City of St. Joseph, Missouri

Facilities Plan

Volume 1

Combined Sewer Overflow Control Facilities Assessment Report

Executive Summary

By

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B&V Project 163509

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Executive Summary

1.0 Introduction

The purpose of this executive summary document is to summarize the findings and conclusions of 14 technical memoranda that were prepared for the St. Joseph, Missouri, Combined Sewer Overflow (CSO) Control Facilities Plan. The CSO Control Facilities Plan provides refinement of the 2008 CSO Long Term Control Plan (LTCP) and presents more detailed information for the LTCP facility recommendations and improvements. The CSO Control Facilities Plan serves as an addendum to the 2008 LTCP and will serve as the basis for implementation of the CSO Control Program.

The following 14 sections provide an executive summary of the CSO Control Facilities Plan technical memoranda. The complete technical memoranda and associated appendices are provided in Volume 1 of the Facilities Plan Report.

2.0 TM-CS0-1: Flow and Rainfall Data Evaluation

The purpose of Technical Memorandum (TM) TM-CSO-1 is to summarize the updated rainfall and flow monitoring data, identify potential wet weather calibration events, and make recommendations, if any, for additional monitoring data collection.

As part of the 2008 CSO LTCP, the typical year combined sewer overflow volume and potential combined sewer system (CSS) improvements were evaluated using a mathematical model of the collection system. The CSS model was constructed using the one-dimensional, unsteady state hydrology and hydraulics computer model XP-SWMM. Within the model, the flow runoff from a watershed is determined by the impervious area, the pervious soil infiltration, basin depression storage, surface wetting, and basin geometry. These variables cannot be determined precisely so preliminary estimates are developed using standard engineering methods. The CSS model and the runoff variables are then calibrated using actual monitored rainfall and flow data.

The calibration process involves adjusting the runoff variables to more closely estimate the actual watershed conditions. To calibrate the CSS model and conform to a requirement of the United States Environmental Protection Agency (USEPA) Nine

Minimum Controls for combined sewers, the City of St. Joseph has been collecting flow and rainfall data. This updated flow and rainfall data was used to calibrate the CSS model. TM-CSO-1 reviews the data provided and discusses the wet weather events that were used for model calibration.

Of the 44 wet weather events that were monitored during the period from November 2007 to July 2008, 12 possible events were identified that could be used to calibrate the CSS model. Calibration of the CSS model is presented in TM-CSO-2 – CSS Model Calibration and Existing Conditions. Additionally, recommendations were made within TM-CSO-1 to improve the City's ongoing flowmeter and rainfall data collection program. Recommendations include:

- Some of the flowmeters appeared to be mounted within the manhole structure. Generally, flowmeters are mounted within the upstream or downstream pipe, a few diameters from the manhole. The flow sensors that are not located within a pipe should be evaluated to see if the flow sensors could be moved into a pipe segment and mounted a few pipe diameters from the nearest manhole.
- Flowmeter and rain gage data collections could occur on a more frequent basis. One recommendation would be to use a weekly frequency. Most flowmeters and rain gages can hold much more data than a week; however, if an instrument problem does occur, long data gaps can result if the data is not evaluated on a frequent basis. Regular and more frequent site visits would encourage more routine maintenance and reduce the amount of missing or invalid data.
- The Whitehead and Brown's Branch flowmeters should be evaluated to see if area-velocity meters can replace the existing level-sensing meters. During June 2008, both locations were under backwater influence due to a high river stage in the Missouri River. Level-sensing meters are not appropriate flowmeter types for locations that frequently experience backwater as the depth of water is not always correlated with the flow rate. Area-velocity meters installed at the Blacksnake, Messanie, Mitchell, and Patee sites had depth data that indicated backwater conditions from the

Missouri River were experienced at these sites as well. However the velocity-sensing element allowed the meters to provide reasonable flow measurements during high river stages unlike the existing Whitehead and Brown's Branch level sensing flowmeters.

- Some flowmeters are collecting data at 15 minute intervals. From past CSS studies, 5 minutes may be a more appropriate reporting interval for flow data as it would better capture peak runoff flows from storm events.

3.0 TM-CSO-2: Combined Sewer System Model Calibration and Existing Conditions

The purpose of TM-CSO-2 is to summarize the additional CSS model calibration performed as part of the St. Joseph, Missouri Facilities Plan and provide a revised estimate of the CSO volume from the existing CSS. As part of the 2008 LTCP, the typical year CSO volume and potential CSS improvements were evaluated using a mathematical model. The CSS model was constructed using the one-dimensional, unsteady state hydrology and hydraulics computer model, XP-SWMM. Within the model, the runoff from a basin is determined by the amount of impervious area, soil infiltration, depression storage, surface wetting, and the basin geometry. These variables cannot be determined exactly so estimates are initially developed using standard engineering methods and then calibrated using actual monitored data. Limited rainfall and flow monitoring data was available for calibration of the 2008 LTCP CSS hydraulic model. For some basins, data was non-existent while only a few good wet weather calibration events were provided for the other basins. Due to the limited rainfall and flow monitoring data available for use in the 2008 LTCP, additional model calibration was recommended to help refine the CSS model.

The model calibration process involves adjusting the runoff variables to more accurately represent the actual basin conditions. To comply with the monitoring requirement of the USEPA Nine Minimum Controls for combined sewers, the City of St. Joseph has continued collecting rainfall and flow data past the completion of the 2008 LTCP. For the Facilities Plan, the City provided additional monitoring data to allow additional calibration and refinement of the existing CSS model.

The updated monitoring data provided for the Facilities Plan indicated that the runoff response of the Mitchell Basin was greater in peak flow and runoff volume than what was estimated for the 2008 LTCP. The new flowmeter data provided for the Facilities Plan allowed for a detailed check of level, velocity, and flowmeter water level to flow rate conversion. The updated data appeared reasonable and more complete than the data available in the 2008 LTCP. Therefore, the Mitchell Basin in the CSS model was calibrated using the updated data collected for the Facilities Plan, which resulted in higher runoff volumes and peak flows for the Mitchell Basin than was estimated for the 2008 LTCP.

Additionally, the 2008 LTCP monitoring data did not have any smaller rainfall events that were suitable for calibration. The data collected for the Facilities Plan did have some smaller events, and from these events, it was apparent that the monitored runoff volumes and peak flows were greater for many of the basins than was estimated in the 2008 LTCP CSS model. To make the CSS model produce more representative flows for smaller events, each subbasin was split into two subbasins where one subbasin represented the directly-connected impervious area and the other subbasin represented the pervious area. The resulting model better simulates the monitored runoff volumes and peak flows for Blacksnake, Charles, Messanie, Mitchell, Olive, and Patee Basins. Francis was also adjusted, and although the runoff volume and peak flow calibration graphs still show some scatter, it is reasonable since the drainage basin is so small (approximately three acres). Adjustments to the hydrologic response of Brown’s Branch were also made to better simulate the monitored responses; however, there is still substantial variance between the monitored and calculated hydrographs, which would indicate the need for additional monitoring.

The Brown’s Branch and Whitehead level sensing flowmeters appear to be inappropriate flowmeter technologies for their respective locations. Both sensors are fine for indicating when the monitoring water level has risen above the diversion structure overflow weirs; however, determining flow from only a level (water depth) measurement is unreliable if the locations are under a backwater influence (i.e., water level in the Missouri River is above the overflow weir or mild-sloped downstream channels). From the flow data provided for these meters, visually it would appear that the Brown’s Branch flowmeter provides reasonable estimates during some events so some calibration was performed. However, there is a backwater influence when the Missouri River is at high stage, and when this occurs, the meter does not provide good flow data. Hydrograph data for the Whitehead level sensor flowmeter extends too long after precipitation events and tapers off too suddenly towards the end of the flow event. Visually and quantitatively, the Whitehead flows do not appear reasonable, so the data were not used for calibration. Additional flow monitoring using area-velocity meters is recommended for both sites.

Using the updated model, the typical year design storms were then simulated to provide a revised estimate of the typical year CSO volume for existing conditions. The revised CSS model produces more CSO for smaller rain storm events than was estimated for the 2008 LTCP. The estimate of the existing conditions typical year CSO is 4.13 billion gallons, which is approximately 1.5 billion gallons greater than the estimate provided in the 2008 LTCP. For Design Event E, which was the selected design event to achieve the LTCP Phase III level of control, the revised version of the CSS model produces 17 percent more CSO volume than was estimated by the 2008 LTCP model. In other words, the facilities required to achieve the Phase III level of control are preliminarily estimated to be within 17 percent of the original facility sizes. As part of the Facilities Plan, the sizes of the Phase II and Phase III controls were further refined as presented in TM-CSO-3c – Future Phases of CSO Long Term Control Plan.

The monitoring data collected for the Facilities Plan proved valuable in refining the previous version of the CSS model, and the calibration results produced in this study clearly show that the model is better representing the system. However, some basins within the system have not been monitored (Duncan, Hickory, and Maple) and the level sensing flowmeter at the Missouri Avenue diversion structure has not produced any usable flow data. It is possible that additional flow monitoring would justify additional model refinement for these three basins.

4.0 TM-CSO-3a: Phase IA Combined Sewer Overflow Control Recommended Improvements Model

The purpose of TM-CSO-3a is to determine the CSO volume from the existing collection system and compare this with the CSO volume predicted with the proposed

Phase IA CSO control improvements. TM-CSO-3a summaries the effectiveness of the Phase IA improvements, which were modified from the 2008 LTCP, on the combined sewer wet weather percent capture.

The CSS model was updated and re-calibrated using additional flow monitoring data acquired as part of the Facilities Plan. Using the updated CSS model, the existing annual average combined sewage volume is estimated to be 4.7 billion gallons, and of that volume, 4.1 billion gallons leave the CSS as combined sewer overflow.

As required by the Missouri Department of Natural Resources (MDNR) and the USEPA, facility upgrades and additions are required to reduce the frequency and volume of CSOs. Specifically, the goal of the modified Phase IA improvements, derived from the Phase I controls presented in the 2008 LTCP, is to provide the most effective CSO control with the least amount of capital expense (i.e., most cost effective). The modified Phase IA improvements consist of constructing the Blacksnake and Whitehead stormwater separation conduits (see Section 8.0 for additional details), increasing the conveyance at the Whitehead Pump Station to 80 million gallons per day (mgd) (see Section 12.0 for additional details), increasing the treatment capacity at the existing Water Protection Facility (WPF) headworks to 88 mgd (see Section 15.0 for additional details), providing 61 mgd high rate treatment (HRT) and disinfection facilities (see Sections 13.0 and 14.0 for additional details, respectively), and completing partial sewer separation in the Roy's Branch Basin (currently underway).

In a typical year, the proposed Blacksnake and Whitehead stormwater separation conduits will reduce the annual volume of combined sewage overflow by 1.59 billion gallons. Increasing the conveyance capacity at the Whitehead Pump Station, increasing the treatment capacity of the existing WPF headworks to 88 mgd, and providing HRT and disinfection facilities will reduce CSO volume by an additional 0.62 billion gallons annually. Finally, completing the Roy's Branch partial sewer separation project (currently underway) will reduce CSO volume by an additional 0.23 billion gallons annually. The Phase IA CSS model results indicate that the overall CSO volume will be reduced by 2.4 billion gallons annually from approximately 4.1 billion gallons at existing conditions to 1.7 billion gallons at the completion of the Phase IA improvements. The existing CSS system is estimated to capture approximately 12 percent of the combined sewage. By incorporating the modified Phase IA improvements, the combined sewage volumetric capture will be increased to approximately 60 percent.

5.0 TM-CSO-3b: Phase IA Combined Sewer Overflow Control Water Quality Model

The purpose of TM-CSO-3b is to predict the reduction in annual Escherichia coli (E. coli) loadings and concentrations in the Missouri River that are expected to be achieved by implementing the modified Phase IA CSO control improvements.

Based on the hydrograph volumes developed in TM-CSO-3a – Phase IA CSO Control Recommended Improvements Model, E. coli loadings were calculated for each of the design storm events A through H for each of the City's 14 CSO outfalls. The rainfall volume ranged from 0.29 inches for Event A to 2.88 inches for Event H.

The Phase IA improvements are expected to reduce the total annual E. coli loading for a typical year by approximately 70 percent as compared to the annual volumetric CSO reduction of 60 percent. The somewhat higher degree of loading reduction would be achieved because the E. coli concentrations associated with CSOs that were significantly volumetrically improved (e.g., Whitehead) were higher than the concentrations for CSOs receiving less CSO control improvement.

The QUAL2K water quality model was used to predict E. coli concentrations in the Missouri River for each of the design storm events A through H for the existing CSS and the modified Phase IA CSO control improvements. For each storm event, it was assumed that the flow in the river was at the navigation season 7-day low flow that occurs at an average frequency of once every 10 years (7Q10). The E. coli loading for each CSO outfall was calculated by multiplying the peak flow in the XP-SWMM event hydrograph by its event mean concentration.

The Event C existing condition CSOs resulted in the highest E. coli loading and resulting concentration of 72,000 colony forming units (cfu) per 100 milliliters (mL) in the Missouri River. This occurred in the vicinity of the WPF, which is 5.6 kilometers (km) (3.5 miles) downstream of the most upstream CSO outfall, Roy's Branch. The Phase IA improvements were predicted to reduce the Event C concentration by 51 percent, which is a significant reduction even though the concentration exceeds the

E. coli water quality criterion for the river of 206 cfu per 100 mL. The E. coli water quality criterion of 206 cfu per 100 mL is based on a monthly geometric mean. When the peak QUAL2K E. coli concentrations are averaged with the concentrations during the dry weather days, the monthly average concentrations will be much lower. To calculate the monthly geometric averages that include both the wet and dry weather days, a continuous simulation water quality model, such as WASP, would be required. A continuous simulation water quality model would generate a time series of average daily E. coli concentrations for a typical year, which could be used to calculate monthly geometric means for comparison to the criterion.

For Events A through G, the modified Phase IA improvements would provide a significant reduction in E. coli concentrations in the river. Event A would provide the highest reduction in concentration, 77 percent, which is important because during a typical year there are 42 events which are equal to or smaller than Event A. The total number of events per typical year is 78. Events in the A, B, and C ranges, which have the highest percent reductions, occur more often than the other events, 66 out of 78 storm events. Events F, G, and H with the lowest percent reductions occur only once per year. Thus, the Phase IA improvements would result in the highest reductions in E. coli concentrations for the events that occur more frequently during a typical year.

QUAL2K used the peak flow in each of the event hydrographs, so the predicted E. coli concentrations are the maximum concentrations at any location in the river. As the hydrographs and associated loadings rise to the peak flow and fall from the peak flow, the average concentrations at any location would be significantly lower than the maximum concentrations.

Upon completion of the Phase IA CSO control improvements, it is recommended that the City develop a continuous simulation model of the Missouri River as part of the Phase IB tasks (see Section 6.0 for additional discussions on the Phase IB tasks) to demonstrate water quality. The river water quality model could be used to determine the monthly geometric mean concentration of E. coli in the Missouri River for the improved conditions. Furthermore, it would help demonstrate the significant E. coli peak concentration reductions documented herein for the Phase IA improvements. Ultimately, this tool would further support the water quality benefits resulting from the City of St.

Joseph, Missouri's significant investment in reducing the impact of their CSOs on Missouri River water quality.

6.0 TM-CSO-3c: Future Phases of Combined Sewer Overflow Long Term Control Plan

The purpose of TM-CSO-3c is to document the proposed LTCP projects for Phase IB, II, and III CSO control facilities. CSO flow equalization basin options recommended in the 2008 LTCP for the Patee and Missouri Avenue CSO outfalls were reviewed to determine if they would still be required to achieve the goal of capturing 85 percent of the wet weather flow volume. In addition, LTCP recommendations for flow control structure modifications (raising diversion weirs and adding motor-operated gates) were evaluated to determine their potential for obstructing combined sewer flow leaving the system. The CSS recommended improvements were also evaluated for Comprehensive Stormwater Management Plan event flows (i.e., flood flows) to confirm operation of the facilities during peak stormwater flooding events.

The USEPA CSO presumptive approach policy of 85 percent capture of wet weather CSS flow volume was used as the basis for determining CSO control recommendations. In consultation with MDNR and USEPA, it was determined that this approach is more appropriate than the CSO frequency goal of four overflows per year for St. Joseph in order to accommodate phased implementation and financial capability.

To meet the presumptive approach requirements of the USEPA CSO control policy, the City of St. Joseph will be required to increase the volumetric combined sewage wet weather capture from 60 percent, achieved through Phase IA improvements, to 85 percent. Although the Phase IA improvements will provide a significant improvement over the existing conditions wet weather capture of 12.5 percent, additional improvement phases (future Phase IB, Phase II, and Phase III) will be required to meet USEPA presumptive approach requirements.

