boone County; and Springfield, Greene County. The population data for the reference cities was then adjusted by modifying the date for each reference city such that the reference city historical population count was equal to the present-day population count in Rolla. The City of Rolla's population was then projected and compared with adjusted reference city data. Figure 1 shows the adjusted reference city population data and subsequent population project for the City of Rolla. Based on the curvilinear analysis approach, it is expected that the population counts for 2027 and 2037 shall be 24,246 and 28,724, respectively. This projection compares very well with the historic population trends of Cape Girardeau and Springfield, but was somewhat less than the historic population growth observed in Columbia. The average annual percentage increase in the City's population over the duration of the planning period is 1.57%. This average annual percentage increase is very comparable to historic population growth trends in both the City of Rolla and Phelps County, Missouri.

Overall, the curvilinear approach appears to provide a reasonable estimate of future population for the City of Rolla that is in-line with historic population growth observed throughout the region. Compared with the City's forecast for economic development the curvilinear approach appears to be justified. Therefore, the populations projections based on the curvilinear approach shall be utilized for the duration of this analysis.

Table 2 – Population Projection for City of Rolla During Project Planning Period.

Year	Population Count City of Rolla
2016	20,019
2027	24,246
2037	28,724

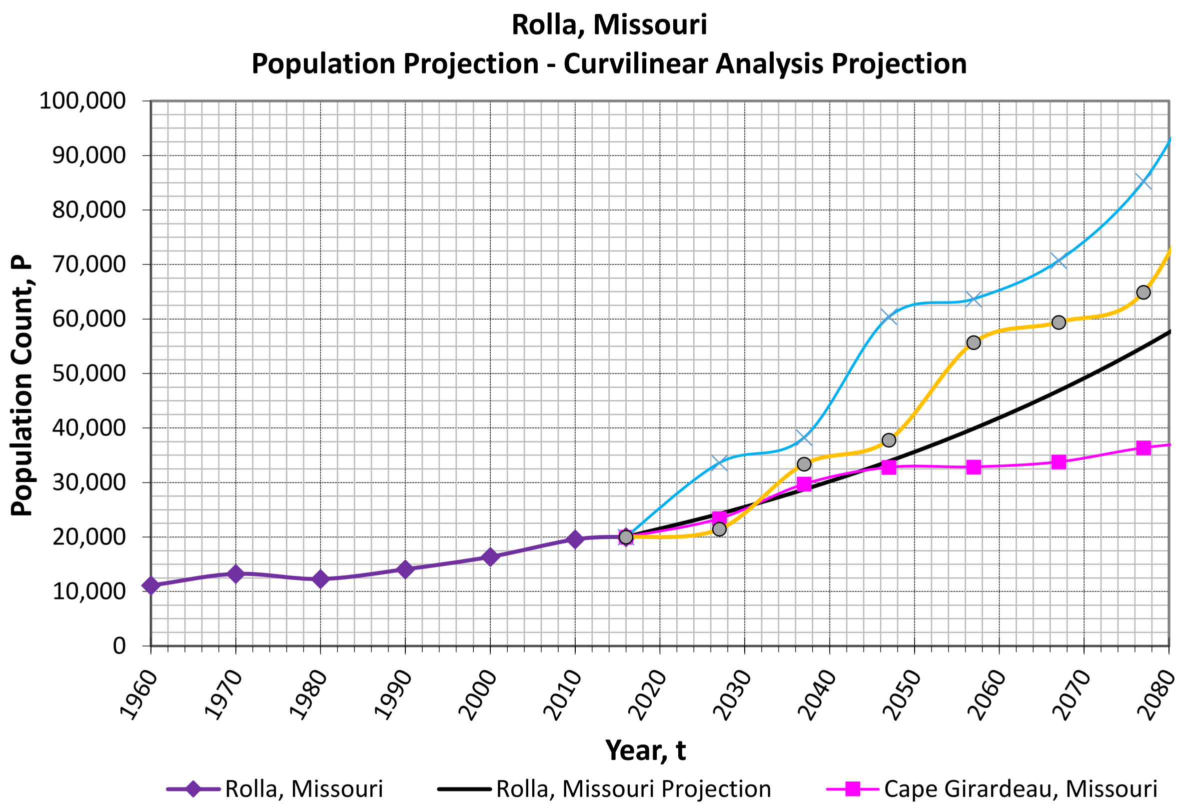


Figure 1 – Curvilinear Population Project for Rolla, Phelps County, Missouri

It must be noted that the City of Rolla does have a large institutional population that is likely not accounted for within the census population counts. The Missouri University of Science & Technology main campus is located within the City limit. In 2016, the total student population was 7,941. Many the students reside within the City limits for 9 months out of every year and therefore influence the wastewater production. Based on historic trends, the student population has grown at an average rate of 3.95 percent per year. It is anticipated that this rate of growth is not sustainable given the current political attitude toward higher education and capacity issues present at the university. For the purposes of this study, it will be assumed that the student population will continue to grow, but at a lower average rate of 2.0 percent annually.

Distribution of Population Amongst WWTP Sewersheds – SE and VR WWTPs

The aforementioned population projection applies to the entire city. However, the sewersheds for individual wastewater treatment plants do not encompass the entire city, so it was necessary to allocate an appropriate percentage of the total population to each sewershed. For both the Southeast (SE) and Vichy Road (VR) WWTPs, it was assumed that the population would be directly proportional to the relative area of the sewershed contributing to flows at each respective WWTP. Table 3 details the relative area for both the SE WWTP and VR WWTP as well as the population projections during the project planning period.

Table 3 – SE and VR WWTP Population Projection During Project Planning Period.

Year	Relative Sewershed Area		Census Population Count		Missouri S&T Student Population	
	SE WWTP	VR WWTP	SE WWTP	VR WWTP	SE WWTP	VR WWTP
2016	91%	9%	18,197	1,822	7,226	715
2027			22,040	2,206	8,808	872
2037			26,110	2,614	10,738	1,063

Population Estimation for SW WWTP

The total population and associated curvilinear projections were not applied to the sewershed for the Southwest (SW) WWTP as it is currently serves a small number of residential users associated with the Rolla population count. As a consequence, an alternative method was utilized to ascertain the sewershed population and associated wastewater production.

The SW WWTP receives flows from the Town of Doolittle, one significant industrial user and numerous commercial and business facilities. The Town of Doolittle has a current population of 630 people and is billed for an average sewage production of 37,054 gpd. Royal Canin, a producer of dog food, is currently the largest single producer of pre-treated wastewater, sending an average of 10,408 gpd. The current average daily flow for the SW WWTP was determined to be 0.181 mgd. The aggregate wastewater production by commercial and business establishments within the existing SW WWTP sewershed is 0.134 mgd. The current land area associated with the commercial and business establishments was estimated to be 252 acres. Therefore, the current wastewater generation per acre was estimated to be 532 gpd/acre. Using a wastewater production rate of 85 gpcd, an equivalent population density associated with the existing commercial and industrial development is 6.25 persons per acre.

For future projections of population and wastewater production, the extent of the sewershed was delineated and all residential dwellings were counted. It was determined that there were approximately 213 single family dwellings and 2 multifamily dwellings within the sewershed. It was assumed that 3.0 persons per dwelling were present, with the multifamily dwelling having four apartments per unit. The residential population was projected at an annual rate of 1.56%, mirroring the historic populations growths of both the City and Phelps County, Missouri.

Master planning for the Rolla West Development were studied in an effort to estimate the population associated with commercial and industrial developments within the sewershed. Land areas were delineated within and adjacent to the sewershed based on the proposed development type. It was assumed that only 70 percent of the total land area would be available for development, which accounts for property right-of-way, setbacks, undevelopable land, etc. An equivalent population of 7.5 people per acre was applied to the commercial and industrial development areas.

Table 4 – SW WWTP Sewershed Land Use

Land Use Description	Total Area (acres)	Developable Area (acres)
Commercial	334	234
Industrial	143	100
Hospitality/Entertainment	82	57
Office/Medical	56	39
Residential	3,612	2,258

Table 5 – SW WWTP Sewershed Population Projection During Project Planning Period.

Year	Rolla		Doolittle[1,3]	Total
	Residential	Other [1,2]		
2016	663	1,575	436	2,674
2027	774	2,558	509	3,841
2037	905	3,225	595	4,725

1 Population equivalent based on average wastewater production of 85 gpcd.
2 2016 data based on existing development and percapita production. 2027 assumes increased population density for existing development and full development of half the remaining undeveloped business and commercial land area. The 2037 data assumes full development of all identified business and commercial areas. See calculations below.
3 Population adjusted to accommodate for percapita sewage production of 58.8 gpcd. Design percapita sewage production shall be 85 gpcd. See example calculation below.

$$Other_{2027} = (252acre)\left(6.25\frac{people}{acre}\right) = 1{,}575\, people$$

$$Other_{2027} = (252acre)\left(7.5\frac{people}{acre}\right) + 0.5(178acre)\left(7.5\frac{people}{acre}\right) = 2{,}558\, people$$

$$Other_{2037} = (252acre)\left(7.5\frac{people}{acre}\right) + (178acre)\left(7.5\frac{people}{acre}\right) = 3{,}225\, people$$

$$Doolittle_{adj} = (Doolittle_{act})\left(\frac{85\ gpcd}{58.8\ gpcd}\right)$$

Flow and Loading Projections for SE WWTP

Based on the review and analysis of wastewater influent flow data for the SE WWTP, it was determined that the average daily flows for the facility was 2.85 MGD. This flow corresponded to a percapita wastewater production of 112.1 gpd which was based on the aggregate census and Missouri S&T population counts. The minimum monthly flows for the facility was determined to be 1.48 MGD, corresponding with percapita wastewater production of 81.6 gpd. These percapita production rates have been calculated exclusive of the Missouri S&T population, as the minimum monthly flows occur during summer months when much of the student population is not in residence within the City's limits. It was assumed that exfiltration, infiltration and inflow of sewage within the collection system was minimal for this calculation.

Influent wastewater flows for the SE WWTP were further segregated to account for flows received at the East and West plants. These flows were a subset of the total SE WWTP and were scaled based on the plant sewershed area in relation to the total. Currently flows received by each facility are not measured prior to redirection of flows from one plant to the other, making a direct determination impossible.

In a similar fashion, mass loadings for the facility were analyzed. The average daily BOD, TSS, TKN and TP mass sloadings were determined to be 2,821 lbs d^{-1}, 2,787 lbs d^{-1}, 778 lbs d^{-1} and 269 lbs d^{-1}, respectively. These mass loadings corresponded with percapita mass loads of 0.11 lbs cap^{-1} d^{-1}, 0.11 lbs cap^{-1} d^{-1}, 0.03 lbs cap^{-1} d^{-1} and 0.01 lbs cap^{-1} d^{-1}, respectively.

The average daily flow and mass loading data were projected based on the abovementioned population projections assuming that the calculated percapita loading would remain constant during the planning period. The currently observed peaking factors were applied to the projected values to obtain appropriate design criteria (maximum month, maximum day, etc.) A summary of projected flow and mass loading data is listed in tables below.

Table 6 – Flow and Mass Loading Projections for the Southeast WWTP, Rolla, Missouri

	Ave Day	Max Month Ave Day	Max Day	Peak Hour Flow
2017				
Flow (Total):	2.85	7.58	21.0	41.8
Flow (East Plant):	1.30	3.45	9.6	19.0
Flow (West Plant):	1.55	4.12	11.4	22.8
BOD conc:	118.7	196.3	198.5	
BOD mass loading:	2,821	4,665	4,717	
TSS conc:	117.3	173.1	199.4	
TSS mass loading:	2,787	4,114	4,738	
NH3-N conc:	16.4		28.9	
NH3-N mass loading:	389.4		687.9	
TKN conc:	32.7		57.9	
TKN mass loading:	778		1,376	
TP conc:	3.69		6.41	
TP mass loading:	87.7		152.3	
2027 Projection				
Flow (Total):	3.46	9.20	25.5	41.8
Flow (East Plant):	1.58	4.20	11.6	19.0
Flow (West Plant):	1.88	5.00	13.9	22.8
BOD conc:	118.7	196.3	198.5	
BOD mass loading:	3,424	5,662	5,725	
TSS conc:	117.3	173.1	199.4	
TSS mass loading:	3,383	4,994	5,751	
NH3-N conc:	16.4		28.9	
NH3-N mass loading:	473		835.1	
TKN conc:	32.7		57.9	
TKN mass loading:	944		1,670	
TP conc:	3.69		6.41	
TP mass loading:	106.3		184.6	
2037 Projection				
Flow (Total):	4.13	11.0	30.4	41.8
Flow (East Plant):	1.89	5.01	13.8	19.0
Flow (West Plant):	2.25	5.99	16.6	22.8
BOD conc:	118.7	196.3	198.5	
BOD mass loading:	4,089	6,762	6,838	
TSS conc:	117.3	173.1	199.4	
TSS mass loading:	4,040	5,964	6,868	
NH3-N conc:	16.4		28.9	
NH3-N mass loading:	564.9		996.8	
TKN conc:	32.7		57.9	
TKN mass loading:	1,128		1,995	
TP conc:	3.69		6.41	
TP mass loading:	126.9		220.1	

Flow and Loading Projections for VR WWTP

Based on the review and analysis of wastewater influent flow data for the VR WWTP, it was determined that the average daily flow for the facility was 0.311 MGD respectively. This flow corresponded to a percapita wastewater production of 122.6 gpd and was based on the aggregate census and Missouri S&T population counts. The minimum monthly flows for the facility was determined to be 0.16 MGD, corresponding with percapita wastewater production 87.8 gpd. This percapita production rate was calculated exclusive of the Missouri S&T population, as the minimum monthly flows occur during summer months when much of the student population is not in residence within the City's limits. It was assumed that exfiltration, infiltration and inflow of sewage within the collection system was minimal for this calculation.

In a similar fashion, mass loadings for the facility were analyzed. The average daily BOD, TSS, TKN and TP mass loadings were determined to be 415 lbs d^{-1}, 294 lbs d^{-1}, 98.6 lbs d^{-1}, and 39.0 lbs d^{-1}, respectively. These mass loadings corresponded with percapita mass loads of 0.16 lbs cap^{-1} d^{-1}, 0.12 lbs cap^{-1} d^{-1}, 0.04 lbs cap^{-1} d^{-1}, and 0.02 lbs cap^{-1} d^{-1}, respectively.

The average daily flow and mass loading data were projected based on the abovementioned population projections assuming that the calculated percapita loading would remain constant during the planning period. The currently observed peaking factors were applied to the projected values to obtain appropriate design criteria (maximum month, maximum day, etc.) A summary of projected flow and mass loading data is listed in tables below.