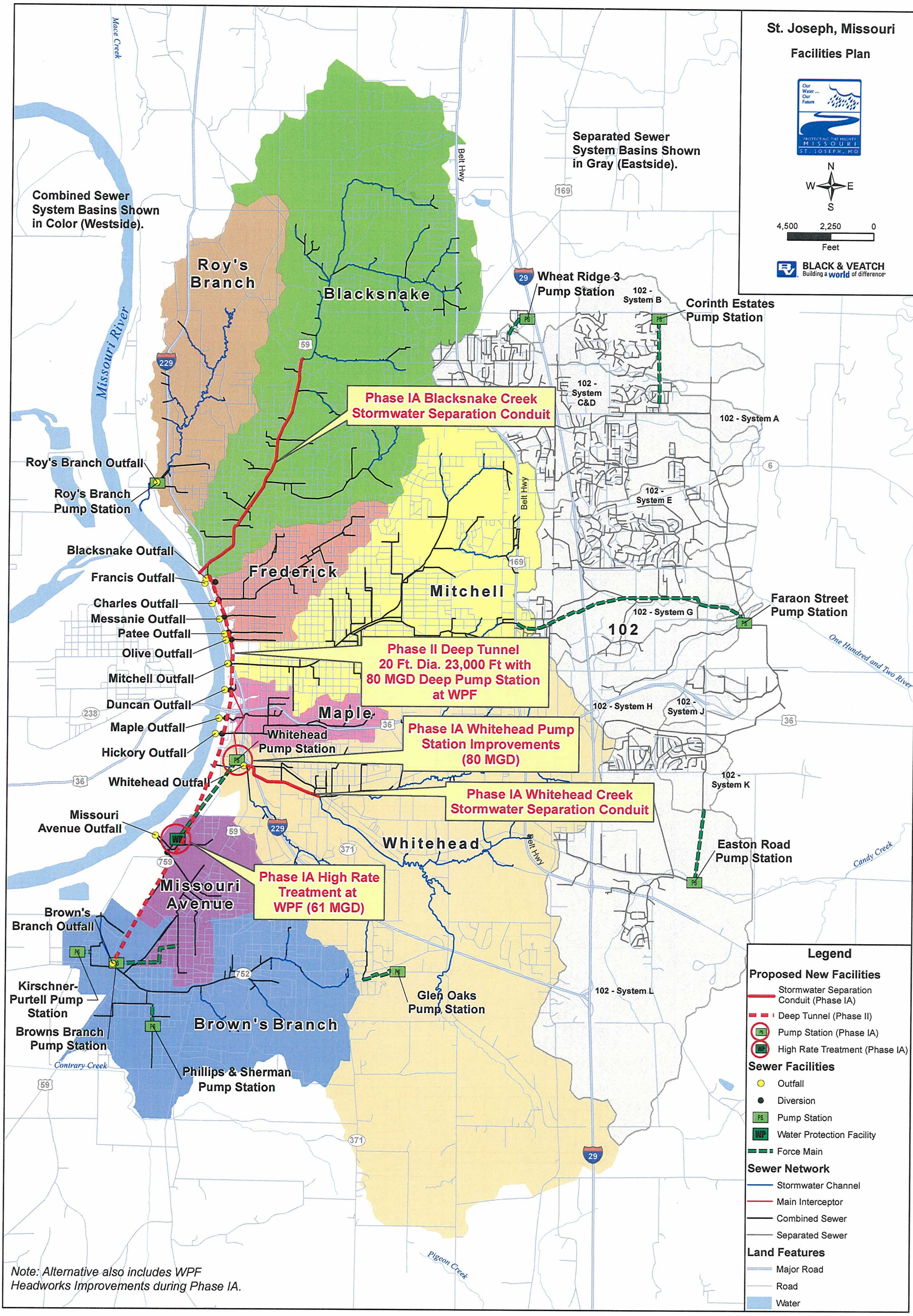
The Phase IB improvements from the 2008 CSO LTCP are being superseded by recommendations made herein. The ultimate objective of any CSO LTCP is to improve water quality within the receiving stream. Therefore, upon completion of the Phase IA improvements, it is recommended that a two-year monitoring and evaluation study of

Missouri River water quality be performed to demonstrate the effectiveness of the Phase IA improvements. This study phase, entitled Phase IB, will help establish the water quality benefits of the Phase IA improvements and will help to further refine the future Phase II and Phase III recommendations. Phase IB is part of an overall adaptive management approach for the City's CSO LTCP to ensure that funding continues to be optimized now and in the future for the improvement of Missouri River water quality.

The original Phase II improvements from the 2008 CSO LTCP consisted of a 23,000 foot long, 17 foot diameter tunnel (39.2 million gallons (MG) of storage) extending from the Blacksnake Diversion Structure to the Brown's Branch Diversion Structure. As part of the Facilities Plan work, the improvement wet weather percent capture results were updated. Based on the updates, it appears that the proposed 17 foot diameter deep tunnel facility increases the wet weather volumetric capture to 81 percent. The Phase III improvements from the 2008 CSO LTCP consisted of a 135 mgd HRT facility located in the vicinity of the existing WPF. Updated modeling, performed as part of the Facilities Plan, indicates that a 135 mgd HRT facility in combination with a 23,000 foot long, 17 foot diameter tunnel could provide 88.5 percent wet weather capture, exceeding the 85 percent wet weather capture required by the USEPA CSO presumptive approach. Therefore, in order to evaluate future phase options, two alternatives were developed to achieve the 85 percent wet weather capture goal.

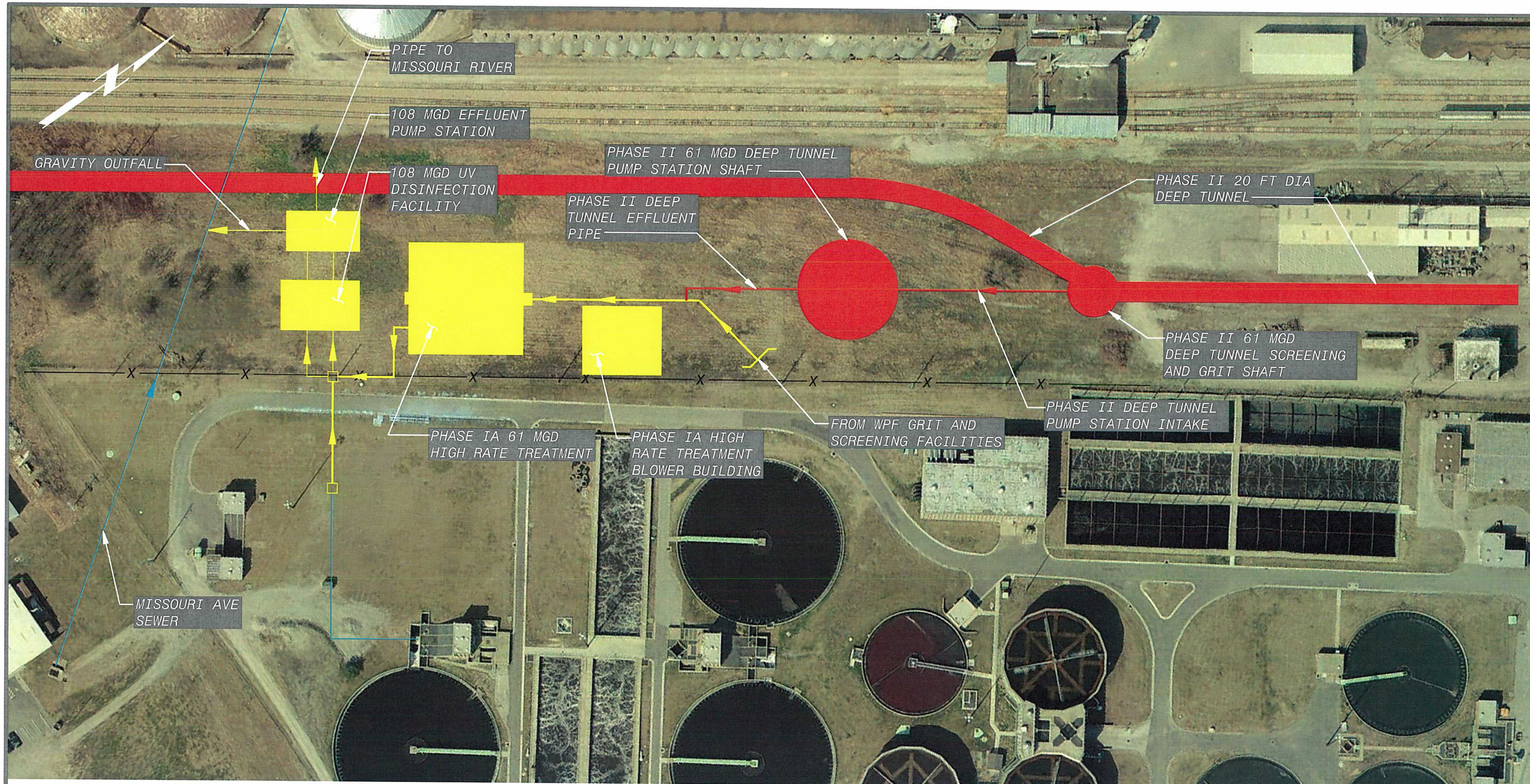
Since the 23,000 foot long, 17 foot diameter tunnel does not achieve an 85 percent wet weather capture by itself, additional high rate treatment will still be required if the tunnel dimensions are not changed. If, however, the tunnel diameter is increased to 20 feet (54 MG of storage), an 85 percent wet weather volumetric reduction can be achieved without the need for additional high rate treatment. Alternative 1, as described in TM-CSO-3c, consists of a 23,000 foot long, 20 foot diameter tunnel (54 MG of storage) that achieves 85 percent wet weather capture (see Figures 1 and 2).

If the 23,000 foot long, 17 foot diameter tunnel is used, additional high rate treatment is required to achieve 85 percent wet weather capture. It was determined that an 80 mgd HRT facility (rather than 135 mgd as initially proposed in the 2008 LTCP) along with the 17 foot diameter deep tunnel would provide 85 percent capture. This



Alternative 1 - Phase IA Improvements and Phase II - 20 Foot Diameter Deep Tunnel

Figure 1



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UV, EFFLUENT PUMP STATION AND PHASE IA FACILITIES

FUTURE PHASE FACILITIES

ST. JOSEPH, MISSOURI
FACILITIES PLAN
PN 163509
ALTERNATIVE 1
SCREENING SHAFT AND
DEEP TUNNEL PUMP STATION LAYOUT

FIGURE 2

CYGNET ID: 163509-2000-GENUP-C-N0001BGPR

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scenario provides another option for the City to achieve 85 percent wet weather capture and is termed Alternative 2 in this evaluation (see Figures 3 and 4).

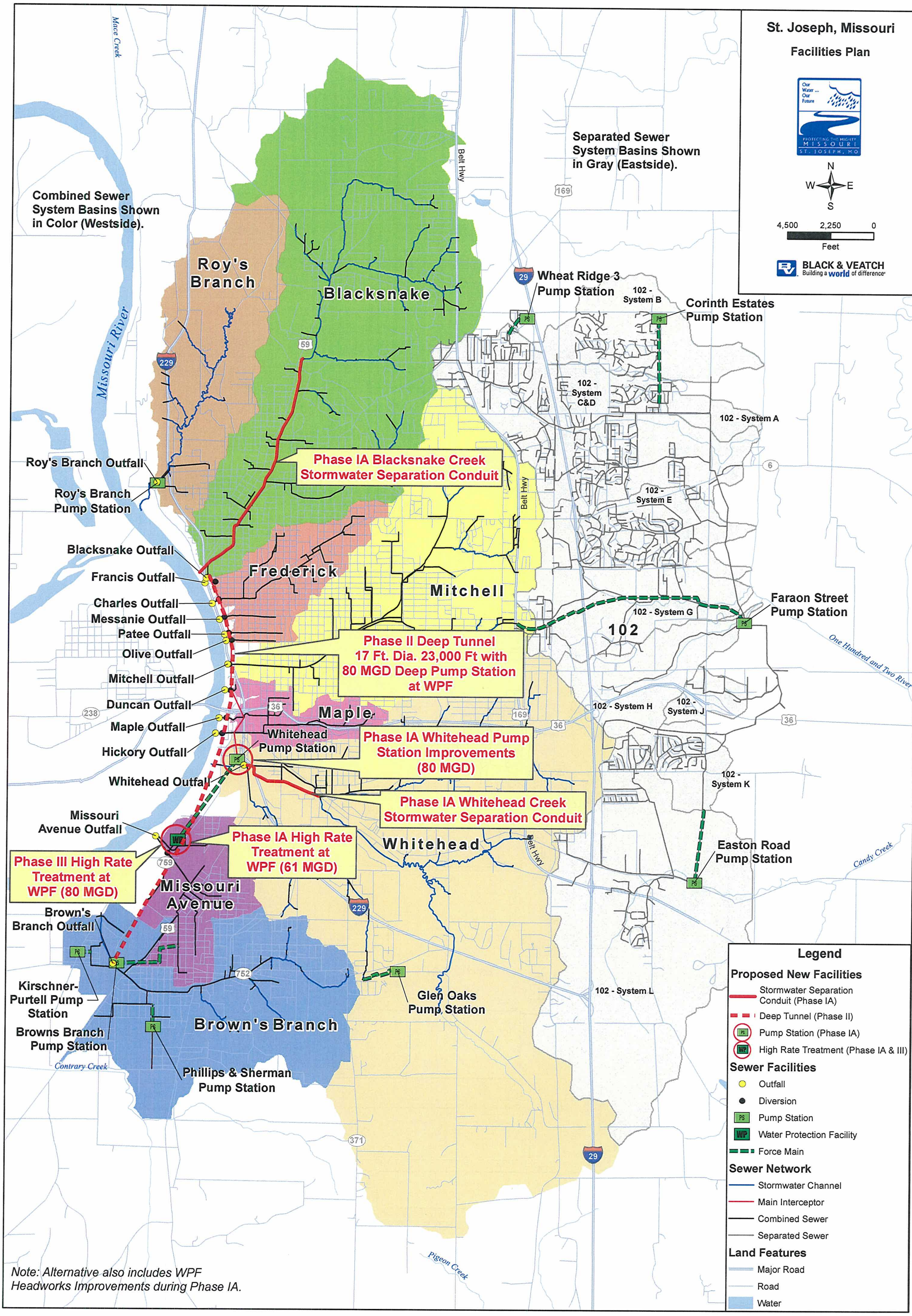
The project costs associated with future phases Alternative 1 and Alternative 2 are presented in Table 1.

Table 1
Summary of Opinion of Probable Project Costs for CSO Future Phases [1]

Item	Alternative 1 20 ft Diameter Tunnel, $	Alternative 2 17 ft Diameter Tunnel and Additional HRT, $
Deep Tunnel, 23,000 lin ft	160,336,000	148,157,000
Deep Tunnel Pump Station, 61 mgd	28,281,000	---
Deep Tunnel Pump Station, 80 mgd	---	32,571,000
High Rate Treatment Facility, 80 mgd	---	20,984,000
UV Disinfection Facility, 80 mgd	---	7,000,000
Effluent Pump Station, 80 mgd	---	4,250,000
Yard Piping, 72 inch	324,000	3,240,000
Flood Protection (placeholder) [2]	370,000	741,000
Site Remediation (placeholder) [2]	2,222,000	4,444,000
Subtotal	*191,533,000*	*221,387,000*
Electrical, I&C, Sitework, Contractor General Requirements [3]	15,447,000	36,744,000
Subtotal	*206,980,000*	*258,131,000*
Contingency [4]	51,745,000	64,533,000
Land Acquisition (placeholder) [2, 5]	106,000	212,000
Opinion of Probable Construction Cost	**258,831,000**	**322,876,000**
Engineering, Legal, and Administration [6]	51,766,000	64,575,000
Opinion of Total Project Cost	**310,597,000**	**387,451,000**

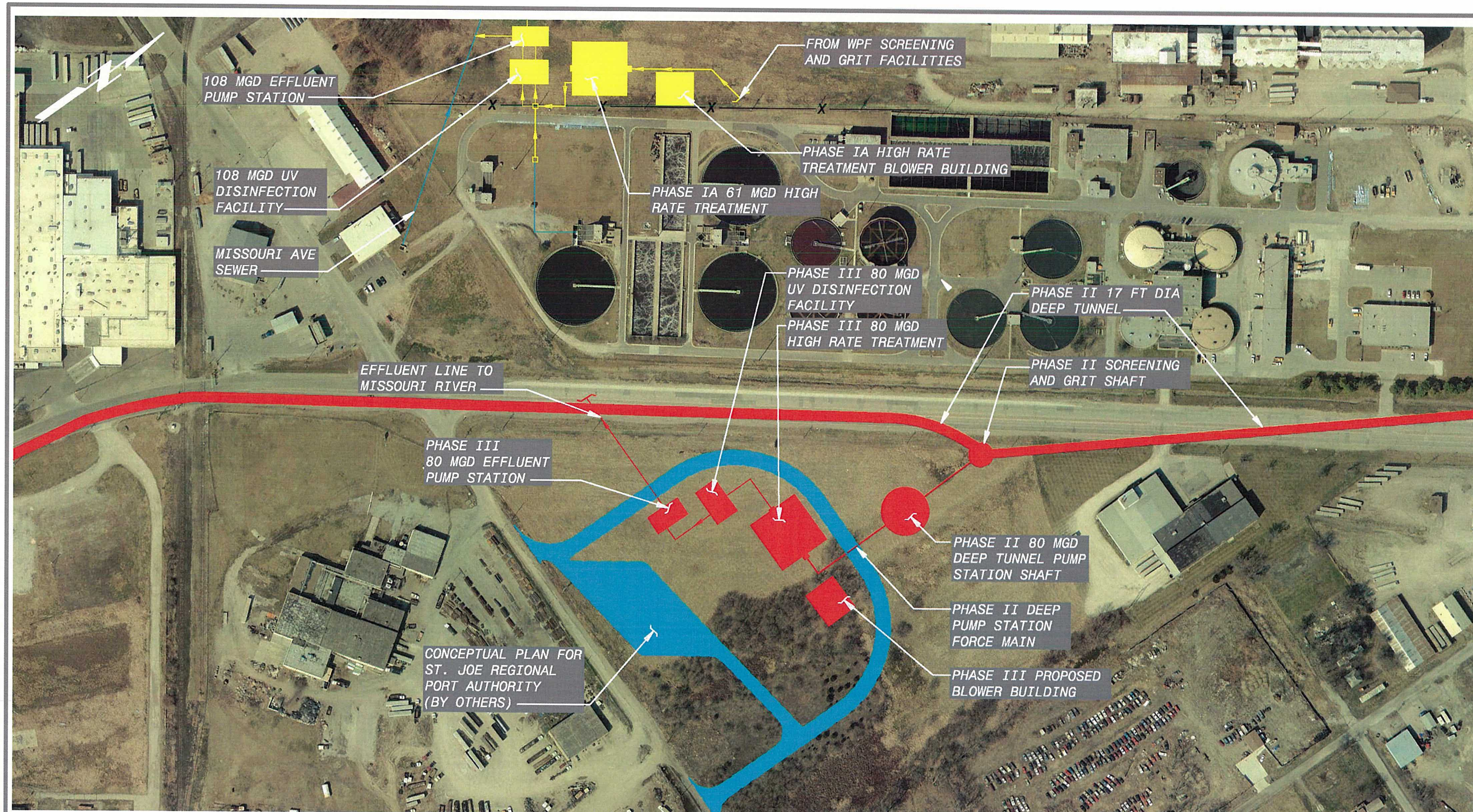
1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities.
3. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs but excludes the deep tunnel. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition cost is based on a projection provided by the City from a recent purchase of land directly south of the WPF.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

Upon review of Table 1, Alternative 1 – 20 foot Diameter Deep Storage Tunnel is more cost effective than Alternative 2 – 17 foot Diameter Deep Storage Tunnel and



Alternative 2 - Phase IA Improvements, Phase II - 17 Foot Diameter Deep Tunnel, and Phase III - 80 MGD HRT

Figure 3



200' 100' 0 200' 400'

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(yellow)	UV, EFFLUENT PUMP STATION AND PHASE IA FACILITIES
(red)	FUTURE PHASE FACILITIES

ST. JOSEPH, MISSOURI
FACILITIES PLAN
PN 163509
ALTERNATIVE 2
SCREENING SHAFT, DEEP TUNNEL
PUMP STATION, AND 80 MGD HRT LAYOUT

FIGURE 4

CYGNET ID: 163509-2000-WWTUP-C-N0001C44S

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80 mgd High Rate Treatment. Furthermore, based on review of similar CSO control programs, it is typically more cost effective to provide more deep tunnel storage and less peak flow treatment rather than providing less tunnel storage and greater peak flow treatment. The results of the analysis presented in TM-CSO-3c support this typical finding. Although there is some initial phased cost savings in the tunnel being downsized in Alternative 2, the initial cost savings is lost when the dedicated 80 mgd high rate treatment facility, 80 mgd ultraviolet (UV) disinfection facility, and 80 mgd effluent pump station are added to provide peak flow treatment.

Alternative 1 also makes use of facilities planned for construction during the Phase IA implementation period. The larger deep tunnel allows combined sewage to be stored and treated through the Phase IA HRT improvements after the wet weather event has passed. Since Alternative 2 provides less storage, treatment with an additional HRT facility must occur during the wet weather event as opposed to afterwards. The 80 mgd HRT would be a dedicated and separate facility from the 61 mgd HRT facilities proposed as part of Phase IA. Alternative 1 is also superior to Alternative 2 in that it allows operation of proposed Phase IA facilities to be maximized. Therefore, based on the results of updated modeling and evaluation, Alternative 1 is the recommended approach for the future LTCP CSO control phase. This recommendation could be modified or refined upon completion of the Phase IB monitoring and water quality study.

7.0 TM-CSO-4: Main Interceptor Hydraulics and Basement Backup Review

The purpose of TM-CSO-4 is to confirm that the Main Interceptor along the Missouri River and the Whitehead Interceptor can together convey 80 mgd to the Whitehead Pump Station. The updated CSS model indicated that if 88 mgd of flow were captured and treated during a wet weather event (80 mgd from the Whitehead Pump Station and 8 mgd from the In-plant Influent Pump Station), along with implementation of the other Phase IA separation improvements, an annual volumetric percent capture of approximately 60 percent could be achieved. The Phase IA improvements and associated 60 percent capture are therefore predicated on the ability of the CSS interceptor to deliver 80 mgd to the Whitehead Pump Station. In addition to analyzing the hydraulic capacity of the interceptors, a review of basement backup reports within the City of St. Joseph was conducted to determine if surcharge conditions within the interceptors may be causing the backups.

The CSS model results indicate that the Main and Whitehead Interceptors can convey 80 mgd to the Whitehead Pump Station. A pipeline conditions assessment should be conducted for the Main Interceptor, Whitehead Interceptor, and both force mains from the Whitehead Pump Station to determine if the pipelines are in need of rehabilitation or repairs for conditions which may inhibit the conveyance of 80 mgd.

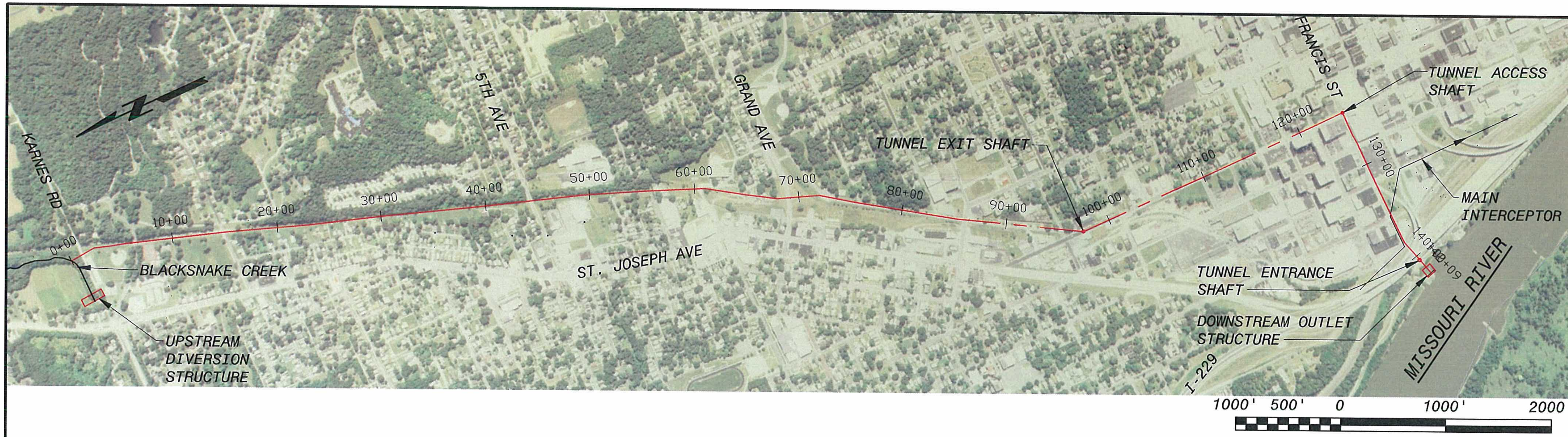
Hydraulic gradeline (HGL) profiles are provided in TM-CSO-4 showing the maximum water surface elevation within both interceptors for the typical year design events. In addition, basement backup reports were evaluated to determine if surcharging within the interceptors is causing basement backups. The data reviewed indicate that surcharging of the Main and Whitehead Interceptors does not appear to be causing basement backups within the CSS service area of the City.

8.0 TM-CSO-5: Stormwater Separation Conduits

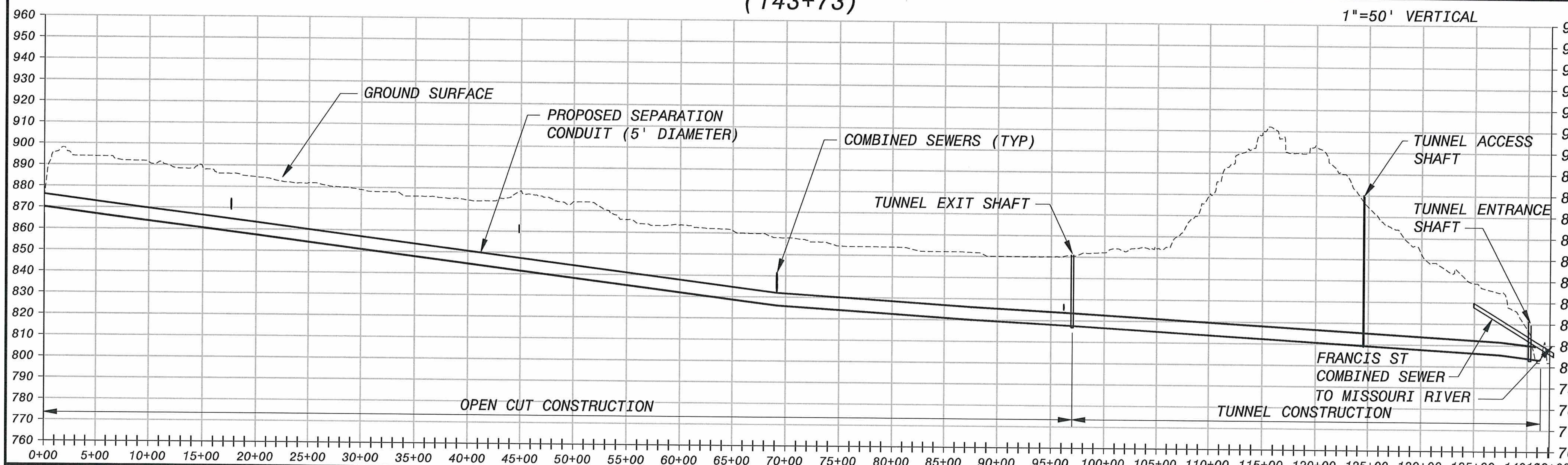
The purpose of TM-CSO-5 is to evaluate and summarize potential alternatives to separate and remove creek (i.e., stormwater) flows from the City's CSS. Ten stormwater separation alternatives were investigated to remove the Whitehead Creek and Blacksnake Creek flows from the City's CSS. In summary, it appears that gravity flowing stormwater conduits sized without upstream detention and peak flow attenuation are the optimal alternatives to remove creek flows from the CSS in both basins.

There is one recommended alternative in the Blacksnake Basin for removing creek flows from the CSS. Alternative B diverts creek flows through a stormwater separation conduit that is aligned along an existing City owned right-of-way (abandoned railway) east of St. Joseph Avenue. The Blacksnake Alternative B alignment is presented in Figure 5. Project costs for the feasible Blacksnake alternatives, including the recommended Alternative B, are summarized in Table 2.

Due to its costs savings, Blacksnake Alternative C, as shown in Figure 6, was also strongly considered. However, this alternative involves a cross-basin stormwater transfer that could create unacceptable flooding, stream bank erosion, and other problems in the



BLACKSNAKE ALTERNATIVE B (PIPE ALONG ABANDONED RAILWAY)
(143+73)



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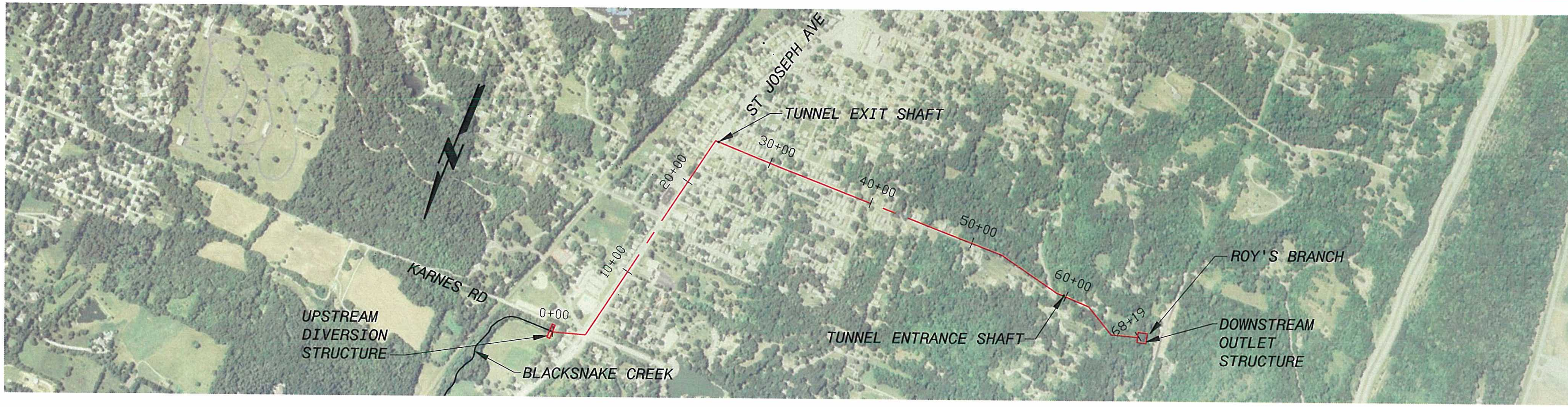
BLACK & VEATCH Corporation
PROJECT 163509

ST. JOSEPH, MO
ALTERNATIVE B

BLACKSNAKE CREEK STORMWATER SEPARATION CONDUIT

Figure 5

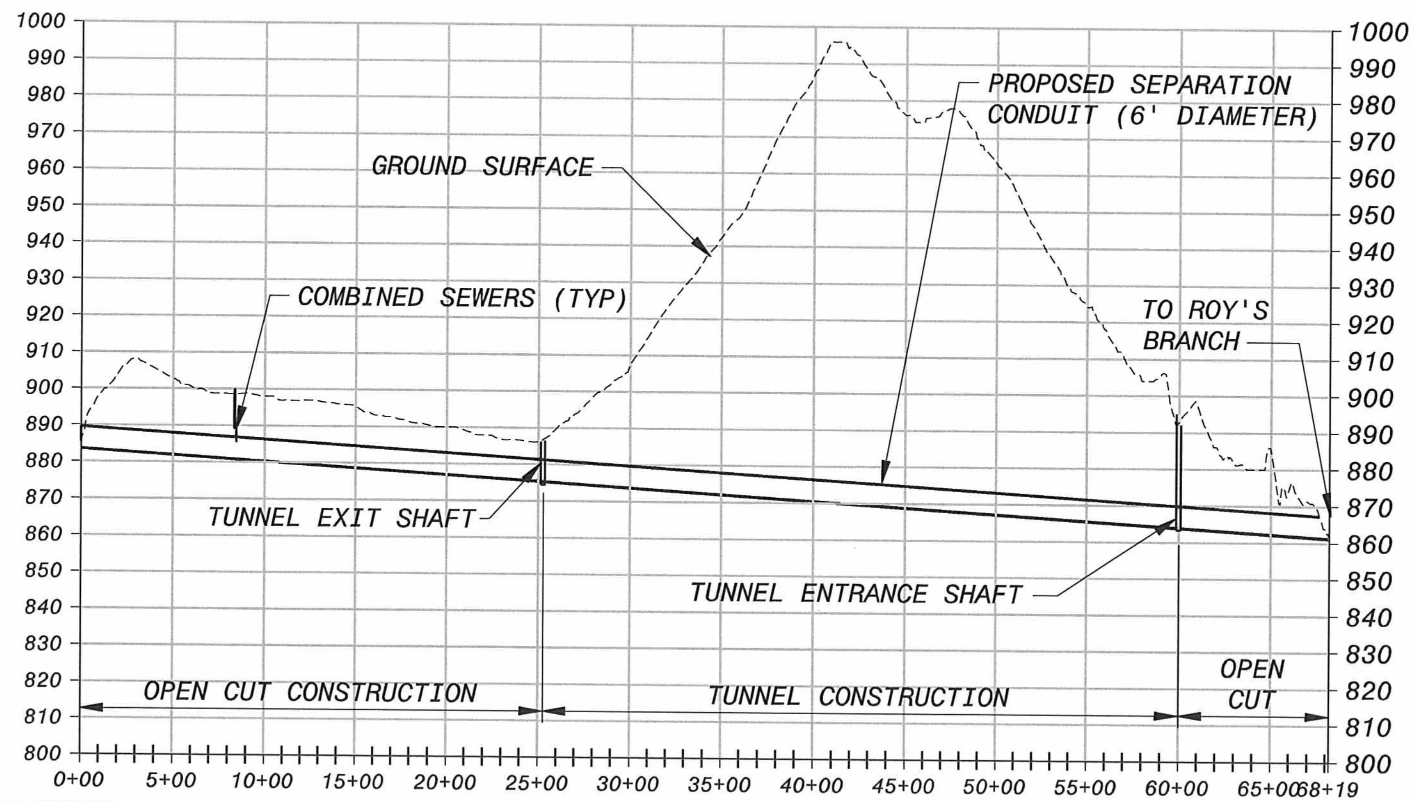
B50000
FB50000



BLACKSNAKE ALTERNATIVE C (PIPE DIVERSION TO ROY'S BRANCH BASIN)
(68+41)