Table 7 - Flow and Mass Loading Projections for the Vichy Road WWTP, Rolla, Missouri

	Ave Day	Max Month Ave Day	Max Day	Peak Hour Flow
2017				
Flow:	0.311	0.567	1.50	3.62
BOD conc:	160	292	540	
BOD mass loading:	415	758	1,400	
TSS conc:	113	440	1,427	
TSS mass loading:	294	1,142	3,700	
NH3-N conc:	16.9		32.2	
NH3-N mass loading:	43.8		83.6	
TKN conc:	38.0		72.6	
TKN mass loading:	98.6		188	
TP conc:	4.90		9.09	
TP mass loading:	12.7		23.6	
2027 Projection				
Flow:	0.377	0.687	1.82	3.62
BOD conc:	160	292	540	
BOD mass loading:	504	921	1,700	
TSS conc:	113	440	1,427	
TSS mass loading:	358	1,391	4,505	
NH3-N conc:	16.9		32.2	
NH3-N mass loading:	53.1		101	
TKN conc:	38.0		72.6	
TKN mass loading:	120		228	
TP conc:	4.90		9.09	
TP mass loading:	15.4		28.7	
2037 Projection				
Flow:	0.451	0.822	2.18	3.62
BOD conc:	160.0	292.2	539.8	
BOD mass loading:	602	1,100	2,030	
TSS conc:	113.3	440.3	1,427	
TSS mass loading:	428	1,663	5,386	
NH3-N conc:	16.9		32.2	
NH3-N mass loading:	63.6		121	
TKN conc:	38.0		72.6	
TKN mass loading:	143		273	
TP conc:	4.90		9.09	
TP mass loading:	18.4		34.2	

Units: flow = MGD; concentration = mg L^{-1}; mass loading = lbs d^{-1}

Flow and Loading Projections for SW WWTP

Based on the review and analysis of wastewater influent flow data for the SW WWTP, it was determined that the average daily flow for the facility was 0.181 MGD respectively. For the purposes of design, a percapita wastewater production of 85 gpd was assumed which is reflective of percapita flows observed in the SE and VR WWTP sewersheds. This wastewater production rate was applied to the population counts projected during the project planning period.

In a similar fashion, mass loadings for the facility were analyzed. The average daily BOD, TSS, TKN and TP mass loadings were determined to be 415 lbs d^{-1}, 294 lbs d^{-1}, 37.0 lbs d^{-1}, and 16.5 lbs d^{-1}, respectively. The regulatory values of 0.17 lbs cap^{-1} d^{-1}, 0.20 lbs cap^{-1} d^{-1} were utilized for the purposes of projecting BOD and TSS mass loadings, respectively, at the facility. Percapita TKN and TP production was taken to be 0.036 lbs cap^{-1} d^{-1} and 0.006 lbs cap^{-1} d^{-1}.

The average daily flow and mass loading data were projected based on the abovementioned population projections assuming that the percapita loading would remain constant during the planning period. The currently observed peaking factors were not applied to the projected values as they appear to be largely influenced by the small size of the sewershed and the current nature of the observed development. An average peaking factor between the SE and VR WWTPs was calculated and applied to the projected average day values to obtain appropriate design criteria (maximum month, maximum day, etc.) A summary of projected flow and mass loading data is listed in tables below.

Table 8 - Flow and Mass Loading Projections for the Southwest WWTP, Rolla, Missouri

	Ave Day	Max Month Ave Day	Max Day	Peak Hour Flow
2017				
Flow:	0.181	1.204	2.10	2.31
BOD conc:	129.8	475.6	993.6	
BOD mass loading:	196	718	1,500	
TSS conc:	194.8	612.8	3,643	
TSS mass loading:	294	925	5,500	
NH3-N conc:	12.3		22.2	
NH3-N mass loading:	18.6		33.5	
TKN conc:	24.5		44.5	
TKN mass loading:	37.0		67.2	
TP conc:	3.58		6.41	
TP mass loading:	5.40		9.68	
2027 Projection				
Flow:	0.338	1.204	2.10	2.26
BOD conc:	239.8	419.7	604.8	
BOD mass loading:	676.0	1,183	1,705	
TSS conc:	282.0	756.0	2,013.5	
TSS mass loading:	795.0	2,131	5,676	
NH3-N conc:	25.5		46.9	
NH3-N mass loading:	72.0		132.3	
TKN conc:	50.8		93.4	
TKN mass loading:	143.2		263.2	
TP conc:	8.48		15.3	
TP mass loading:	23.9		43.0	
2037 Projection				
Flow:	0.402	1.405	2.45	2.70
BOD conc:	239.8	419.7	604.8	
BOD mass loading:	803.0	1,405	2,026	
TSS conc:	282.0	756.0	2,013.5	
TSS mass loading:	945.0	2,533	6,747	
NH3-N conc:	25.5		46.9	
NH3-N mass loading:	85.5		157.2	
TKN conc:	50.8		93.4	
TKN mass loading:	170.1		312.7	
TP conc:	8.48		15.3	
TP mass loading:	28.4		51.0	

Units: flow = MGD; concentration = mg L^{-1}; mass loading = lbs d^{-1}

Appendix D

DMR Data Analysis Design Memorandums

DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: March 6, 2017
Subject: Rolla SE WWTP DMR Data Analysis

Background

Data regarding the operation and performance of the Rolla Southeast Wastewater Treatment Plant (SE WWTP) was collected from the facility operators. The collected data was in the form of bench sheets utilized for daily operations. Paper Daily Monitoring Reports (DMRs) were not available for the facility as the requisite data was submitted to the Missouri Department of Natural Resources (MDNR) via the eDMR web porthole. The data from the bench sheets was entered into a Microsoft Excel spreadsheet and subsequently manipulated to provide the necessary information for analysis of the facility.

It must be noted that the flow is received at the both the East and West Plants. A portion of the flow received at the West Plant is diverted and conveyed by gravity to the East Plant. Influent BOD, TSS, pH, temperature and hardness samples are taken at the East Plant immediately downstream of the combined East and West Plant Flows. Flow measurement of East Plant influent occurs downstream of the East and West Plant confluence. Therefore, the values obtained for aforementioned influent parameters should be considered an aggregate sample of both East and West Plant flows.

Summary Influent Characteristics

The influent parameters which were sampled where analyzed to ascertain the nature of the statistical distribution of the data. In the case of the influent flow data, it appears that a log-normal distribution more closely matches the observed distribution of the data. This is predominantly due the presence of large peak flows which tends to skew the distribution. The influent BOD and TSS mass loadings appear to be reasonably described by a normal distribution, as both data sets pass the Kolmogorov-Smirnov goodness of fit test with a confidence level of 95%.

Average daily flow and mass loadings were determined by averaging the available flow data based on the selected statistical distribution. The maximum day flow and mass loadings were determined via the use of the log-probability or arithmetic-probability plots. A regression line was determined for the distribution and extended to the 100 percent probability threshold. The value of flow or mass loading corresponding to this threshold was assumed to be the maximum daily value. Comparing the obtained values with the full data sets, the obtained maximum daily value typically fell in the 95th percentile.

Peak daily values of the flow and mass loadings were taken to be the maximal value observed during the analysis period. These peak daily values should not be confused with the peak hourly or peak instantaneous values as the DMR data is averaged over 24 hour period.

Table 1 – Flow Summary: January 1, 2014 through August 31, 2017

Population	**Flow, MGD**			
	Minimum	**Average**	**Max Day**	**Peak**
20,019	1.0	3.04	18.0	41.0

Table 2 – Influent BOD Mass Loading Summary: January 1, 2014 through August 31, 2017

Population	**BOD Mass Load, lbs d^{-1}**			
	Minimum	**Average**	**Max Day**	**Peak**
20,019	164.7	2,672.7	4,281.7	3,293.2

Table 3 – Influent TSS Mass Loading Summary: January 1, 2014 through August 31, 2017

Population	**BOD Mass Load, lbs d^{-1}**			
	Minimum	**Average**	**Max Day**	**Peak**
20,019	177.7	2,587.0	4,093.0	6,931.3

Table 4 – Supplementary Influent Testing: February 6, 2017 through Present

Date	TP (mg L^{-1})	OP (mg L^{-1})	TN (mg L^{-1})	NH_3-N (mg L^{-1})	TCOD (mg L^{-1})	rbCOD (mg L^{-1})	BOD_5 (mg L^{-1})
02-06-17	11.5	8.62	31.4		235	92.6	90
02-15-17	14.5	9.95					141
02-22-17	8.94	5.70	22.40	12.6			102
03-01-17	11.76	8.22		18.7			
03-07-17							

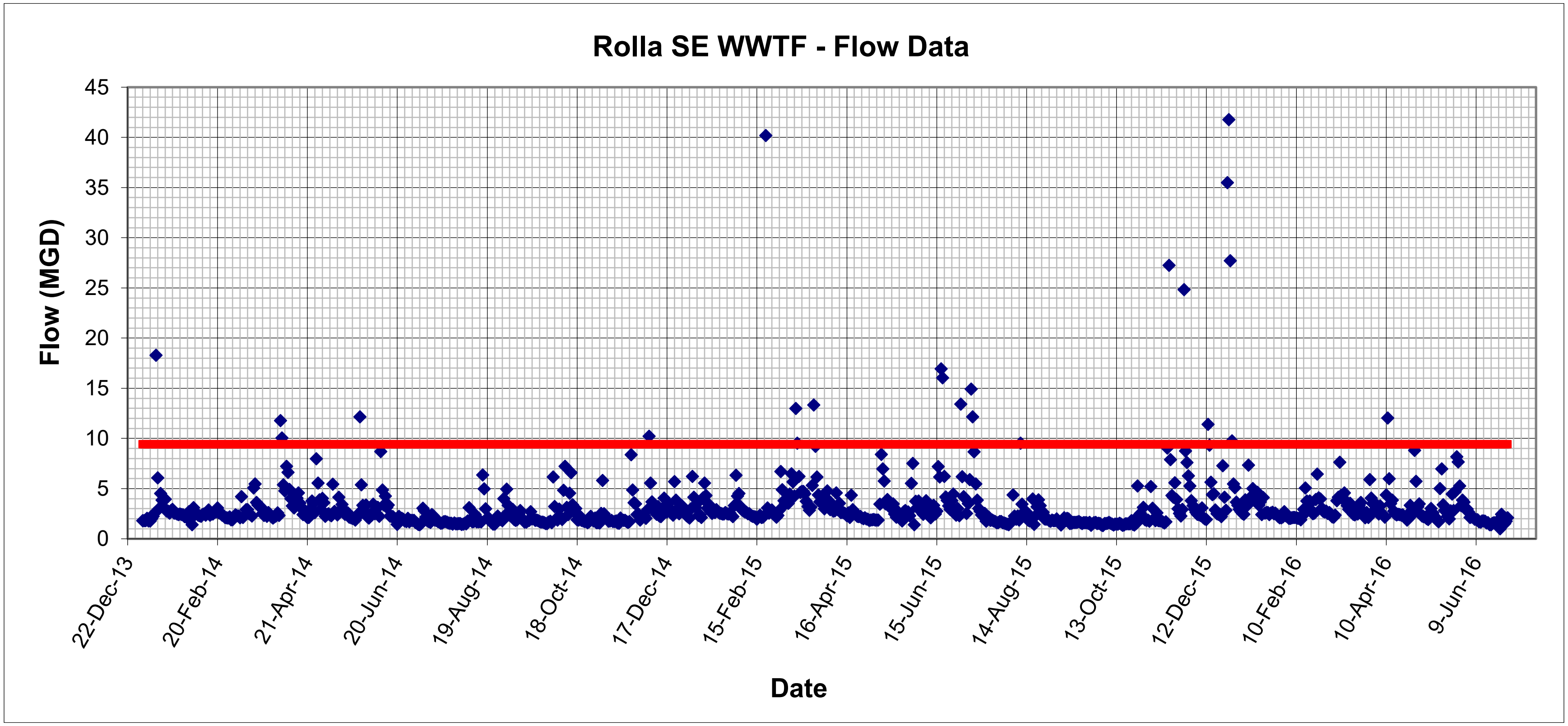


Figure 1 – Rolla SE WWTF flow data: January 1, 2014 through August 1, 2016

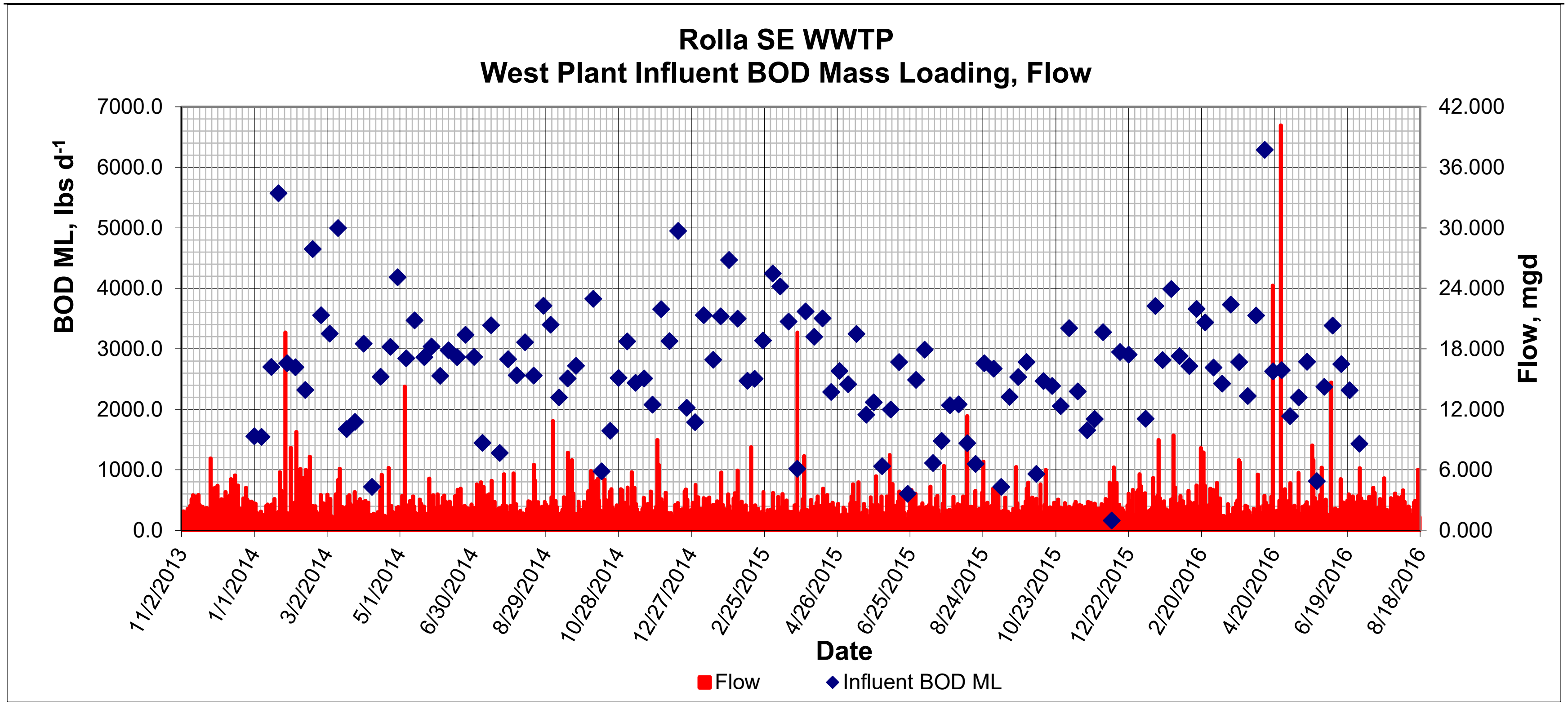


Figure 2 – Rolla SE WWTF influent BOD mass loading data: January 1, 2014 through August 1, 2016