1000' 500' 0 1000' 2000'
1"=1000' HORIZONTAL

50' 25' 0 50' 100'
1"=50' VERTICAL



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PROJECT
163509

ST. JOSEPH, MO
ALTERNATIVE C

BLACKSNAKE CREEK STORMWATER
SEPARATION CONDUIT

Figure 6

B50000
FB50000

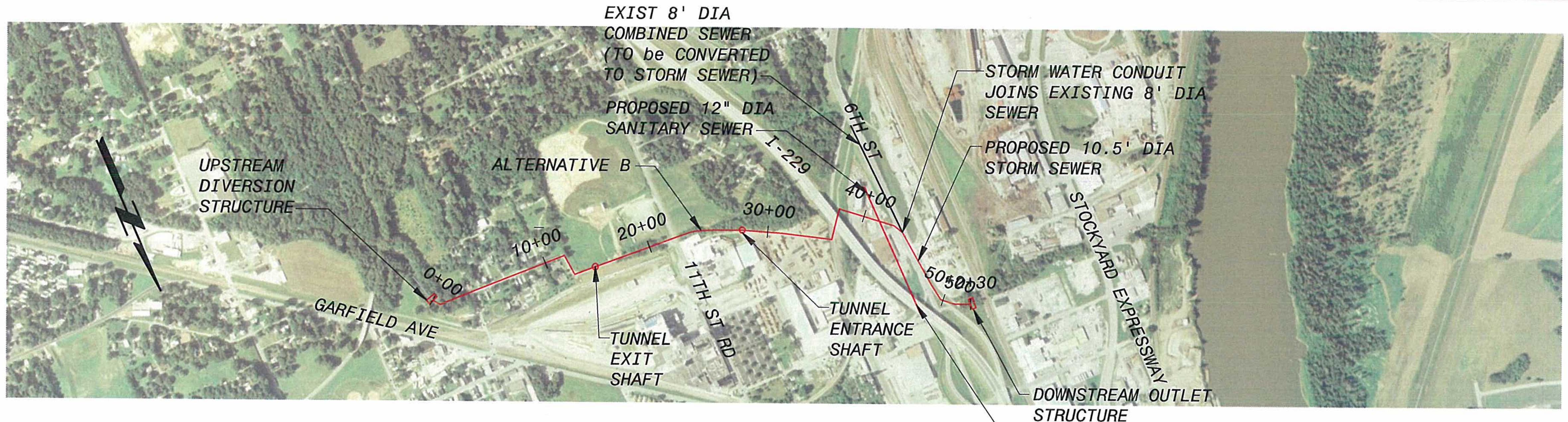
Roy's Branch Basin. Furthermore, the City could be held responsible for any adverse changes this alternative might create in Roy's Branch. The City could be obligated to purchase over a mile worth of stream easements, perform flooding and stream bank stabilization improvement projects, and address other stream issues at the request of downstream property owners. In addition, various state and federal agencies, such as the Federal Emergency Management Agency (FEMA) and the United States Army Corps of Engineers (USACE), could have jurisdiction regarding cross-basin stormwater transfers that could change, limit, or eliminate the alternative in its entirety. Due to liability concerns as well as the potential for complicated regulatory issues, Alterative C is not being recommended herein.

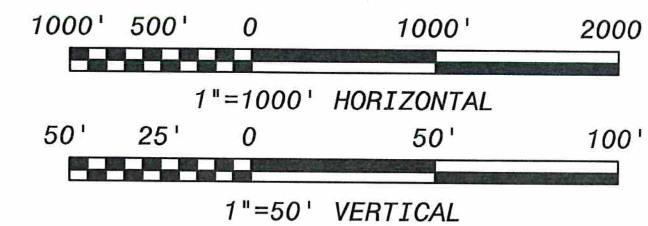
Table 2
Summary of Opinion of Probable Project Costs for
Blacksnake Stormwater Separation Alternatives

Item	Alternative			
	B, $	**C, $**	**D, $**	**E, $**
Opinion of Total Project Cost	39,707,000	26,574,000	45,018,000	37,362,000

Notes:
1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. See TM-CSO-5 for a more detailed breakdown of the project costs.

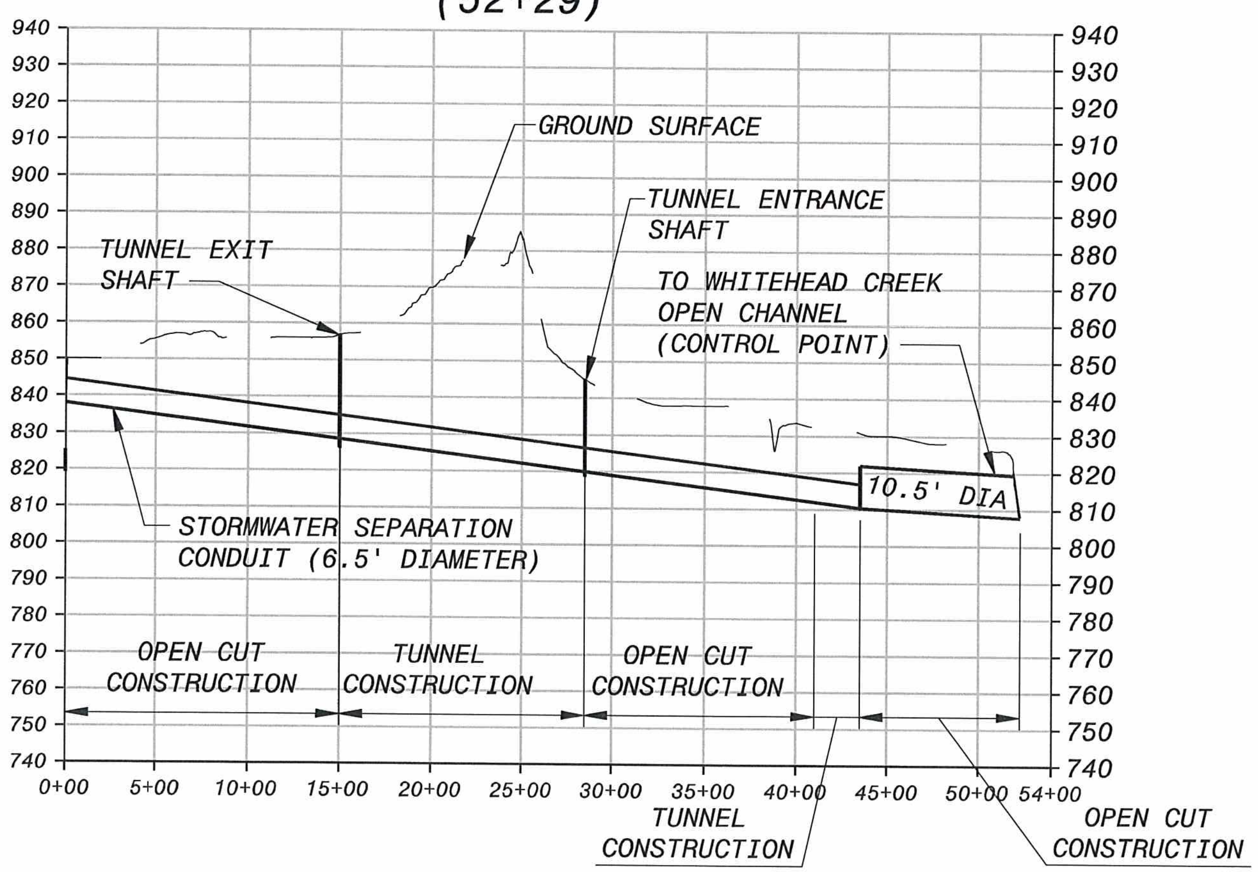
There is one recommended stormwater separation conduit alternative for the Whitehead Basin. Whitehead Alternative B redirects creek flow from the Whitehead Basin to the Missouri River. The separation conduit begins near the intersection of 16th and Garfield and parallels, to the south, the existing Whitehead combined trunk sewer. The stormwater conduit daylights in the open channel downstream from the Whitehead Diversion Structure. Figure 7 presents the Whitehead Alternative B alignment. The project cost for the feasible Whitehead alternatives is summarized in Table 3.

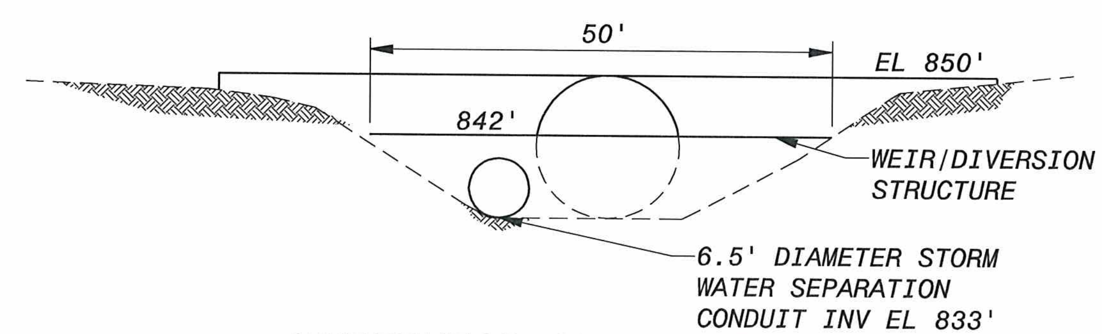




ALTERNATIVE B (SOUTHERN ROUTE)

(52+29)





WHITEHEAD ALTERNATIVE B

WEIR STRUCTURE

1" = 20'-0"

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PROJECT 163509

ST. JOSEPH, MISSOURI

ALTERNATIVE B

WHITEHEAD CREEK STORMWATER SEPARATION CONDUIT

Figure 7

B50000
FB50000

Table 3 Summary of Opinion of Probable Project Costs for Whitehead Stormwater Separation Alternatives			
Item	Alternative		
	B,$	C, $	E, $
Opinion of Total Project Cost	21,349,000	23,159,000	34,074,000
Notes: 1. All costs presented in May 2009 dollars (ENR BCI = 4773). 2. See TM-CSO-5 for a more detailed breakdown of the project costs.			

For all of the recommended alternatives, a detailed alignment study is recommended to finalize the stormwater conduit alignment. The alignment study would allow a detailed review of the alignment corridor and finalize:

1. Selection of the upstream diversion structure location.
2. Location of large trees and other natural resources that could be avoided and preserved by slight adjustments to the alignment.
3. Location of underground and overhead power lines.
4. Location of gas, water, telephone, and cable utilities.
5. Selection of tunnel shaft and point of intersection locations.
6. Location of other pertinent obstacles that are relevant to the stormwater conduit placement.

The stormwater separation conduits will significantly reduce the amount of stormwater delivered to the existing CSS and will help the City achieve its Long Term Control Plan Phase IA objectives of 60 percent wet weather capture.

9.0 TM-CSO-6: Identification and Prioritization of Green Solution Opportunities

The purpose of TM-CSO-6 is to:

- Document the green solutions modeling (i.e., identification) process.
- Present green solutions opportunities for public, semi-public, vacant, and right-of-way areas.

- Set the stage for TM-CSO-7 – Green Solutions Opportunities Evaluation and Refinement that will present specific green solutions concepts, costs, and design criteria that could be used at the various suitable locations identified in TM-CSO-6.

A green solutions infrastructure locator model was developed that considers a natural resources suitability index for stormwater Best Management Practices (BMPs) otherwise known as green solutions. Detailed urban hydrology, parcel data, and remote sensing data were utilized to identify and rank green solutions opportunities at a City-wide scale. One application of this model is to identify public and semi-public green solutions opportunities for further study and refinement that will assist the St. Joseph CSO program. The green solutions identification was also extended to the areas of the City served by the separate sanitary sewer system as this information can be useful for future planning and utilized as part of a holistic stormwater management effort. Public and semi-public green solutions opportunities include City-owned and semi-public owned schools, golf courses (public and private), parks, cemeteries (public and private), and boulevards with available open space and appropriate drainage and environmental characteristics to retain/detain stormwater runoff prior to entering the sewer system. The identified open space locations suitable for these purposes could be retrofitted with a number of green solution technologies which may:

1. Provide a factor of safety for the CSO Long Term Control Plan,
2. Mitigate hard infrastructure facilities and/or reduce hard infrastructure facility costs, and/or
3. Improve water quality.

In addition to the benefits mentioned above, implementation of the green solutions can create neighborhood amenities and enhance wildlife habitat and will serve to improve public awareness and learning opportunities of CSO control technologies.

The modeling process identified 366 City-owned and semi-public sites totaling 3,846 acres that could be considered for public green infrastructure within the combined sewer system and separate sanitary sewer areas. The identified City-owned and semi-public sites range in size from less than 1 acre to 156 acres. Locations of the green solution opportunities are displayed on Plates 5, 6, and 7 which are included in Appendix B of TM-CSO-6. In addition, the ranked green infrastructure locator and BMP suitability index results presented in TM-CSO-6 could be useful for future stormwater, transportation, parks and recreation, planning, and development projects that are not directly associated with the CSO program.

10.0 TM-CSO-7: Green Solutions Opportunities Evaluation and Refinement

The purpose of TM-CSO-7 is to:

- Identify green solutions opportunities that could be used as part of the CSO Control Facilities Plan.
- Describe the potential green solutions and their potential wet weather benefits.
- Provide a preliminary cost opinion of the green solution concepts.
- Provide a summary map with the locations and general layout of the green solutions.
- Provide conceptual illustrations of three green solutions sites including small, medium, and large site solutions.

The green solutions model developed and presented in TM-CSO-6 – Identification and Prioritization of Green Solutions Opportunities was evaluated and refined to provide the best green solutions opportunities for the City of St. Joseph Water Protection Program. A green solution is a vegetated, natural stormwater management practice that works in harmony with or mimics natural systems. Green solutions provide multiple benefits, including offsetting imperviousness, improving water quality, reducing wet weather flow, and providing floral, faunal, and aquatic habitat. Green solutions may also provide recreational opportunities and community amenities. Refinement of the opportunities identified in TM-CSO-6 was performed by creating a 1,000-foot buffer around the City’s Parks, Open Space and Trails shapefile layers to identify City- and publicly-owned parcels for potential green solutions that could be integrated into the City's parks and trails system as amenities. The green solutions model identified various opportunities within the Brown's Branch, Whitehead, and Blacksnake Basins. The following four areas were identified as the best locations that could be retrofitted with multiple green solutions:

- Hyde Park
- Southwest Parkway
- Corby Parkway
- Parkway A

The green solutions refinement effort identified 23 potential green solutions with a total possible stormwater storage capacity of 9.4 MG at a probable project cost of $10.9 million. Green solutions opportunities were prioritized according to land ownership. The evaluation results presented within TM-CSO-7 focus on Tier 1 (City-owned) properties, although some Tier 2 (vacant parcels) and Tier 3 (boulevards and rights-of-way) opportunities are also presented. Identified green solutions consist of site scale, neighborhood scale, and watershed scale opportunities. Furthermore, where feasible, green solutions were specifically developed to help offset stormwater infrastructure proposed as part of the 1998 Comprehensive Stormwater Management Plan.

Green solutions opportunities in Hyde Park total 1.8 MG of potential wet weather runoff storage at a probable project cost of $1.1 million. Hyde Park opportunities include:

- Wetland channel
- Extended detention wetlands
- Neighborhood downspout disconnection and rain gardens

Green solutions opportunities for Southwest Parkway total 3.2 MG of potential wet weather runoff storage at a probable project cost of $3.9 million. Southwest Parkway opportunities include:

- Extended dry detention
- Stream stabilization
- Extended detention wetland
- Parking lot retrofit
- Neighborhood rain gardens and green streets with bioretention in the street right-of-way

Green solutions opportunities for Corby Parkway total 2.0 MG of potential wet weather runoff storage at a probable project cost of $2.3 million. Corby Parkway opportunities include:

- Wetland bench and sediment forebay for Corby Pond
- Extended detention wetland
- Neighborhood rain gardens and green streets with bioretention in the street right-of-way

Green solutions opportunities for the upper tributary area of Parkway A total 2.4 MG of potential wet weather runoff storage at a probable project cost of $3.6 million. Parkway A opportunities include:

- Extended dry detention on several vacant (Tier 2) parcels
- Neighborhood rain gardens and green streets with bioretention in the right-of-way

These green solutions opportunities are presented in detail in TM-CSO-7. Appendix A of TM-CSO-7 includes detailed figures of the green solution concepts, and Appendix B of TM-CSO-7 provides the green solution hydrologic calculations.

It is recommended that the City review and prioritize the green solutions opportunities presented in TM-CSO-7 based on community priorities as well as the City's ability to pay for them. In addition, the City is encouraged to implement a green solutions demonstration project to showcase the concepts to the public and demonstrate the effectiveness of these stormwater management techniques.

In addition to the 23 opportunities presented in TM-CSO-7, there are many vacant property and right-of-way (ROW) green solutions opportunities that could be explored in greater detail. Similar criteria and costing as presented in TM-CSO-7 could be used to evaluate these opportunities in the future.

11.0 TM-CSO-8: Diversion Structure Modifications

The purpose of TM-CSO-8 is to evaluate and summarize recommendations to modify and improve the existing combined sewer diversion structures. As part of the 2008 CSO LTCP, various diversion structure modifications were proposed including the installation of automated gates and increasing weir heights to better utilize the existing sewer system capacity. The main goal of the 2008 LTCP was to reduce average annual frequency of CSOs at each diversion structure for Phase I to 12 events and for Phase III to four events or less. Since completion of the 2008 LTCP, the Facilities Plan was initiated to refine the recommendation of the LTCP and detail other needed collection system and treatment facility improvements. As documented in TM-CSO-3a – Phase IA CSO Control Recommended Improvements Model, although reducing the CSO frequency is still important, the main focus of the CSO Facilities Plan is to increase the percent capture of the combined sewer system by conveying and treating wet weather flows at a higher rate. Therefore, the diversion structure modifications documented in TM-CSO-8 have been revised from the LTCP recommendations to focus on conveyance and treatment of combined sewage to increase the wet weather percent capture, which is the revised criteria for the CSO control program.

In order to increase the conveyance capacity of the diversion structures and eliminate hydraulic bottlenecks, it is recommended to enlarge the existing orifices and slide gates of the following diversion structures: Francis, Messanie, Patee, Olive, Duncan, Maple, and Hickory. It is also recommended that the Whitehead outfall be modified and enclosed so that a flap gate can be mounted to prevent Missouri River water from backing up and entering the combined sewer system during periods of high river water levels. Lastly, the existing slide gate in the Blacksnake Diversion Structure no longer seals properly and leaks. This slide gate is recommended to be replaced. Automation of three manually cleaned bar screens at the Blacksnake, Whitehead, and

Brown's Branch Diversion Structures was also investigated. Upon review of the costs, the City elected not to move forward with those improvements. The project costs for the aforementioned modifications are presented in Tables 4 and 5. Table 4 presents the opinion of probable costs for the diversion structure modifications that include the automation of the three manually cleaned bar screens. Table 5 presents the opinion of probable costs for the diversion structure modifications excluding the costs for automation of the three manually cleaned bar screens. City staff elected to move forward with the diversion structure modifications summarized in Table 5.

Table 4
Summary of Opinion of Probable Project Costs for Diversion Structure Modifications Including Automation of Manually Cleaned Bar Screens [1]

Item	Cost, $
Diversion Structure Modifications	
Blacksnake Improvements	651,000
Whitehead Improvements	783,000
Brown's Branch Improvements	280,000
Miscellaneous Diversion Structure Improvements	210,000
Flood Protection/Fill (placeholder) [2]	0
Site Remediation (placeholder) [2]	75,000
Subtotal	*1,999,000*
Electrical, I&C, Sitework, Contractor General Requirements [3]	839,000
Subtotal	*2,838,000*
Contingency [4]	710,000
Land Acquisition (placeholder) [2, 5]	0
Opinion of Probable Construction Cost	**3,548,000**
Engineering, Legal, and Administration [6]	710,000
Opinion of Total Project Cost	**4,258,000**

1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. Site related costs are placeholders and must be revised following final siting of the facilities. No site related costs are anticipated for the diversion structure modifications.
3. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition is not anticipated for the diversion structure modifications.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

Table 5
Summary of Opinion of Probable Project Costs for Diversion Structure Modifications Excluding Automation of Manually Cleaned Bar Screens [1]

Item	Cost, $
Diversion Structure Modifications	
Blacksnake Improvements	32,000
Whitehead Improvements	179,000
Brown's Branch Improvements	0
Miscellaneous Diversion Structure Improvements	210,000
Flood Protection/Fill (placeholder) [2]	0
Site Remediation (placeholder) [2]	53,000
Subtotal	*474,000*
Electrical, I&C, Sitework, Contractor General Requirements [3]	98,000
Subtotal	*572,000*
Contingency [4]	143,000
Land Acquisition (placeholder) [2, 5]	0
Opinion of Probable Construction Cost	**715,000**
Engineering, Legal, and Administration [6]	143,000
Opinion of Total Project Cost	**858,000**

1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. Site related costs are placeholders and must be revised following final siting of the facilities. No site related costs are anticipated for the diversion structure modifications.
3. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition is not anticipated for the diversion structure modifications.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

The diversion structure modifications are intended to supplement the CSO program by adding conveyance capacity to the diversion structures, preventing river water from entering the collection system during high river stages, and maximizing the first flush pollutant load into the diversion structures. In addition, automation of three manually cleaned bar screens at the Blacksnake, Whitehead, and Brown's Branch Diversion Structures was investigated. Upon review of the costs, the City elected not to move forward with those improvements. The diversion structure modifications are not required to meet the wet weather capture and treatment goals of the LTCP, however, the modifications are recommended enhancements that should be implemented to optimize the system's conveyance capacity and first flush capture.

12.0 TM-CSO-9: Whitehead Pump Station Improvements

The purpose of TM-CSO-9 is to determine the improvements needed to upgrade the existing Whitehead Pump Station to convey a minimum peak flow of 80 mgd and an optional peak flow of 88 mgd. The possible option of providing 88 mgd was requested by City staff for situations when the 8 mgd In-plant Influent Pump Station is out of service. Specific activities performed for the Whitehead Pump Station facility assessment include:

- Conducting a pump station inspection and evaluation.
- Evaluating the force main capacity and performance.
- Evaluating the excess flow pump station requirements.
- Evaluating preliminary grit and screenings removal at the pump station.
- Developing conceptual layouts.
- Preparing an opinion of construction and operations and maintenance (O&M) costs.

Various improvements were proposed in the LTCP to reduce the frequency and volume of CSOs. The LTCP recommended initial improvements to increase conveyance capacity at the Whitehead Pump Station to 80 mgd, increase treatment capacity at the existing WPF headworks to 88 mgd, and provide 61 mgd HRT and disinfection facilities.

Based on the force main and pump station evaluation, the Whitehead Pump Station would require the following improvements to convey 80 mgd to the WPF and proposed HRT:

- Modifications to the existing pump discharge header to connect the entire header to the existing 36 inch force main.
- Addition of three new 250 horsepower (hp) drives and larger pump impellers to increase the existing pump station capacity to 30 mgd.
- Addition of valves to the existing pump station to increase flexibility for use during future conditions and allow isolation from both the 36 and 42 inch force mains.

- A new 50 mgd Excess Flow Pump Station with three 600 hp drives and pumps.
- Recirculation line at the proposed Excess Flow Pump Station to allow modulation of low flows downstream from this larger pump station.
- Relocation of a portion of the existing 42 inch force main to allow construction of the proposed Excess Flow Pump Station.
- A new overflow weir and 54 inch upstream gravity sewer to direct flows to the proposed Excess Flow Pump Station.
- Addition of a 480 volt, 2,000 kilowatt (kW) backup power generator, underground power line, transformer, switchgear, and pull out breaker.
- New 1-½ inch bar screens at both the existing Whitehead and proposed Excess Flow Pump Stations.

The improvements listed above will allow a peak flow of 80 mgd to be conveyed to the WPF and proposed HRT at a projected project cost of $24.6 million.

If the optional peak flow of 88 mgd is selected for the Whitehead Pump Station, modifications in addition to the aforementioned 80 mgd improvements would be required. The needed modifications to allow 88 mgd to be conveyed to the WPF and proposed HRT include:

- Addition of a parallel 36 inch force main next to the existing 42 inch force main to reduce peak flow velocities.
- Upsizing the proposed 50 mgd Excess Flow Pump Station capacity to 58 mgd. Downsizing the proposed 600 hp motors and drives to 500 hp units (power decreases due to new force main which reduces the peak dynamic head).

These modifications will allow a peak flow of 88 mgd to be conveyed to the WPF and proposed HRT at a projected project cost of $29.0 million.

By conveying a combined 88 mgd through the headworks of the WPF and proposed HRT (either 80 mgd from the Whitehead Pump Station and 8 mgd from the

In plant Influent Pump Station or 88 mgd from the Whitehead Pump Station and 0 mgd from the In-plant Influent Pump Station), the proposed Whitehead Pump Station improvements will help achieve the CSS conveyance goals for the CSO program. Figure 8 presents the proposed layout of the 80 mgd Whitehead Pump Station improvements while Table 6 summarizes the opinion of probable project costs. Table 7 summarizes the anticipated opinion of probable project costs for the 88 mgd option. The 88 mgd pump station layout would be identical to the 80 mgd option, with the exception of the additional proposed 36 inch force main.

The 88 mgd option is estimated to be approximately $4.4 million more than the 80 mgd option. Although the pump sizes and associated power requirements would decrease because the new force main reduces the peak dynamic head, the capital cost of the proposed 36 inch force main would not be offset by the savings in operating costs with the pump reductions. Based upon a review of the necessary improvements (i.e., new force main or significant surge protection) and associated $4.4 million cost increase required for the 88 mgd option, it is recommended that the 80 mgd option (i.e., 50 mgd Excess Flow Pump Station) be selected for the Whitehead Pump Station with an anticipated project cost of $24.6 million.

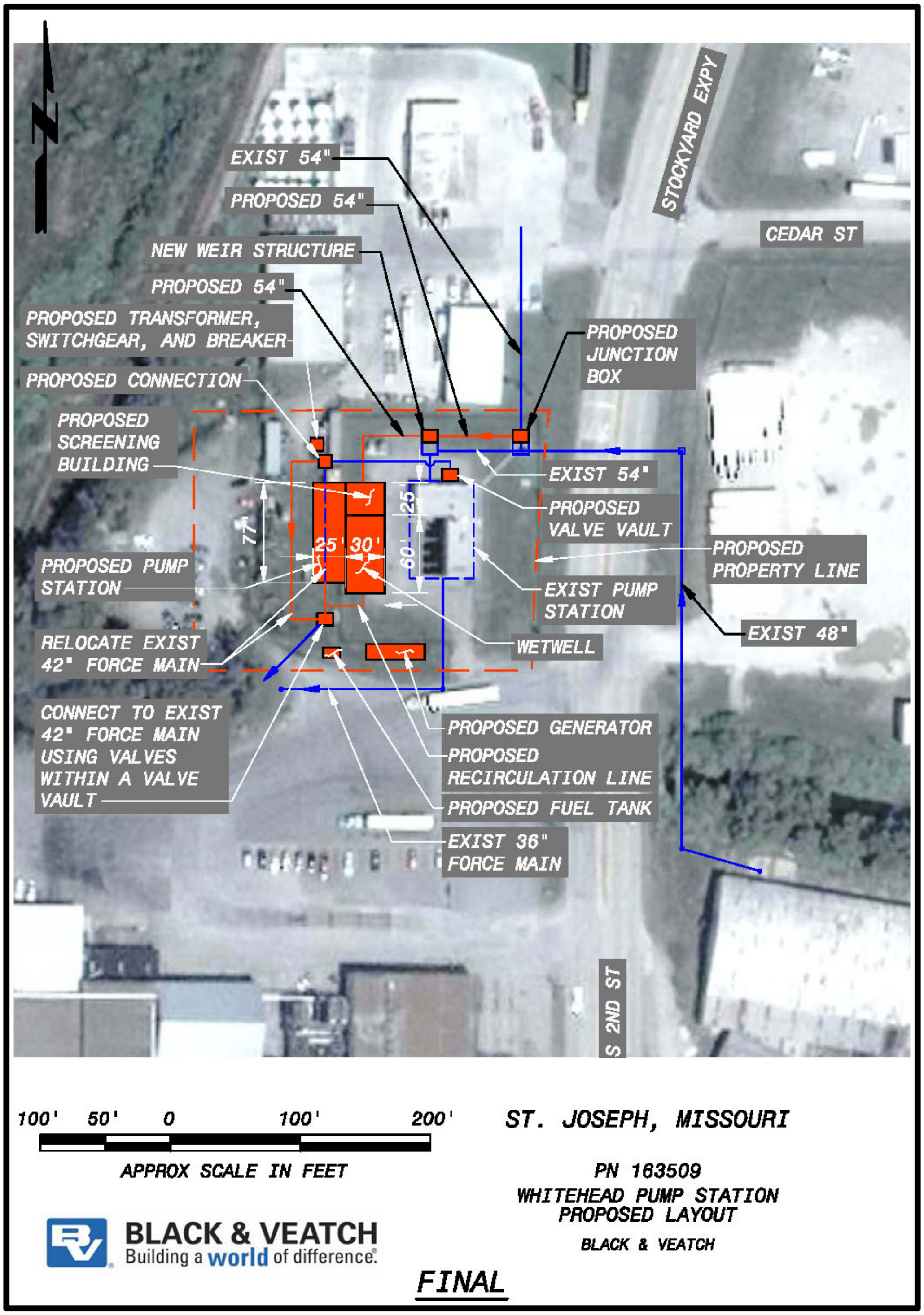


Figure 8 – Proposed 80 mgd Whitehead Pump Station Layout

Table 6
Summary of Opinion of Probable Project Costs for Whitehead Pump Station
80 mgd Option [1]

Item	Improvement Costs, $
Excess Flow Pump Station	
Structure, Valves, and Piping	2,856,000
Equipment	3,192,000
Existing Whitehead Pump Station	
Structure, Valves, and Piping	166,000
Equipment	1,401,000
Collection System Upgrades	958,000
Backup Generator and Transformer	1,119,000
Flood Protection/Fill (placeholder) [2]	---
Site Remediation (placeholder) [2]	1,723,000
Subtotal	*11,415,000*
Electrical, I&C, Sitework, Contractor General Requirements [3]	4,940,000
Subtotal	*16,355,000*
Contingency [4]	4,089,000
Land Acquisition (placeholder) [2, 5]	35,000
Opinion of Probable Construction Cost	**20,479,000**
Engineering, Legal, and Administration [6]	4,096,000
Opinion of Total Project Cost	**24,575,000**

1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities.
3. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs but excludes collection system upgrades. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition cost is based on a projection provided by the City from a recent purchase of land directly south of the WPF.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

Table 7
Summary of Opinion of Probable Project Costs for Whitehead Pump Station
88 mgd Option [1]

Item	Improvement Costs, $
Excess Flow Pump Station	
Structure, Valves, and Piping	2,856,000
Equipment	3,087,000
Existing Whitehead Pump Station	
Structure, Valves, and Piping	166,000
Equipment	1,401,000
Collection System and Force Main Upgrades	3,505,000
Backup Generator and Transformer	1,119,000
Flood Protection/Fill (placeholder) [2]	---
Site Remediation (placeholder) [2]	1,723,000
Subtotal	*13,857,000*
Electrical, I&C, Sitework, Contractor General Requirements [3]	5,472,000
Subtotal	*19,329,000*
Contingency [4]	4,832,000
Land Acquisition (placeholder) [2, 5]	35,000
Opinion of Probable Construction Cost	**24,196,000**
Engineering, Legal, and Administration [6]	4,839,000
Opinion of Total Project Cost	**29,035,000**

1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities.
3. Electrical and instrumentation, and controls (I&C) projected at 25% of the total of all equipment and structure costs but excludes collection system upgrades. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition cost is based on a projection provided by the City from a recent purchase of land directly south of the WPF.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

13.0 TM-CSO-10: Wet Weather Treatment Facilities

The purpose of TM-CSO-10 is to document the evaluation of alternative high rate treatment technologies in treating wet weather flow in excess of the 27 mgd primary treatment capacity provided at the WPF. This additional treatment is needed to achieve the CSO LTCP Phase IA objective, which is to attain an annual wet weather percent capture of 60 percent and treat a captured peak flow of 88 mgd. An additional 61 mgd of HRT capacity is required to treat this captured flow. A flow schematic representing this scenario is illustrated in Figure 9.

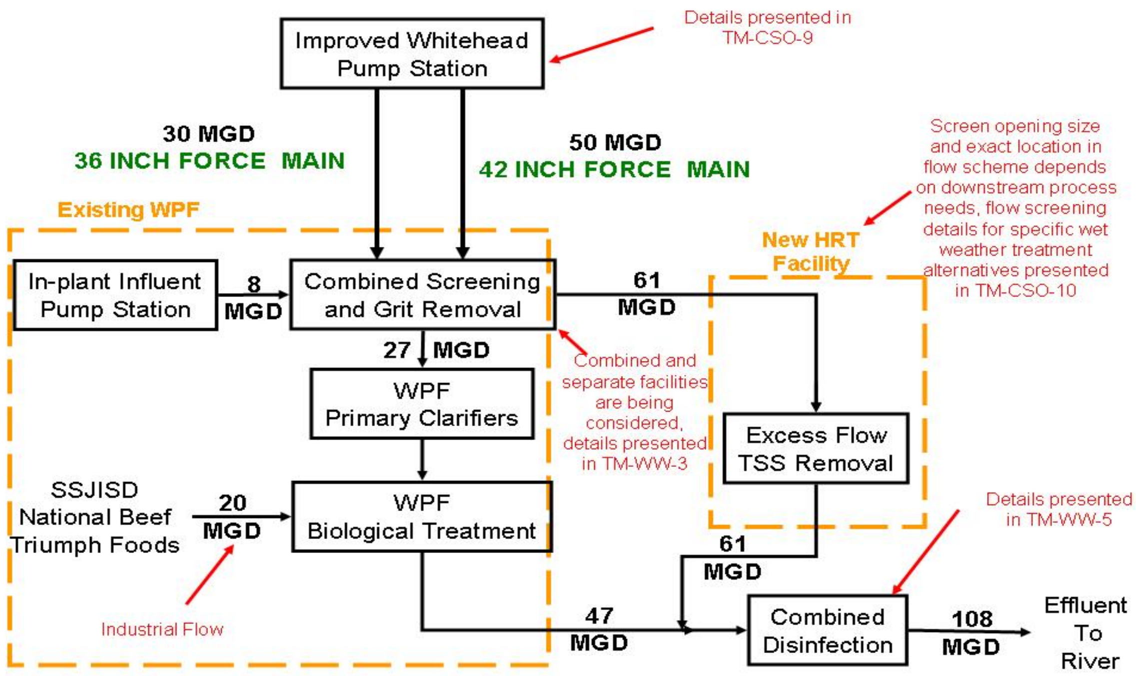


Figure 9 – Wet Weather Treatment Flow Schematic for Phase IA

Treatability tests were conducted to determine which HRT technologies were most applicable to the City's wet weather flow. The HRT technologies studied included: compressible media filtration (CMF), which is a specific type of high rate filtration (HRF); chemically enhanced primary treatment (CEPT); and high rate clarification (HRC).