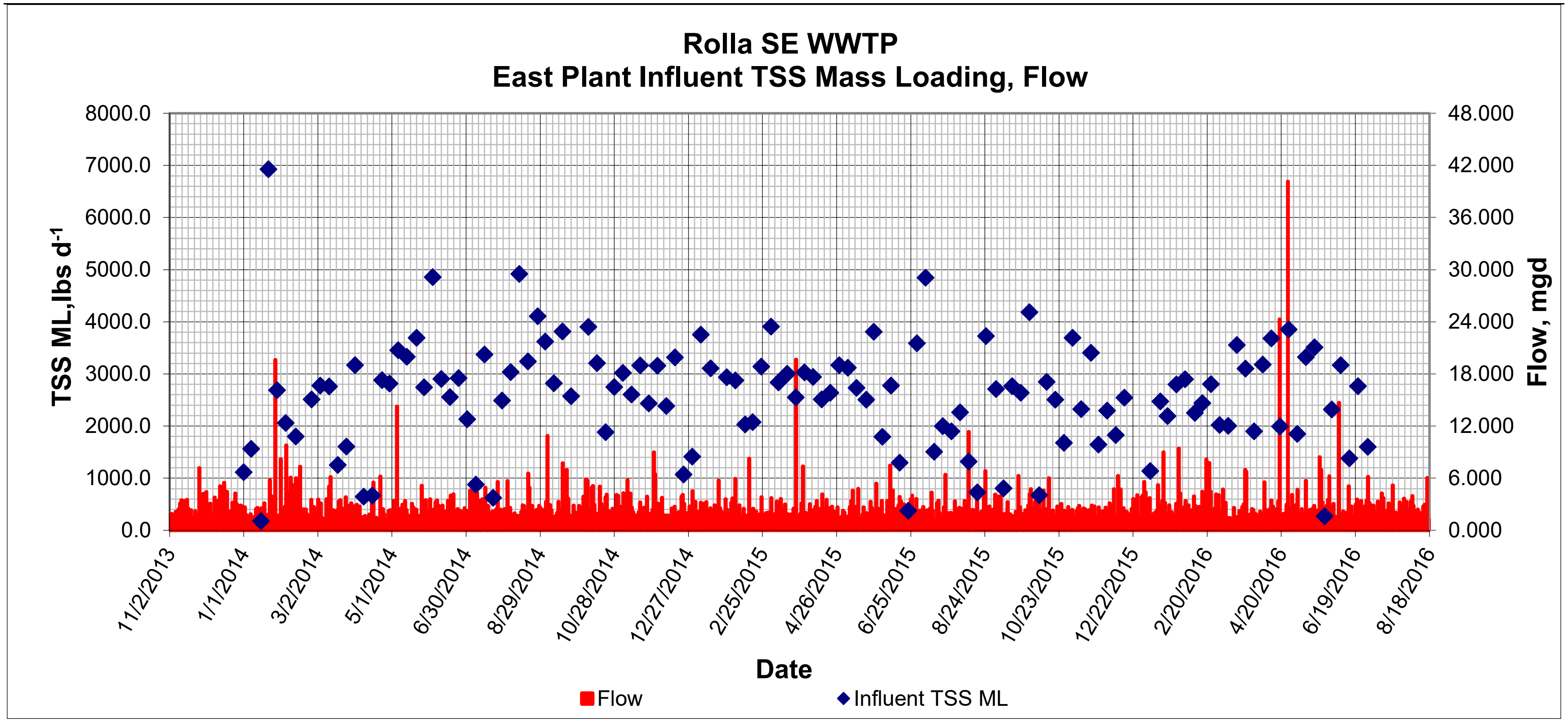


Figure 3 – Rolla SE WWTF influent TSS mass loading data: January 1, 2014 through August 1, 2016

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DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: March 29, 2017
Subject: Rolla VR WWTP DMR Data Analysis

Background

Data regarding the operation and performance of the Rolla Vichy Road Wastewater Treatment Plant (VR WWTP) was collected. Electronically scanned and original hard copies of Daily Monitoring Reports (DMRs) were available for the facility. This was augmented with data which had been saved in Microsoft Excel format by facility operators. The entire data set was compiled into an Excel spreadsheet and subsequently manipulated to provide the necessary information for analysis of the facility.

Summary Influent Characteristics

The influent parameters which were sampled where analyzed to ascertain the nature of the statistical distribution of the data. The influent flow, BOD mass loading and TSS mass loading data were found to be log-normally distributed. Because there is a physical limit to how small individual measurements can be, the distributions were to be right-tailed, positively skewed. All data sets passed the Kolmogorov-Smirnov goodness-of-fit test with a confidence level of 95%.

Average daily flow and mass loadings were determined by averaging the available flow data based on the selected statistical distribution. The maximum day flow and mass loadings were determined via the use of the log-probability or arithmetic-probability plots. A regression line was determined for the distribution and extended to the 100 percent probability threshold. The value of flow or mass loading corresponding to this threshold was assumed to be the maximum daily value. Comparing the obtained values with the full data sets, the obtained maximum daily value typically met or exceeded the 100th percentile measurement.

Maximum monthly flow and mass loadings were calculated utilizing a 30-day running average. The maximum 30 day running average value was selected as being the maximum observed value during the selected analysis period.

Table 1 – Flow Summary: January 1, 2014 through December 31, 2016

Flow, MGD				
Minimum	**Average**	**Max Day**	**Max Month**	**Peak**
0.109	0.311	1.500	0.567	3.620

Table 2 – Influent BOD Mass Loading Summary: January 1, 2014 through December 31, 2016

BOD Mass Load, lbs d^{-1}			
Minimum	**Average**	**Max Month**	**Max Day**
95	415	758	1,400 (*)

(*) Projected mass loading

Table 3 – Influent TSS Mass Loading Summary: January 1, 2014 through December 31, 2016

TSS Mass Load, lbs d^{-1}			
Minimum	**Average**	**Max Month**	**Max Day**
101	294	1,142	3,700 (*)

(*) Projected mass loading

Table 4 – Supplementary Influent Testing: February 6, 2017 through Present

Date	TP (mg PO_4^{3-} L^{-1})	OP (mg $PO_4^{3-}L^{-1}$)	TN (mg N L^{-1})	NH_3-N (mg N L^{-1})	TCOD (mg L^{-1})	rbCOD (mg L^{-1})	BOD_5 (mg L^{-1})
02-06-17	--	20.3	57.8		487	114	
02-15-17	21.8	14.4					228
02-22-17	10.66	7.04	47.40	22.5			159
03-01-17	14.38	8.68		23.4			222
03-08-17	7.62	4.80		5.47			90
03-15-17	37.8	25.4	40.1	24.7			183
03-22-17	14.48	9.58					

Table 5 – Influent NH_3-N Mass Loading Summary: February 6, 2017 through April 5, 2017

NH_3-N Mass Load, lbs NH_3-N d^{-1}			
Minimum	**Average**	**Maximum Day**	**Maximum Month**
4.0 (*)	43.8	83.6 (*)	--

(*) Projected

Table 6 – Influent TKN Mass Loading Summary (*)

TKN Mass Load, lbs N d^{-1}			
Minimum	**Average**	**Maximum Day**	**Maximum Month**
9.0	98.6	188.1	--

(*) Calculated as the average ratio of the influent TN and influent NH_3-N assuming that NO_2^--N and NO_3^--N concentrations in the influent were negligible. March 15, 2017 testing seems to demonstrate that this assumption is valid.

Table 7 – Influent TP Mass Loading Summary: February 6, 2017 through April 5, 2017

TP Mass Load, lbs PO_4^{3-} d^{-1}			
Minimum	**Average**	**Maximum Day**	**Maximum Month**
5.6 (*)	39.0	72.5 (*)	--

(*) Projected

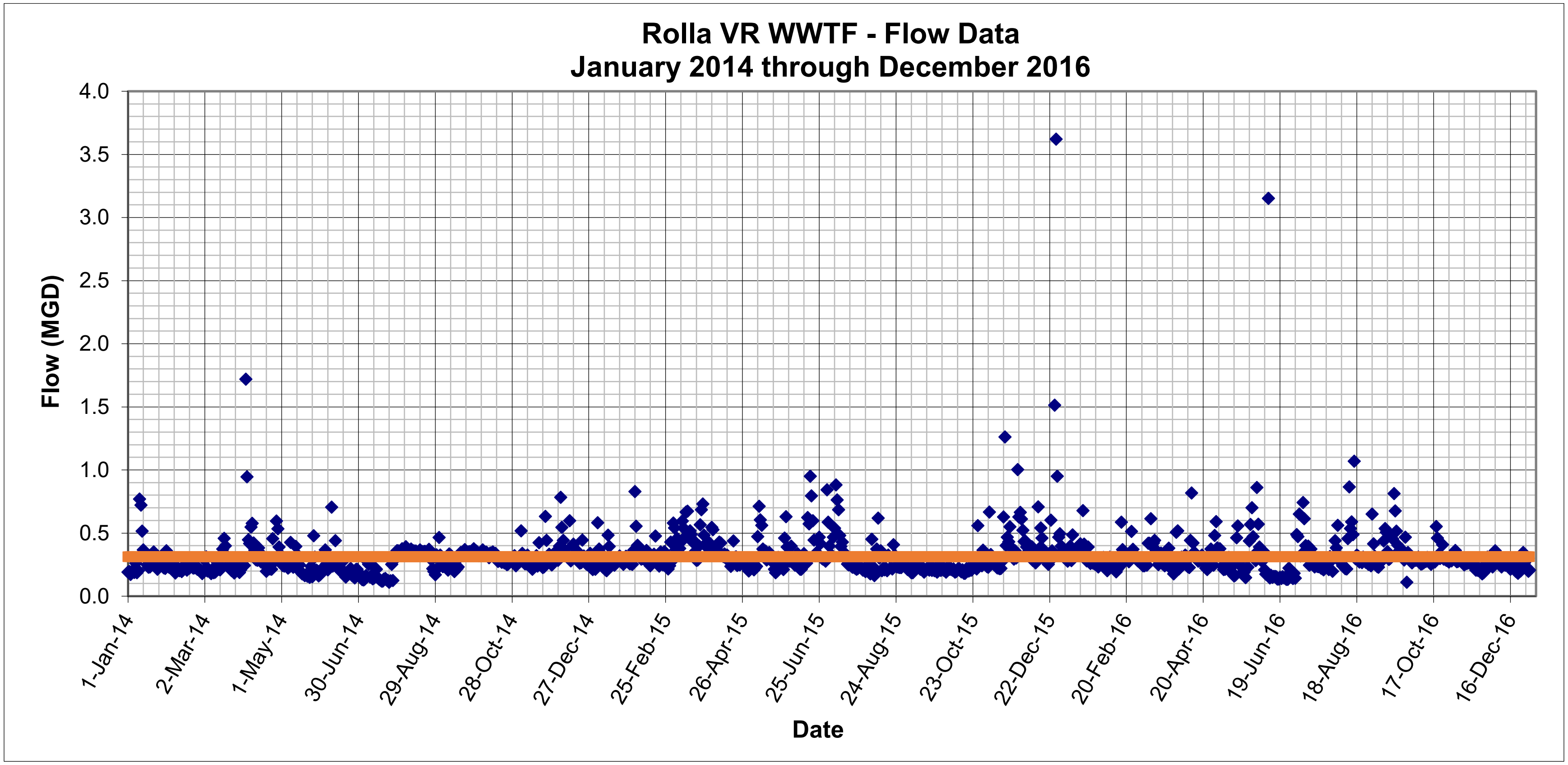

Figure 1 – Rolla VR WWTF flow data: January 1, 2014 through December 31, 2016

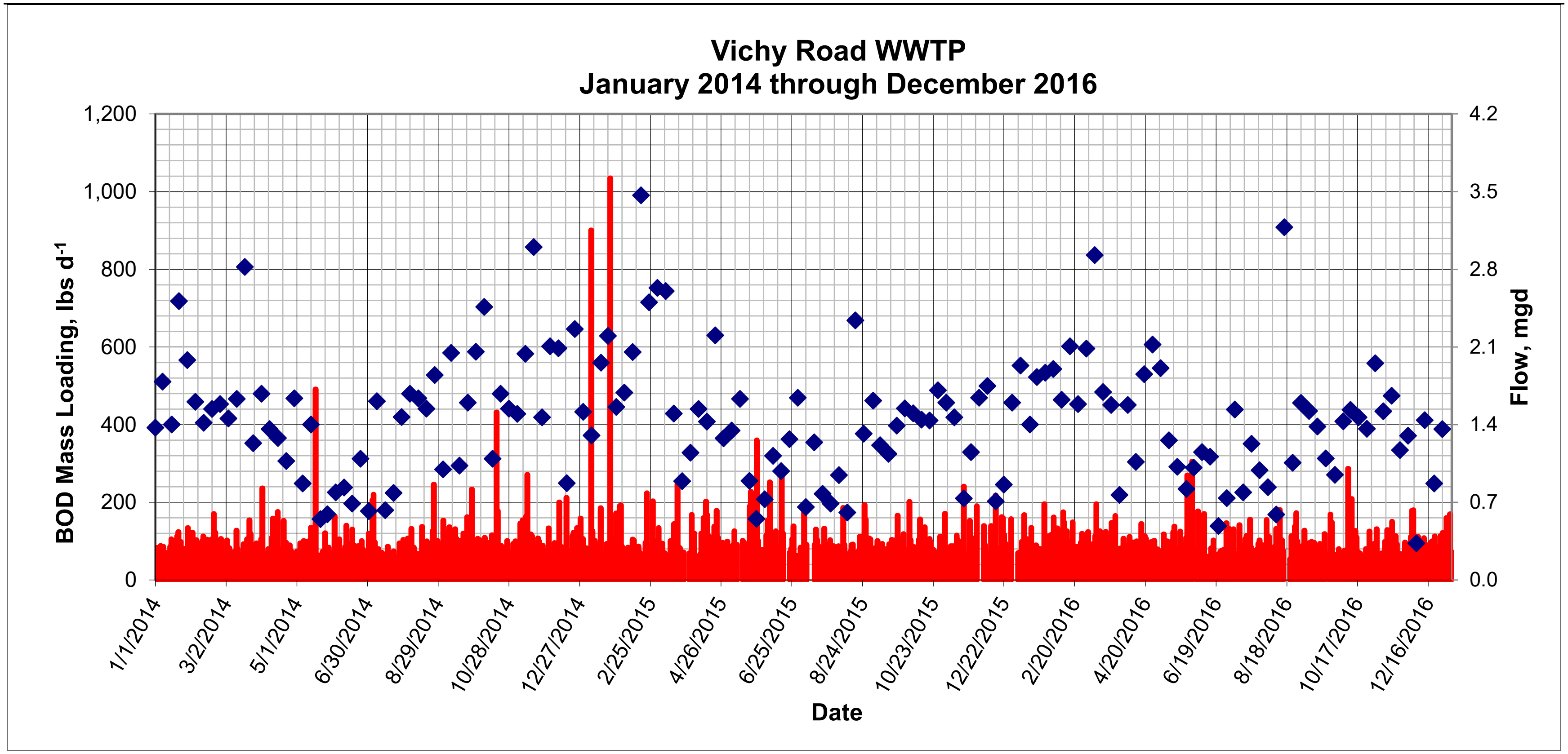

Figure 2 – Rolla VR WWTF influent BOD mass loading data: January 1, 2014 through December 31, 2016

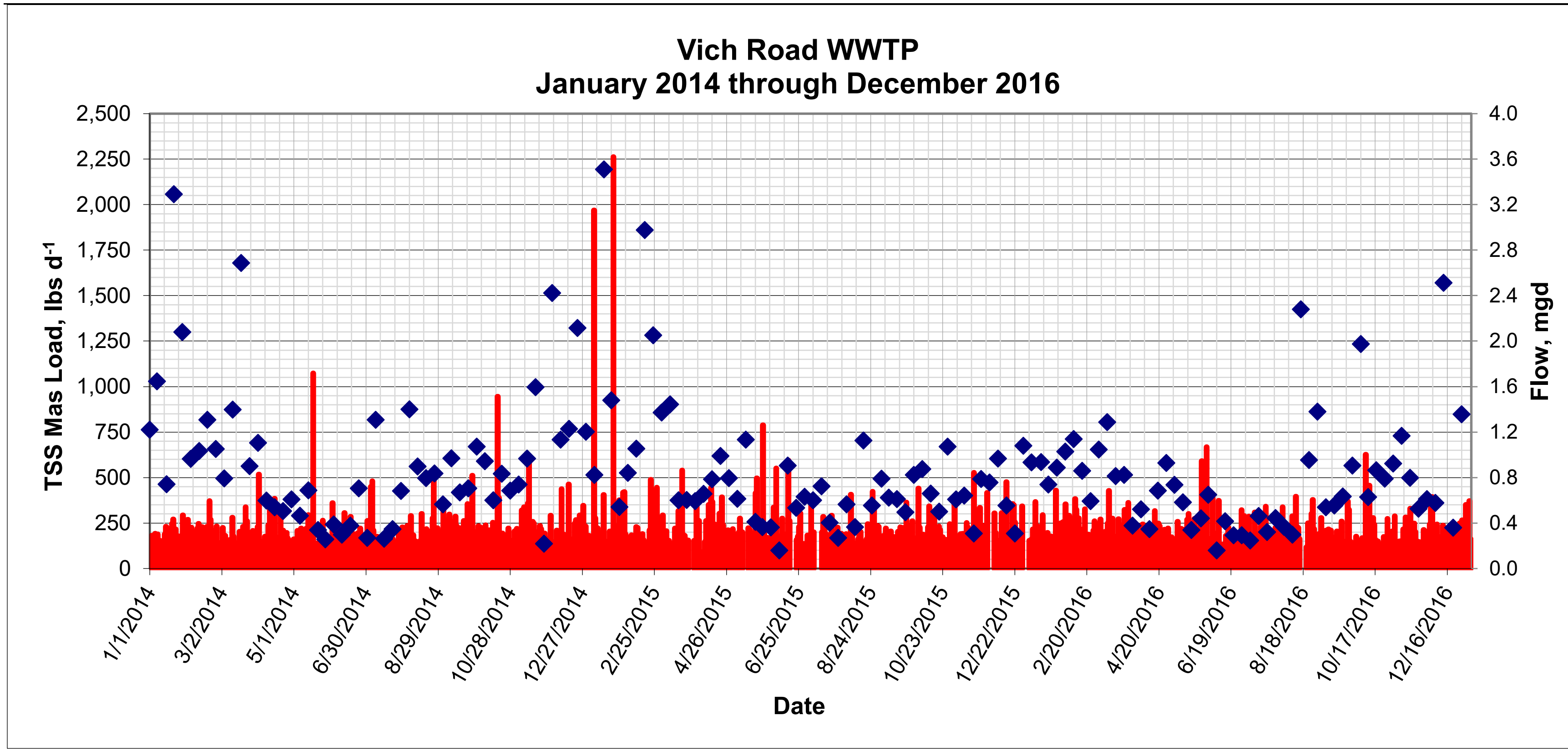

Figure 3 – Rolla VR WWTF influent TSS mass loading data: January 1, 2014 through December 31, 2016

DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: March 9, 2017
Subject: Rolla SW WWTP DMR Data Analysis

Background

Data regarding the operation and performance of the Rolla Southwest Wastewater Treatment Plant (SW WWTP) was collected. Electronically scanned Daily Monitoring Reports (DMRs) were available for the facility. This was augmented with data which had been saved in Microsoft Excel format by facility operators. The entire data set was compiled into an Excel spreadsheet and subsequently manipulated to provide the necessary information for analysis of the facility.

Summary Influent Characteristics

The influent parameters which were sampled where analyzed to ascertain the nature of the statistical distribution of the data. The influent flow, BOD mass loading and TSS mass loading data were found to be log-normally distributed. Because there is a physical limit to how small individual measurements can be, the distributions were to be right-tailed, positively skewed. All data sets passed the Kolmogorov-Smirnov goodness-of-fit test with a confidence level of 95%.

Average daily flow and mass loadings were determined by averaging the available flow data based on the selected statistical distribution. The maximum day flow and mass loadings were determined via the use of the log-probability or arithmetic-probability plots. A regression line was determined for the distribution and extended to the 100 percent probability threshold. The value of flow or mass loading corresponding to this threshold was assumed to be the maximum daily value. Comparing the obtained values with the full data sets, the obtained maximum daily value typically met or exceeded the 100^{th} percentile measurement.

It must be noted, that the design capacity of the SW WWTP is 1.0 MGD. It was designed to be capable of passing a 2.6 MGD peak flow with two secondary clarifiers installed.

Table 1 – Flow Summary: January 1, 2014 through January 31, 2016

Population	Flow, MGD			
	Minimum	**Average**	**Max Day**	**Peak**
--	0.013	0.195	2.500	2.500

Table 2 – Influent BOD Mass Loading Summary: January 1, 2014 through January 31, 2016

Population	BOD Mass Load, lbs d^{-1}			
	Minimum	**Average**	**Max Day**	**Peak**
--	20	211	2,000 (*)	2,000 (*)

(*) Projected mass loading

Table 3 – Influent TSS Mass Loading Summary: January 1, 2014 through January 31, 2016

Population	TSS Mass Load, lbs d^{-1}			
	Minimum	**Average**	**Max Day**	**Peak**
--	27	294	5,500 (*)	5,500 (*)

(*) Projected mass loading

Table 4 – Supplementary Influent Testing: February 6, 2017 through Present

Date	TP (mg L^{-1})	OP (mg L^{-1})	TN (mg L^{-1})	NH_3-N (mg L^{-1})	TCOD (mg L^{-1})	rbCOD (mg L^{-1})	BOD_5 (mg L^{-1})
02-06-17	--	20.3	57.8		824		
02-15-17	25.8						225
02-22-17	19.3	13.14	47.40	22.5			222
03-01-17	13.36	9.54		23.4			213
03-07-17				5.47			

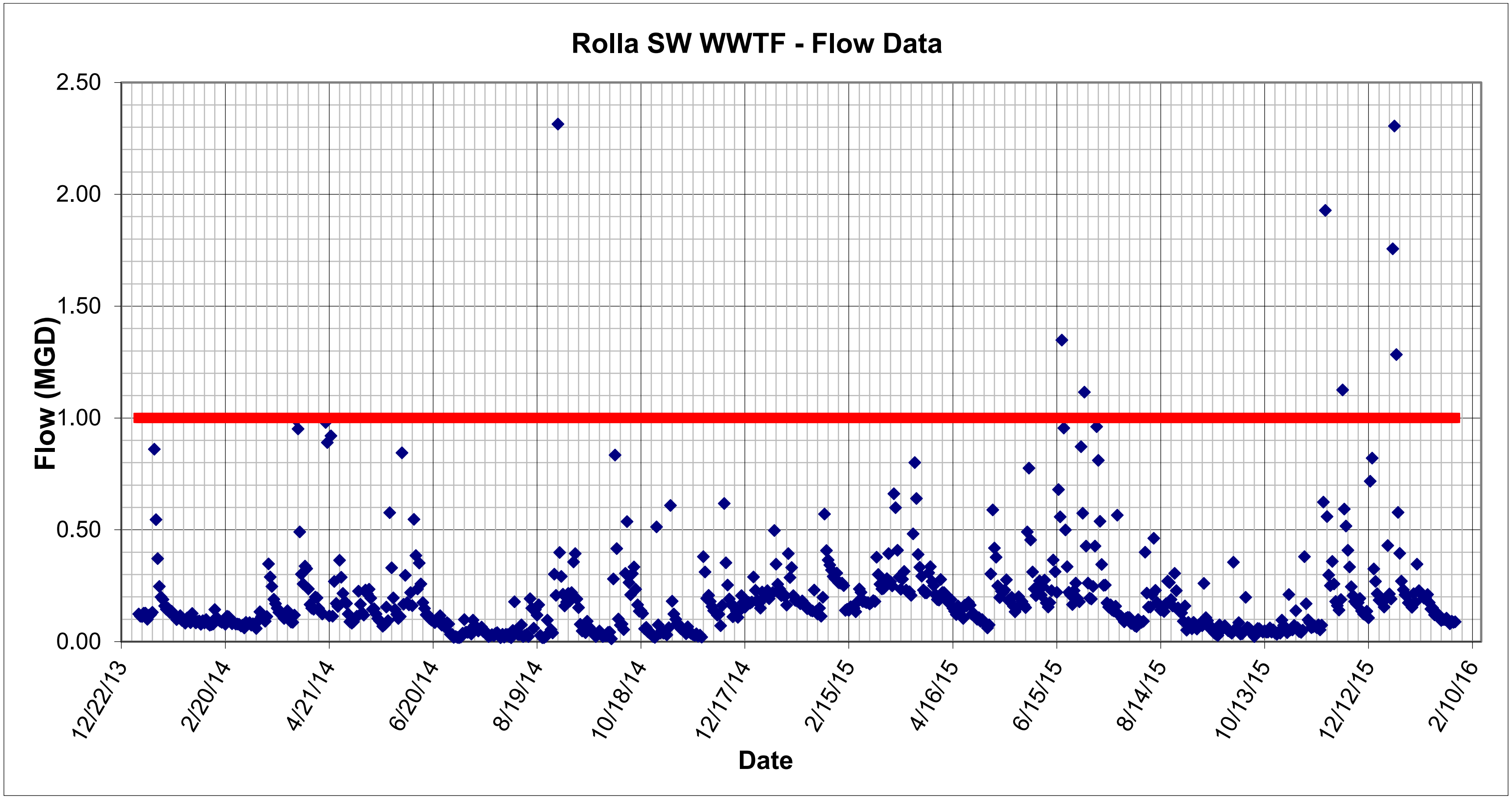

Figure 1 – Rolla SW WWTF flow data: January 1, 2014 through January 31, 2016

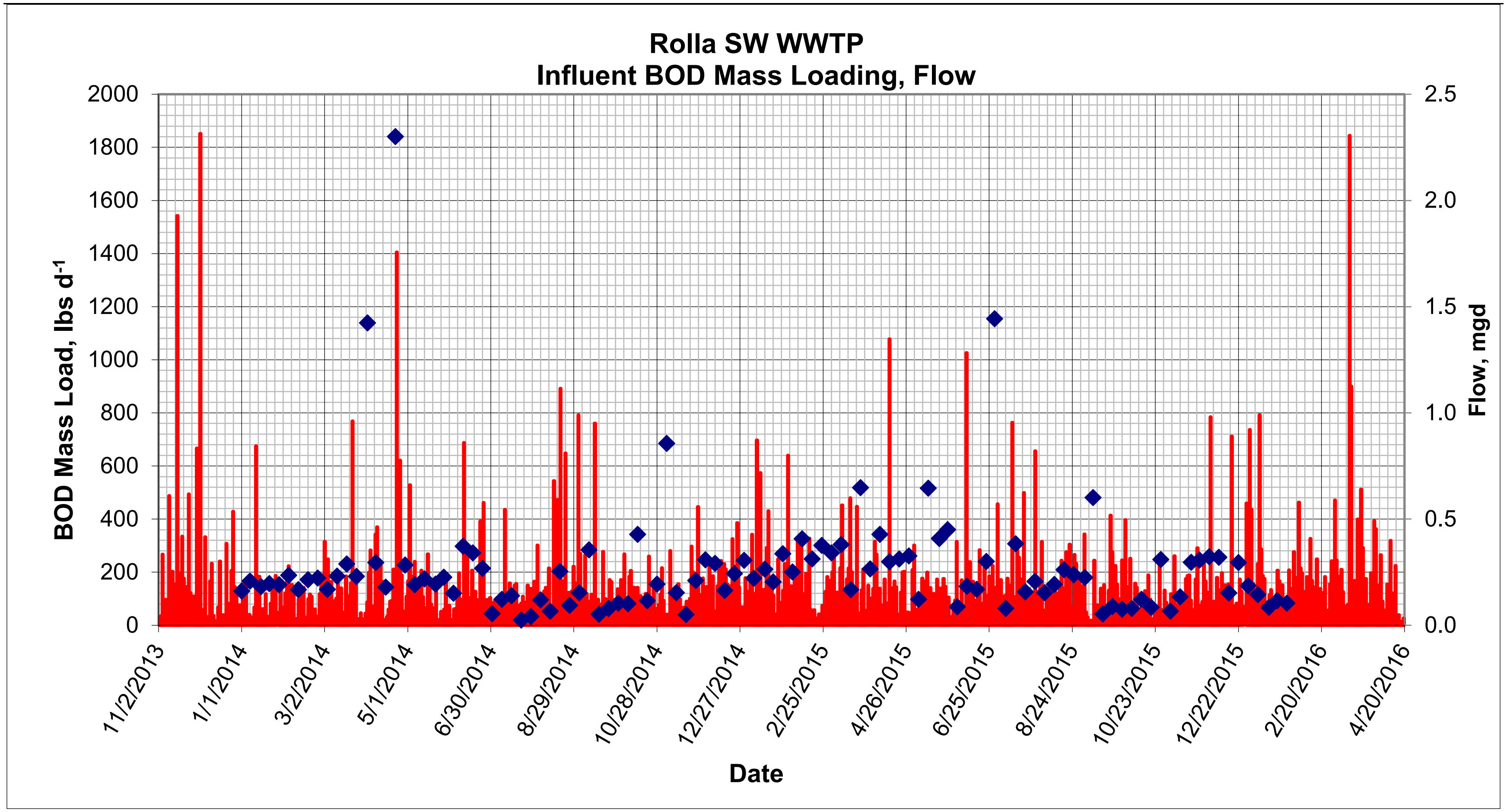

Figure 2 – Rolla SW WWTF influent BOD mass loading data: January 1, 2014 through January 31, 2016