A workshop was conducted with City staff on April 29, 2009 to confirm the wet weather flow values to use for this evaluation; review wet weather treatment strategies, regulations, technologies, and treatability test results; and identify which technologies merited further consideration. Based on that workshop and subsequent discussions with City staff, the following HRT alternatives were selected:

- Alternative 1 – HRC Technologies
  - Alternative 1A – Ballasted Flocculation HRC
  - Alternative 1B – Sludge Recirculation HRC
- Alternative 2 – HRF based on CMF Technologies

The CEPT option was screened out because it performed poorly for ultraviolet disinfection.

Evaluation of these HRT technologies included developing capital, O&M, and net present worth costs and non-economic factors. Table 8 presents the capital costs and Table 9 presents the net present worth costs for the HRT alternatives evaluated and discussed in detail in TM-CSO-10 for the City.

Table 8
Summary of Opinion of Probable Project Costs for High Rate Treatment [1]

Item	Alternative 1A Actiflo HRC, $	Alternative 1B DensaDeg HRC, $	Alternative 2 WWETCO CMF, $
Wet Weather Treatment Facility			
Structure, Valves, and Piping	3,521,000	4,078,000	5,864,000
Equipment	4,480,000	5,180,000	5,495,000
Chemical Storage/Blower Building			
Structure, Valves, and Piping	1,616,000	1,616,000	2,124,000
Equipment	203,000	203,000	1,092,000
Screening Building [2]			
Structure, Valves, and Piping	548,000	Base screening costs are presented in TM-CSO-12	Base screening costs are presented in TM-CSO-12
Equipment	1,353,000	Base screening costs are presented in TM-CSO-12	Base screening costs are presented in TM-CSO-12
Miscellaneous Yard Structures and Piping	1,310,000	1,310,000	1,310,000
Flood Protection/Fill (placeholder) [3]	202,000	263,000	332,000
Site Remediation (placeholder) [3]	1,211,000	1,577,000	1,993,000
Subtotal	*14,444,000*	*14,227,000*	*18,210,000*
Electrical, I&C, Sitework, Contractor General Requirements [4]	7,037,000	6,689,000	8,578,000
Subtotal	*21,481,000*	*20,916,000*	*26,788,000*
Contingency [5]	5,370,000	5,229,000	6,697,000
Land Acquisition (placeholder) [3, 6]	58,000	76,000	95,000
Opinion of Probable Construction Cost	**26,910,000**	**26,221,000**	**33,580,000**
Engineering, Legal, and Administration [7]	5,382,000	5,244,000	6,716,000
Opinion of Total Project Cost	**32,292,000**	**31,465,000**	**40,296,000**

Table 8
Summary of Opinion of Probable Project Costs for High Rate Treatment [1]

Item	Alternative 1A Actiflo HRC, $	Alternative 1B DensaDeg HRC, $	Alternative 2 WWETCO CMF, $

1. All costs presented in May 2009 dollars (ENR BCI = 4773).
2. An Actiflo facility will require an additional fine screening facility not required by the other alternatives. The additional screening costs for Actiflo are presented herein. The base screening costs for the remaining wet weather alternatives are presented in TM-CSO-12/TM-WW-3 – Screening and Grit Removal Facilities.
3. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the HRT facilities.
4. Electrical and instrumentation and controls (I&C) projected at 25% of the total of all equipment and structure costs. The electrical and I&C cost does not include any new or back-up power feeds; these facilities will be evaluated in TM-WW-9 – Site Considerations, Utility Improvements, and Ancillary Facilities. Sitework projected at 10% of the total of equipment, structures, electrical, and I&C costs. Contractor general requirements projected at 12% of the total of equipment, structures, electrical, I&C, and sitework costs.
5. Project contingency is projected at 25% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
6. Land acquisition cost is based on a projection provided by the City from a recent purchase of land directly south of the WPF.
7. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, electrical, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

Table 9
Net Present Worth Costs by Alternative for High Rate Treatment [1]

	Alternative 1A Actiflo HRC, $	Alternative 1B DensaDeg HRC, $	Alternative 2 WWETCO CMF, $
Net Project Capital Present Worth [2]	26,145,000	25,311,000	32,130,000
O&M Present Worth [3]	6,454,000	6,246,000	479,000
Total Net Present Worth	**32,599,000**	**31,557,000**	**32,609,000**

1. Costs are in May 2009 dollars. Present worth calculated with 20-year life cycle costs at 5% interest.
2. Net project capital present worth represents the present worth of project costs less the remaining value of facilities at the end of the 20-year life cycle. Service life for determination of replacement frequency and salvage value was projected as follows: structures – 50 years; equipment, electrical, instrumentation and controls – 20 years.
3. O&M costs were assumed to escalate at 5% per year.

Capital costs for the two HRC options were found to be less expensive than the CMF technologies. However, the O&M costs for the CMF technologies are significantly less expensive than the HRC technologies due in large part to the high chemical use associated with HRC treatment. The net present worth value of the HRC and CMF technologies over a 20-year life cycle are within 5 percent of each other, which for planning level costs are essentially equal. Non-economic factors were also considered. While there are several non-economic considerations that differentiate the HRT alternatives, two of the more notable non-economic factors are process operation and process flexibility.

Wet weather events are inherently unpredictable from a storm frequency and intensity basis and will cause a wide variation in process operation requirements. In addition to normal tasks, plant operators may be faced with many unplanned tasks during a wet weather event (power losses, flooding, etc.). Therefore, having a wet weather treatment process that requires minimal operator interaction, especially at start-up, can be particularly advantageous. Starting up an HRC process requires that the operator visually observe the flocculation process and make any adjustments to the coagulant or polymer feed rates or other process adjustments such as flocculation mixer speed required to achieve effective treatment. Throughout operation of the Actiflo HRC process, the operator must take samples at the hydrocyclones to monitor the sand inventory and periodically add sand to the system. The DensaDeg HRC process may require the operator to monitor sludge thicknesses during the treatment event to optimize the process. On the other hand, filtration processes such as the CMF process are typically monitored and controlled by level instrumentation, requiring very little operator interaction. In summary, since the CMF technology is a physical process rather than a chemical process, it will require less hands-on control during unpredictable wet weather events.

Process flexibility refers to the ability to make adjustments to the process to handle different influent characteristics. Operations at other existing facilities have demonstrated that both the HRC and CMF processes can handle significant variations in influent flows and concentrations and still produce consistent effluent quality. Chemical types, doses, and flocculation mixing intensity can generally be adjusted somewhat to optimize the HRC process. CMF processes accommodate changes in influent solids loading by automatically adjusting filter backwash frequency based on the level of influent above the filter media.

Another process flexibility feature unique to wet weather HRT applications is the ability to use wet weather facilities to perform other functions when not being used for wet weather treatment. For example, the HRC processes could be designed to provide additional primary treatment redundancy or be designed to provide tertiary phosphorus removal during normal dry weather conditions. However, HRC use during dry weather would require chemical dosing that could have significant cost implications. The CMF process could be designed to provide tertiary filtration during dry weather as well. The CMF technology appears to be the only financially viable alternative that could perform dual use tertiary treatment.

In review of the economic and non-economic evaluation and current LTCP implementation schedule, a number of conclusions and recommendations can be made. Based on the current proposed implementation schedule of the LTCP, construction of the HRT facilities will not take place for approximately 15 years. Therefore, it is not imperative that a decision be made at this time. Alternative 1A, 1B, and Alternative 2 appear to be viable options for the new HRT facilities. Alternative 2 appears to have higher capital costs, but lower O&M costs and more non-economic benefits. It also appears that Alternative 2 may have the potential to more significantly lower its capital costs over time as the designs for the emerging CMF technologies are further refined and optimized.

Conclusions and recommendations for the HRT evaluation include the following points:

- Defer selecting the specific HRT technology until the actual time when wet weather treatment facilities must be implemented.
- Conduct long-term pilot testing of the CMF technology over multiple wet weather events to confirm process design criteria. During the pilot study, influent samples of wet weather event flows should also be sent to HRC manufacturers to conduct additional jar tests to further evaluate coagulants and polymers and help confirm the process design criteria for the HRC technologies.
- Different HRT alternatives require different equipment and different facility designs; therefore, the equipment should be pre-selected prior to detailed design of the facilities. During a pre-design phase (closer to the construction date), the information presented in TM-CSO-10 should be updated to select the HRT equipment. The designs for each alternative could be re-evaluated, taking advantage of any developments that may have taken place with each technology. At that time, vendor quotes could be requested again for each technology to update the life cycle costs and to select the HRT equipment prior to detailed design.

14.0 TM-CSO-11: Disinfection Facilities

The MDNR National Pollutant Discharge Elimination System (NPDES) permit for the St. Joseph WPF requires disinfection of effluent flow by December 31, 2013. Permit requirements mandate disinfection of treated effluent occurs from April 1 through October 31 each year. In addition to flows from the WPF, disinfection will be required for treatment of effluent from a future HRT facility to be constructed as part of Phase IA of the CSO Implementation Plan (refer to Section 16.0 for more details on the CSO Implementation Plan). TM-CSO-11 documents the results of disinfection technology screening to narrow the technologies and configurations for further evaluation as well as an economic assessment of the selected alternatives. The following alternatives were considered for disinfection of flows from the WPF and from a future HRT:

- Alternative 1 – Combined UV disinfection of WPF and HRT flows (108 mgd)

- Alternative 2 – Combined bulk sodium hypochlorite and sodium bisulfite disinfection of WPF and HRT flows (108 mgd)
- Alternative 3 – Combined on-site generation of sodium hypochlorite and bulk sodium bisulfite for disinfection of WPF and HRT flows (108 mgd)
- Alternative 4 – UV disinfection of WPF flows (54 mgd), bulk sodium hypochlorite and sodium bisulfite disinfection of wet weather flows from HRT (61 mgd)
- Alternative 5 – UV disinfection of WPF flows (54 mgd), on-site generation of sodium hypochlorite and bulk sodium bisulfite for disinfection of wet weather flows from HRT (61 mgd)

Based on an evaluation of each of the alternatives on the criteria of project capital investment, O&M costs, net present worth, and non-economic factors, Alternative 1 – Combined UV disinfection of WPF and HRT flows is recommended for implementation. Table 10 presents the results of the project capital, O&M, and net present worth analysis for each of the alternatives.

Table 10
Net Present Worth Costs by Alternative for Disinfection [1]

	Alternative 1 108 mgd UV $	Alternative 2 108 mgd Bulk Hypochlorite $	Alternative 3 108 mgd On-site Generation $	Alternative 4 54 mgd UV + 61 mgd Bulk Hypochlorite $	Alternative 5 54 mgd UV + 61 mgd On-site Generation $
Net Project Capital Present Worth [2]	16,933,000	17,942,000	26,295,000	22,461,000	28,701,000
O&M Present Worth [3]	8,340,000	90,400,000	13,480,000	46,110,000	10,700,000
Total Net Present Worth	**25,273,000**	**108,342,000**	**39,775,000**	**68,571,000**	**39,401,000**

1. Costs are in May 2009 dollars. Present worth calculated with 20-year life cycle costs at 5% interest.
2. Net project capital present worth represents the present worth of project costs less the remaining value of facilities at the end of the 20-year life cycle. Service life for determination of replacement frequency and salvage value was projected as follows: structures – 50 years; equipment, electrical, instrumentation and controls – 20 years.
3. O&M costs were assumed to escalate at 5% per year.

From a project capital cost standpoint, Alternative 1 was found to be approximately equivalent to the next lowest project capital cost alternative (Alternative 2

– 108 mgd bulk sodium hypochlorite). The O&M evaluation demonstrated that the combined UV alternative is the lowest cost alternative on the basis of annual O&M costs. Likewise, the net present worth analysis showed that Alternative 1 is the lowest cost option on the basis of net present worth. The net present worth of the 108 mgd UV alternative ($25 million) is about $14 million less expensive over the 20-year life cycle than the next closest alternative.

On the basis of non-economic criteria, UV disinfection is the highest ranking technology. UV disinfection does not require significant use of hazardous chemicals, is independent of the chemicals market, will not form disinfection byproducts, and is fairly straightforward to operate and maintain after initial training.

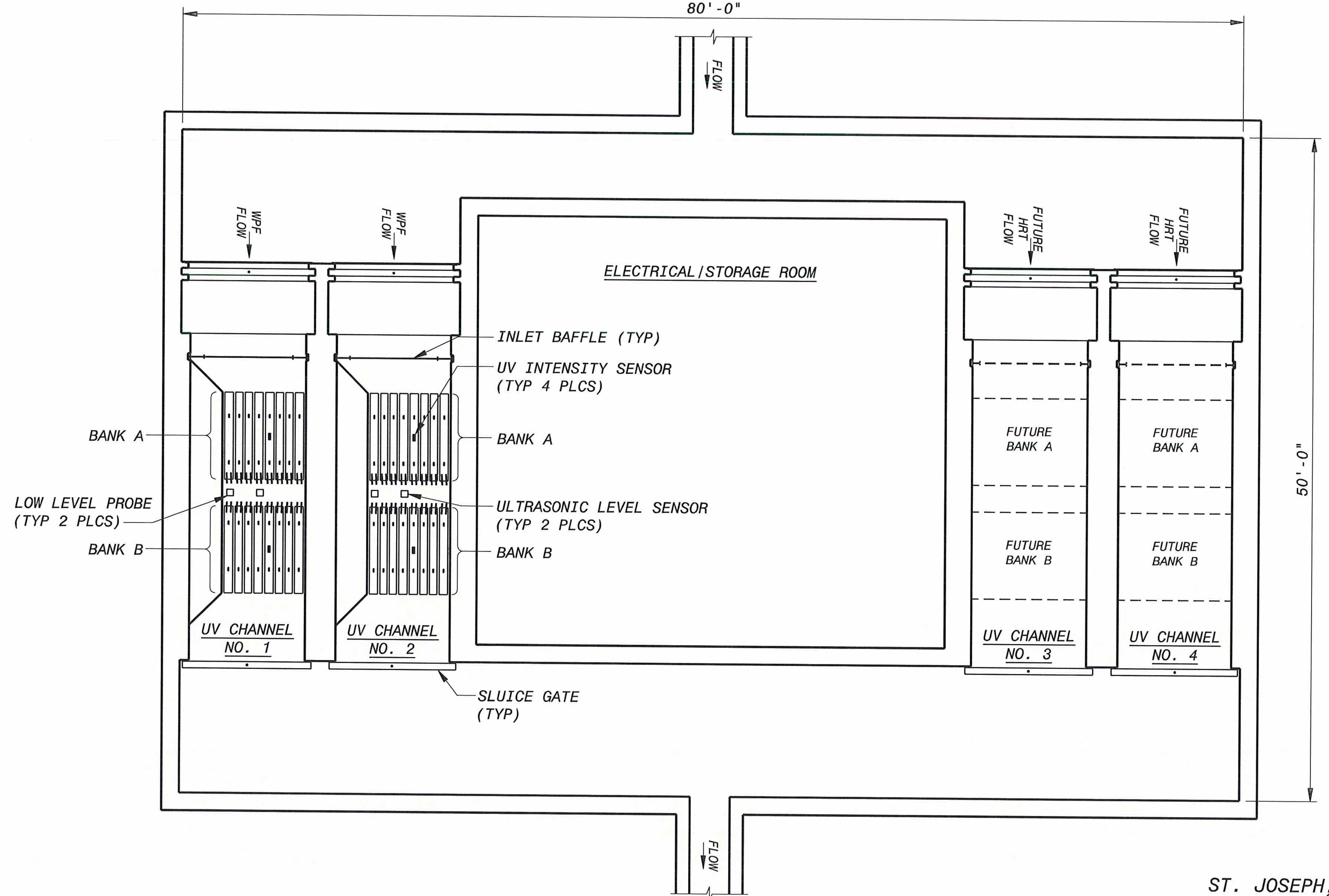
It is recommended that the City initiate the design for the $25.3 million (total net present worth, construction cost is $17.3 million) 108 mgd combined UV disinfection facility to treat WPF and HRT flows. Figure 10 shows a conceptual layout of the proposed UV disinfection facility. The design should consider phasing of the UV equipment to treat HRT flows, based on the anticipated timing of the HRT construction.