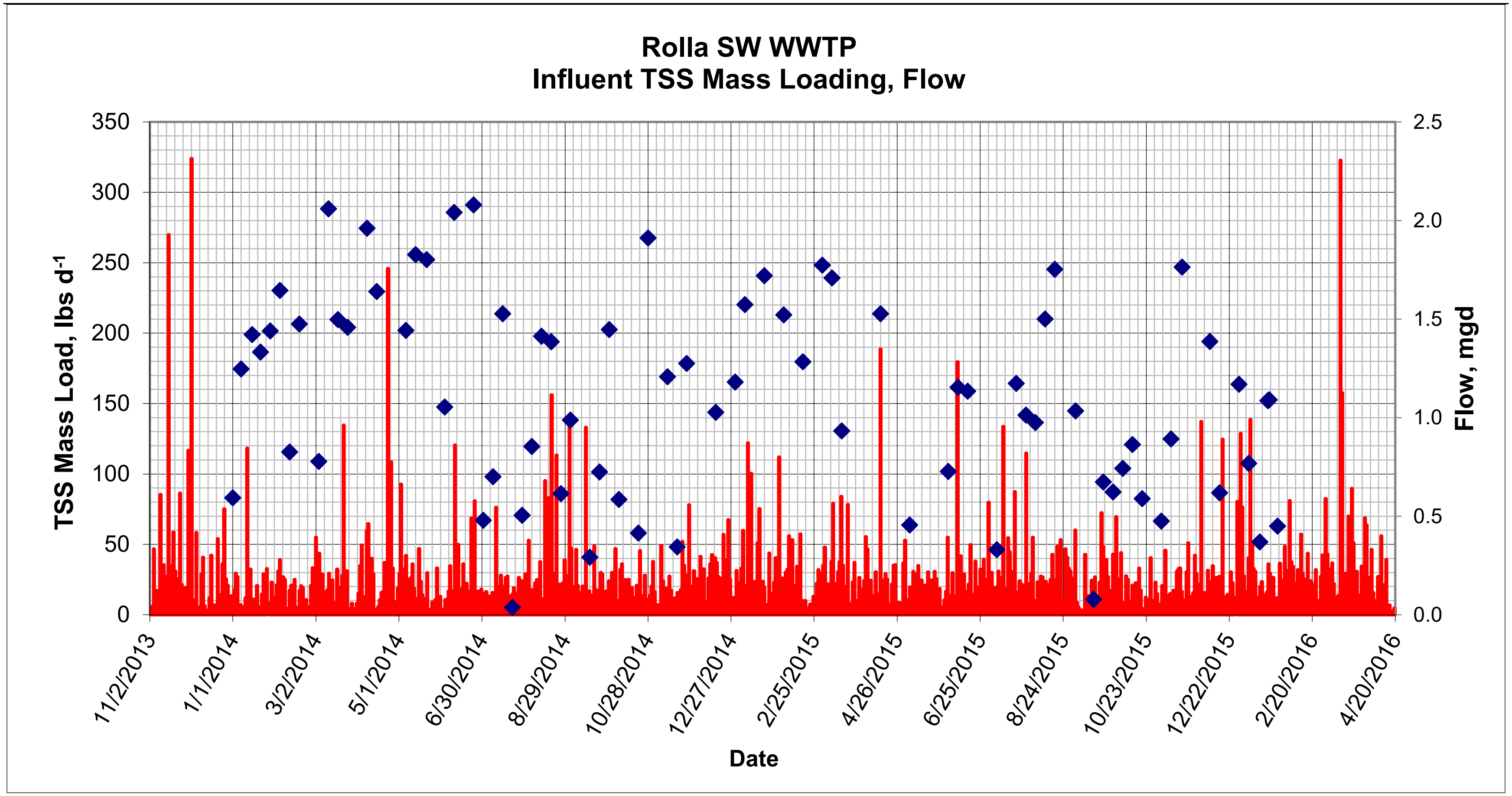

Figure 3 – Rolla SW WWTF influent TSS mass loading data: January 1, 2014 through January 31, 2016

Appendix E

Opinion of Probable Costs for Wastewater Treatment Improvements

City of Rolla
Estimated Probable Project Costs for Southeast WWTP Improvements
Phasing Alternative 1

		Phase 1- Disinfection and Ammonia Removal[1]	Phase 2- Nutrient Removal Improvements
West Plant Unit Processes			
Item	**Total Cost**	**Total Cost**	**Total Cost**
Temporary Bypass Pumping	$50,000	$50,000	
Splitter Structure No. 1 Rehabilitation	$33,000	$33,000	
New Splitter Structure No. 2- Demolish Existing Splitter	$100,000	$100,000	
New Peak Flow Screening and Flow Measurement Structure	$225,000	$225,000	
Peak Flow Clarifier- Remove and Demolish Clarifier Mechanism	$25,000	$25,000	
Headworks- Screen Rehabilitation and Epoxy Line Main Channel	$130,000	$130,000	
Headworks- Grit Chamber Rehabilitation Allowance	$50,000	$50,000	
Primary Clarifier Demolition and Add Asphalt Parking Area	$90,000	$90,000	
Trickling Filter Demolition	$200,000	$200,000	
Secondary Clarifier Demolition	$50,000	$50,000	
Walker Donut Style Ditch/Clarifier- Convert CMAS & Clarifier to Digester	$323,000		$323,000
New Chemical Building for Hypochlorite, Bisulfite, and Ferric Chloride	$1,023,000	$1,023,000	
Expand Sludge Lagoon	$143,000	$143,000	
East Plant Unit Processes			
New Splitter Structure No. 3	$146,000	$146,000	
New Peak Flow Screening and Measurement Structure	$338,000	$338,000	
Demolition of Biotower	$76,000		$76,000
New Anoxic Basins Flow Splitter No. 1	$115,000		$115,000
New Anoxic Basins No. 1 & 2	$2,031,000		$2,031,000
New Oxidation Ditch Flow Splitter No. 1	$115,000	$115,000	
New Oxidation Ditch Flow Splitter No. 2	$78,000	$78,000	
Oxidation Ditches 1 & 2- Add VFDs, DO control, and Integration	$165,000		$165,000
New Oxidation Ditches 3 & 4	$3,860,000	$3,860,000	
New Clarifier Flow Splitter No. 1 & 2	$176,000	$176,000	
Clarifier Flow Splitter No. 3- Add Weir Gate	$23,000	$23,000	
Clarifier No. 1- Replace Clarifier Mechanism	$174,000		$174,000
Clarifier No. 2- Add Launder Covers	$45,000	$45,000	
New Clarifier No. 3	$924,000	$924,000	
RAS Lift Station- Additional Wet Well to Increase Capacity	$300,000	$300,000	
New Tertiary Pump Station (8.5 MGD capacity)	$600,000		$600,000
New Tertiary Filters (8.5 MGD capacity)	$1,434,000		$1,434,000
UV- Cover Weir	$9,000	$9,000	
New Plant Drain Lift Station	$325,000		$325,000
New Ferric Chloride Building	$231,000		$231,000
Tie Outfalls Together	$584,000	$584,000	
Unit Processes Subtotal	**$14,191,000**	**$8,717,000**	**$5,474,000**
Site Work (7%)	$994,000	$611,000	$384,000
Yard Piping (10%)	$1,420,000	$872,000	$548,000
Electrical (10%)	$1,420,000	$872,000	$548,000
Instrumentation and Controls (8%)	$1,136,000	$698,000	$438,000
Subtotal	**$19,161,000**	**$11,770,000**	**$7,392,000**
Contingency (20%)	$3,833,000	$2,354,000	$1,479,000
Subtotal	**$22,994,000**	**$14,124,000**	**$8,871,000**
Engineering, Inspection, and Administration (20%)	$4,599,000	$2,825,000	$1,775,000
Total	**$27,593,000**	**$16,949,000**	**$10,646,000**

[1]Peak flow disinfection; add Oxidation Ditch

City of Rolla
Estimated Probable Project Costs for Southeast WWTP Improvements
Phasing Alternative 2

		Phase 1A- Disinfection and Ammonia Removal[1]	Phase 1B - Replace West Plant	Phase 2- Nutrient Removal Improvements
West Plant Unit Processes				
Item	**Total Cost**	**Total Cost**	**Total Cost**	**Total Cost**
Temporary Bypass Pumping	$50,000	$50,000		
Splitter Structure No. 1 Rehabilitation	$33,000	$33,000		
New Splitter Structure No. 2- Demolish Existing Splitter	$100,000	$100,000		
New Peak Flow Screening and Flow Measurement Structure	$225,000	$225,000		
Peak Flow Clarifier- Remove and Demolish Clarifier Mechanism	$25,000	$25,000		
Headworks- Screen Rehabilitation and Epoxy Line Main Channel	$130,000	$130,000		
Headworks- Grit Chamber Rehabilitation Allowance	$50,000	$50,000		
Primary Clarifier Demolition and Add Asphalt Parking Area	$90,000	$90,000		
Trickling Filter Demolition	$200,000	$200,000		
Secondary Clarifier Demolition	$50,000	$50,000		
Walker Donut Style Ditch/Clarifier- Convert to Aeration Basins	$1,304,000	$1,304,000		
New Chemical Building for Hypochlorite, Bisulfite, and Ferric Chloride	$1,023,000	$1,023,000		
Expand Sludge Lagoon	$143,000	$143,000		
East Plant Unit Processes				
New Splitter Structure No. 3	$146,000	$146,000		
New Peak Flow Screening and Measurement Structure	$338,000	$338,000		
Demolition of Biotower	$76,000			$76,000
New Anoxic Basins Flow Splitter No. 1	$115,000			$115,000
New Anoxic Basins No. 1 & 2	$2,031,000			$2,031,000
New Oxidation Ditch Flow Splitter No. 1	$115,000		$115,000	
New Oxidation Ditch Flow Splitter No. 2	$78,000		$78,000	
Oxidation Ditches 1 & 2- Add VFDs, DO control, and Integration	$165,000			$165,000
New Oxidation Ditches 3 & 4	$3,860,000		$3,860,000	
New Digester	$1,056,000	$1,056,000		
New Clarifier Flow Splitter No. 1 & 2	$176,000		$176,000	
Clarifier Flow Splitter No. 3- Add Weir Gate	$23,000		$23,000	
Clarifier No. 1- Replace Clarifier Mechanism	$174,000			$174,000
Clarifier No. 2- Add Launder Covers	$45,000	$45,000		
New Clarifier No. 3	$924,000		$924,000	
RAS Lift Station- Additional Wet Well to Increase Capacity	$300,000	$300,000		
New Tertiary Pump Station (8.5 MGD capacity)	$600,000			$600,000
New Tertiary Filters (8.5 MGD capacity)	$1,434,000			$1,434,000
UV- Cover Weir	$9,000	$9,000		
New Plant Drain Lift Station	$325,000			$325,000
New Ferric Chloride Building	$231,000			$231,000
Tie Outfalls Together	$584,000	$584,000		
Unit Processes Subtotal	**$16,228,000**	**$5,901,000**	**$5,176,000**	**$5,151,000**
Site Work (7%)	$1,136,000	$414,000	$363,000	$361,000
Yard Piping (10%)	$1,623,000	$591,000	$518,000	$516,000
Electrical (10%)	$1,623,000	$591,000	$518,000	$516,000
Instrumentation and Controls (8%)	$1,299,000	$473,000	$415,000	$413,000
Subtotal	**$21,909,000**	**$7,970,000**	**$6,990,000**	**$6,957,000**
Contingency (20%)	$4,382,000	$1,594,000	$1,398,000	$1,392,000
Subtotal	**$26,291,000**	**$9,564,000**	**$8,388,000**	**$8,349,000**
Engineering, Inspection, and Administration (20%)	$5,259,000	$1,913,000	$1,678,000	$1,670,000
Total	**$31,550,000**	**$11,477,000**	**$10,066,000**	**$10,019,000**

[1] Peak flow disinfection; Convert Walker Unit to Aeration Basin and add Digester

City of Rolla
Estimated Probable Project Costs for New Vichy Road WWTP

New Vichy Road 0.5 MGD Plant		Phase 1- Disinfection and Ammonia Removal[1]	Phase 2- Nutrient Removal
Item	**Total Cost**		
Southwest Plant 2008 Construction Cost Scaled to 2017 Dollars	$3,000,000	$3,000,000	
Additional Unit Processes			
New Flow Splitter No. 3 for Influent Flow Splitting	$79,000	$79,000	
New Peak Flow Screening and Flow Measurement Structure	$165,000	$165,000	
Peak Flow Clarifier	$458,000	$458,000	
New Chemical Building for Hypochlorite, Bisulfite, and Ferric Chloride	$505,000	$505,000	
Oxidation Ditch No. 1- Mixing Improvements	$52,000	$52,000	
Secondary Clarifier- Launder Covers (2)	$46,000	$46,000	
New Tertiary Pump Station (1.0 MGD capacity)	$250,000		$250,000
New Tertiary Filters (1.0 MGD capacity)	$655,000		$655,000
Sludge Lagoon	$250,000	$250,000	
Unit Processes Subtotal	**$2,460,000**	**$1,555,000**	**$905,000**
Site Work (7%)	$173,000	$109,000	$64,000
Yard Piping (10%)	$246,000	$156,000	$91,000
Electrical (10%)	$246,000	$156,000	$91,000
Instrumentation and Controls (8%)	$197,000	$125,000	$73,000
Unit Processes Subtotal	**$3,322,000**	**$2,101,000**	**$1,224,000**
Subtotal	**$6,322,000**	**$5,101,000**	**$1,224,000**
Contingency (20%)	$1,265,000	$1,021,000	$245,000
Subtotal	**$7,587,000**	**$6,122,000**	**$1,469,000**
Engineering, Inspection, and Administration (20%)	$1,518,000	$1,225,000	$294,000
Land Acquisition and Offsite Improvements	$500,000	$500,000	
Total	**$9,605,000**	**$7,847,000**	**$1,763,000**

(1) Peak flow disinfection

City of Rolla

Estimated Probable Project Costs for Southwest WWTP Improvements

Alternative 1- Southwest WWTP Improvements and New Vichy Road WWTP		Phase 1- Disinfection and Ammonia[1]	Phase 2- Nutrient Removal
Southwest WWTP Improvements			
Item	**Total Cost**	**Total Cost**	**Total Cost**
New Flow Splitter No. 3 for Influent Flow Splitting	$79,000	$79,000	
New Peak Flow Screening and Flow Measurement Structure	$165,000	$165,000	
Convert Walker Process Contact Stabilization Unit to Peak Flow Clarifier	$50,000	$50,000	
New Chemical Building for Hypochlorite, Bisulfite, and Ferric Chloride	$505,000	$505,000	
Oxidation Ditch No. 1- Mixing Improvements	$52,000	$52,000	
Secondary Clarifier- Launder Covers (2)	$46,000	$46,000	
New Tertiary Pump Station (1.0 MGD capacity)	$250,000		$250,000
New Tertiary Filters (1.0 MGD capacity)	$655,000		$655,000
Tie Outfalls Together	$173,000	$173,000	
Unit Processes Subtotal	**$1,975,000**	**$1,070,000**	**$905,000**
Site Work (7%)	$139,000	$75,000	$64,000
Yard Piping (10%)	$198,000	$107,000	$91,000
Electrical (10%)	$198,000	$107,000	$91,000
Instrumentation and Controls (8%)	$158,000	$86,000	$73,000
Subtotal	**$2,668,000**	**$1,445,000**	**$1,224,000**
Contingency (20%)	$534,000	$289,000	$245,000
Subtotal	**$3,202,000**	**$1,734,000**	**$1,469,000**
Engineering, Inspection, and Administration (20%)	$641,000	$347,000	$294,000
Southwest WWTP Improvements Total	**$3,843,000**	**$2,081,000**	**$1,763,000**

[1]Peak flow disinfection

Vichy Road WWTP Improvements			
New Vichy Road 0.5 MGD Plant	$9,605,000	$7,847,000	$1,763,000
Vichy Road WWTPTotal	**$9,605,000**	**$7,847,000**	**$1,763,000**
Alternative 1 Total	**$13,448,000**	**$9,928,000**	**$3,526,000**

Alternative 2- Pump Vichy Road flows to Southwest WWTP and Expand Southwest WWTP			
Expand Southwest WWTP			
Item	**Total Cost**	**Total Cost**	**Total Cost**
New Flow Splitter No. 3 for Influent Flow Splitting	$89,000	$89,000	
New Peak Flow Screening and Flow Measurement Structure	$190,000	$190,000	
New Flow Splitter No. 5 for Peak Flow Splitting	$86,000	$86,000	
Convert Walker Process Contact Stabilization Unit to Peak Flow Clarifier	$50,000	$50,000	
New Peak Flow Clarifier	$458,000	$458,000	
New Chemical Building for Hypochlorite, Bisulfite, and Ferric Chloride	$583,000	$583,000	
Oxidation Ditch No. 1- Mixing Improvements	$52,000	$52,000	
New Oxidation Ditch No. 2	$750,000	$750,000	
New Flow Splitter No. 4- Oxidation Ditch 2 Effluent to Splitter No. 2	$30,000	$30,000	
Flow Splitter No. 2- Grout Demolition and Gate Addition	$11,200	$11,200	
Secondary Clarifier- Launder Covers (2)	$46,000	$46,000	
New Clarifier No. 3	$414,000	$414,000	
RAS Lift Station- Additional Wet Well to Increase Capacity	$165,000	$165,000	
New Tertiary Pump Station (2.0 MGD capacity)	$325,000		$325,000
New Tertiary Filters (2.0 MGD capacity)	$936,000		$936,000
UV- Increase Capacity from 1.4 MGD to 2.0 MGD	$196,000	$196,000	
Tie Outfalls Together	$173,000	$173,000	
Unit Processes Subtotal	**$4,555,000**	**$3,294,000**	**$1,261,000**
Site Work (7%)	$319,000	$231,000	$89,000
Yard Piping (10%)	$456,000	$330,000	$127,000
Electrical (10%)	$456,000	$330,000	$127,000
Instrumentation and Controls (8%)	$365,000	$264,000	$101,000
Subtotal	**$6,151,000**	**$4,449,000**	**$1,705,000**
Contingency (20%)	$1,231,000	$890,000	$341,000
Subtotal	**$7,382,000**	**$5,339,000**	**$2,046,000**
Engineering, Inspection, and Administration (20%)	$1,477,000	$1,068,000	$410,000
Expansion of Southwest WWTP Total	**$8,859,000**	**$6,407,000**	**$2,456,000**
Vichy Road WWTP Improvements			
New Forcemain to Replace Existing Vichy Road WWTP	$3,166,000	$3,166,000	
New Pump Station to Replace Existing Vichy Road WWTP	$2,351,000	$2,351,000	
Subtotal	**$5,517,000**	**$5,517,000**	
Contingency (20%)	$1,104,000	$1,104,000	
Subtotal	**$6,621,000**	**$6,621,000**	
Engineering, Inspection, and Administration (20%)	$1,325,000	$1,325,000	
Forcemain and Pump Station Total	**$7,946,000**	**$7,946,000**	
Alternative 2 Total	**$16,805,000**	**$14,353,000**	**$2,456,000**

[1]Peak flow disinfection

Appendix F

Vichy Road WWTP Pump Station and Forcemain Alternative

DESIGN MEMORANDUM

To: File
From: Ken Campbell, P.E.
Date: July 12, 2017
Subject: Rolla WWTP Preliminary Engineering Report
Vichy Road WWTP - Instantaneous Flow Analysis & Pump Station Preliminary Design

Background

Within the scope of the Rolla WWTP PER project, it will be necessary to assess the capacity of the Vichy Road WWTP (**MO-0047031)** and develop alternatives necessary for the improvement of the facility to meet future regulatory requirements. One alternative that has been developed for the facility involves the abandonment of the existing wastewater treatment facility and its replacement with a new sanitary sewer pump station. The pump station would be designed to convey all received flows to the Rolla Southwest WWTP (**MO-0047023**).

Influent wastewater is measured at two locations within the Vichy Road (VR) WWTP. Flow enters the facility via a 21 inch diameter gravity main. The flow is immediately split. The main process flow passes through a mechanical screen prior to flow measurement within a 9-inch Parshall flume. Flow in excess of the main process capacity is diverted to a separate channel containing a second Parshall flume prior to its conveyance to a stormwater clarifier. The splitting of flows is performed utilizing an operator adjustable gate. Both process flows are measured in real time via ultrasonic transducers and the data is stored on a paperless data recorder.

On May 17, 2017, influent flow measurement data was collected from the facility data logger. The data was subsequently imported into a Microsoft Excel file and analyzed. The data collected spanned between November 2016 through May 2017 and included the recent storm events occurring after April 26, 2017. Rainfall data was supplied by the City's hydrologic consultant, Allgeier-Martin & Associates, on May 19, 2017. The rainfall data included information regarding intensity, duration and frequency of the observed rainfall events. This rainfall data was incorporated into the analysis of the instantaneous flow data for the facility.

Summary Influent Flow Characteristics

Based on the review of the available instantaneous flow data, it was apparent that there were numerous storm events which generated extreme peak flows at the facility. A summary of significant flow events at the facility are listed below. The controlling event which shall be studied in further depth occurred on

April 28, 2017. Based on the analysis provide by Allgeier Martin & Associates, this storm event had an annual exceedance probability of 9.2 percent and a controlling storm duration of 48 hours. Raw data for both the storm water clarifier flume and the main process flow showed a maximum aggregate flow of 5.00 MGD. During this time, the storm water clarifier flume appeared to be operating at the maximum end of its calibration range. Looking at the ascension and recession limbs of the hydrograph, it is likely that flows in excess of the maximum capacity of the flow meter were achieved. The flows metered by the main process flow varied gradually after 2:00 p.m. on April 29, 2017. A maximum flow through the main process of 2.00 MGD was achieved 2:00 a.m. on April 30, 2017. This maximal flow as a result of a period of high intensity rainfall that occurred approximately 2.5 hours earlier. It is anticipated that the resulting flows at the plant were in excess of the flow meter calibration based on a review the ascension and recession limbs of the hydrograph.

Table 1 – Summary of Significant Flow Events and Associated Rainfall

Storm Event	Rainfall Depth (in)	AEP	Controlling Duration	Peak Flow (MGD)
April 4, 2017	1.47	100.0%	15 min	3.48
April 26, 2017	1.79	100.0%	15 min	2.96
April 28, 2017	5.61	9.2%	48 Hr	10.48 (*)
May 3, 2017	2.17	100.0%	15 min	3.90

(*) Flow projection

It was necessary to project the flows for both the stormwater and main process flow to accommodate for the apparent exceedance of the flow meter equipment calibrated capacity. A linear regression analysis was performed on both the ascension and recession limbs of the hydrograph. The determined regression functions were then extrapolated until an intersection of the two lines was observed. The intersection was taken to be the projected peak flow for use in the design of the pump station and associated force main. A similar projection was performed for the main process flow during that portion of time that the measured flow exceeded the calibrated capacity of the flow measurement apparatus. The projected hydrographs where then combined by a method of superposition, providing a projected aggregate peak of 10.48 MGD for the storm event. Figure 1 illustrates the response of WWTP flows to rainfall, as well as the projection of flows.

Reviewing the flow projection for the selected storm event, it is readily apparent that the peak occurs approximately 2.5 hours after the occurrence of high intensity rainfall. It is anticipated that the flow that was generated is exclusive of initial abstractions as approximately 1.79 inches of rainfall fell in the 48 hours preceding the storm event. A second peak flow was observed after a subsequent period of high intensity rainfall. It should be noted that this projected peak may underestimate the actual flow received at the facility. This is a result of a lack of data to demonstrate the response of flow through the stormwater process as the main treatment process flow rapidly increased.

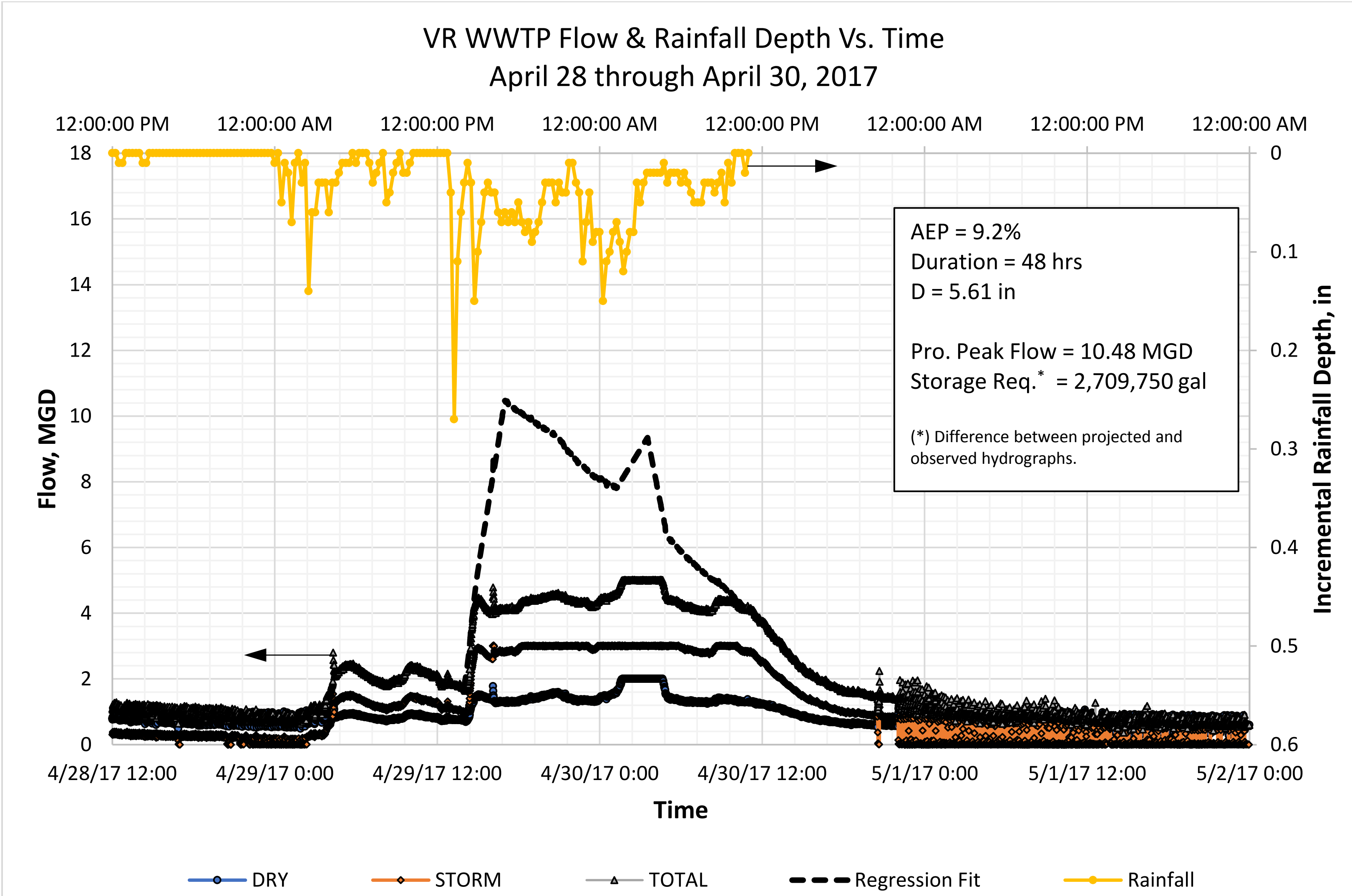

Figure 1 – Rolla WWTF Influent Flow and Incremental Rainfall Detph – April 28, 2017 Storm Event

Pump Station and Force Main Design Considerations

The pump station and force main should be designed to convey an anticipated peak flow received at the facility for the appropriate design storm event. A 10% Annual Exceedance Probability (AEP) storm event has historically been utilized as the basis of design for wastewater conveyance and equalization facilities across the state. The storm duration utilized for design is generally taken to be equal to the time of concentration for the sewershed. The utilization of this storm duration generally results in a maximization of peak flows, which is appropriate for this type of facility.