15.0 TM-CSO-12: Screening and Grit Removal Facilities

The purpose of TM-CSO-12 is to document the evaluation of alternative screening and grit removal technologies and alternatives for both the WPF and the future HRT facility. In addition, grit removal was evaluated for flow from the Missouri Avenue Diversion Structure since WPF staff have concerns about grit accumulation in the pipeline from the diversion structure to the In-plant Influent Pump Station.

The following groupings of alternatives were considered for the WPF and HRT flows:

- Alternative 1 – Provide a combined screening and grit removal facility for flows to both the WPF and HRT. Combined facilities offer the advantage of lower costs and single point handling of screenings and grit.
- Alternative 2 – Provide separate screening and grit removal facilities for the WPF and HRT. Separate facilities offer the advantage of being able to utilize existing WPF facilities or WPF property.



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ALTERNATIVE 1
UV DISINFECTION BUILDING
JULY 2009

Figure 10

BFIGBORD
FBFIGBORD

- Alternative 3 – Provide a combined screening facility for both the WPF and HRT, but separate grit removal facilities for each. This alternative offers the advantage of combining screening facilities while still utilizing some existing WPF facilities and property for grit removal.

The following alternatives were considered for the Missouri Avenue Diversion Structure flow:

- Alternative A – Provide pipeline improvements to address grit accumulation.
- Alternative B – Provide a dedicated grit facility for flows from the Missouri Avenue Diversion Structure.
- Alternative C – Provide a dedicated horizontal grit chamber for flows from the Missouri Avenue Diversion Structure.
- Alternative D – Provide for periodic cleaning of the pipeline to prevent grit build-up.

WPF and HRT Flow

Alternatives 1, 2, and 3 represent three configurations for screenings and grit removal covering a range from a combined facility to handle both WPF and HRT flow to completely separate facilities dedicated to the WPF and HRT to a combination of the two. Sub-alternatives as described below were developed for each configuration using grit removal technologies deemed by City staff as appropriate for further consideration. These technologies included the existing aerated grit basins, vortex type grit removal equipment such as Smith & Loveless PISTA, and grit removal equipment manufactured by Hydro International including the Eutek Headcell, Storm King, and Grit King. Figure 11 presents an overview of the existing WPF and indicates possible locations for the facilities. Final locations will be determined when a siting study is conducted and detailed design performed.

- Alternative 1A – Upgrade existing aerated grit basins to process all flow (88 mgd) and screening facility near the existing grit basins.

200' 100' 0 200' 400'

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POSSIBLE SCREENING AND
GRIT FACILITY LOCATIONS

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Figure 11

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BFIGBORD
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- Alternative 1B – Screening and grit removal facility in location of existing aerated grit basins to process all flow (88 mgd).
- Alternative 1C-1 – Screening and vortex grit removal facility at north property to process all flow (88 mgd).
- Alternative 1C-2 – Screening and Eutek Headcell grit removal facility at north property to process all flow (88 mgd).
- Alternative 2A – Upgrade existing aerated grit basins to process WPF flow (34 mgd), screening facility to process WPF flow (34 mgd) near the existing grit basins, and screening and grit removal facility to process HRT flow (61 mgd) in alternate location.
- Alternative 2B – Upgrade existing aerated grit basins to process HRT flow (61 mgd), screening facility to process HRT flow (61 mgd) near the existing grit basins, and screening and grit removal facility to process WPF flow (34 mgd) in alternate location.
- Alternative 2C – Eutek Headcell grit removal facility retro-fitted in existing aerated grit basins to process WPF flow (34 mgd), screening facility to process WPF flow (34 mgd) at north property, screening and Storm King/Grit King grit removal facility to process HRT flow (61 mgd) at west property.
- Alternative 3A-1 – Screening to process all flow (88 mgd) at north property, vortex grit removal to process HRT flow (61 mgd) at north property, and vortex grit removal to process WPF flow (34 mgd) near existing grit basins.
- Alternative 3A-2 – Screening to process all flow (88 mgd) at north property, Storm King/Grit King grit removal to process HRT flow (61 mgd) at north property, and Eutek Headcell grit removal to process WPF flow (34 mgd) in existing grit basins.

Table 11 provides a summary of the sub-alternatives and the initial evaluation. After initial screening, the following five sub-alternatives were selected for further evaluation based on costs, present worth, and non-economic factors:

- Alternative 1C-1
- Alternative 1C-2
- Alternative 2C
- Alternative 3A-1
- Alternative 3A-2

Each of the five alternatives listed above was evaluated using the criteria of project capital investment, O&M costs, net present worth, and non-economic factors. Table 12 presents the results of the project capital, O&M, and net present worth analysis for each of the alternatives.

Table 11
Screening and Grit Removal Alternatives

Alternative	Screens	Grit System	Location	Description	Potential Benefit	Preliminary Screening Action
1A	Front Cleaned Bar Rack 1/2" opening	Aerated Grit System	Existing WPF grit basins	Upgrade existing aerated grit basins to process all flow (88 mgd), screening facility near the existing grit basins.	Maximize use of existing facilities. Locates operation in single spot nearest existing connection point.	Eliminated from further consideration due to poor performance of current aerated grit system and poor configuration of existing basins hindering performance at higher capacity.
1B	Front Cleaned Bar Rack 1/2" opening	Vortex or Headcell	Existing WPF grit basin area	Screening and grit removal facility in location of existing aerated grit basins to process all flow (88 mgd).	New and better grit technology than existing aerated grit. Single spot location at nearest existing connection point to WPF.	Eliminated from further consideration. Initial facility layouts indicate 88 mgd cannot fit in this location.
1C-1	Front Cleaned Bar Rack 1/2" opening	Vortex	Alternate location	Screening and vortex grit removal facility at north property to process all flow (88 mgd).	New and better grit technology than existing aerated grit. Single spot location better for operation. Though somewhat limited, alternate sites provide more space for facilities.	Alternative was selected for further consideration. Location north of Administration Building selected.
1C-2	Front Cleaned Bar Rack 1/2" opening	Headcell	Alternate location	Screening and Eutek Headcell grit removal facility at north property to process all flow (88 mgd).	New and better grit technology than existing aerated grit. Single spot location better for operation. Though somewhat limited, alternate sites provide more space for facilities.	Alternative was selected for further consideration. Note that Storm King / Grit King not applicable for a combined facility approach. Location north of Administration Building selected.
2A	Front Cleaned Bar Rack 1/2" opening	Aerated Grit System and Vortex or Storm King / Grit King	Existing WPF grit basins and alternate location for new facilities	Upgrade existing aerated grit basins to process WPF flow (34 mgd), screening facility to process WPF flow (34 mgd) near the existing grit basins, and screening and grit removal facility to process HRT flow (61 mgd) in alternate location.	Maximizes use of existing facilities. Locates grit and screen facility near each subsequent process (WPF or HRT).	Eliminated from further consideration due to poor performance of current aerated grit system and poor configuration of existing basins hindering performance at higher capacity.
2B	Front Cleaned Bar Rack 1/2" opening	Aerated Grit System and Vortex or Headcell	Existing WPF grit basins and alternate location for new facilities	Upgrade existing aerated grit basins to process HRT flow (61 mgd), screening facility to process HRT flow (61 mgd) near the existing grit basins, and screening and grit removal facility to process WPF flow (34 mgd) in alternate location.	Maximizes use of existing facilities.	Eliminated from further consideration due to poor performance of current aerated grit system and poor configuration of existing basins hindering performance at higher capacity.
2C	Front Cleaned Bar Rack 1/2" opening	Headcell and Storm King / Grit King	Existing WPF grit basins and alternate locations for new facilities	Eutek Headcell grit removal facility retrofitted in existing aerated grit basins to process WPF flow (34 mgd), screening facility to process WPF flow (34 mgd) at north property, screening and Storm King / Grit King grit removal facility to process HRT flow (61 mgd) at west property.	Re-uses existing aeration basin structure.	Alternative was selected for further consideration. WPF screening facility located north of Administration Building and HRT screening and grit facility located west of WPF.
3A-1	Front Cleaned Bar Rack 1/2" opening	Vortex	Existing WPF grit basin area and alternate location for other new facilities	Screening to process all flow (88 mgd) at north property, vortex grit removal to process HRT flow (61 mgd) at north property, and vortex grit removal to process WPF flow (34 mgd) near existing grit basins.	Single spot location for screening. Utilizes existing WPF property at existing grit basins.	Alternative was selected for further consideration. Location north of Administration Building selected.
3A-2	Front Cleaned Bar Rack 1/2" opening	Headcell and Storm King / Grit King	Existing WPF grit basins and alternate location for other new facilities	Screening to process all flow (88 mgd) at north property, Storm King / Grit King grit removal to process HRT flow (61 mgd) at north property, and Eutek Headcell grit removal to process WPF flow (34 mgd) in existing grit basins.	Single spot location for screening. Utilizes existing grit basins for WPF grit removal equipment.	Alternative was selected for further consideration. Location north of Administration Building selected.

Table 12
Net Present Worth by Alternative for Screening and Grit Removal Facilities [1]

	Alternative 1C-1 (Vortex Grit Removal), $	Alternative 1C-2 (Hydro International Grit Removal), $	Alternative 2C (Hydro International Grit Removal), $	Alternative 3A-1 (Vortex Grit Removal), $	Alternative 3A-2 (Hydro International Grit Removal), $
Net Project Capital Present Worth [2]	19,566,000	20,509,000	31,481,000	22,221,000	25,859,000
O&M Present Worth [3]	5,736,000	5,826,000	9,978,000	8,063,000	7,879,000
Total Net Present Worth	**25,302,000**	**26,335,000**	**41,459,000**	**30,284,000**	**33,738,000**

1. Costs are in May 2009 dollars. Present worth calculated with 20-year life cycle costs at 5% interest.
2. Net project capital present worth represents the present worth of project costs less the remaining value of facilities at the end of the 20-year life cycle. Service life for determination of replacement frequency and salvage value was projected as follows: structures – 50 years; equipment, electrical, instrumentation and controls – 20 years.
3. O&M costs were assumed to escalate at 5% per year.

From a project capital cost standpoint, both Alternatives 1C-1 (based on Smith & Loveless PISTA vortex equipment) and 1C-2 (Eutek Headcell) were found to be approximately equivalent. The O&M evaluation demonstrated that the two alternatives were also essentially the same. Likewise, the net present worth analysis showed that the two alternatives were the least expensive options on the basis of net present worth. The net present worth of Alternative 1C-2 ($26 million for the Eutek Headcell alternative) was about $4 million less expensive over the 20-year life cycle than the next closest alternative. On the basis of non-economic criteria, all alternatives were similar; however, the Eutek Headcell equipment is proprietary and would require sole source negotiations with the manufacturer.

Due to the proprietary issues with the Eutek Headcell equipment, it is recommended that the City initiate the design for the $25.3 million (total net present worth, construction cost is $26.8 million) 88 mgd combined screening and grit removal facility to treat WPF and HRT flows based on a vortex type system such as Smith & Loveless PISTA. Figure 12 shows a general layout of the recommended Alternative 1C-1. Figures 13 and 14 show a conceptual plan and section of the proposed screening and vortex grit removal facility. Locations of facilities shown are preliminary. Locations may be changed when a siting study is conducted and during detailed design.

Construction of facilities and equipment should be phased in order to provide initial capacity for the WPF and then expanded in the future when the HRT is

200' 100' 0 200' 400'

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ALTERNATIVE 1C-1
SCREENING AND GRIT REMOVAL
FOR 88 MGD (VORTEX)
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DECEMBER 2009

Figure 12

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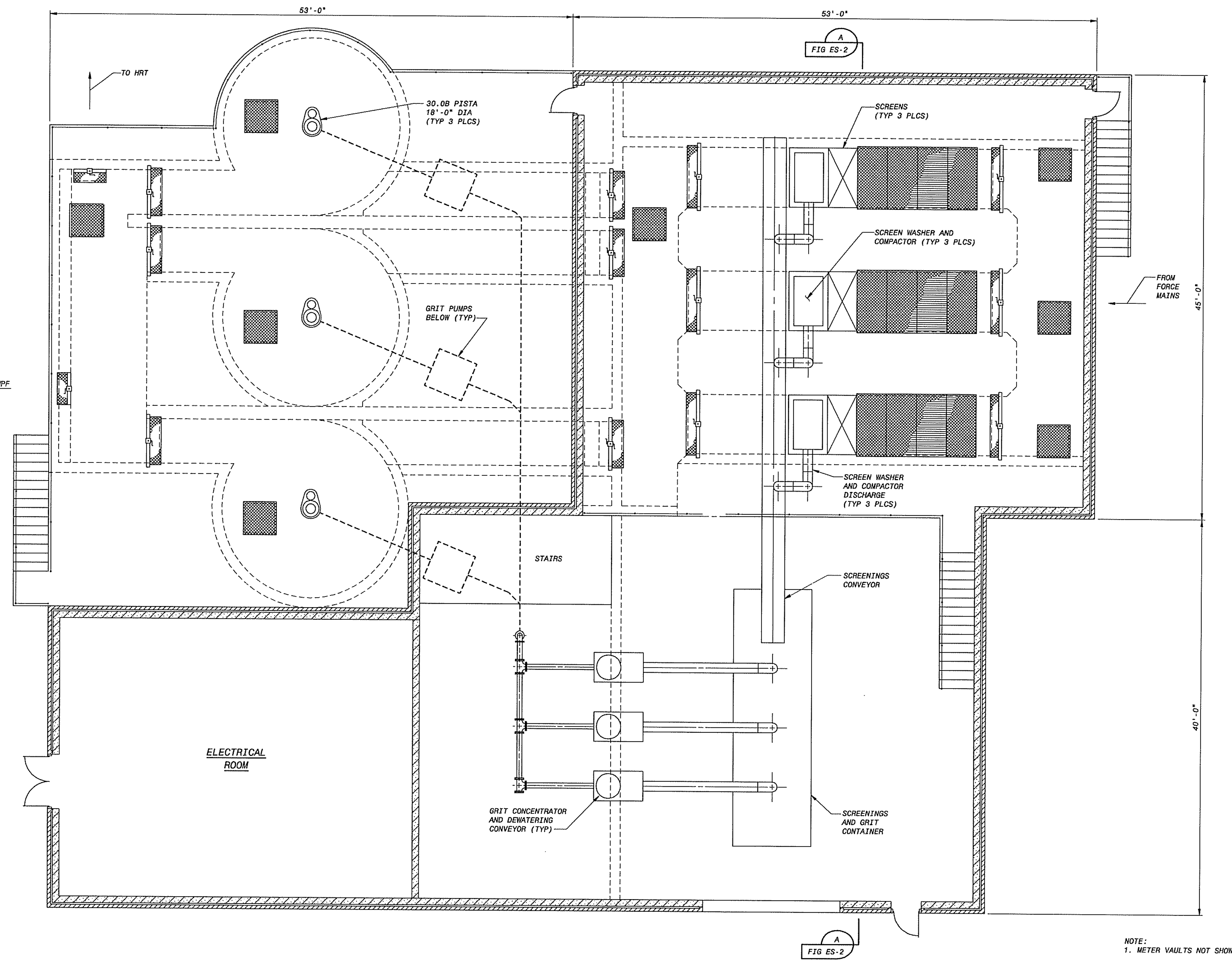

PLAN

3/32" = 1'-0"

NOTE:
1. METER VAULTS NOT SHOWN.