The April 28, 2017 storm event meets the AEP criterial well; however, conversion of the observed hydrograph from a 48 hour storm duration to a 3 hour storm duration will be necessary to ascertain the actual peak flow.

Primary Design considerations:

- For the flow data associated with the 10 year, 48 hour storm event, the projected peak flow was 10.48 MGD. It will not be feasible to convey this peak flow to the Southwest WWTP.
- The force main and pumps should be sized to accommodate a projected 2037 average daily flow of 0.451 MGD and a peak flow of 3.62 MGD (2,500 gpm). Two force mains should be considered: one for average daily flow and one for the peak hour flow.
    - The average daily flow force main shall be an 10 inch diameter AWWA C-905, DR-18 PVC. An approximate duty point for preliminary design is 500 gpm at 270 ft TDH. Flygt NP3202.185 SH 72 Hp, 3 phase, 480 VAC pumps were preliminarily selected. One firm unit shall be installed; one spare unit shall be supplied.
    - The peak hour flow force main shall be an 18 inch diameter AWWA C-905, DR-18 PVC. An approximate duty point for preliminary design is 2,250 gpm at 266 ft TDH. Flygt NP3315 HT, 160 Hp, 3 phase, 480 VAC pumps were preliminarily selected. Two firm units and one standby unit shall be installed.
    - The pump station site shall have an approximate site elevation of 950 ft with a proposed wetwell WSE of 935 ft.
    - Proposed Force Main Alignment No. 1 has a length and maximal elevation of approximately 26,000 ft and 1160 ft, respectively.
    - Each pump shall be installed in separate wells to limit potential for hydraulic interactions between the pumps, as well as facilitate operator maintenance of pump discharge during normal operations of the facility.
- Flows in excess of the selected pump station and force main capacities shall be stored onsite until such a time that the peak flow can recede to a reasonable level.
- Based on the 10 year, 3 hour design storm, initial estimates of storm water storage basin volume are 2.0 million gallons.
- Excess flow shall pass through a manual bar screen and the existing storm water clarifier prior to being sent to the storage basin. After the storm induced flow recedes, the stored water shall be mixed

with primary sludge and pumped to the facility influent headworks where it shall be blended with facility influent. The flow shall then be pump directly to the Southwest WWTP.

- Force Main Odor Control
    - ADF Force Main: The hydraulic retention time under normal conditions shall be ≥ 5 hours. Addition of calcium nitrate shall be necessary to prevent sulfate reduction and the generation of hydrogen sulfide gas. Chemical storage and feed equipment shall be house in the existing Control Building.
    - PF Force Main: Granular activated carbon (GAC) filters shall be installed to scrub odor causing compounds (hydrogen sulfides, VOCs., etc.) during force main filling. GAC filters shall be installed at all air valve locations.
- Emergency standby power generation shall be provided to power the site in the case of power outage. Emergency standby power generation shall be sized to accommodate the operation of the ADF pump, two PF pumps and any ancillary electrical loads. Care should be taken in the design of pump controls to limit the possibility of multiple pumps starting simultaneously.
- An overhead crane shall be provided to facilitate the removal of pumps from the station wetwell and their placement in the bed of a service truck.

Opinion of Probable Project Costs and Life Cycle Cost Analysis:

An opinion of probable project cost was generated for the proposed improvements. The opinion of probable project cost is $7,944,000. This cost includes the construction of both the force main and pump station, a 20 percent construction contingency and all anticipated engineering, surveying and construction administration costs.

A life cycle cost analysis was performed for this alternative. All anticipated annual operations and maintenances costs were accounted for in the analysis, including labor and electrical costs. Furthermore, future replacement of key pieces of equipment was planned. The analysis was performed for a planning period of 20 years. Based on the life cycle analysis, it was determined that the present work value of this alternative was $9,040,000.

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Project:	HDR Rolla WWTP PER
Client:	City of Rolla, Missouri
By: KAC	**Chk:**
Date: 7/11/2017	**Date:**

Opinion of Probable Project Cost

Vichy Road WWTP - Pump Station and Force Main Alternative

Vichy Road WWTP Pump Station and Force Main Alternative - This alternative involves the construction of a force main and pump station to replace the existing Vichy Road WWTP. The force main shall consist of 8" DR-18 AWWA C-900 PVC for the average daily flows and 18" DR-18 AWWA C-905 PVC for peak flows. The two mains shall be installed within a common trench. The pump station shall have one Flygt NP3202 SH 273, 72 Hp, 160/3/60 pump (one spare unit provided) for average daily flows and three Flygt NP3315 HT 455, 160 Hp, 460/3/60 pumps (two firm, one standby) for peak flow. Average daily flow pump shall be operated via VFD; Peak flow pumps shall be constant speed.

Item No.	Description	Qty	Unit	Unit Price	Total
Force Main					
1	18" DR-18 AWWA C-905 PVC Force Main, including trenching, backfill, etc.	26,000	LF	$80.00	$2,080,000.00
2	18" Burried-service Plug Valves	26	Ea	$6,000.00	$156,000.00
3	18" Highway Bore, Steel Encasement	300	LF	$350.00	$105,000.00
4	10" DR-18 AWWA C-900 PVC Force Main, installed in common trench	26,000	LF	$20.00	$520,000.00
5	10" Highway Bore, Steel Encasement	300	Ea	$250.00	$75,000.00
6	10" Burried-service Plug Valves	26	Ea	$3,750.00	$97,500.00
7	2" Combination Air Valve and Vault	5	Ea	$7,500.00	$37,500.00
8	1" Combination Air Valve and Vault	5	Ea	$6,000.00	$30,000.00
9	Right of Way/Easement Acquisition	26,000	LF	$2.50	$65,000.00
Earthwork					
10	Unclassified Excavation & Embankment, including clearing, grubbing - Pump Station	4575	CY	$15.00	$68,625.00
11	Granular backfill, 1 inch clean, compacted	3926	CY	$18.25	$71,649.50
12	Erosion Control.	1	LS	$5,000.00	$5,000.00
Pavement					
13	Granular Paving	2500	SY	$15.00	$37,500.00
Yard Process Piping					
14	6” DIP Process Piping	75	LF	$135.00	$10,125.00
15	6” Buried Service Plug Valves	1	EA	$1,500.00	$1,500.00
16	12” DIP Process Piping	50	LF	$250.00	$12,500.00
17	12” Buried Service Plug Valves	1	EA	$6,000.00	$6,000.00
18	2" PE4710, SDR-13 HDPE Water Line	100	LF	$15.00	$1,500.00
Equipment/Process					
19	Pump Station Pumps & Controls	1	LS	$465,000.00	$465,000.00
20	Pump Station Process Piping	1	LS	$70,000.00	$70,000.00
21	Overhead Monorail Wire Hoist Trolley	1	LS	$25,000.00	$25,000.00
22	Stainless Steel Sluice Gate, Frame and Operator	4	Ea	$15,000.00	$60,000.00
23	Aluminum Hatches, Wetwell and Valve Vault	1	LS	$27,500.00	$27,500.00
24	Electromagnetic Flow Meter, ADF and P.F.	1	LS	$18,000.00	$18,000.00
25	Electrical, Instrumentation & Control Equipment	1	LS	$250,000.00	$250,000.00
26	Emergency Standby Generator w/ ATS	1	LS	$250,000.00	$250,000.00
27	Odor Control Chemical Feed System	1	LS	$60,000.00	$60,000.00
27	Odor Control GAC Filtration	3	Ea	$25,000.00	$75,000.00
28	Water well, 35 gpm, installed complete with pump, hydropnuematic tank	1	LS	$12,000.00	$12,000.00

Project:	HDR Rolla WWTP PER
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Chk:	
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Date:	

Structures					
29	Pump Station Wetwell & Valve Vault	325	CY	$750.00	$243,750.00
30	Flow Meter & Force Main Drain Vault	13	CY	$750.00	$9,750.00
31	Peak Flow Storage Basin	1425	CY	$400.00	$570,000.00

Force Main Subtotal =	$3,166,000.00
Pump Station Subtotal =	$2,350,399.50
Construction SubTotal =	$5,516,400
Contingency (20%) =	$1,103,280
Construction Subtotal =	$6,619,679
Engineering, Surveying & Construction Admin =	$1,323,936
Opinion of Probable Project Cost, P =	**$7,944,000**

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Project:	HDR Rolla WWTP PER		
Client:	City of Rolla, Missouri		
By:	KAC	**Chk:**	
Date:	7/11/2017	**Date:**	

Operation & Maintenance & Replacement

Vichy Road WWTP Force Main and Pump Station Alternative

Equipment Replacement

Analysis Period:	20	yr	
Inflation Rate:	2.45%		(Approximate Savings Interest Rate)
Interest Rate:	3.00%		(Estimated 15-yr inflation rate projection)

Equipment Replacement:	Present Day Cost, P	F/P Interest Factor	Inflation Adjusted Cost, F	A/F Interest Factor	Annual Replacement Cost, A	Replacement Period
ADF Pump Replacement	$35,000	1.274	44,590	0.000	$3,890	10 yr
PF Pump Replacement	$75,000	1.623	121,710	0.000	$4,530	20 yr
Overhead Trolley Hoist Replacement	$10,000	1.623	16,230	0.000	$610	20 yr
		Annual Equipment Replacement Cost:			**$9,030**	

Operation & Maintenance Costs

Maintenance Provider Costs:	$25.00	per hour
Power Usage Costs:	$0.10	per KWH
Interest Rate:	3.00%	(Approximate Finance Rate)
Inflation Rate:	2.45%	(Estimated 15-yr inflation rate projection)
Analysis Period:	20	yrs

Chemical Feed Unit:

Component Maintenance:	Comp. Qty	Events per Year	Labor per Event	Yearly Labor	Yearly Costs	
Visual inspection:	1	52	0.25	13	$325.00	
Tubing element replacement:	1	4	0.25	1	$25.00	
Tubing element:	1	1			$100.00	
Chemical Delivery:	1	2	0.5	1	$25.00	
Chemical:	1	365			$3,000.00	
Emergency Maintenance:	1	1	8	8	$200.00	
Unit Operation:	**Comp. Qty**	**Hours per Year**	**Run Time (%)**	**Yearly Run Time**	**Yearly Costs**	
Power Usage:	1	8760	66%	5781.6	$143.71	**$3,818.71**

Activated Carbon Adsorption Unit (ACAU):

Component Maintenance:	Comp. Qty	Events per Year	Labor per Event	Yearly Labor	Yearly Costs	
Activated Carbon Recharge:	3	0.2	1	0.6	$15.00	
Activated Carbon:	3	0.2	--	--	$1,800.00	
Mist & Grease Filter Replacement:	3	0.2	0.5	0.3	$7.50	
Mist & Grease Filter:	3	0.2	--	--	$60.00	
Blower Filter Replacement:	3	1	0.5	1.5	$37.50	
Blower Filter:	3	1	--	--	$60.00	
Blower Lubrication:	3	0.1	0.5	0.15	$3.75	
Blower Lubrication:	3	0.1	--	--	$6.00	
Unit Operation:	**Comp. Qty**	**Hours per Year**	**Run Time (%)**	**Yearly Run Time**	**Yearly Costs**	
Power Usage, ACAU:	3	480	100%	1440	$10,738.08	**$12,727.83**

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Project:	HDR Rolla WWTP PER		
Client:	City of Rolla, Missouri		
By:	KAC	**Chk:**	
Date:	7/11/2017	**Date:**	

Vichy Road Pump Station

Component Maintenance:	Comp. Qty	Events per Year	Labor per Event	Yearly Labor	Yearly Costs
Pump Station Equipment Visual Inspection:	1	52	0.5	26	$650.00
ADF Pump Motor Oil Change Supplies:	--	--	--	--	$900.00
ADF Pump Motor Oil Change Labor:	1	1	4	4	$100.00
PF Pump Motor Oil Change Supplies:	--	--	--	--	$2,700.00
PF Pump Motor Oil Change Labor:	3	1	4	12	$300.00
ADF Pump Motor Overhaul/Repair Supplies:	--	--	--	--	$1,000.00
ADF Pump Motor Overhaul/Repair Labor:	1	0.2	16	3.2	$80.00
PF Pump Motor Overhaul/Repair Supplies:	--	--	--	--	$1,050.00
PF Pump Motor Overhaul/Repair Labor:	3	0.05	16	2.4	$60.00
Emergency Maintenance:	2	1	8	16	$400.00

Equipment Operation:	Comp. Qty	Hours per Year	Run Time (%)	Yearly Run Time	Yearly Costs	
Power Usage, ADF Pump Motor:	1	8760	66%	5781.6	$31,041.64	
Power Usage, PF Pump Motor:	2	8760	5%	960.1	$11,455.10	**$48,086.74**

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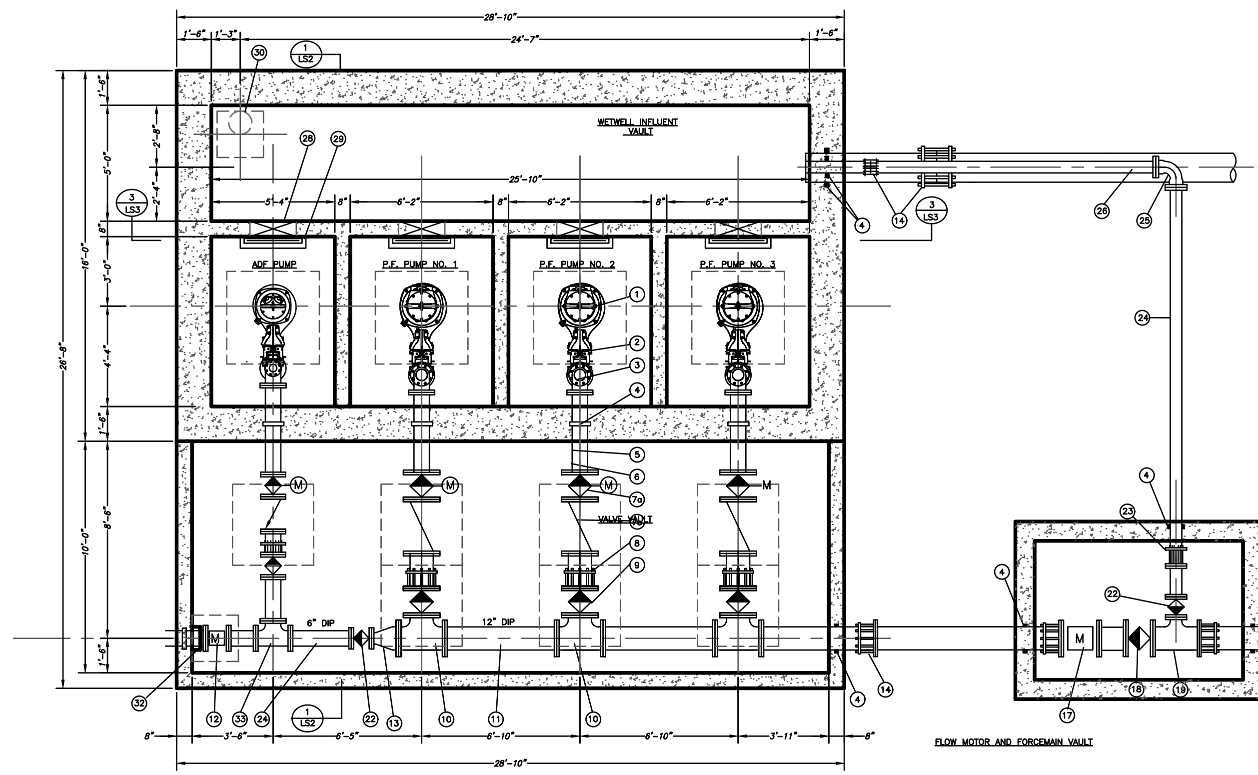
Project:	HDR Rolla WWTP PER		
Client:	City of Rolla, Missouri		
By:	KAC	**Chk:**	
Date:	7/11/2017	**Date:**	

Operation & Maintenance & Replacement (Cont.)

Vichy Road WWTP Force Main and Pump Station Alternative

Operation & Maintenance Cost Summary

Annual Operation & Maintenance Cost:	**$64,633**		
Total Annual Operation, Maintenance and Replacement Cost, $A_{O\&M}$:	**$73,663**		
Total Present Worth Operation, Maintenance and Replacement Cost, $P_{O\&M}$:	**$1,095,930**	where $A_{O\&M}/P_{O\&M}$ =	14.88
Total Project Present Worth Cost, P + $P_{O\&M}$:	**$9,040,000**		



PLAN VIEW @ ELEV. 932.50
SCALE: 1/4" = 1'-0"

KEY

ITEM	DESCRIPTIONS
1	SUBMERSIBLE PUMP
2	S.S. GUIDERAILS
3	12" FLG. 90° BEND
4	12" FLG WALL PIPE W/ THRUST COLLAR
5	SURGE SUPPRESSION AIR/VACUUM VALVE
6	½" THREADED TAP FOR PRESSURE GAUGE
7a	PUMP CONTROL VALVE
7b	12" FLG CHECK VALVE
8	12" FLG. COUPLING ADAPTOR (RESTRAINED)
9	12" FLG PLUG VALVE
10	12" FLG TEE
11	12" DIP
12	6" FLG ELECTROMAGNETIC FLOW METER
13	12"x6" FLG REDUCER
14	RESTRAINED FLEXIBLE JOINT
15	12" DIP
17	ELECTRO MAGNETIC FLOW METER
19	12"x6" FLG TEE
22	6" FLG ECCENTRIC PLUG VALVE
23	6" FLANGE FLANGE COUPLING ADAPTOR (RESTRAINED)
24	6" DIP
25	6" MJ 90° BEND
26	24" DIP
28	2'x2' SQUARE OPENING
29	SLUICE GATE, NUT OPERATED
30	STILLING WELL FOR PRESSURE X-DCR
32	MANHOLE STEPS
33	6" FLG TEE

NOTES

1. FOUNDATION AND REINFORCEMENT NOT SHOWN FOR CLARITY
2. DISCHARGE PIPING, BETWEEN THE PUMP BASE AND DISCHARGE HEADER, INCLUDING ALL VALVES AND ACCESSORIES SHALL BE IDENTICAL FOR EACH PUMP, UNLESS OTHERWISE INDICATED.
3. CONCRETE REINFORCEMENT NOT SHOWN FOR CLARITY.
4. SURGE SUPPRESSION AIR VACUUM VALVE SHALL BE A SINGLE BODY VAL-MATIC 801SS, OR APPROVED EQUAL. CONTRACTOR TO VENT AIR VACUUM EXHAUST PORT DIRECTLY TO THE WET WELL WITH 1" STAINLESS STEEL TUBING.
5. PRESSURE GAUGE SHALL BE OMEGA PGH-45L-160PSI/½-100-SS-½CG STAINLESS STEEL, LIQUID FILLALBE INDUSTRIAL PRESSURE GAUGE, DIAPHRAGM PRESSURE SEAL, ½" NPT STAINLESS STEEL BALL VALVE AND STAINLESS STEEL THREADED NIPPLE.
6. THE SLUICE GATES SHALL HAVE STAINLESS STEEL FRAMES AND GATES AND BE SUPPLIED WITH A NON-RISING STEM AND NUT OPERATOR.

DRAWING FILE NAME: 11129910 – Rolla Wastewater System		PROJECT NO.: 11129910	
DATE LAST SAVED: 8–25–17	PLOT SCALE: 1:1	DATE/TIME PLOTTED: 8–25–17	
FILES ATTACHED:	DESIGNED BY: KAC	DRAWN BY: CgL	CHECKED BY: KAC
ATTACHED FILE NAMES:			

HDR ENGINEERING, INC.
MO. STATE CERTIFICATE OF AUTHORITY #000856
3741 NE TROON DRIVE
LEE'S SUMMIT, MO. 64064

CM Archer Group, P.C. dba:
ARCHER-ELGIN
engineering ▪ surveying ▪ architecture
Corporate Authority:
CM Archer Group, P.C.: E: 2003023612-D, LS: 2004017577-D, A-2016017179
Archer-Elgin Surveying & Engineering, LLC: E: 2011024038, LS: 2011025471, A-2012014618
310 East 6th Street; Rolla, Missouri 65401 ▪ Phone: 573-364-6362 Fax: 573-364-4782 ▪ www.archer-elgin.com

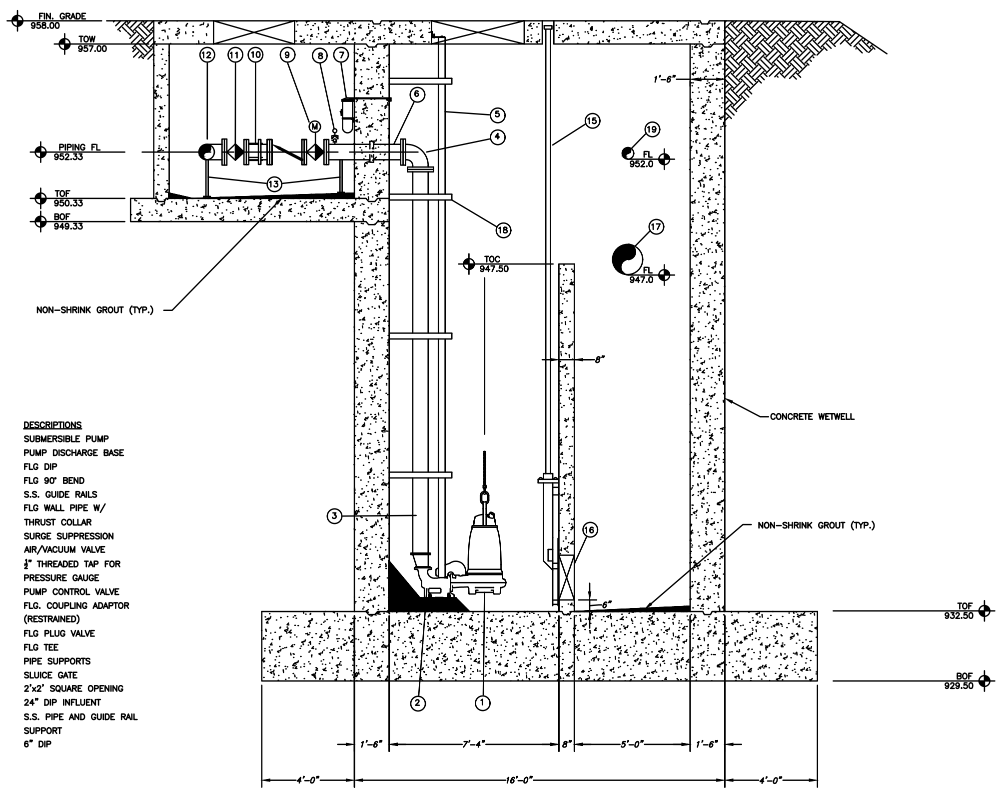
City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER TREATMENT PLANT PER

VICHY ROAD PUMP STATION
PLAN VIEW
ALTERNATIVE 2 PHASE 1

PROJECT NO. 154630

DRAWING NO. LS-1



KEY

ITEM	DESCRIPTIONS
1	SUBMERSIBLE PUMP
2	PUMP DISCHARGE BASE
3	FLG DIP
4	FLG 90° BEND
5	S.S. GUIDE RAILS
6	FLG WALL PIPE W/ THRUST COLLAR
7	SURGE SUPPRESSION AIR/VACUUM VALVE
8	½" THREADED TAP FOR PRESSURE GAUGE
9	PUMP CONTROL VALVE
10	FLG. COUPLING ADAPTOR (RESTRAINED)
11	FLG PLUG VALVE
12	FLG TEE
13	PIPE SUPPORTS
15	SLUICE GATE
16	2'x2' SQUARE OPENING
17	24" DIP INFLUENT
18	S.S. PIPE AND GUIDE RAIL SUPPORT
19	6" DIP

SECTION
SCALE: 1/4" = 1'-0"

NOTES

1. DISCHARGE PIPING, BETWEEN THE PUMP BASE AND DISCHARGE HEADER, INCLUDING ALL VALVES AND ACCESSORIES SHALL BE IDENTICAL FOR EACH PUMP, UNLESS OTHERWISE INDICATED.
2. SURGE SUPPRESSION AIR VACUUM VALVE SHALL BE A SINGLE BODY VAL-MATIC 801SS, OR APPROVED EQUAL. CONTRACTOR TO VENT AIR VACUUM EXHAUST PORT DIRECTLY TO THE WET WELL WITH 1" STAINLESS STEEL TUBING.
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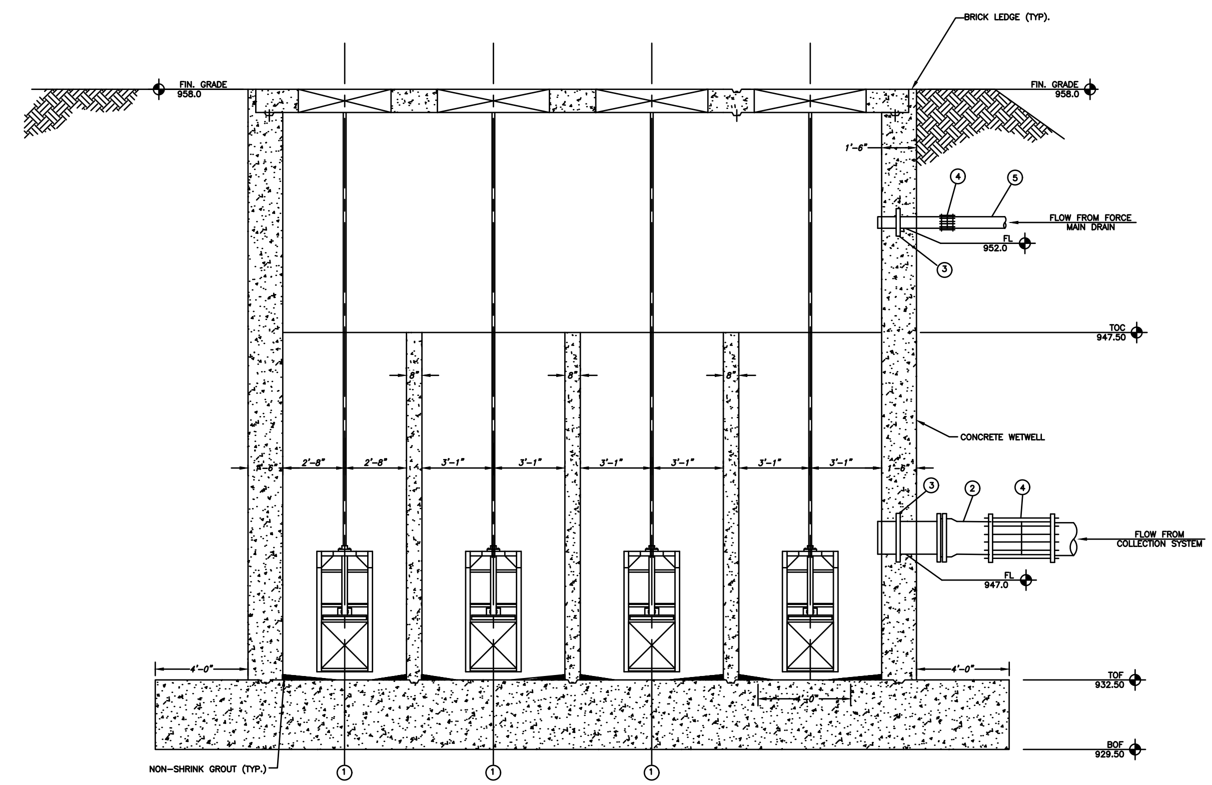
4. THE SLUICE GATES SHALL HAVE STAINLESS STEEL FRAMES AND GATES AND BE SUPPLIED WITH A NON-RISING STEM AND NUT OPERATOR.
5. CONDUIT PENETRATIONS FOR PROCESSES EQUIPMENT SHALL BE AS DETAIL HEREIN AND AS REQUIRED BY PROCESS EQUIPMENT SUPPLIER TO FACILITATE COMPLETE INSTALLATION.



KEY

ITEM	DESCRIPTIONS
1	SLUICE GATE
2	24" DIP
3	WALL PIPE W/ THRUST COLLAR
4	FLEXIBLE JOINT
5	6" DIP
6	RESTRAINED FLEXIBLE JOINT

SECTION
SCALE: 1/4" = 1'-0"

NOTES

1. THE SLUICE GATES SHALL HAVE STAINLESS STEEL FRAMES AND GATES AND BE SUPPLIED WITH A NON-RISING STEM AND NUT OPERATOR.
2. CONDUIT PENETRATIONS FOR PROCESSES EQUIPMENT SHALL BE AS DETAIL HEREIN AND AS REQUIRED BY PROCESS EQUIPMENT SUPPLIER TO FACILITATE COMPLETE INSTALLATION.

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FILES ATTACHED:	DESIGNED BY: KAC	DRAWN BY: CgL	CHECKED BY: KAC
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City of ROLLA

CITY OF ROLLA, MO
ROLLA WASTEWATER TREATMENT PLANT PER

VICHY ROAD PUMP STATION
SECTIONS
ALTERNATIVE 2 PHASE 1

PROJECT NO. 154630

DRAWING NO. LS-2