REVISIONS AND RECORD OF ISSUE

NO.	BY	CK	APP	DATE

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USER: GLA10863

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XREF4 ID:
XREF5 ID:
SW: FIGURE ES-3.dwg

BLACK & VEATCH Corporation
Kansas City, Missouri

ST. JOSEPH, MISSOURI
FACILITIES PLAN

ALTERNATIVE 1C-1
SCREENING AND GRIT REMOVAL
FOR 88 MGD (VORTEX) PLAN

DESIGNED: RCB
DETAILED: JKS
CHECKED:
APPROVED:
DATE:

PROJECT NO.
163509

Figure 13

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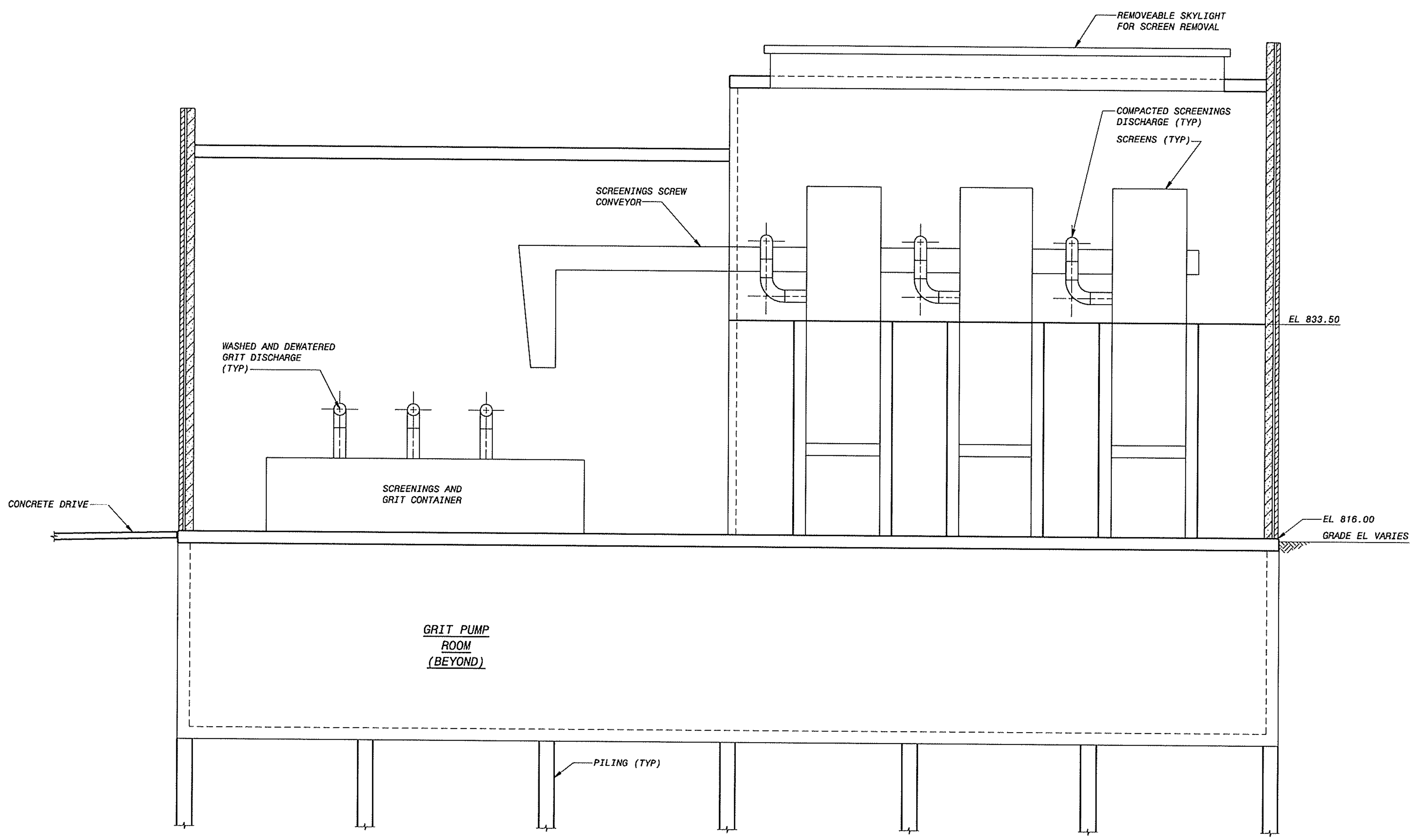

SECTION A
3/32" = 1'-0" FIG ES-3

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XREF1 ID: ES-Screening_G_F_Sections.dwg
XREF2 ID:
XREF3 ID:
XREF4 ID:
XREF5 ID:

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ALTERNATIVE 1C-1
SCREENING AND GRIT REMOVAL
FOR 88 MGD (VORTEX) SECTION

DESIGNED: RCB
DETAILED: JKS
CHECKED:
APPROVED:
DATE:

PROJECT NO.
163509

Figure 14

SHEET
OF

FD5000
D5000

constructed. Based on conceptual layouts and equipment selection, phasing would initially include three screen channels and two screens and two grit removal basins. Exact numbers and sizes of equipment may change during detailed design.

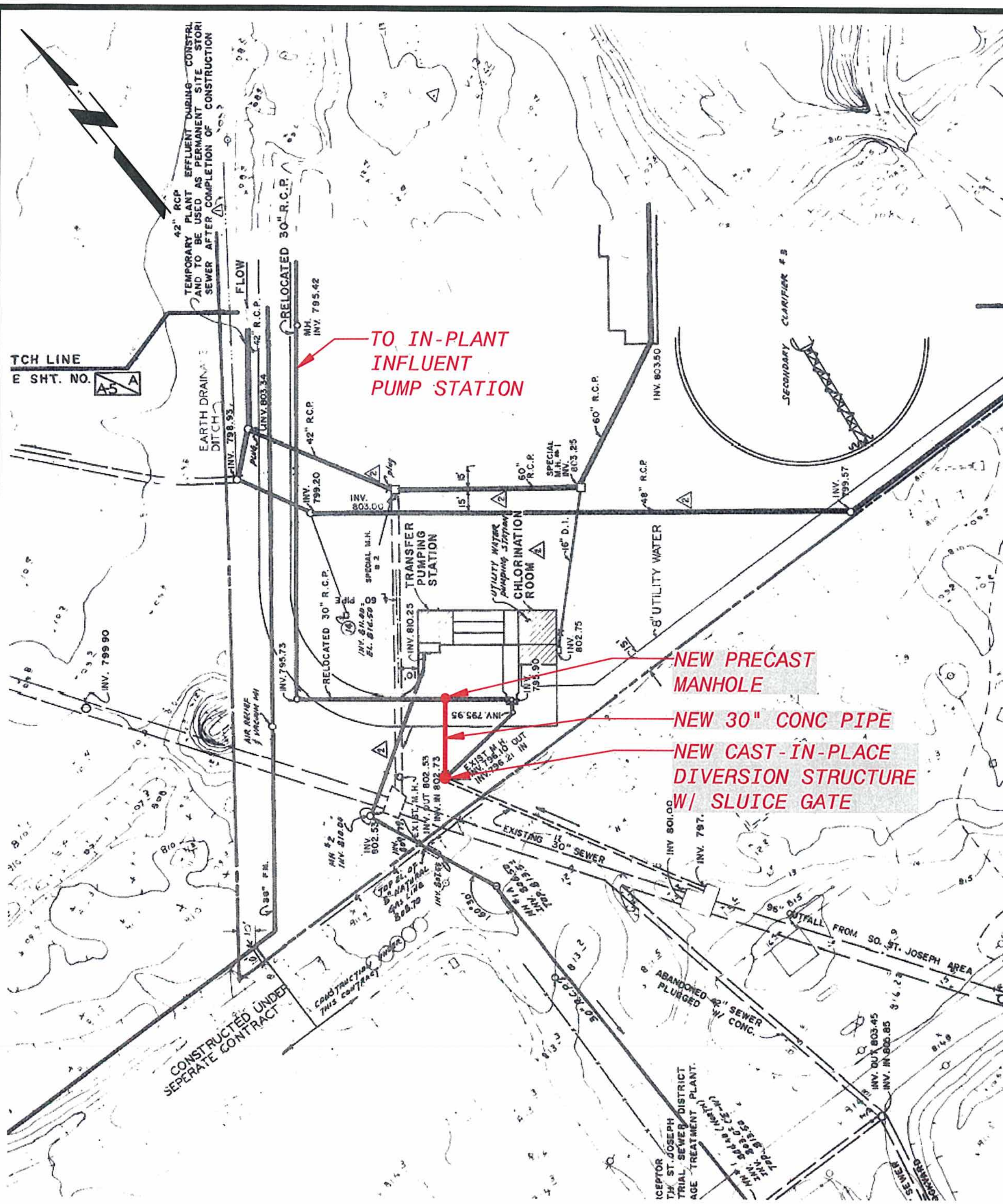
Missouri Avenue Diversion Structure Flow

Operations personnel have noticed significant grit accumulation in the pipeline from the diversion structure to the In-plant Influent Pump Station. In addition, pump wear at the In-plant Influent Pump Station suggests possible grit impacts. The following alternatives to address the grit issue were evaluated.

Alternative A included a hydraulic evaluation of the pipeline which indicated that the pipeline has some sections with very shallow slopes resulting in low velocities during low flows. Given the low velocities, it is understandable that there would be grit settlement issues in the pipeline. If the pipeline were reconstructed to eliminate the shallow slope segments, the resulting slope would still be insufficient to prevent the accumulation of grit in the pipeline. The cost of reconstructing the line would be high due to the depth of the line and the amount of existing piping that is in the same general path of or crosses the current pipeline. Figure 15 shows the south end of the plant where the pipeline forms a “Z” shaped bend to connect to the Transfer Pump Station. This reversal in pipeline direction is a potential area where grit would accumulate. The reversal could be eliminated as indicated in Figure 15; however, eliminating the reversal would not solve the issues with the downstream shallow slopes.

Alternative B would include constructing dedicated screening and grit facilities for flows from the Missouri Avenue Diversion Structure. The depth of the pipeline from the diversion structure (approximately 16 feet) and the fact that there would be additional headloss through the grit system would require that a pump station be constructed to lift the flow to near grade level. The cost of this pump station along with the cost of the screening and grit facilities would be several million dollars.

Alternative C would include constructing two (one standby) dedicated horizontal grit chambers. The grit chambers would have to be located at the elevation of the pipeline (approximately 16 feet below grade). Grit chambers 2.5 feet wide and 90 feet long would be required in order to settle grit similar in size to the proposed WPF and



100' 50' 0 100' 200'

APPROX SCALE IN FEET

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ST. JOSEPH, MISSOURI
FACILITIES PLAN
PN 163509
MISSOURI AVENUE
PIPELINE MODIFICATIONS

DECEMBER 2009

Figure 15

AFIGBORD
FAFIGBORD
CYGNET ID: 163509-2000-WWTCN-C-N0001BTWV

HRT grit facilities. The grit chambers would need to be enclosed in a building and provided with odor control in order to prevent offsite odors. The cost of this grit chamber, building, and odor control would be several million dollars.

Alternative D provides for the periodic cleaning of the pipeline from the Missouri Avenue Diversion Structure. Preliminary quotes indicate that the cost of an initial cleaning for the line would be approximately $16,400 not including disposal. The cost of disposal of the grit is approximately $10,000. Subsequent cleaning of the line every one to two years would cost approximately $8,000.

Periodic cleaning of the Missouri Avenue pipeline on a biannual basis, Alternative D, is recommended given the high cost of constructing the other alternatives.

16.0 Combined Sewer Overflow Control Implementation Plan

16.1 Phase IA

The Phase IA CSO control projects will allow the City to achieve 60 percent wet weather capture for the combined sewer system. In negotiations with MDNR and USEPA, it was determined that the Phase IA projects should be completed within the next 20 years for the CSO Long Term Control Plan The Phase IA Long Term Control Plan implementation schedule is shown in Figure 16. A summary of the Phase IA opinion of probable project costs is provided in Table 13. Additional projects, like the green solutions concepts summarized in TM-CSO-7 – Green Solutions Opportunities Evaluation and Refinement, could also be implemented if desired by the City. The green solutions concepts are not included in the Phase IA projects and therefore remain optional for the City to implement as supplemental projects. Only those projects shown in Figure 16 are mandated to be completed by December 30, 2028.

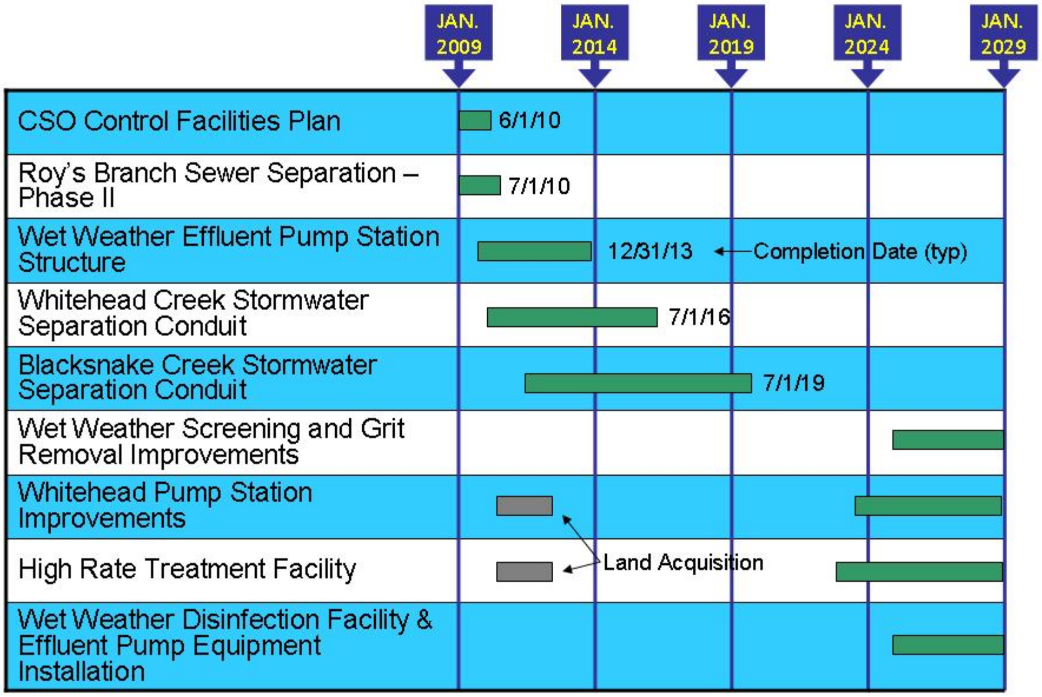

Figure 16 – Phase IA Implementation Schedule

Table 13
Phase IA Opinion of Probable Project Costs [1]

Project Name	$, Millions
CSO Control Facilities Plan [2]	1.3
Roy's Branch Sewer Separation – Phase II	1.0
Wet Weather Effluent Pump Station Structure [3]	2.0
Whitehead Creek Stormwater Separation Conduit	21.4
Blacksnake Creek Stormwater Separation Conduit	39.7
Wet Weather Screening and Grit Removal Improvements [4]	11.3
Whitehead Pump Station Improvements and Diversion Structure Modifications	25.5
High Rate Treatment Facility and Back-Up Power	41.2
Wet Weather Disinfection Facility and Effluent Pump Equipment Installation	8.7
Phase IA Facility Cost	**152.1**

1. Project costs are in 2009 dollars.
2. The Facilities Plan project cost is $2.7 million; of this cost, $1.3 million is associated with the CSO control portion.
3. Total Effluent Pump Station project cost is 6.0 million; of this cost, $2.0 million is associated with the CSO control program.
4. Total project cost is $26.8 million; of this cost, $11.3 million is associated with the CSO control program.

16.2 Phase IB

Improvement projects beyond the Phase IA CSO controls are required for the City to achieve 85 percent wet weather capture and meet the USEPA presumptive approach control policy. Upon completion of the Phase IA improvements, it is recommended that a two-year monitoring and evaluation study of Missouri River water quality be performed to demonstrate the effectiveness of the Phase IA improvements. This study phase, entitled Phase IB, will help establish the water quality benefits of the Phase IA improvements and further refine the future Phase II recommendations, perhaps reducing both the scope and cost of the work envisioned in the future as a result. The water quality study is anticipated to consist of the following activities:

- Flow and Water Quality Data Collection
- Missouri River Water Quality Modeling
- Phase II Tunnel Combined Sewer System Hydrologic and Hydraulic Modeling and Recommendations Update

- MDNR and USEPA Meetings
- Public Involvement
- Phase IB Water Quality Report
- Phase II Update Report

Phase IB is part of an overall adaptive management approach for the City's CSO Long Term Control Plan to ensure that funding continues to be optimized now and in the future for the improvement of Missouri River water quality. If it is determined that the Phase IA improvements exceed the 60 percent wet weather capture goal or exceed anticipated water quality requirements, it may be possible to reduce the size of the Phase II deep tunnel. The anticipated cost to perform the Phase IB water quality study is approximately $1 million (in 2009 dollars); however, it is dependent on the actual scope and level of effort for this project.

16.3 Phase II

The Phase II CSO control projects will allow the City to achieve 85 percent wet weather capture for the combined sewer system. Phase II consists of a 20 foot diameter, 23,000 foot long, deep tunnel with a storage capacity of 54 MG. In addition, the deep tunnel system would also require a deep tunnel pump station, a deep screening shaft, drop shafts, consolidation sewers, and grit handling. This tunnel, in combination with the Phase IA improvements, will allow the City to achieve 85 percent wet weather capture. Furthermore, this alternative assumes that the Phase IA facilities including 61 mgd high rate treatment, 61 mgd UV disinfection, and 61 mgd effluent pumping will provide the facilities to treat, disinfect, and convey the treated flows captured by the deep tunnel. The opinion of probable project cost for the Phase II deep tunnel and deep pump station system is $310 million (in 2009 dollars). The anticipated Phase II implementation timeline for project funding, preliminary studies, geotechnical drilling and evaluations, alignment and siting studies, design, and construction will be developed upon conclusion of the Phase IB water quality study. Cash flow and financing limitations may require decades of funding accumulation to pay for a Phase II program while maintaining the maximum financial capability rate at 2 percent of the median household income.

Upon completion of the Phase IA and IB projects, the deep storage tunnel recommendation will be re-evaluated and modified as necessary. The CSO control program is based on an overall adaptive management approach for the City's CSO Long Term Control Plan to ensure that funding continues to be optimized now and in the future for the improvement of Missouri River water quality.

16.4 Combined Sewer Overflow Control Implementation Plan Cost Summary

The overall project cost summary by phase for the St. Joseph CSO control program is shown in Table 14.

Table 14
St. Joseph CSO Control Implementation Plan Cost Summary [1]

Phase	$, Millions
Phase IA	152.1
Phase IB	1.0
Phase II	310.6
Total CSO Control Program Cost	**463.7**

1. Project costs are in 2009 dollars.